EEMSS Background Report & USER MANUAL

EEMSS

estuary entrance management support system

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WELCOME TO THE ESTUARY ENTRANCE MANAGEMENT SUPPORT SYSTEM (EEMSS)

The EEMSS is a decision support tool that guides estuary managers when making the decision whether or not to artificially open an estuary.

The EEMSS database is on the CD attached to this report.

The report is presented in three parts:

Part 1 provides background information and an overview of the EEMSS (sections 1-3);

Part 2 provides information about the environmental, cultural and socioeconomic assets potentially impacted by the opening decision and the rules for scoring both the importance of, and threats to those assets. Information about community engagement is also included in this part (sections 4-8); and

Part 3 is a step by step guide to installing the database and using EEMSS on your estuary.

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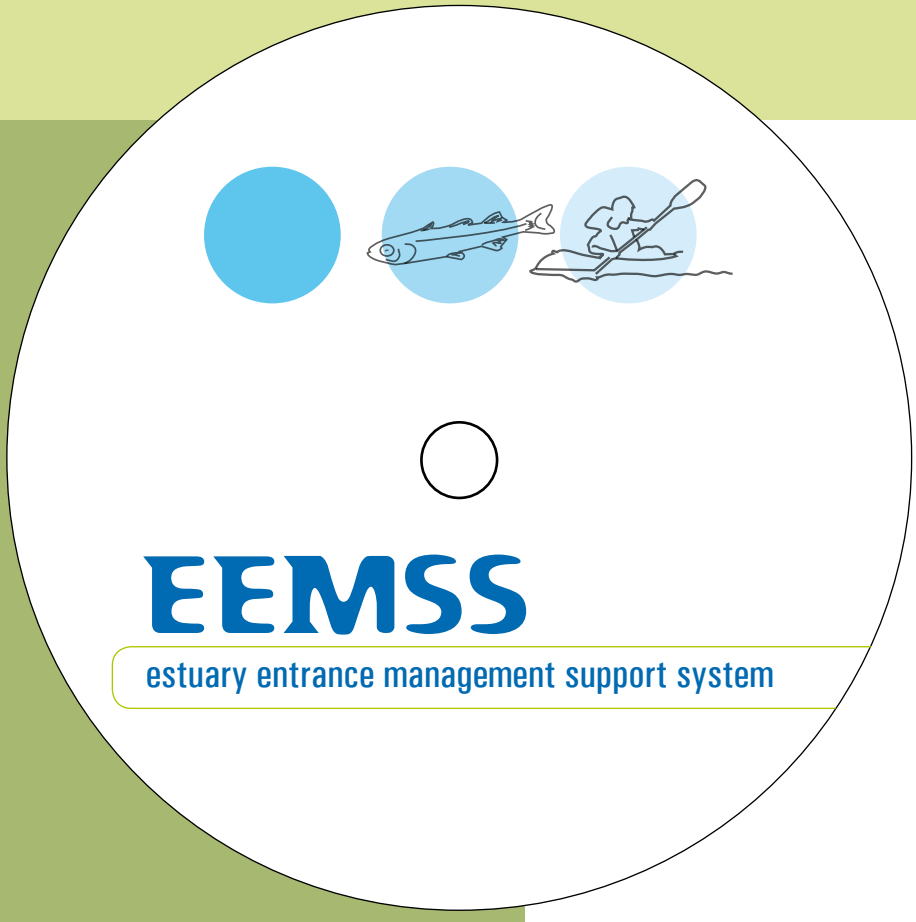

Contents

Acknowledgements

The EEMSS was developed in collaboration with agencies and community members. Community workshops were an important component of the EEMSS development involving individual community members and representatives of many community groups.

A steering group provided guidance during development of the EEMSS database. There were some changes to the membership during the project and earlier members are shown in brackets after the current members in the list below.

Deakin University: Helen Arundel (Project officer), John Sherwood, Julie Mondon & Mary Graham
Glenelg Hopkins Catchment Management Authority: Graeme Jeffery (Linda Grant) (Project manager) & Kylie Bishop
Corangamite Catchment Management Authority: John Turner
The Environment Protection Authority Victoria: Dianne Rose
Parks Victoria: Anthony Boxshall and Evan McDowell (Kate Maltby)
The Western Coastal Board: Steve Blackley (Jennifer Lilburn)
Department of Sustainability and Environment: Ingrid Holliday & Andrew Gosden
Department of Primary Industries: James Andrews

Members of technical advisory groups, and consultants who provided expert advice, are listed in the section 7 of the report.

The EEMSS concept was translated into specific business requirements for the software by Arnie Phillips (Deakin University).

The database was developed by Shelley Heron (Heron Environmental Consulting Services) and Artie Sovlitsis (As One Consultants).

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Photos courtesy of Glenelg Hopkins CMA (pp 35 and 57), Jan Barton (p 27) and Dave Burton, Parks Victoria (p 112). All other photos supplied by Rodney Hyett.

1 Background

1.1 Why was the EEMSS developed?

The Value of estuaries

Estuaries and associated wetlands are one of the most valuable ecosystems. They are highly productive areas and provide spawning and nursery areas for fish, and breeding and foraging areas for birds. Estuaries and their wetlands also have an important function as natural sediment and nutrient filters. This function provides cleaner water to both the estuary and inshore zones.

Victorian estuaries support rare and threatened flora and fauna, internationally significant bird species and are associated with wetlands listed in the Directory of Important Wetlands in Australia.

Apart from their ecological importance and scenic beauty, many estuaries are popular tourist destinations and are valued for the recreational opportunities they provide. These include activities such as fishing, swimming, bird watching and boating. Estuaries are often the site of agricultural activity and many towns are located adjacent to estuaries.

Many of the estuaries in Victoria intermittently close following the formation of a sand bar at the mouth of the estuary. This usually occurs during periods of low freshwater inflow (see appendices A & B for more information on estuary mouth closure). Estuary mouth closure results in an increased water level within the estuary and inundation of adjacent areas. The higher water level can cause flooding of agricultural land and infrastructure such as jetties and roads but there are also environmental benefits associated with flooding of adjoining wetlands and fringing vegetation.

Socioeconomic costs associated with flooding are alleviated by artificially opening the estuary mouth. However, there are potential environmental impacts associated with this intervention. Although the most obvious is a mass 'fish kill' (appendix C), other impacts such as loss of fish spawning and bird nesting habitat also need to be considered when deciding whether or not to open an estuary.

The Victorian Coastal Strategy (2002) recognised the complexity of artificial estuary mouth opening decisions and the need for guidance of estuary managers. Action 1.1.4 recommends that 'Best practice guidelines for the management of estuarine mouth openings be developed, incorporating environmental, social and economic issues.' A history of unlicensed river mouth openings and community concern about the lack of clear, consistent guidelines provided further impetus for development of the Estuary Entrance Management Support System (EEMSS).

1.2 What is the EEMSS?

The EEMSS is a decision support tool that will guide estuary managers when making the decision whether or not to artificially open an estuary. The EEMSS ensures a consistent process is followed each time so all assets are considered and openings are safe and effective.

The EEMSS also provides a means of storing data that can be used to inform future management decisions and allow agencies to better target monitoring programs.

The EEMSS provides a comprehensive assessment of the potential impact to the various social, cultural, economic and environmental assets associated with both opening and not opening the estuary mouth. This information is used only to guide the estuary manager's decision, which is made after comparing the impact of both scenarios.

Application of the EEMSS to the artificial estuary opening decision making process will:

- ensure a consistent process is followed when making the decision whether or not to open an estuary;
- ensure environmental, cultural and socio-economic assets are considered in that decision;
- ensure a consistent protocol is followed when agencies artificially open an estuary; taking better account of public safety and effectiveness of the opening;
- identify assets that are at risk when the decision is made to open or not open an estuary. These assets can then be targeted in future monitoring programs;
- store information such as water quality, water levels, mouth status etc. This data will allow managers to better monitor their management decisions over time;
- support decisions with the best scientific information available;
- allow incorporation of new information as it becomes available.

1.3 Relevant legislation & strategies (Victoria)

There are two authorisations required before any estuary mouths are artificially opened.

1. A 'works on waterways' permit issued by the Catchment Management Authority (CMA) as an authority under the Water Act 1989 (section 67); and

2. A consent to 'use' or 'develop' coastal Crown land, issued under the Coastal Management Act 1995 (section 37). The consent is issued by the Department of Sustainability and Environment, or Parks Victoria if the land is reserved under the National Parks Act 1975 (section 27)

Artificial estuary mouth openings in Victoria are regulated under section 67 of the Water Act 1989 which governs Works on Waterways. An artificial estuary mouth opening can only be legally undertaken by the holder of a valid Works on Waterway permit. Issue and regulation of these permits is currently the responsibility of CMAs. Permits are issued to public land managers with the responsibility for management of the strip of land that constitutes the estuary mouth.

CMAs are also designated as the 'custodians of river health' and are responsible for the development and implementation of River Health Strategies. These provide strategic direction for investment in the long-term health of waterways including estuaries.

> Catchment Management Authorities (CMAs) are pivotal in coordinating decision making related to artificial openings of estuaries because of their responsibility for the Works on Waterway Permit, floodplain and drainage management and river health. The CMAs have a role in integrated natural resource management under the Catchment and Land Protection Act 1994 and for management of waterway, floodplain and drainage services under the Water Act 1989.

A list of legislation referred to in the EEMSS is given in Appendix D

2 Development of the EEMSS

2.1 Project brief

The aims of the EEMSS project were to:

- develop a decision support system (DSS) that protects the cultural, socio-economic and environmental assets of an estuary; and
- improve public and agency understanding and support for estuary entrance management using the DSS.

> The EEMSS was developed in close collaboration with agencies and the broader community and incorporates many of the features required by those groups.

The agencies responsible for the development of the EEMSS, required that the decision support system be:

- transparent
- easy to use
- not reliant on extensive data collection
- adaptive i.e. able to respond to monitoring
- applicable to all intermittently-closed estuaries in Victoria but able to incorporate the uniqueness of each estuary.

Community workshops, undertaken during the EEMSS development, identified ways to improve current estuary entrance management (see section 2.3.1). Where applicable these requirements were also incorporated into EEMSS. They included:

- investigation of other ways to minimise the impacts of flooding
- stronger, ongoing communication between researchers, community and managers
- monitoring the impact of artificially opening an estuary
- consideration of 'indicators' other than just water height when deciding whether to open an estuary
- consistency (in both how the decision is made and the protocol followed if an estuary is opened).

2.2 Decision support systems

> A Decision Support System uses any method, though it is usually computer based, to integrate a variety of information and present it in a way that assists the decision maker to assess the various options.

A general approach to decision making involves:

- clearly defining the issue;
- identifying the various options;
- determining what criteria (or objectives) will be used to assess the options; and
- assessing the different options against the selected criteria (Fig 2.1).

The complexity of natural resource management (NRM) decisions has been a catalyst for the development of a range of more formal decision making processes. NRM decisions typically involve a variety of stakeholders, multiple (often conflicting) objectives and high level of uncertainty. The interest of community in both NRM decisions and the decision process, has also contributed to the need for more formal decision techniques that are transparent, repeatable and scientifically defensible.

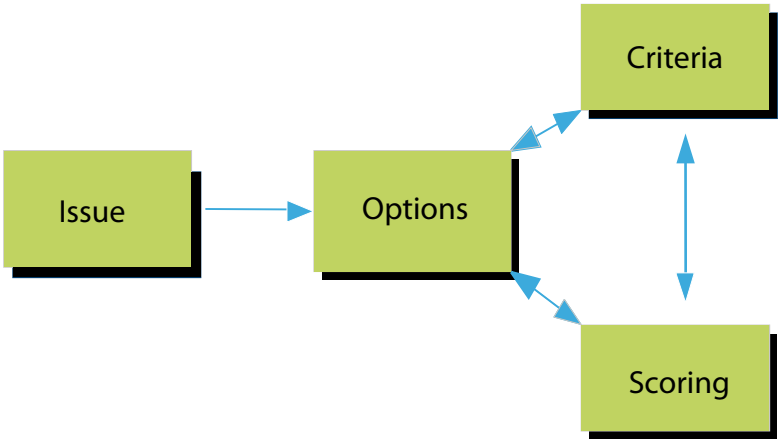


Figure 2.1 Decision making process

The choice of DSS will depend on many factors such as: the requirements of the stakeholders; available information; cost; and policy setting. Existing decision support methodologies were reviewed in the early stages of the EEMSS development project. This was done to assess their suitability for adaptation to the needs of a decision support tool for estuary management. These methodologies included cost benefit analysis, multi- criteria analysis and risk assessment.

One decision tool assessed during this phase of the project was the River Values and Environmental Risk System (RiVERS). The RiVERS database is a priority setting (decision support) tool for river management, which was developed to support the Victorian River Health Strategy. RiVERS is a Microsoft Access built application that provides a framework for prioritising investment in river health on a regional basis. RiVERS enables managers to determine the relative importance of river reaches by providing a set of rules for scoring both the quality of the riverine assets in each reach and the level of threat to those assets.

For consistency with this database, assets included in RiVERS were reviewed to assess their applicability to the estuarine environment and hence their suitability for inclusion in the EEMSS.

There were also advantages in the EEMSS being consistent with an asset-based approach, which is currently used in natural resource management in Victoria.

2.3 Data input

2.3.1 Community advice

The EEMSS needed to be relevant to all estuaries within Victoria. It was therefore essential that engagement reach as many communities as possible so all potential impacts of mouth status on estuarine values could be captured.

A series of five community workshops were used to provide input into the EEMSS development. Invitees to the workshops included representatives of government agencies, indigenous communities, environment groups, tourism groups, committees of management and recreational groups. Also invited were individuals, such as adjoining landholders, who may be directly affected by, or have an interest in estuary entrance management.

A variety of methods were used in the workshops to:

- gather knowledge and data from local community members specifically, how community use or enjoyment of estuaries and adjoining land is impacted by estuary mouth status
- determine current community perception of estuary entrance management and provide an opportunity for community members to suggest means of improvement (see section 2.1).

The uses and functions of the estuary that the community thought should be protected when making the decision whether or not to open the estuary included socio-economic, environmental and cultural assets. These are the criteria used in the EEMSS to evaluate the two management options that is, to open or not open an estuary (Table 3.1).

2.3.2 Scientific and technical advice

A literature review at the beginning of the project revealed a substantial lack of written information required for the development of the EEMSS. Expert knowledge was therefore sought in order to fill these information gaps. A range of experts were engaged to assess the impact of the opening decision on the estuarine assets identified. Technical advisory groups (TAGs) were established to assess the environmental assets (see section 4). Consultants were engaged to assess agricultural land, septics systems, stormwater, human health, and roads. Information about the consultants, members of the fish, birds and EVCs (plant groups) TAGs and individuals who provided guidance and advice are listed in section 9.

3 Major functional components of the EEMSS

In order to incorporate the requirements identified in the development phase, EEMSS comprises three basic components.

1. An impact assessment
2. A checklist
3. Data storage

3.1 Impact assessment

An impact assessment, based on an assets-threats model ensures a consistent process is used when making the decision whether or not to open an estuary. It also ensures that the decision considers the environmental, cultural and socioeconomic values of estuaries identified in the community workshops.

The decision to artificially open an estuary or not will depend on an assessment of the impact of that decision on the assets identified for that estuary.

Assets (Criteria)

The uses and functions of the estuary and surrounding land that the community thought should be protected when making the opening decision included socioeconomic, cultural and environmental assets. Assets identified in the community workshops, and used as the criteria to evaluate the two management options, are listed in Table 3.1.

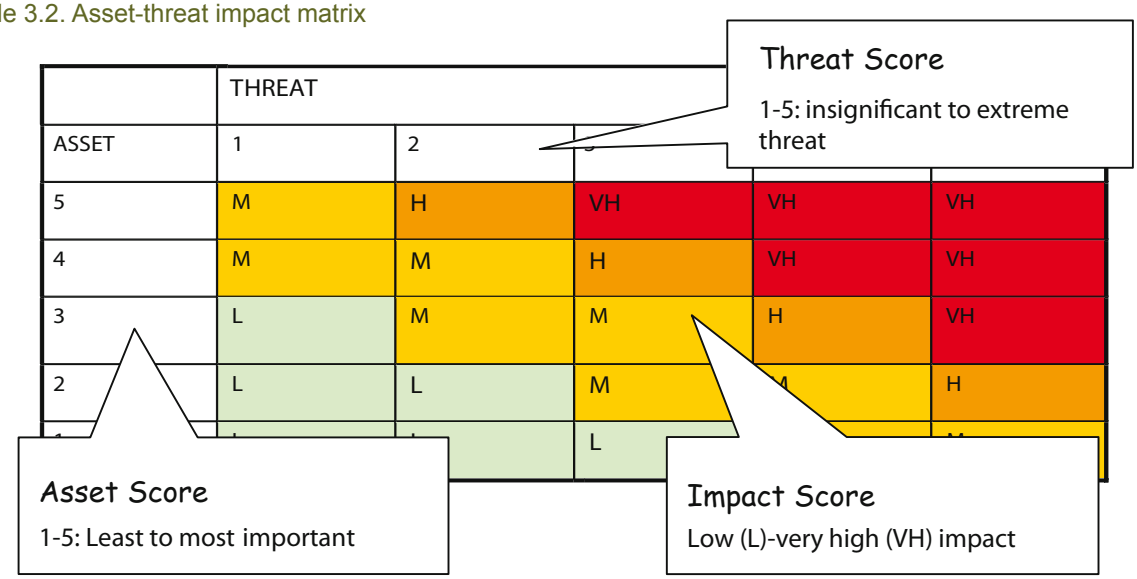
Table 3.1. Estuarine assets included in EEMSS

SOCIOECONOMIC ASSETS	
Roads & bridges	
Agricultural land	
Fishing	ENVIRONMENTAL ASSETS
Jetties	Fish
Walking tracks	Birds
Boat ramps	Plant communities (EVCs)
Recreational land	
Camping	CULTURAL ASSETS
Swimming	Cultural heritage
Stormwater	Indigenous culture
Septics	
Human health	
Watercraft	
Built infrastructure	

Scoring

The scoring system enables the manager to evaluate the impact of each management option, on the selected assets in a consistent manner (Table 3.2).

Table 3.2. Asset-threat impact matrix



An **asset score** reflects the level of importance of that asset to the use or function of the estuary. The EEMSS acknowledges that the importance of an asset may change during the year and hence, the asset score should also change.

The **threat score** reflects the level of harm to a given asset. For consistency with the assets - threat model used in other Victorian government strategies, the term threat has been used. However, threat as used in EEMSS is more accurately referred to as a hazard. Threat implies that a probability of harm occurring is assigned; which Is not the case in EEMSS.

For some assets the threat relates to opening the estuary and for others the threat relates to not opening. The threat to a given asset can alter with both time of year and water level.

The rules for scoring both the assets and the threat to those assets posed by opening or not opening an estuary were developed in consultation with experts in relevant disciplines. For each estuary, community workshops are used to assign assets and threats scores for various estuarine water levels (EWLs) and times of the year.

At the time of making the decision, current conditions may alter a previously assigned threat level. The current conditions are taken into account by applying **Threat modifiers**. Their value can only be assigned immediately prior to making the decision.
Threat modifiers include:

- how long the water has been at a given level (Duration of inundation (DI));
- period since the estuary was last open (PO);
- period since an asset was last inundated (PI);
- scale of drought (DR), i.e. local, regional or continental;
- depth of oxygenated water (> 5 mg/L) in the central channel and in any adjoining wetlands (DO);
- mosquito abundance.

Rules were developed to describe how each of these threat modifiers alters the level of threat associated with opening or not opening an estuary.

EEMSS combines the asset and threat scores to produce an **Impact score**.

Impact assessment report

The impact assessment report presents all the assets of a particular estuary that are likely to be affected by the manager's decision. The impact on assets of opening the estuary can be compared with the impact of not opening on other assets. The impact scores are displayed over a range of estuarine water levels (EWLs), which enables the manager to identify critical water levels and plan ahead. The report makes clear at what water levels the impact scores associated with not opening the estuary dramatically increase. Only those assets that were selected to assign threat scores are displayed in the report. It also includes any other information that the manager should consider when making their decision for example, whether the river is a Heritage River, and whether the wetlands are listed in the Directory of Important Wetlands in Australia.

To help managers interpret the impact scores, the report displays relevant threat modifiers. It also allows comparison of the current depth of oxygenated water in the wetlands and channel with any minimum requirement recommended for that estuary. While freshwater discharge is not a threat modifier (as it does not change any previously assigned threat scores), the report allows a comparison of the current flow with the minimum requirement. A minimum freshwater flow has been identified for some estuaries to either maintain the entrance or to ensure an adequate flow of oxygenated water to the estuary to prevent a fish kill.

Once the impact assessment report is reviewed, the manager makes a decision and includes its rationale on the report. If the recommendation is to open the estuary it should be noted that the decision is conditional on also meeting the requirements of the checklist report.

3.2 Manager checklist

The checklist identifies the actions the manager needs to undertake to ensure an opening is safe and effective, and all legislative requirements are satisfied.

Estuary users need to be warned of an imminent opening by the placement of signs at key access points and also if required, verbal warnings to swimmers and boat users.

A consent to use or develop Crown Land is issued under the Coastal Management Act 1995 and must be obtained from the Department of Sustainability and Environment, or Parks Victoria if the land at the estuary entrance is reserved under the National Park Act 1975..

Prior to opening the estuary the local Cultural Heritage Officer must be contacted to ensure the manager, and in particular the machine operators, are aware of any indigenous cultural sites that could potentially be disturbed.

Sea state and tides both contribute to the effectiveness of an artificial opening. Rough seas and high tides can deposit sand at the entrance and make breaching the mouth more difficult. For some estuaries spring tides are preferred as they ensure maximum tidal exchange. The position of the opening and estuarine water level may also determine the ease of opening and the length of time the entrance remains open. It is important to record each parameter in a consistent way so the 'success' of openings can be compared over time. The descriptions 'calm',

'rough', 'high' are recommended for sea state. Tidal height should be recorded in metres if possible, or 'high', 'low', 'ebbing', 'flooding' and the position of the mouth opening should be recorded as latitude and longitude or a description relative to a fixed structure.

> For an estuary to be artificially opened both the impact assessment report and the checklist report must support that decision.

3.3 Data storage

The EEMSS has the capacity to store physicochemical data and also information about estuarine assets identified as potentially impacted by mouth status. This information is essential for modelling the extent and timing of inundation on an estuary and hence refining both the rules for assigning threat scores and the threat scores assigned.

Details of the various socioeconomic, cultural and environmental assets present on an estuary are stored in the 'Asset Description' section of the EEMSS.

Mouth status, EWL, date and observation time should be regularly entered on the estuary status page. This information is displayed on the estuary list page so managers can quickly check which estuaries are open and closed and the last time data was entered.

A range of physicochemical parameters can be stored in the monitoring section of the EEMSS, this includes water quality data such as; Flow (ML/day) estuarine water level (EWL), depth, dissolved oxygen (mg /L & % saturation), salinity (ppt), electrical conductivity (µS/cm), chlorophyll a (µg/L) and pH. A subset of this data is presented on the checklist report and therefore should be entered prior to making the decision whether or not to open an estuary.

Community involvement in monitoring mouth status and EWL should be encouraged. It might also be appropriate to monitor other assets such as bird species and abundance, or numbers of recreational users. However any data collected should be part of a well designed monitoring program so data can be analysed and compared over time. The EEMSS can store both casual observations and numerical data.

Maps and photos can be stored in the EEMSS but they slow the function of the database. It is recommended that the 'photos' and 'maps' sheets be used to store links to the location of relevant information.

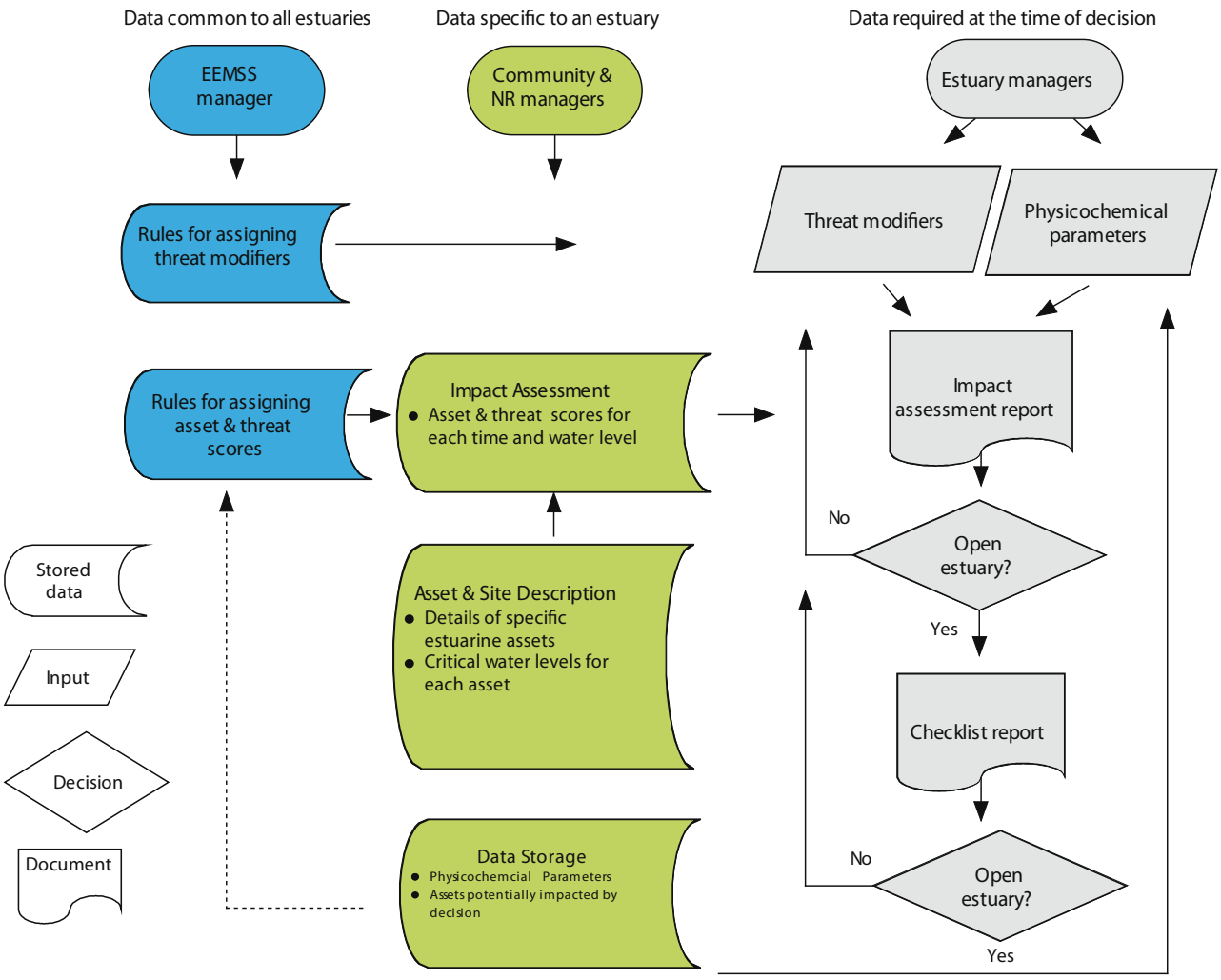
It is important that the data stored in EEMSS does not replicate existing state-wide databases.

3.4 Conceptual model of the EEMSS

Figure 3.1 shows how the three basic components; the impact assessment, the checklist and data storage, fit into the conceptual model of the EEMSS. The model is divided into three parts:

- data that is common to all estuaries. This includes the rules developed for scoring the assets and threats;
- data that is specific to an estuary. This data has to be added to tailor the EEMSS for use on each estuary; and
- information that is required at the time of making the opening decision.

Figure 3.1. Conceptual model of EEMSS



4 Assessing environmental assets & threats

Technical advisory groups (TAGs) were established to develop rules for scoring the assets (birds, fish and plants) and the threats to those assets. The TAGs were asked to:

- review the suitability of the assets and asset attributes used in RiVERS for inclusion in the EEMSS
- review species' lists so only those associated with estuaries that are impacted by the decision to open or not open an estuary are included
- group species that are similarly affected by estuary entrance decisions
- select attributes of the assets to be used when assigning asset scores
- assign asset scores to reflect the importance of attributes
- identify the threats to the asset from opening and not opening the estuary
- assign scores to reflect the level of threat to the asset.

In the impact assessment component of the EEMSS, there is the capability to list either the functional group described by the technical advisory groups, or individual species in each group. It is recommended that managers use the groups assigned to avoid lengthy impact assessment reports. However, managers may choose to list individual species. This would be appropriate if a species has a conservation status of near threatened or greater or is a species that the community identifies as important. For example, a recreational target fish species or a flagship bird species may be assessed separately and will therefore be included on the impact assessment report.

The asset and threat scores provided by the TAGS are automatically displayed in the EEMSS. The scores assigned to the threat of opening and not opening an estuary at different times are based on the expert advice of TAG members. The basis of this advice ranges from information available in the peer-reviewed scientific literature to personal observation or expert opinion. There were many knowledge gaps identified while developing the EEMSS. The attributes used to describe the level of threat, and the scores assigned to them, should be considered a first draft. Refining these will depend on the development and implementation of targeted research and monitoring programs designed to assess the impact of estuary entrance management decisions on the assets identified.

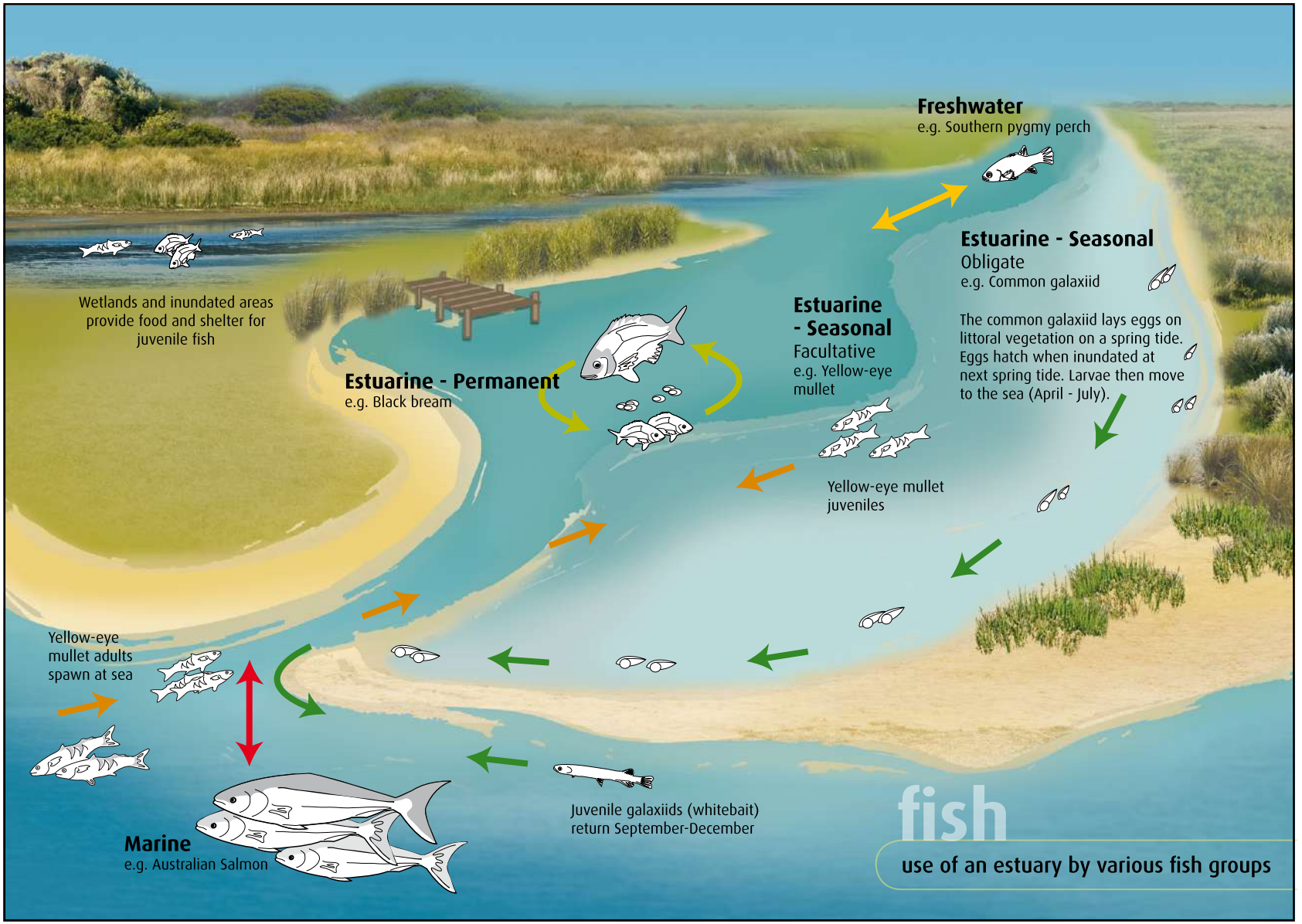
4.1 Fish

Fish groups

A complete list of fish species previously recorded from Victorian estuaries was reviewed by the TAG. Only the 49 species that were considered to be potentially impacted by estuary entrance decisions were included in EEMSS. Species that are infrequent visitors from marine and freshwater habitats and introduced species were not included (Appendix F).

Species that are likely to be similarly impacted by estuary entrance management decisions are grouped using the characteristics life history; time of year when the estuary is utilised; and obligatory requirement for estuaries (See Fig. 4.1).

Figure 4.1. Fish



Species in the **marine** group are regularly recorded from estuaries but are more commonly found in the marine environment. They only move into the estuary on flood tides or when freshwater discharge has decreased and salinity levels in the estuary are close to seawater.

The **freshwater** group species are generally only in the estuary during periods of high freshwater flow or may also be found in wetlands adjacent to the estuary.

Estuarine dependent, seasonal group species use the estuary at different times in their life history. Species in the **seasonal facultative** group often utilise the estuary as juveniles but also utilise sheltered marine embayments. Use of the estuary for migration, between the sea and freshwater, is an essential part of the lifecycle for species in the **seasonal obligate** group.

Species in the **permanent** group are able to complete their lifecycle in the estuary.

Table 4.1 The EEMSS fish groups

Non-estuarine dependent	1. Marine
	2. Freshwater
Estuarine dependent	3. Seasonal – Obligate (3O)
	Seasonal – Facultative (3F)
	4. Permanent

Asset scores

Two attributes, conservation status and the extent of estuarine dependence, are used to assign asset scores to either fish groups or individual fish species. Three fish species included in the EEMSS are listed as threatened under State or Commonwealth legislation (Table 4.2).

Asset score	Asset attribute
1	Non-estuarine dependent (Groups 1 & 2)
4	• Estuarine dependent (Groups 3 & 4) • TVF Near threatened
5	EPBC listed species present OR TVF Vulnerable or greater OR listed on FFG

Table 4.2 Conservation status of fish species included in the EEMSS (see appendix E for key to symbols).

Common Name	Scientific Name	Group	TVF	FFG	EPBC
Yarra Pygmy Perch	*Nanoperca obscura*	2	v	L	V
Australian Mudfish	*Galaxias cleveri*	3O	c	L	
Australian Grayling	*Prototroctes maraena*	3O	v	L	V

Threat scores

Opening an estuary often rapidly reduces the water level within the estuary and can result in a range of threats to fish populations within estuaries. Depending on factors such as oxygen levels and time of the year the threats can include fish kills, egg and larvae loss to sea, possible stranding of juvenile fish in the drained areas, and loss of shallow water habitats in the littoral vegetation and adjacent wetlands. These habitats are important foraging areas and provide refuge from predators, particularly for juvenile fish.

Planktonic eggs of species such as estuary perch and black bream are more vulnerable to being flushed from the estuary than eggs that are attached. However eggs attached to vegetation in the littoral margins may be stranded once the water level drops following opening.

For species in the 'estuarine dependent-seasonal' group that move between the marine and estuarine environments, there is a potential threat associated with not having access to the estuary. This is particularly so for species in the 'seasonal obligate' group that require access to the different environments as part of their lifecycle.

Threat level	Threat score	Threat attributes associated with opening	Threat attributes associated with not opening
Insignificant	1	No habitat loss; no egg or larvae loss	Period of no fish movement
Minor	2	Flushing of freshwater fish to sea	Period of minimal fish movement
Moderate	3	Low number of strandings; egg and larvae loss in pre and post peak periods; some habitat loss	Inhibited access/connectivity for species with facultative use of estuary during periods of movement
Major	4		Inhibited access/connectivity for species with obligate use of estuary during periods of movement
Extreme	5	Potential fish kill; egg and larvae loss in peak periods; substantial habitat loss	

The threat attributes were used to assign scores to reflect the level of threat associated with opening and not opening on the different fish groups at different times of the year (Table 4.3). The impact on the entire fish population was considered when assigning scores. For example, individual marine and freshwater fish may be impacted by estuary entrance decisions but it was considered unlikely they would impact on the population as a whole. Documented periods of fish movement both in and out of estuaries and months of egg production were used to assign scores to the different months.

Table 4.3 Threat scores associated with opening and not opening an estuary

Fish Group	Threat of opening		Threat of not opening	
	Month	Threat score	Month	Threat score
Marine	All months	1-2	All months	2
Freshwater	All months	1-2	All months	1
Estuarine Seasonal - Obligate	Aug-Feb Mar-July	1 3	Jan-Mar April-July Aug Sept-Dec	1 4 1 4
Estuarine Seasonal - Facultative	Feb-Aug Sept-Jan	3 1	Feb-Aug Sept-Jan	3 1
Estuarine Permanent	Nov-Feb Oct & Mar April-Sept	5 4 2	All months	2

Threat modifiers

Dissolved oxygen (DO)

If the depth of oxygenated water (dissolved oxygen levels greater than 5mg/L), is less than the predicted decrease in water level following opening (i.e the minimum requirement) there is the potential for a fish kill. Similarly, any water in adjoining wetlands that drains into the channel when the estuary is open also needs to have adequate oxygen levels. If either of these situations is recorded then the threat of opening on all fish species will be changed to a five.

Period since estuary was last open (PO)

If the estuary is closed for more than one year the threat of not opening becomes five for species in the seasonal obligate group. This score reflects the reliance on connectivity between the marine and estuarine environments for this group.

4.2 Birds

Bird groups

Ninety nine bird species were considered by the TAG to be potentially impacted by changed estuarine water levels and are therefore included in the EEMSS (Appendix G).

Estuarine bird species are assigned to five functional groups (Fig.4.2 & Table 4.4). Species are grouped according to what part of the estuarine habitat they utilise. Water birds are further classified into groups which utilise a similar water depth when foraging. Species can be allocated to more than one group.

Figure 4.2. Birds

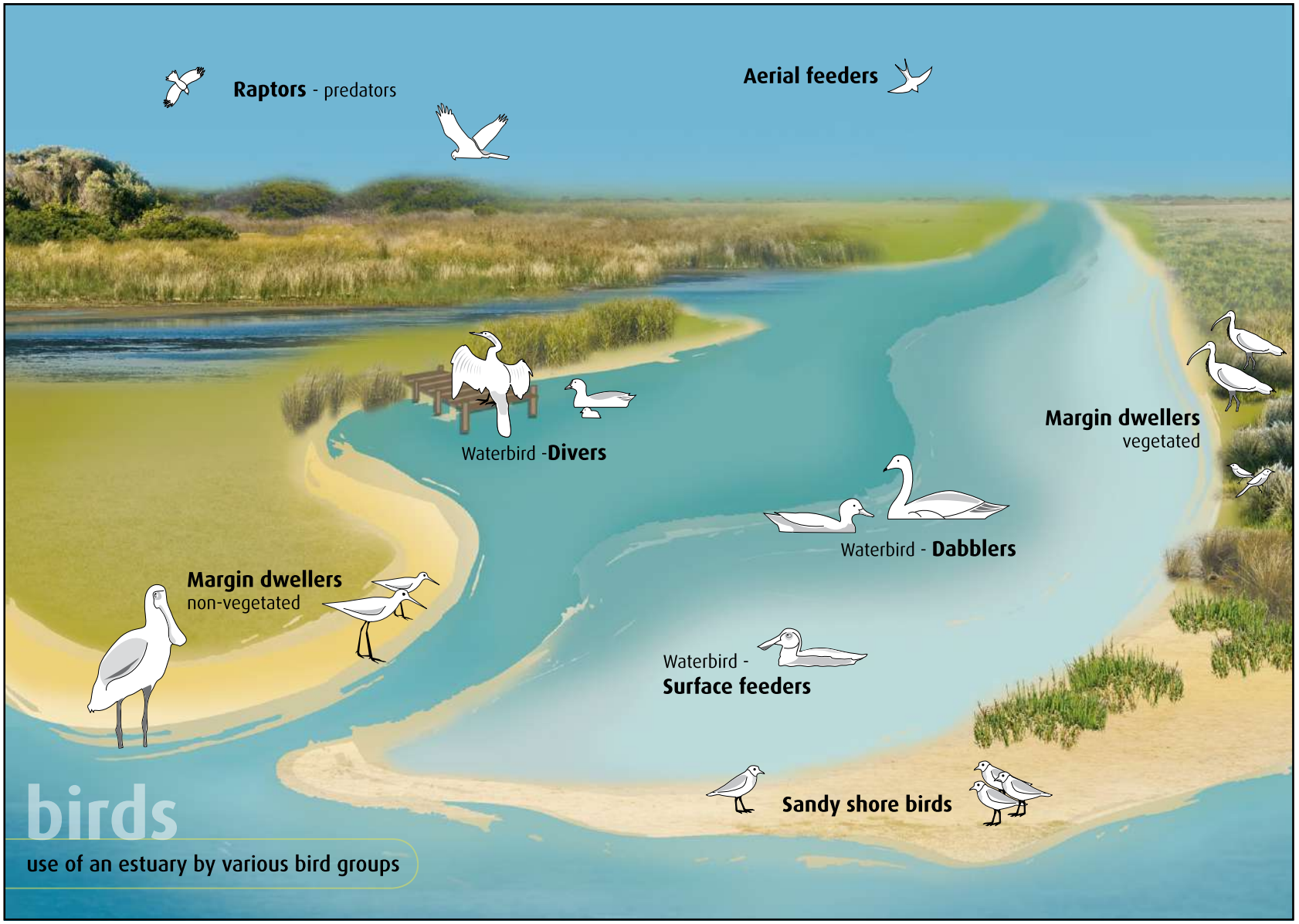


Table 4.4 The EEMSS bird groups

1. Waterbirds	a) Diving birds b) Dabbling birds c) Surface feeders
2. Margin Dwellers	a) Non-vegetated habitat b) Vegetated habitat
3. Aerial feeders 4. Raptors & other predators 5. Sandy shorebirds	

Asset score

Each functional group, and species within each group, is assigned an asset score that reflects the group's or species' importance in estuaries. Three attributes are used to assign an asset score to each species: conservation status; estuarine dependence; and percentage of the population historically recorded using the estuary. If different scores are allocated for each characteristic, the highest score is assigned as the asset score for the species.
The estuarine dependence score for an individual species is generally the same as that allocated to that species' group. However, the few exceptions to this are: swamp harriers, which have a stronger association with estuaries than the other raptors; Black-winged stilts and red-capped plovers which only breed in low numbers in estuaries; and banded stilts that can occur in very high numbers in response to increased abundances of prey items. These species are all assigned an asset score of 4.

Asset score	Threatened status	Estuarine dependence	Population (Maximum % of national population)
1	Not TVF, FFG or EPBC	Incidental habitat use listed species	Low numbers occur now or previously
2		Occasional habitat use **Groups 2a, 2b, 3 & 4**	
3		Some breeding or feeding habitat **Groups 1a & 1b**	Moderate numbers occur now or previously
4	Near threatened	Important breeding or feeding habitat **Group 5**	
5	EPBC listed species present or TVF Vulnerable or greater OR listed on FFG / Migratory species listed in CAMBA and/or JAMBA	Critical breeding or feeding habitat	Significant numbers occur now or previously

The asset score assigned to each functional group reflects only the general estuarine dependence of the species in that group. That is, they do not consider attributes such as conservation status or population size, which can only be assigned to individual species.

Threat scores

A closed estuary increases the extent of open water and provides a range of water levels in the inundated areas that can be utilised by birds for foraging, nesting and roosting. Opening an estuary reduces the water level and hence results in the loss of some habitat for birds in the groups; waterbirds, margin dwellers-vegetated and raptors. In contrast, opening an estuary will increase the available mudflats for birds in the margin dwellers - non vegetated group. The same threat attributes, namely loss of foraging and breeding habitat, are used for both opening and not opening but will be applicable to different species and groups. The extent of habitat loss will vary with each estuary. The EEMSS automatically uploads scores as per Table 4.5. For birds known to breed on Victorian estuaries, the breeding period is assumed to be from September to April. The scores were provided by the TAG but if required, the manager is able to include scores that better reflect the extent of habitat loss for a particular estuary and also change scores to more accurately reflect the known breeding periods.

A range of threat scores is provided for raptors as the threat of opening will depend to a large extent on the species present and their prey item. Whereas the threat to ospreys and kites is one, the threat score associated with opening for swamp harriers and white-bellied sea eagles is a four as these species prey on fish and waterbirds and prefer to nest close to, or over water.

Some bird species such as the parrots, fieldwrens, reed warblers, grass birds and cisticola utilise the vegetated margins of the estuary (group 2b) but are not reliant on a given depth of water for breeding or foraging. It is recommended that these species are not assessed individually. The impact of the opening decision on the EVC with which they associate is a better measure of the potential impact on these species.

The Orange-bellied parrot is critically endangered and has a population of fewer than 200 adult birds. It spends summer in south-west Tasmania and winters along the coasts of Victoria and South Australia. Access to saltmarsh, its preferred foraging habitat, is particularly important during June to August. Protection of this EVC is an essential component of the recovery plan for this species and the impact of the opening decision on saltmarsh should be considered when assessing the potential impact of the opening decision on the Orange-bellied parrot.
The threat score to sandy shorebirds can only be assigned at the time of the decision whether or not to open an estuary. Pied oystercatcher, breeding terns (little, fairy, crested, and caspian), Hooded plovers and Red-capped plovers breed on sand bars and can be positively or negatively affected by the estuary entrance status. Managers will need to consider the potential impacts of trampling, physical barriers to access, disturbance by machinery, flooding and erosion when assigning a threat score. Although not a threat modifier, for convenience the threat level is selected when assigning threat modifiers.

Threat Level	Threat scores	Opening an estuary	Not opening an estuary
Insignificant	1	No habitat loss	No habitat loss
Minor	2	Some loss of foraging habitat	Some loss of foraging habitat
Moderate	3	Some loss of breeding habitat	Some loss of breeding habitat
Major	4	Substantial loss of foraging habitat	Substantial loss of foraging habitat
Extreme threat	5	Substantial loss of breeding habitat	Substantial loss of breeding habitat

Table 4.5 Bird groups, water level requirements and threat scores

Functional group	Water level requirement			Threat scores			Drought Applicable (A) / Not applicable (NA)
	Breeding cm	Loafing/ Roosting cm	Foraging cm	Opening Sept-Apr	Opening May-Oct	Not opening	
1. Waterbirds							
a. Diving birds	0	0	≥ 200	3	2	NA	A
b. Dabbling birds	0	0	≤ 100	3	2	NA	A
c. Surface Feeders	0	0	≥ 10	3	2	NA	A
2. Margin dwellers (non-veg)	0	0	0 - 50	1	1	5	A
3. Margin dwellers (veg)	5 - 50	5 - 50	0 - 20	3	2	NA	A
4. Aerial feeders	NA	NA	≥ 1	1	1	NA	NA
5. Raptors	0 - 50	NA	> 0	1-4	1-3	NA	NA
6. Sandy shorebirds	0	0	0 - 50	**		**	NA

** the manager needs to assign score (see Part 3 step 19)

Threat modifiers

Drought (DR)

Drought in the EEMSS is considered at three spatial scales (Table 4.6). During periods of drought closed estuaries provide a refuge for a variety of bird species. The extent of a drought will affect the availability of water bodies for bird species to utilise. Hence, the impact of drought on birds will be greater if it occurs at larger spatial scales. If there is a drought at the time of running the impact assessment, the drought score will be added to the previously allocated threat score. The drought modified score only applies to species in functional groups 1, 2 and 3.

Table 4.6 Drought modifier scores

Level of Drought	**Drought modifier score**
Local (100 km)	1
Regional (1000 km)	2
Continental (5000 km)	3

4.3 Ecological Vegetation Classes (EVCs) and rare and threatened flora

Asset description

Native vegetation in Victoria is grouped into Ecological Vegetation Classes (EVCs). Each EVC includes one or more floristic communities (i.e. groups based on co-occurring plant species). Although species within a particular EVC may vary, each EVC occupies a similar habitat and has a similar form. Only EVCs and plant species that are impacted by estuary entrance management decisions, namely, changed estuarine water levels are included in the EEMSS. For a full description of each EVC see Appendix H.

Current EVC typology is not always reflected in the DSE mapping of EVCs in Victoria (Biodiversity Interactive Database). Current EVCs and the equivalent EVCs that appear on some earlier mapping are indicated in Table 4.7. Note that Estuarine Wetland as it appears in the mapping has been recently split into Estuarine Wetland (*Juncus*) in a new narrower sense, Estuarine Reedbed (*Phragmites*), and Brackish Sedgeland (*Gahnia, Bolboschoenus*).

Table 4.7 Current and previous classification of estuarine EVCs

Current estuarine EVC	**EVC No.**	**Previous EVC (may appear in DSE mapping)**	**EVC No.**
Coastal Saltmarsh	009	Same	
Estuarine Wetland	010	Same (but see below)	
Brackish Sedgeland	013	Estuarine Wetland	010
Mangrove Shrubland	014	Same	
Seasonally Inundated Sub-saline Herbland	196	Same	
Brackish Herbland	538	Brackish Wetland	656
Saline Aquatic Meadow	842	Same	
Seagrass Meadow	845	Same	
Estuarine Flats Grassland	914	Coastal Tussock Grassland	163
Brackish Grassland	934	Coastal Tussock Grassland	163
Estuarine Reedbed	952	Estuarine Wetland Estuarine Wetland (Gippsland)	010 010
Estuarine Scrub	953	Swamp Scrub	053
Littoral Rainforest	new	N/A	
Non-vegetated	990	Same	

Freshwater EVCs		
Coastal Lagoon Wetland	011	Same
Swamp Scrub	053	Same
Tall Marsh	821	Reed swamp
Blocked Coastal Stream Swamp	875	Same
Warm Temperate Rainforest	032	Same
Damp Sands Herb-rich Woodland	003	Same

The relationship between the different EVCs is illustrated in figure 4.3. The vegetation of estuaries is largely a function of inundation in relation to vertical elevation, made more complex by variable salinity. The vegetation is strongly influenced by the salinity gradient, which generally decreases inland although areas of hypersalinity may occur in the upper reaches of estuaries not regularly flushed by water. The salinity gradient may fluctuate greatly in relation to several factors including fresh water discharge, tidal exchange, degree of mixing (lateral and vertical), elevation in relation to tidal penetration including geomorphic features such as lagoons, abandoned river channels and levees, rainfall on the estuary itself, evaporation and degree of estuary closure. The interaction of these variables results in complex vegetation patterns that are dynamic in time and space.

The ability of an EVC to recover from an altered hydrological regime will partly depend on its ability to migrate to different levels within the estuary. The position of barriers such as roads and grazing can often restrict recruitment and establishment of EVCs at higher levels in the estuary.

Figure 4.3. Schematic representation of the salinity and water requirements of estuarine EVCs

Arrows indicate likely changes associated with changed conditions of salinity and water level. Common EVCs that are sensitive to mouth status are in bold and EVCs only present in permanently open estuaries in grey. Opening an estuary reduces the water level and increases salinity levels within the estuary.

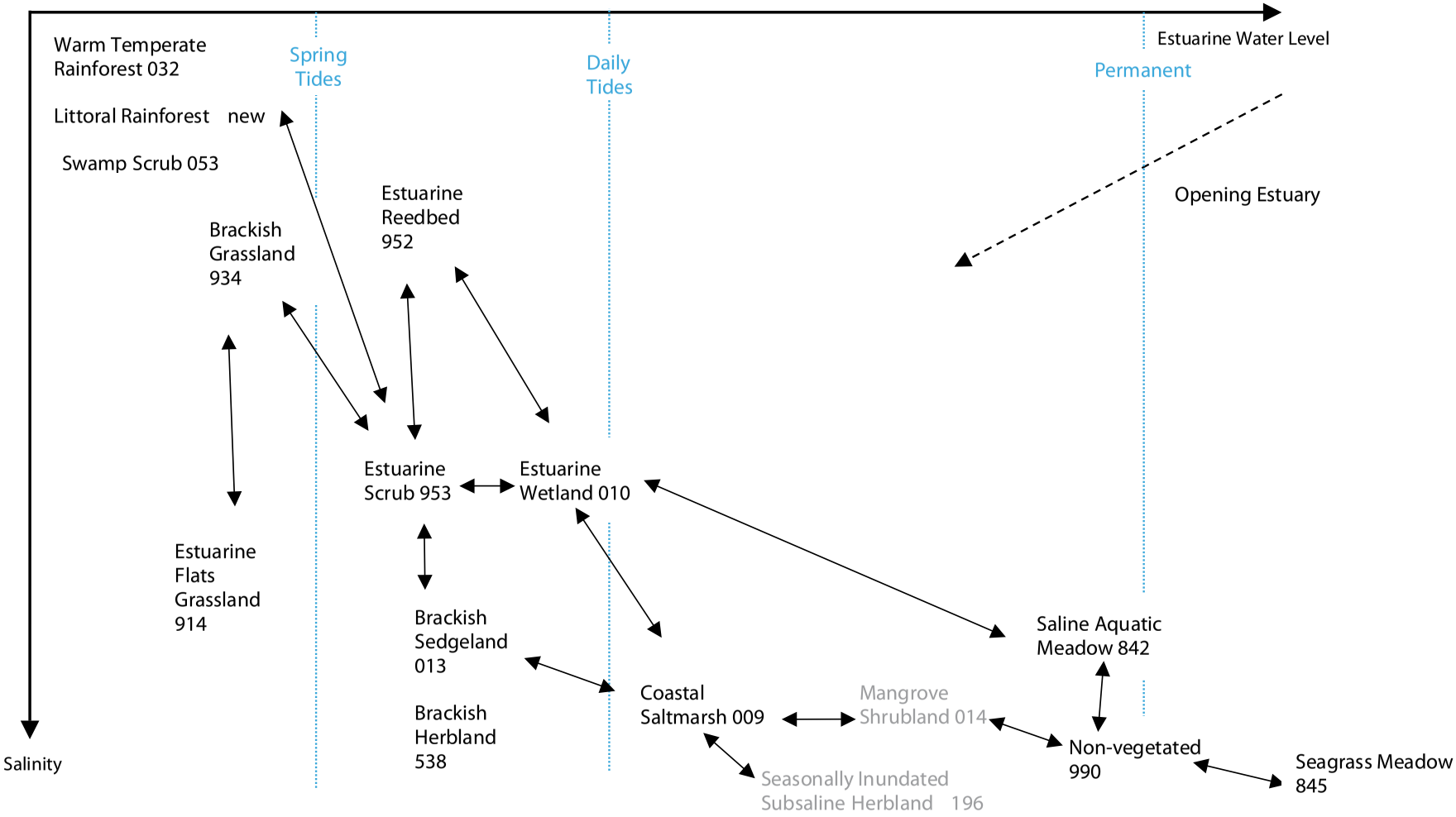
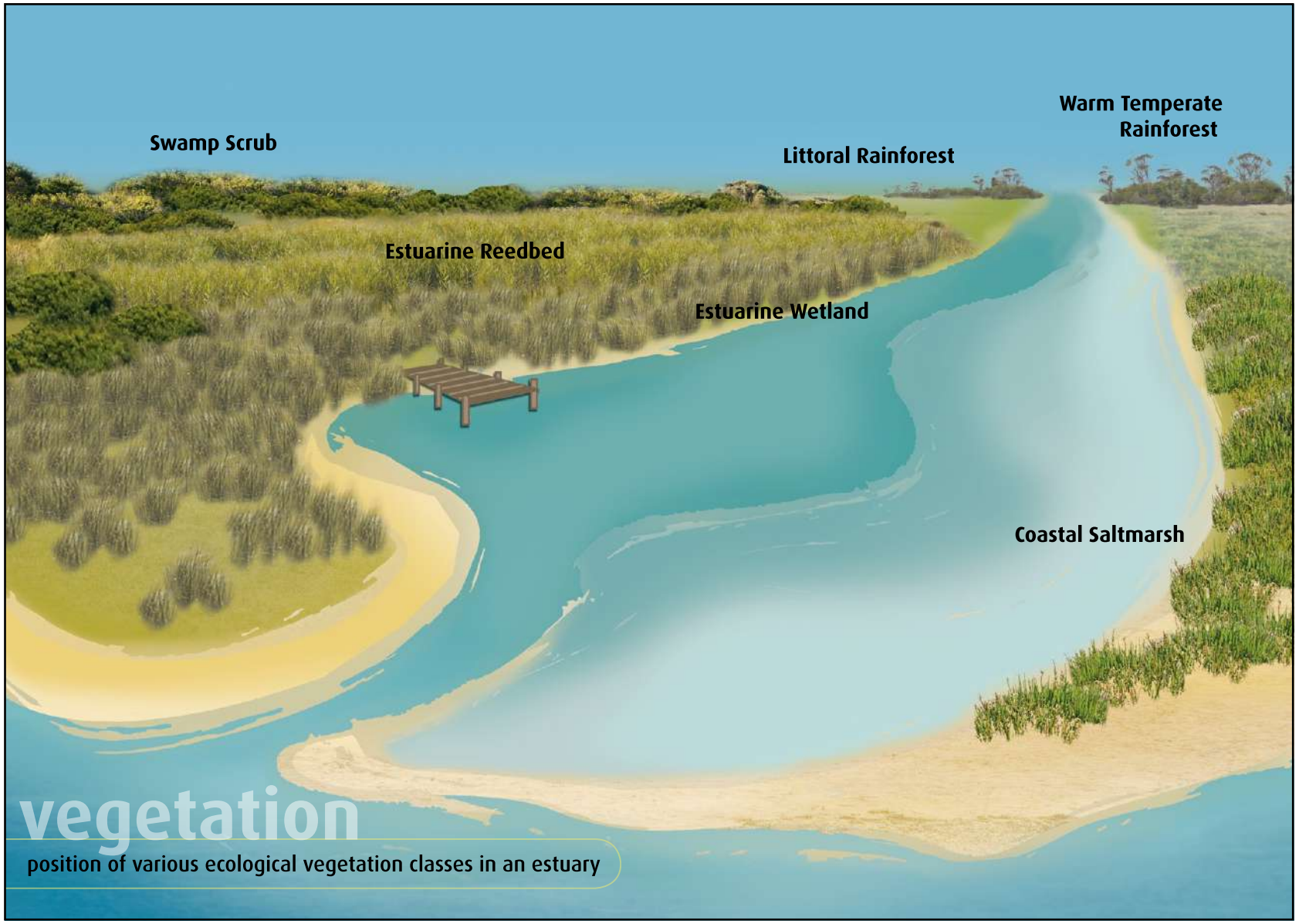


Figure 4.4. Vegetation



Rare and threatened species

Rare and threatened species of flora are best protected by meeting the habitat requirements for the EVC in which they are recorded. Only species that occur in those EVCs listed in Table 4.7 are included in the EEMSS (Table 4.8).

Table 4.8. Estuarine significant species and their EVC association

(See appendix E for key to conservation symbols)

NAME	COMMON NAME	VROTS	FFG	EPBC	EVC
Atriplex paludosa subsp. paludosa	Marsh Saltbush	r			Coastal Saltmarsh
Avicennia marina subsp. australasica	Grey Mangrove	r			
Lawrencia spicata	Salt Lawrencia	r			Coastal Saltmarsh
Limonium australe	Yellow Sea-lavender	r			Coastal Saltmarsh
Triglochin minutissima	Tiny Arrowgrass	r			Coastal Saltmarsh
Triglochin mucronata	Prickly Arrowgrass	r			Coastal Saltmarsh
Pterostylis tenuissima	Swamp Greenhood	v		V	Swamp Scrub/ Estuarine Scrub interface
Cladium procerum	Leafy Twig-sedge	r			Estuarine Reedbed/ Tall marsh interface
Lachnagrostis robusta	Salt Blown-grass	r			Estuarine Scrub; Brackish Sedgeland
Lepidium desvuaxii	Bushy Peppercress	r			Coastal Saltmarsh: Brackish sedgeland; Brackish grassland
Lepidium aschersonii	Spiny Peppercress	e	L	V	Brackish grassland; Coastal saltmarsh
Lepidium hyssopifolium	Basalt Peppercress	e	L	E	Brackish Wetland
Juncus revolutus	Creeping Rush	r			Brackish Sedgeland Estuarine Scrub

Asset scores

Two characteristics of estuarine EVCs contribute to the ranking of all EVCs as of equal and very high importance. Firstly, all EVCs in estuaries, irrespective of conservation status, have essential functions in estuaries, for example, as habitat, nutrient recyclers and sediment filters, and secondly, EVCs in estuaries cannot be considered independently. Changes to the water regime in an estuary will potentially change the type and condition of all EVCs present. That is, changes in water level and salinity may cause migration of all EVCs to different levels.

Asset score	Asset title
5	EVCs
5	Rare or threatened species

Threat scores

All EVCs depicted in Figure 4.3 are potentially affected by an altered hydrological regime. While threat scores associated with opening and not opening can be assigned to all EVCs, only the more commonly occurring EVCs, which are lower in the estuary and have better known hydrological requirements, were selected for allocation of threat modifiers (Fig 4.4). If estuary opening regimes protect these EVCs then other EVCs, at higher levels in the estuary, should also be protected. In terms of threat levels in the model, this means that if a low elevation EVC experiences no significant damage (threat score = 1), then other EVCs also experience no significant damage. However, swamp scrub and littoral rainforest were considered to be exceptions and are also included in the EEMSS.

The threat to all estuarine EVCs is insignificant if they are inundated (or not inundated) for a period of one day. A threat score of 1 is therefore automatically assigned to all EVCs. The higher threat scores will only apply if the EVCs are inundated (or not inundated) for longer periods and hence modifiers will be assigned. (Table 4.9).

Threat Levels	Threat score	Threat attributes
Insignificant	1	No significant damage to vegetation
Minor	2	Vegetation damaged, rapid short-term recovery (<6 months)
Moderate	3	Vegetation damaged (some species killed), slow medium-term recovery (>6 months)
Major	4	Vegetation largely killed, long-term recovery (>12 months)
Extreme	5	Vegetation largely killed, long-term or no recovery of EVC within estuary (>2 years)

Table 4.9 EVC Threat modifiers

		Threat modifier associated with NOT opening				Threat modifier associated with opening	
EVC	Critical water depth	Duration of inundation	DI score	Period since mouth was last open PO	PO Score	Period since last inundation PI	PI score
Coastal Saltmarsh	Any depth above surface	< 1 day 1–4 weeks > 12 weeks	0 2 4	< 1 day 12–24 weeks >48 weeks	0 2 4	Indefinite	0
Estuarine Wetland	Any depth above surface	< 1 week 2–8 weeks > 24 weeks	0 2 4	< 1 week 4–12 weeks > 72 weeks	0 2 4	< 1 week 8–24 weeks > 96 weeks	0 2 4
Estuarine Reedbed	Any depth above surface	< 4 weeks 16-24 weeks > 48 weeks	0 2 4	< 4 weeks 16–48 weeks > 96 weeks	0 2 4	< 1 week 4–12 weeks > 48 weeks	0 2 4
Swamp Scrub	Any depth above surface	< 1 week 2–8 weeks > 24 weeks	0 2 4	Indefinite	0	Indefinite	0
Littoral Rainforest	Any depth within 30-50 cm of the surface	< 1 week 1-4 weeks > 8 weeks	0 2 4	Indefinite	0	Indefinite	0
Warm temperate rainforest	Any depth within 30 cm of the surface	< 1 week 1-4 weeks	0 4	Indefinite	0	Indefinite	0

Threat modifiers

The various time periods and scores assigned for the effect of inundation on each EVC are indicative rather than validated (Table 4.9). There is a general lack of research to quantify the threshold values in the model; they are therefore based on collective observations of the Technical Advisory Group. While the thresholds are uncertain, the relative position of the EVCs is more likely to be correct. Any quantitative data or observations that become available should be considered in future refinement of the EEMSS.

At the time of making the decision whether or not to open the estuary, the manager will need to enter information about each of the threat modifiers.

- Duration of inundation (DI);
- Period since it was last inundated (PI) and
- Period since the mouth was last open (PO).

The relevant modifier scores are added to the initial threat score of 1. If both modifiers, DI and PO apply, then the higher threat modifier score (i.e. either DI or PO) is used.

Duration of inundation (DI): There is a decreasing risk to EVCs from inundation, from Coastal Saltmarsh (most sensitive), through Estuarine Wetland, to Estuarine Reedbed (least sensitive). Plant damage and death due to inundation is related to species tolerances, for example *Sarcocornia* is more easily killed by inundation than *Phragmites* regardless of salinity. The periods specified assume the water is fresh to brackish. The recruitment and growth of both Juncus and Phragmites are reported to be negatively impacted if inundated with water having salinity levels of greater than 20 ppt.

The critical water level required to be entered in the EEMSS varies with EVC (Appendix J). This generally reflects either the sensitivity of an EVC to inundation or the form of the dominant species. For example, the mid point is used as the critical height for 'Estuarine Reedbed' because *Phragmites*, the dominant species in that EVC, is clonal and therefore even if some of the plant is inundated it was considered that the whole plant would not be affected to the same extent.

Period since mouth was last open (PO): There is a decreasing risk to EVCs from lack of salinity in the system, from Coastal Saltmarsh (most sensitive), through Estuarine Wetland, to Estuarine Reedbed (least sensitive). Loss of salinity means relatively brackish EVCs may replace relatively saline EVCs after or even before water recedes. Tidal input restores salinity in the system.

For period since last inundation (PI): There is an increasing risk to EVCs from lack of inundation, from Coastal Saltmarsh (least sensitive), through Estuarine Wetland, to Estuarine Reedbed (most sensitive). Keeping an estuary artificially open will reduce the height of water in the estuary and will affect water availability to EVCs especially higher level EVCs. Generally at the time of deciding whether to open the mouth the water level is already high. Lower EVCs are likely to be inundated therefore for those EVCs, PI = 0. Where infrastructure is situated at lower levels there may be pressure to open the estuary before EVCs at higher levels have been inundated. Inundation also refers to freshwater inundation during periods of high river discharge.

5 Assessing cultural assets & threats

5.1 Indigenous culture

Asset description

Contact details of the local Heritage Officer can be entered in the asset description section of the EEMSS. They must be involved in assessing the impact of estuary entrance on indigenous culture.

If a specific cultural value such as an important site is to be given a numerical score it must also be included in the asset description section.

Asset scores

There are several options for scoring the importance of indigenous cultural values in the EEMSS:

- inclusion of a numerical score (1-5) which reflects the importance of that asset;
- a statement regarding estuaries and entrance management that appears on the impact assessment report; or
- both a score and a statement.

If there is a particular site which is potentially impacted by opening or not opening the estuary this can be assigned a numerical score. However, indigenous communities are also able to include a statement regarding the community's response to artificially opening the estuary, which is considered by the manager as part of the decision making process.

Threat scores

If a numerical score was assigned to an asset, then a score of the threat to those assets of opening and/or not opening an estuary must also be included. Threat scores range from 1 to 5; insignificant to extreme.
Cultural heritage officers also need to be contacted as part of the checklist requirements. This is to ensure any cultural sites are protected during the operation of artificially opening the estuary.

5.2 Cultural heritage

Asset score	Asset attribute
1	Sites known not to be of importance
3	Site or structure of local community significance or nothing is known
5	Listed on the Victorian Heritage Register or the Victorian Heritage Inventory

Threat score	Threat attribute – not opening
1	Insignificant damage to site and impact on access
2	Access to site impaired
3	Minor damage to site or structure
5	Substantial permanent damage to site or structure

6 Assessing socioeconomic assets & threats

Estuaries are the focus of much recreational activity (Fig. 6.1). Popularity or use level of an activity is used in EEMSS as an indication of the importance of that activity to the estuary; this is consistent with the approach used in RiVERS. All recreational assets are scored for each month so changes in use and importance of the asset over the year can be reflected in the scores. Relative qualitative descriptions of use levels are used as no systematic survey of community use of these assets has been undertaken to provide quantitative data. Future surveys may further refine both the asset attribute descriptions to include number of users and also enable scores to be assigned, which more accurately reflect the use level.

The threat to most recreational assets is from not opening an estuary and the threat scores generally relate to how use of the asset is affected by inundation. This includes both inundation of the asset and access to the asset. The threat score is not as high if other equivalent assets are available (e.g. for jetties).

However, there is also a potential threat to some assets from artificially opening an estuary. The calm, sheltered waters at estuary mouths make them popular destinations for swimming and watercraft activities. Artificially opening the estuary can impact on these recreational activities by reducing the water level and exposing large tracts of mud. This can make access to the estuary difficult or the water too shallow for swimming or watercraft use. Water flow across the beach berm following opening can also potentially prevent safe access to the beach adjacent to the estuary mouth.

6.1 Jetties

Asset score	Asset attribute
1	Low level use
3	Moderate level use
5	Very popular –high level use

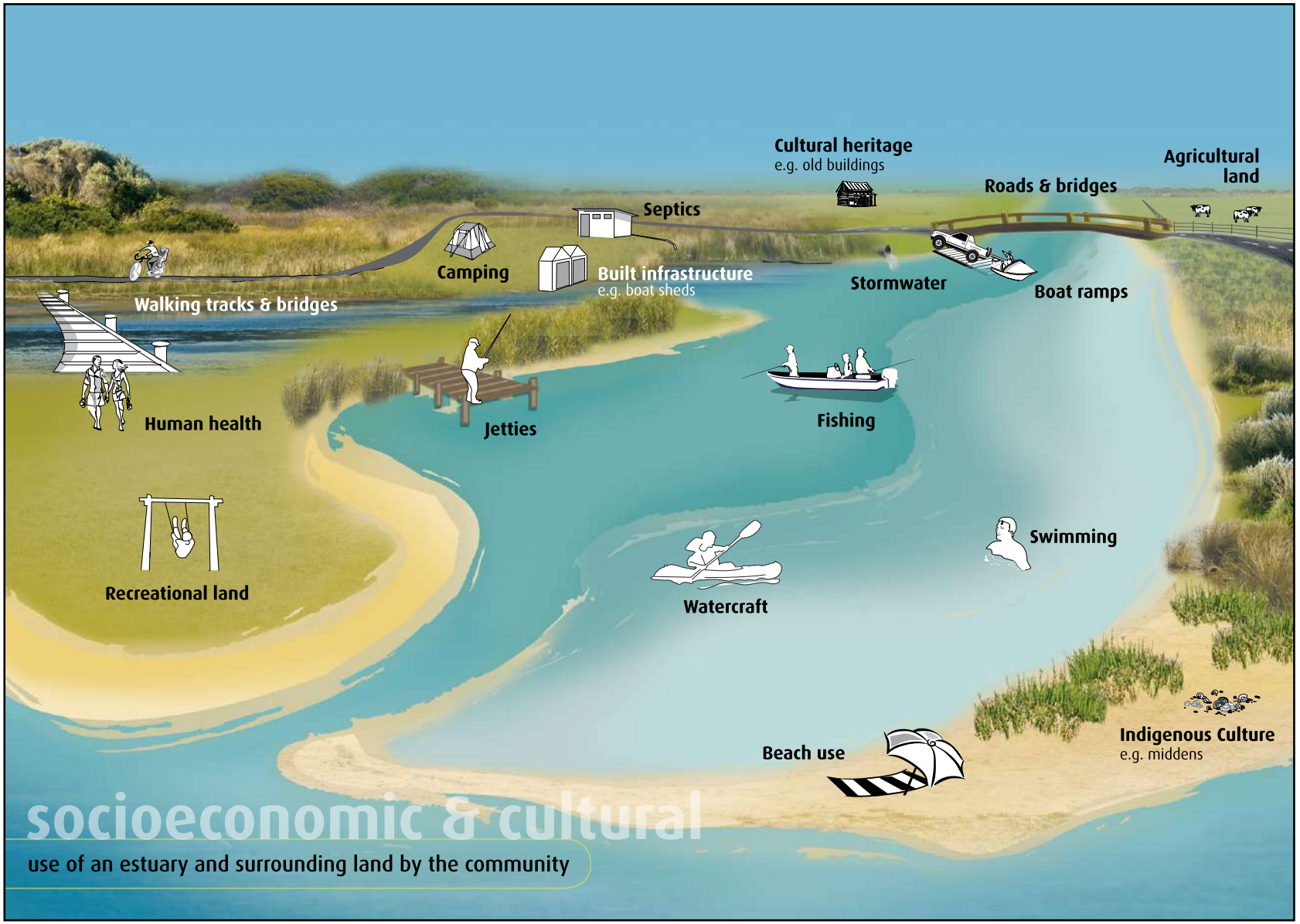
Threat score	Threat attributes – not opening
1	Access to jetty affected by inundation. No water on jetty
3	Jetty inundated but other access available
5	Jetty inundated no other equivalent access available

6.2 Boat ramps

Asset score	Asset attribute
1	Low level use
3	Moderate level use
5	Very popular –high level use

Threat score	Threat attributes – not opening
1	Access to boat ramp affected by inundation
3	Some problems associated with use of boat ramp
4	Boat ramp unusable but other boat access available
5	Boat ramp unusable and no other equivalent boat access available

Figure 6.1. Socioeconomic & Cultural



6.3 Walking Tracks

Asset score	Asset attribute
1	Low level use
3	Moderate level use
5	Very popular – high level use

Threat Score	Threat attributes – not opening
1	Access to track affected by inundation
3	Some problems associated with use of parts of the track
4	Track unusable but other track access available
5	Track unusable and no other equivalent track access available

6.4 Recreational land

Asset score	Asset attribute
1	Low level use
3	Moderate level use
5	Very popular – high level use

Threat Score	Threat attributes – not opening
1	No loss of recreational land
2	Some loss of recreational land due to inundation of access tracks
3	Some loss of recreational land due to inundation
4	Substantial loss of recreational land due to inundation of access tracks
5	Substantial loss of recreational land due to inundation

6.5 Camping

Asset score	Asset attribute
1	Low level use
3	Moderate level use
5	Very popular – high level use

Threat Score	Threat attributes – not opening
1	No loss of camping sites
2	Some loss of camping sites due to inundation of access tracks
3	Some loss of camping sites due to inundation of sites
4	Substantial loss of camping sites due to inundation of access tracks
5	Substantial loss of camping sites due to inundation of sites

6.6 Swimming

Asset score	Asset attributes
1	Low level use
3	Moderate level use
5	Very popular swimming location – high level use

Threat score	Threat attribute - opening
1	Mud flats restrict access to water
3	Water level suitable for some swimming
5	Water too shallow for any swimming

6.7 Watercraft

Asset score	Asset attributes
1	Low level use
3	Moderate level use
5	Very high level use

Threat score	Threat attributes - opening
1	Mud flats restrict access to water
3	Water level suitable for some watercraft
5	Water too shallow for any watercraft

6.8 Beach Access

Asset score	Asset attribute
1	Low beach use
3	Moderate beach use
5	Very popular –high level beach use

Threat Score	Threat attributes – opening
1	Beach access not restricted
3	Beach access restricted; other equivalent access available
5	Beach access restricted; no other access available

6.9 Fishing

The status of the estuary mouth does not generally prevent fishing activity on an estuary but it may influence which species are targeted by fishers.

The EEMSS includes fishing as an activity by valuing the target species and also the assets, such as jetties and boat ramps, which are utilised by fishers.

The list of estuarine species, which is included in the 'Fish' asset, was further refined to identify recreational and commercial fish species (Table 6.1)

Table 6.1 Recreational and commercial estuarine fish species and asset scores.

Group	Common name	Scientific name	Asset scores	Comments
1	Tommy Ruff	*Arripis georgianus*	3	
1	Australian Salmon	*Arripis spp*	4	
1	Eastern Australian Salmon	*Arripis trutta*	5	
1	Tailor	*Pomatomus saltator*	4	
1	Trevally	*Pseudocaranx dentex*	4	
2	Australian Smelt	*Retropinna semoni*	3	
3O	Short-finned Eel	*Anguilla australis*	3 to 5	Score will depend on presence of commercial fishery in an estuary
3O	Long-finned Eel	*Anguilla reinhardtii*	3 to 5	Score will depend on presence of commercial fishery in an estuary
3O	Common Galaxias	*Galaxias maculatus*	3	Potential use as bait species
3O	Eastern River Garfish	*Hyporhamphus regularis*	3	
3F	Yellow-eye Mullet	*Aldrichetta forsteri*	4	
3F	Sea Mullet	*Mugil cephalus*	3	
3F	Long-nosed Flounder	*Ammotretis rostratus*	4	
3F	Greenback Flounder	*Rhombosolea tapirina*	4	
3F	Mulloway	*Argyrosomus hololepidotus (japonicus)*	5	
3F	Luderick	*Girella tricuspidata*	4	
3F	Dusky Morwong	*Dactylophora nigricans*	3	
3F	Dusky Flathead	*Platycephalus fuscus*	5	
3F	Pink Snapper	*Chrysophyrs auratus*	5	
3F	Sea Garfish	*Hyporhamphus melanochir*	4	
3F	King George Whiting	*Sillaginodes punctatus*	5	
4	Black Bream	*Acanthopagrus butcheri*	5	
4	Estuary Perch	*Macquaria colonorum*	5	
4	Australian Bass	*Macquaria novemaculeata*	0 to 5	Score will depend on endemnicity of the species to an estuary
4	Tupong	*Pseudaphritis urvilli*	2	
4	Flathead Gudgeon	*Philypnodon grandiceps*	2	

Asset scores

Asset scores were assigned to each recreational and commercial fish species (Table 6.1) using the 'fishing' attributes developed for RiVERS.

Asset score	Asset attributes
1	Very low recreational value
2	Low recreational value
3	Moderate recreational value
4	High recreational value
5	Commercial fishers or very high recreational value

Threat scores & modifiers

The threat scores and modifiers for Fishing are the same as those assigned to the relevant fish groups in section 4.1 'Fish'.

6.10 Roads

The EEMSS uses a national road classification system developed by Austroads. The primary purpose of the road classification system or hierarchy is to ensure that appropriate management, engineering standards and planning practices are applied to a road based on its function. Because this hierarchy is primarily based on a road's strategic importance and use level, it is also relevant to EEMSS. The classification covers all road types and is based on a nine road classifications system; five for rural areas and four for urban areas (Table 6.2).

Rural and Urban local roads are further classified by each local municipal council under the Victorian Road Management Act 2004 (Table 6.3).

Table 6.2. Austroads National Functional Roads Classification System

Rural class	Explanatory Notes	Road Surface
Class R1 Arterial Road (1)	Those roads, which form the principal avenue for communications between major regions of Australia, including direct connections between capital cities.	Sealed roads with bituminous seal or asphalt surface.In some locations can be a concrete surface (rigid pavement).
Class R2 Arterial Road (2)	Those roads, not being Class 1, whose main function is to form the principal avenue of communication for movements between:	Sealed roads with bituminous seal or asphalt surface.Rural Classification.
Class R3 Arterial Road (3)	Those roads, not being Class 1 or 2, whose main function is to form an avenue of communication for movements.	Sealed roads with bituminous seal or asphalt surface.
Class R4 Local Roads (4)	Those roads, not being Class 1, 2 or 3, whose main function is to provide access to abutting property (including property within a town in a rural area).*Further details in Table 2.	Sealed roads with bituminous seal or asphalt surface. In lower volume roads can be unsealed.
Class R5 Local Road (5)	Those roads, which provide almost exclusively for one activity or function which cannot be assigned to Classes 1 to 4. (Eg access to parks and tourist areas).	Mainly unsealed roads with the occasional sealed section.
Urban Class		
Class U1 Arterial Road (6)	Those roads whose main function is to form the principal avenue of communication for massive traffic movements.	Sealed roads with bituminous seal or asphalt surface.
Class U2 Arterial Road (7)	Those roads not being Class 6 whose main function is to supplement the Class 6 roads in providing for traffic movements or which distribute traffic to the local street system.	Sealed roads with bituminous seal or asphalt surface.
Class U3 Local Road (8)	Those roads not being Class 7, whose main function is to provide access to abutting property *Further details in Table 2.	Sealed roads with bituminous seal or asphalt surface.
Class U4 Local Road (9)	Those roads which provide exclusively for one activity or function and which cannot be assigned to classes 6,7 or 8.	Sealed roads with bituminous seal or asphalt surface.

Table 6.3. Descriptions of local roads

Classification	Explanatory Notes	Road Surface
Class 3A Urban Link	Roads of this classification primarily provide a linkage between significant residential, industrial and commercial, nodes and or the declared road network. These roads have an identifiable Origin and Destination.	Sealed surface.
Class 3B Urban Collector	Roads of this classification primarily provide a route between and through residential, industrial and commercial areas and convey traffic to the Urban Link or Declared Road network system.	Sealed surface.
Class 3C Urban Access	A road, street, court or laneway that primarily provides direct access for abutting residential, industrial and commercial, properties to their associated nodes.	Maybe either sealed or gravel surface.
Class 3D Urban Minor	Provides secondary access to residential properties or provides access to non-residential property.	Generally either gravel, formed or natural surface.
Class 4A Rural Link	Roads of this classification primarily provide a direct linkage between significant population centres and major traffic generators such as residential, industrial, commercial, agricultural and tourist areas and/or Declared Roads. These roads have an identifiable origin and destination.	Generally a sealed surface, may be a gravel surface.
Class 4B Rural Collector	Roads of this classification primarily provide a route between, and through, residential, industrial, agricultural, tourist and forest traffic nodes and the Rural Link and /or Declared road network.	May be either sealed or gravel surface.
Class 4C Rural Access	A road in this category provides direct access for abutting properties and generally connects into the Collector road network. There is minimal to no through traffic.	May be either sealed or gravel surface.
Class 4D Rural Minor	These roads generally provide occasional access to non-residential property only. Includes those roads identified as providing 'fire access'.	Generally either gravel, formed or natural surface.

Asset scores

The Austroads and municipal road classifications were used to assign asset scores to the various road categories. (U refers to urban and R to rural roads). Therefore the scores reflect the use and strategic importance of a road.

Asset score	Asset attributes
1	U4 R5
2	U3D; R4C; R4D
3	U3C; R4A; R4B
4	R2; R3; U2; U3A; U3B.
5	R1; U1

Threat scores

The depth of the water on the road, the length of road affected and the length of time the road is inundated (see threat modifiers) will influence access, safety of the road user and the extent of road damage. The overall threat score is therefore a complex interaction of each of these threat attributes.

It is considered that a water level of less than 10mm will have a minimal impact on safety, accessibility or the pavement. At 10 to 50mm depth aqua-planing can occur so water begins to be a safety hazard. This will slow traffic and lead to some inconvenience and traffic delays. Pavement damage will be minor but will increase with duration as water ingress occurs, leading to cracking of the seal and softening of pavement edges. At depths of greater than 300 mm, passenger vehicles can become buoyant and this will present an extreme safety hazard; traffic will need to be re-directed so there will be a major impact on accessibility, road damage will also be major as increased water flow will lead to scour of the pavement surface and loss of shoulder material.

If the length of road affected is less than 50 m inundation will pose only minor impacts, depending on the depth and duration of water, whereas, greater than 200 m length will pose a major obstruction to traffic flows and causes considerable damage to pavements.

Threat level	Threat score	Threat attributes – not opening
Insignificant	1	No threat to road or users: Water less than 10 mm deep and affecting a length of road less than 50 m
Minor	2	Minor safety, access and/or damage problems: Water between 10 to 50 mm and affecting a road distance between 50 m and 100 m
Moderate	3	Some moderate safety, access and /or damage problems: Water between 51-300 mm and affecting a road distance between 101-200 m
Major	4	Water between 51-300 mm and affecting a road distance > 200 m
Extreme	5	Asset unusable or substantial permanent damage: Road closed - greater than 300 mm of water over road and no other equivalent access routes.

Threat modifiers

Duration of inundation (DI)

The threat to safety, access and particularly damage to the road surface will increase as the duration of inundation increases. If the threat score is 2 or above, and the road is inundated for greater than 5 days, the threat score will increase by 1.

6.11 Agricultural Land

Asset description

The Agricultural land categories used in the EEMSS are based on the 'Land Value' categories used in RiVERS. The types of land use adjacent to estuaries is narrower than the RiVERS database coverage and asset attributes were therefore confined to activities that would be seen on the estuaries being managed in Victoria.

Predominant Agricultural Use Categories

Category 1 – Non-agricultural land

Category 2 – Dryland grazing/non-irrigated pasture/forestry

These enterprises have low level use of the affected asset areas for agricultural production. The land is part of a larger extensive grazing or forestry enterprise. If stock is grazed on the land, it is for short periods of time during the year. The impact of inundation is minimal as the farm is run at a low stocking rate with significant alternative grazing options.

In general this asset will be in lower rainfall areas where pasture production is less than 4 tonnes of dry matter per hectare per annum.

Category 3 – High rainfall farming/lifestyle farming

These areas are subject to more intensive productive processes. This is achieved through the greater capacity to produce pasture (4-6 tonnes dry matter per hectare per annum) due to higher rainfall. As a result there is greater stocking pressure and less alternative grazing options. The enterprise would still be considered to be extensive grazing. Paddock sizes would be smaller (less than 20ha).

Lifestyle blocks may still be used for income generation but are not considered the primary source of income for the owners. They are also of smaller area (less than 10 ha). Generally use is for small numbers of production animals, horses or bush areas.

Category 4 – Mixed grazing – possibly some irrigation

These areas have significant income generation usage. Irrigated land in this category would be land that has occasional irrigation or is part of a larger area of irrigation that is not threatened with inundation. Mixed grazing areas would run at reasonably high stocking rates. This area would be a higher rainfall area than Category 3.
Category 5 – Intensive agriculture (e.g. dairy, orchard, vineyard) – possibly significant irrigation

These areas are used for intensive agricultural pursuits. Grazing of dairy cows is at a high stocking rate (greater than 1.5 cows per hectare of the entire milking area). Orchard and vineyard use is part of a viable enterprise that is a significant part of the farm business. Properties in this category have significant areas of flood affected land that are capable of being used for these enterprises. For example, dairy land that is capable of growing 6 tonnes of dry matter of pasture per hectare per year or potato farming that is capable of producing yields similar to that of unaffected areas in the same enterprise.

Land type descriptions

For each property, a percentage figure is used for the loss of utilisation of the assets compared with not having any inundation for the period in question. This requires an assessment of the potential production from the inundated land. This will vary with the land type inundated as potential production will be greater on some areas of land than others. In order to assign threat scores to each property, the area of each of the three land types described is required.

HIGH LAND – Land that is not affected by inundation at all. This classification is only assigned so the proportion of the farming enterprise affected by inundation can be calculated.

INTERMEDIATE LAND – Land that is only inundated for short periods of time. These are the higher areas that are the last areas inundated and the first to have the water recede. These areas normally have a capability for production of pasture or crops. These areas of land are the most affected by estuary entrance management decisions.

LOW LAND – These land areas have minimal productivity due to constant inundation. These are areas that normally have minimal productive output and are only seen as opportunistic use areas. Plant species that survive in these areas are of minimal productive use.

Asset scores

The primary criterion for assigning asset scores is the productive capability of the land; this is reflected in the predominant agricultural land use categories described above. An agricultural land assessment proforma is provided (Appendix K). This report guides the consultant engaged to undertake the property assessments when assigning asset and threat scores to a property.

Asset score	Asset attributes
1	Non agricultural
2	Dryland grazing/non irrigated pasture/forestry
3	High rainfall farming/lifestyle farming
4	Mixed grazing – possibly some irrigation
5	Dairy, orchard, vineyard, intensive agriculture – possibly significant irrigation used.

Threat scores

When assessing the extent of production loss on each property, for each month and water level, the following characteristics need to be taken into account:

- proportion of land affected that is low or marginal;
- capacity to mitigate loss. This includes the flexibility of a landholder to manage loss by moving stock to other land and/or buying in feed;
- time and expenditure to restore land or fences after inundation recedes. That is, to renovate land to its previous level of production and/or repair fences; and
- access to land that is isolated during inundation.

There are two major changes in the soil due to inundation; these are the effects of extended periods of waterlogging and the increase in salinity of the land. The physical, chemical and biological properties of soil can all be negatively affected by waterlogging. Some of the impacts on the soil can be further exacerbated by compaction due to grazing.

Soil requires regular leaching to maintain sodium concentrations at levels that are conducive to productive pasture growth. Due to the shallow water table, there will be minimal leaching of agricultural land affected by inundation from estuaries. During periods of inundation this leaching process will be further inhibited. Following inundation the levels of salt left in the soil will depend on the degree of leaching that occurs due to follow up rainfall. This has implications for the timing of estuary openings. Opening during winter and early spring means a higher likelihood of follow up rain to enable some leaching. Opening in late spring and summer is likely to have minimal follow up rain and result in higher sodium levels.

The threat score will not take into account the economic value of the production loss per se. This is accounted for in the asset score assigned to each property. Each property is assessed using the threat attributes and scores shown overleaf. The total threat score for each month and water level is the maximum of the individual threat scores assigned to each attribute.

Threat Score	Threat Level	Threat Attributes – not opening
2	Minor	• Less than 50% of low land inundated. • Loss can be mitigated with minimal extra inputs, e.g. stock can be moved to other land and no extra bought in feed is required. • No renovation or extra input required to revert land to previous productivity following inundation. b) No damage to fences. • No loss of access to other high land.
3	Moderate	• All low land is inundated and less than 20% of marginal land is inundated. • Mitigation of losses requires minimal extra inputs, e.g. stock can be moved to other land and less than 10% of feed requirements need to be bought in. • Minimal input required to return land to previous productivity, e.g. weeds sprayed with no extra seed required. b) Debris to be removed to maintain fence integrity. • Access is restricted to less than 5% of the rest of the farming land.
4	Major	• All low land is inundated and 20-50% of intermediate land is inundated. • Stock can be moved to non-inundated land but feeding out is difficult. 10-50% of feed requirements need to be brought in. • Pasture renovation is achieved through drilling of appropriate seed b) Some fence rewiring required • Access to 5-10% of the rest of the enterprise is affected.
5	Extreme	• All low land inundated and greater then 50% of intermediate land inundated. • No suitable land is available for hand feeding and greater than 50% of stock requirements need to be brought in. • All land needs to be fully renovated with cultivation and lime or gypsum treatment to address soil quality issues b) fences need to be replaced. • Access is lost to greater than 20% of the farm area.

Cropping

In situations where the farming enterprise relies on cropping for its primary income from the affected land there needs to be special consideration to the effects of times of inundation. Crops need to be planted at certain times of the year and need to be free of inundation during the course of their growing season to produce any saleable yield. This will need to be taken into account when assessing threat attributes. Inundation during any part of this growing season will result in minimal opportunity to generate income from the affected land for up to 12 months depending on the crop.

The opportunities to mitigate losses in a cropping enterprise are not as great as that of a grazing enterprise. For example, grazing stock can be moved to another part of the farm whereas crops cannot. This means that most affected land used for cropping will be assigned a threat score of 5 “extreme” for most months of the year.

Threat modifiers

Duration of inundation (DI)

It is generally felt by agronomists that significant damage occurs to pastures that are waterlogged for greater than 14 days. It should be remembered that waterlogging is likely to remain in place for a significant amount of time before and after the period of inundation.

If the water level is equal to or higher than the height of the intermediate land for a property and duration of inundation is greater than 14 days, then one is added to each threat score. This score assumes the land is inundated with fresh water.

Drought (DR)

The extent of drought conditions affects the productive capability of an asset. The EEMSS changes the threat scores to reflect the increased level of threat associated with each level of drought.

Local drought (100 km) – Causes a reduction in the productive capability of the entire farming enterprise. This results in reduced capability to mitigate losses through decreased production of pasture from the high land. Consequently increased amounts of brought in feed are required. This increases the threat value as assigned by one.

Regional drought (1000 km) – A reduction in the supply of brought in feeds due to drought in the areas where these feeds are sourced results in increased prices of these feeds. This increases the threat value as assigned by 2.

Continental Drought (5000km) - Feed prices are more severely affected by continental drought. The effect of a regional drought is increased costs of transportation of feed from distant areas. Continental drought results in feed prices being related to the cost of importation of feed from overseas. A continental drought increases the assigned threat value by 3.

The EEMSS adds the threat modifier scores to the total threat score. If both modifiers are applicable, that is the property is experiencing drought and some land has been inundated for greater than 14 days, both modifiers are added to the threat score.

6.12 Septic systems

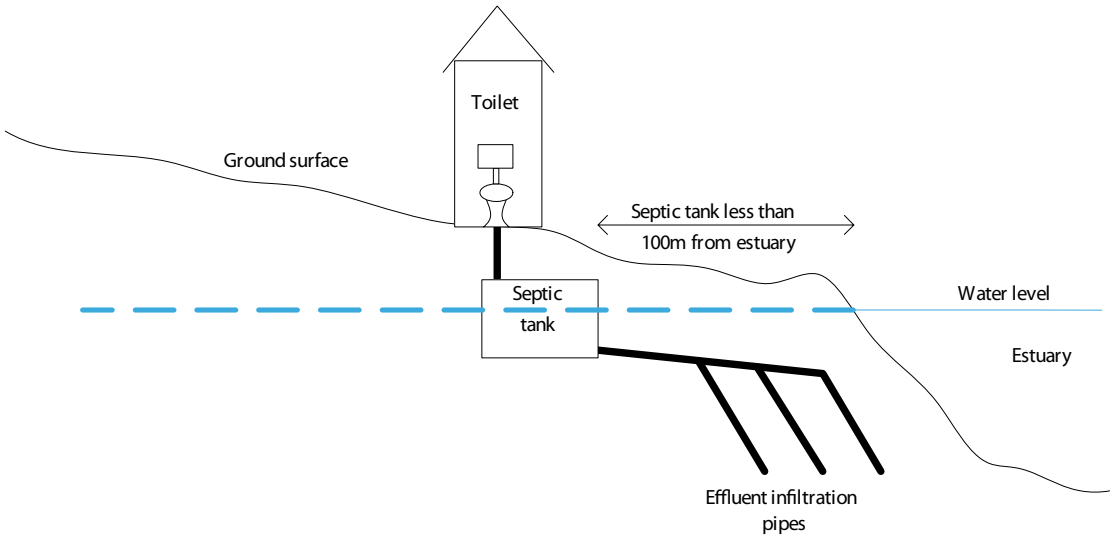
Asset description

Where septic tanks are located in close proximity to an estuary, the water level in the estuary can influence the functioning of the septic tank. Figure 6.2 illustrates the interaction between the estuary water level and a nearby septic tank. If the septic tank is within approximately 100m of the estuary, the water level in the estuary can raise the level of the groundwater surrounding the tank. This may take several days to occur, but once it does, it can affect the functioning of the septic tank. The saturated soil around the effluent infiltration pipes means that greater pressure is required for the effluent to leave the septic tank. As the water level rises, this may lead to a build-up of effluent in the septic tank and eventually prevent the tank from functioning at all, causing odour and public health issues. These guidelines apply only to conventional septic tanks with a network of effluent infiltration pipes. Modern septic tanks that treat and store water for reuse do not need to be included as they are not influenced by the surrounding groundwater.

In Victoria the location of septic tanks in relation to waterways including estuaries is regulated under the EPA Act 1970. The Victorian Septic Tanks Code of Practice (2003) establishes a minimum required setback distance of septic tank effluent fields of 60 m upslope of any surface waterbody.

If a septic system is located so that its function can be affected by the water level within the estuary then alternatives to the system should be investigated.

Figure 6.2 Schematic diagram showing the effects of a high water level in the estuary on nearby septic tanks.



Asset scores

The number of people potentially impacted by the failure of the septic tanks has been chosen as the asset attributes. A septic tank attached to a single dwelling will have less of an impact if it stops functioning than a septic tank servicing a camping ground or caravan park with a large number of occupants. The impact will be greater still if a septic system at an industrial facility fails, as the tank may be treating a range of pollutants other than human wastes.

Asset score	Asset attributes
1	Septic tank associated with a private house.
2	Septic tank associated with a small camping ground or caravan park (less than 20 sites, approx.).
3	Septic tank associated with a moderate sized camping ground or caravan park (20 to 50 sites, approx.).
4	Septic tank associated with a large camping ground or caravan park (greater than 50 sites, approx.).
5	Septic tank associated with industrial site.

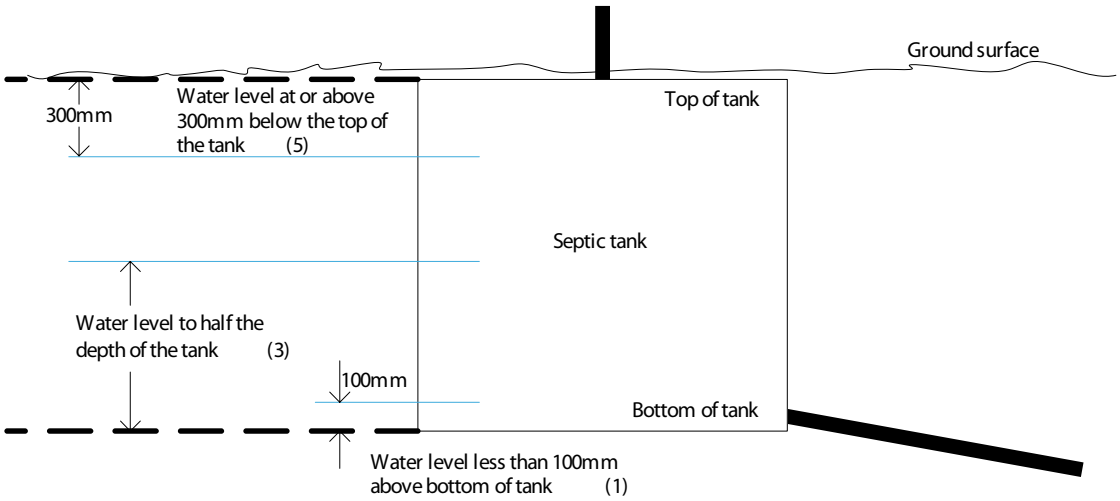
Threat scores

The estuary water level, in relation to the top and bottom levels of the septic tanks, will determine the level of threat to the function of the septic system. Different water levels relate to gradual reductions in the functionality of the septic tanks. As the water level climbs above the bottom of a tank, some extra pressure is required for the effluent in that tank to discharge, and this causes some build up of effluent levels in the tank. As the water level continues to rise, this effect becomes more pronounced until the water level reaches the top of the tank, at which point the tank ceases to function and may spill, causing odour and public health issues (Fig. 6.3). Only three threat levels are identified because a finer definition is unnecessary.

A distance of 100m from the estuary has been used as an approximate margin within which the estuary water level will influence septic systems. However, this will vary with the topography of the surrounding land and some common sense should be used when applying this distance.

Threat score	Threat Attributes
1	Septic tank within 100m of estuary (approx). Estuary water level 0 to 100mm higher than the bottom of the septic tank. Some accumulation of effluent.
3	Septic tank within 100m of estuary (approx). Estuary water level greater than 100mm above the bottom of the septic tank and less than half way up the tank. Moderate accumulation of effluent.
5	Septic tank within 100m of estuary (approx). Estuary water level at or above 300mm below the top of the septic tank. Septic barely functioning, possible spills and odour issues.

Figure 6.3. Threat characteristics and associated threat scores (shown in brackets)



Threat modifiers

Duration of inundation (DI)

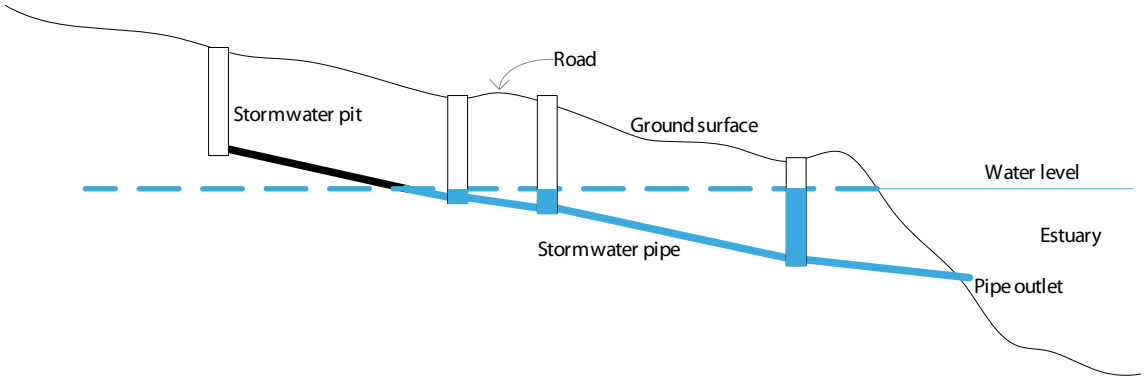
If the tank has been inundated for less than 10 days the system should still function. The threat scores assigned will therefore only be valid if the estuarine water level is greater than the AHD of the bottom of the septic tank, and it has been at that level for more than 10 days, otherwise the threat score will be one.

6.13 Stormwater

Asset description

If the stormwater pipe network has an outlet pipe discharging into the estuary, the system can be affected by an increase in water level in an estuary. Figure 6.4 shows the effect of the water level in the estuary on the stormwater system. In this case there is a stormwater outlet pipe discharging into the estuary below the water level. In the figure, pits and pipes that are shaded blue are filled with water to the water level of the estuary.

Figure 6.4. Schematic showing the effects of a high water level in the estuary on the surrounding stormwater system



Once the water level in the estuary is higher than the pipe outlet this will affect the capacity of the drainage system to convey storm flows without the pits filling further and water spilling from the tops of the pits and causing surface flooding. In low lying areas, the water level in the estuary may eventually get high enough so that even without rainfall, water fills the pipes and spills from the tops of the pits. The ponded water may then cause a risk to safety and has the potential to cause property damage.

Asset score

The nominal diameters of the pipe outlet have been chosen as the asset attributes. The outlet size is generally proportional to the size of the catchment discharging stormwater runoff through that pipe. The catchment area is important because a large catchment will produce more stormwater runoff than a small catchment. The greater the runoff, the more chance that flooding will result if the pipe system is blocked. As catchment size is also related to the number of properties serviced by the system, it is also indicative of the number of properties and buildings in the catchment that may be impacted upon by flooding if the stormwater network becomes blocked.

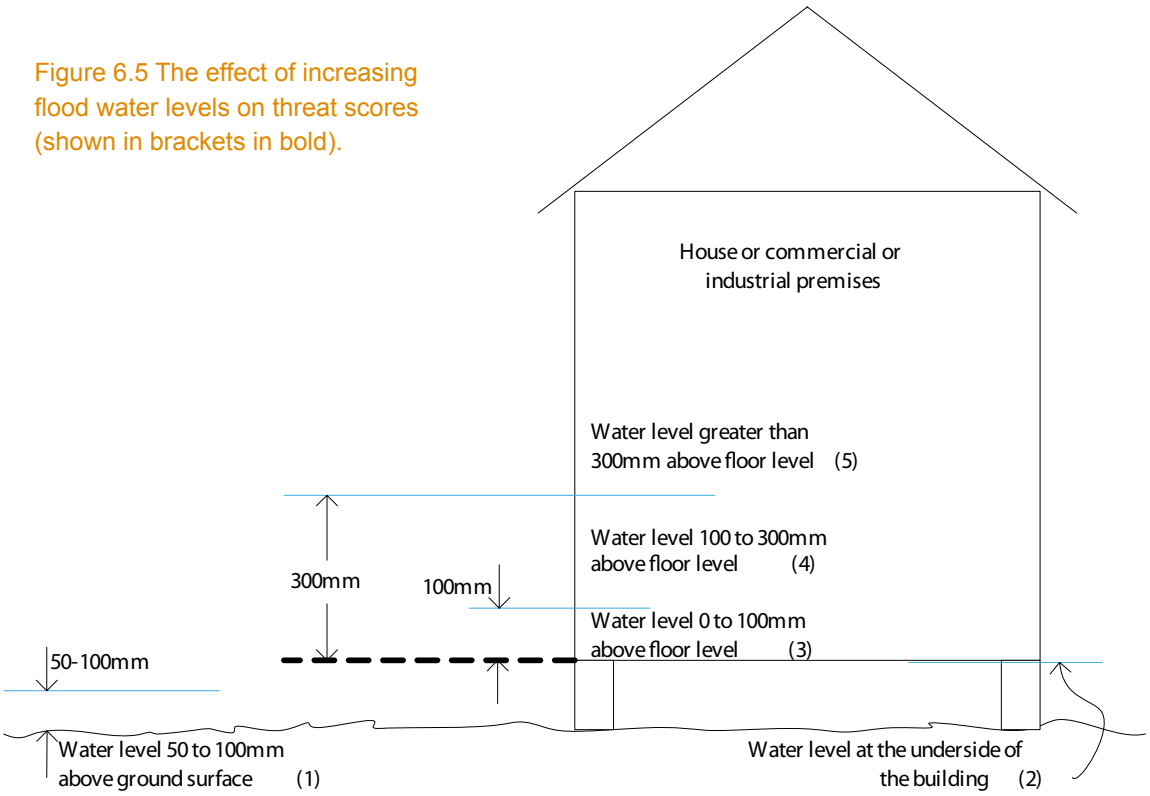
Asset score	Asset attributes
1	Pipe nominal diameter less than 300mm
2	Pipe nominal diameter greater than 300mm and less than 600mm
3	Pipe nominal diameter greater than 600mm and less than 900mm
4	Pipe nominal diameter greater than 900mm and less than 1200mm
5	Pipe nominal diameter greater than 1200mm

Threat Score

Impedance of the stormwater system is only considered a threat once surface flooding occurs. The level of threat is determined by the depth of water over the ground and in relation to buildings. Different depths relate to the relative risk to safety and the potential for temporary or permanent property damage. When water pools on the ground it causes some temporary property damage, but at higher water levels property flooding can cause permanent damage. For the range of water levels that may occur in estuaries, flooding will only occur in low-lying flat areas and water will therefore pond rather than flow swiftly, so the safety risk associated with high velocity flows has not been considered (Fig 6.5)

Threat score	Threat attributes
1	50 to 100mm of water on property grounds; temporary damage to grounds / gardens.
2	Water depth is to the level of the underside of the floor of the house or commercial / industrial building; temporary dampness inside the building.
3	0 to 100mm of water above the floor level of the building; permanent damage to carpets.
4	100 – 300mm of water above the floor level of the building; permanent damage to furniture.
5	Greater than 300mm of water above the floor level of the building; permanent structural damage to the building.

Figure 6.5 The effect of increasing flood water levels on threat scores (shown in brackets in bold).



6.14 Built infrastructure

Asset description

There are a range of buildings that have historically been located on estuaries close to the water's edge and are therefore subject to inundation when the estuary closes. These include boat sheds, clubrooms of recreational groups (e.g. angling clubs and ski clubs) and commercial boat hire operators.

Asset score

The level of importance of the built infrastructure asset is considered in the EEMSS to be proportional to the cost of any damage or loss incurred if the building is inundated.

Asset score	Asset attributes
2	Built structures used for storage with no internal fittings. For example boat sheds.
3	Residence or commercial property with limited internal fittings.
5	Residence or commercial property with extensive internal fittings.

Threat Score

The level of threat to built infrastructure relates directly to the potential damage to the property and risks to pubic safety caused by the depth of water inundating the property grounds and the building (Fig 6.5).

Threat score	Threat attributes
1	50 to 100mm of water on property grounds; temporary damage to grounds or gardens.
2	Water depth is to the level of the underside of the floor of the house or commercial / industrial building; temporary dampness inside the building
3	0 to 100mm of water above the floor level of the building; permanent damage to carpets.
4	100 – 300mm of water above the floor level of the building; permanent damage to furniture.
5	Greater than 300mm of water above the floor level of the building; permanent structural damage to the building.

6.15 Human health

Mosquitoes are a natural part of estuarine and freshwater wetland ecosystems but have the potential to cause pest and public health impacts. In Australia there are over 300 different species of mosquito each closely associated with particular habitats but they all, generally, share the same biology and ecological requirements to complete their life cycle.

Mosquitoes have a relatively short but complex life cycle consisting of eggs, four aquatic larval stages (instars), an aquatic pupal stage and a terrestrial adult stage. Mosquitoes are dependent on water with the immature stage totally aquatic and without access to free standing water of some kind the larvae cannot complete their development to the adult phase. Eggs are laid either on the water surface (usually with eggs in the form of a floating raft) or on a frequently inundated substrate (usually singularly or in small groups). On hatching, the larvae grow through four different instars or moults until the final larval stage develops into a pupa from which the adult mosquito emerges. Development from egg hatching to the emergence of an adult mosquito generally takes at least one to two weeks.

Nuisance biting from pest mosquitoes, particularly large populations, can have negative impacts on living standards as well as economic impacts on residential, recreational and tourist developments. However, it is difficult to quantify an actual or potential nuisance-biting problem due to the large variation in human tolerance of mosquitoes.

Ross River (RRV) and Barmah Forest (BFV) virus are the most common disease causing pathogens spread by mosquitoes in Australia. There are, on average, approximately 4,000 and 600 human cases of RRV and BFV respectively per year across Australia. While the symptoms can vary greatly between individuals, infection with either of these viruses may result in a condition known as polyarthritis causing a range of symptoms including rash, fever, myalgia and arthritic pain in the ankles, fingers, knees and wrists.

Both viruses can be spread by a range of mosquito species associated with estuarine and freshwater wetlands, but as the transmission cycle requires the presence of suitable reservoir hosts such as native macropods (i.e., kangaroos and wallabies), there is a much greater risk of disease transmission in rural and semi-rural areas compared to urban areas.

Bairnsdale ulcer is a skin disease caused by the bacterium Mycobacterium ulcerans, which is found naturally in the environment. The toxins produced from the bacterium can cause damage to skin cells and small blood vessels resulting in ulceration and skin loss. Epidemics of Bairnsdale ulcer have been reported from coastal areas of Victoria including the Mornington Peninsula and East Gippsland.

Pest mosquitoes

There is spatial and temporal variance in the relative abundance of mosquito species representing a risk to human health. Differences in the diversity of mosquito fauna and abundance of individual species will influence the site-specific risks of mosquito-borne disease.

In coastal areas of Victoria, the most important pest and vector mosquito associated with estuarine and brackish water habitats is Ochlerotatus camptorhynchus. In southern coastal areas of NSW, Victoria, South Australia and Western Australia, Oc. camptorhynchus is usually associated with estuarine marshlands but is also commonly collected in flooded brackish water and freshwater marsh and pastures located immediately behind saltmarsh and mangrove wetlands. This species can be a serious biting pest and vector of arboviruses (including RRV and BFV) due to the propensity of this species to bite humans (during the day and night) and the exceptionally large populations that can occur.

Population increases of Oc. camptorhynchus are triggered by water level changes in coastal lakes. Fluctuations in water levels are primarily the result of tidal inundation, estuary closure and rainfall but are also caused by atmospheric pressure and wind. While the timing of population increases can be predicted from the habitat inundation, the magnitude of population increases is dependent on a range of interacting factors that include the time of the season, extent of inundation and previous inundation and population increases that may predispose a site to higher (or lower) relative population increases.

The mosquito fauna of estuarine/brackish water wetlands is dominated by Oc. camptorhynchus that has been recorded making up over 90% of total mosquitoes collected in coastal areas of Victoria over a 6 month survey period. There are, however, other mosquitoes that may be associated with coastal wetlands. Ochlerotatus alternans has been recorded from estuarine wetlands and is a large conspicuous sandy/orange mosquito that bites humans but the distribution of this species in Victoria is generally limited to northern areas of the state, particularly around the Murray Valley. Anopheles annulipes may also be found in freshwater to brackish water habitats associated with ephemeral ground pools and permanent wetlands. This species does bite humans, generally at dusk/night, but is only considered a serious pest when populations are exceptionally large and such situations may for short periods during the ‘mosquito season’.

Asset scores

Local municipal councils are required (under the Health Act (1958) and The Health (General Amendment) Act (1988)) to develop Municipal Public Health Plans (MPHP). It is the function of municipal councils to prevent disease and promote public health. These plans are designed to identify and assess actual and potential public health dangers affecting the municipal district; and outline programmes and strategies which the council intends to pursue to prevent or minimise those dangers.

There are approximately 250 notifications of human infection with RRV and 20 of BFV annually in Victoria but the annual arbovirus notifications can vary dramatically (RRV range from 1057 – 11 and BFV from 58-7). As the symptoms of infection can vary greatly, the notification rates are thought to be under representative of total infection rates in the community.

Municipal councils have a responsibility to minimise the risk of mosquito-borne disease transmission by maintaining populations of vector mosquitoes (i.e. Ochlerotatus camptorhynchus) at tolerable levels.

Asset attribute	Asset value
Human Health	5

Threat scores

There is a potential threat to the Human Health Asset of not opening an estuary as this can result in increases to mosquito populations and subsequent increased risk of mosquito-borne disease transmission.

The abundance of Oc. camptorhynchus will be influenced by factors independent of the estuary's opening as productive habitats around the edge of the estuary may be inundated by high tides and/or rainfall consequently triggering the increase in populations while temperature, wind and time of year may influence the abundance and dispersal of adult populations.

The following will influence the level of threat of not opening an estuary to populations of *Oc. camptorhynchus*:

- The availability of suitable habitat for mosquito production may be reduced by opening the estuary mouth. Wetlands and/or surrounding ephemeral or semi-permanent habitats are less likely to be inundated if the water levels are lowered. The reduction in larval habitat will have a direct impact on the magnitude of the adult mosquito population.
- The localised activity of arboviruses including RRV and BFV will greatly influence the threat to the asset. Both records of locally acquired human infection and the abundance of vertebrate reservoir hosts will contribute to the level of threat. Changes in the activity of these reservoir hosts may be influenced by water levels as macropod and/or bird populations may be greater, or highly concentrated close to mosquito habitats, when water levels are high.
- Increased contact between the community (i.e. residents and visitors) and mosquito populations will raise the threat level to the asset. Notwithstanding the factors influencing mosquito populations, the potential number of people impacted will be dependant on:

    - The permanent and temporary population sizes of residential and recreational areas
    - Proximity of mosquito habitats to residential and recreational areas and
    - The direct impact on mosquito habitats (e.g. inundation) of residential and recreational areas via stormwater flows and runoff.

- The selection of appropriate mosquito control strategies is required. The selection of both the appropriate control agents (e.g. larvicide, insect growth regulator or biological control), method of application (e.g. aerial or ground application) and assessment of effectiveness (e.g. larval and adult mosquito monitoring) is crucial.

When assigning threat scores for the months September to May, assume an intermediate abundance of mosquitoes i.e. 50 -1000 per trap night. The mosquito abundance modifier will then alter the threat score to reflect the threat associated with the current mosquito abundance. For winter months, assign a threat score that is one point lower than that assigned for the other months.

The abundances of reservoir hosts such as macropods and birds also contribute to the level of threat to the public from arbovirus. These are unlikely to be monitored on a regular basis and are therefore not included in the EEMSS.

Implementation of a public education program that includes regular public updates and information about mosquitoes and arbovirus activity should also be considered as part of a comprehensive control program.

It is noteworthy that, the opening of the Peel Inlet and Harvey Estuary, Western Australia resulted in some increases in the production of *Oc. camptorhynchus* and *Ochlerotatus vigilax*. The population increases in some habitats were due to a marked increase in tidal amplitudes within the estuary. Monitoring of estuarine wetlands should therefore be considered following the opening of the estuary to ensure no increases in *Oc. camptorhynchus* populations occur.

Threat modifiers

1. Mosquito abundance. The abundance of Oc. camptorhynchus will have a major impact on the human health asset. While epidemics of RRV and BFV are difficult to predict, a common characteristic of outbreaks is high mosquito populations. However, there is no quantitative correlation between the abundance of mosquitoes and number of human disease notifications. The threat modifier scores can only be assigned if a mosquito monitoring program is established. Typically this involves multiple adult mosquito trap sites where CO2 baited light traps are operated once a week for approximately six months.

Relative mosquito abundance	Threat modifier
High (>1000 mosquitoes per trap night)	1
Moderate (50-1000 mosquitoes per trap night)	0
Low (<50 mosquitoes per trap night)	-1

Table 6.4 Major threat attributes and threat scores associated with not opening an estuary

Threat attribute				Threat score (TS)		
		Insignificant (TS = 1)	**Minor (TS=2)**	**Moderate (TS=3)**	**Major (TS=4)**	**Extreme (TS=5)**
A	**Activity of arboviruses (e.g. RRV and BFV) in mosquito and/or reservoir host populations**	No detected arboviruses	Very low activity or sparsely detected arboviruses	Moderate or small activity of arboviruses	Moderate to high activity	High numbers or concentrated activity
B	**Potential reduction in available larval habitat for *Oc. camptorhynchus***	Minor reduction in larval habitat if estuary opened		Moderate reduction in larval habitat if estuary opened	1-3km or medium to high residential/ recreational populations	Significant reduction in larval habitat if estuary opened
C	**Proximity of residential and/or recreation areas to mosquito habitats**	>10kms or low residential/ recreational populations	5-10kms or medium residential/ recreational populations	3-5km or medium residential/ recreational populations		<1km or high to very high residential/ recreational populations
D	**Implementation of appropriate mosquito control strategies (e.g. larvicide or insect growth regulator)**	Well designed and funded broad scale treatment program targeting known *Oc. camptorhynchus* habitats	Well designed but poorly funded treatment program restricted the amount (or effectiveness) of individual treatments	Small scale treatment undertaken in restricted areas	No control strategy implemented	No control strategy considered or implemented

Table 6.5 A general guide to assigning an overall threat score (TS), of not opening the estuary, using the four major attributes

Overall threat score	Individual threat attribute scores			
	A: Arbovirus activity	B: Availability of mosquito habitat	C: Proximity of residential areas to mosquito habitats	D: Mosquito control strategies
5	TS = 5	TS = 5	TS = 5	TS = 4
4	TS = 5	TS = 4	TS = 4	TS = 3
3	TS = 4	TS = 3	TS = 3	TS = 2
2	TS = 2	TS = 2	TS = 2	TS = 1
1	TS = 1	TS = 1	TS = 1	TS = 1

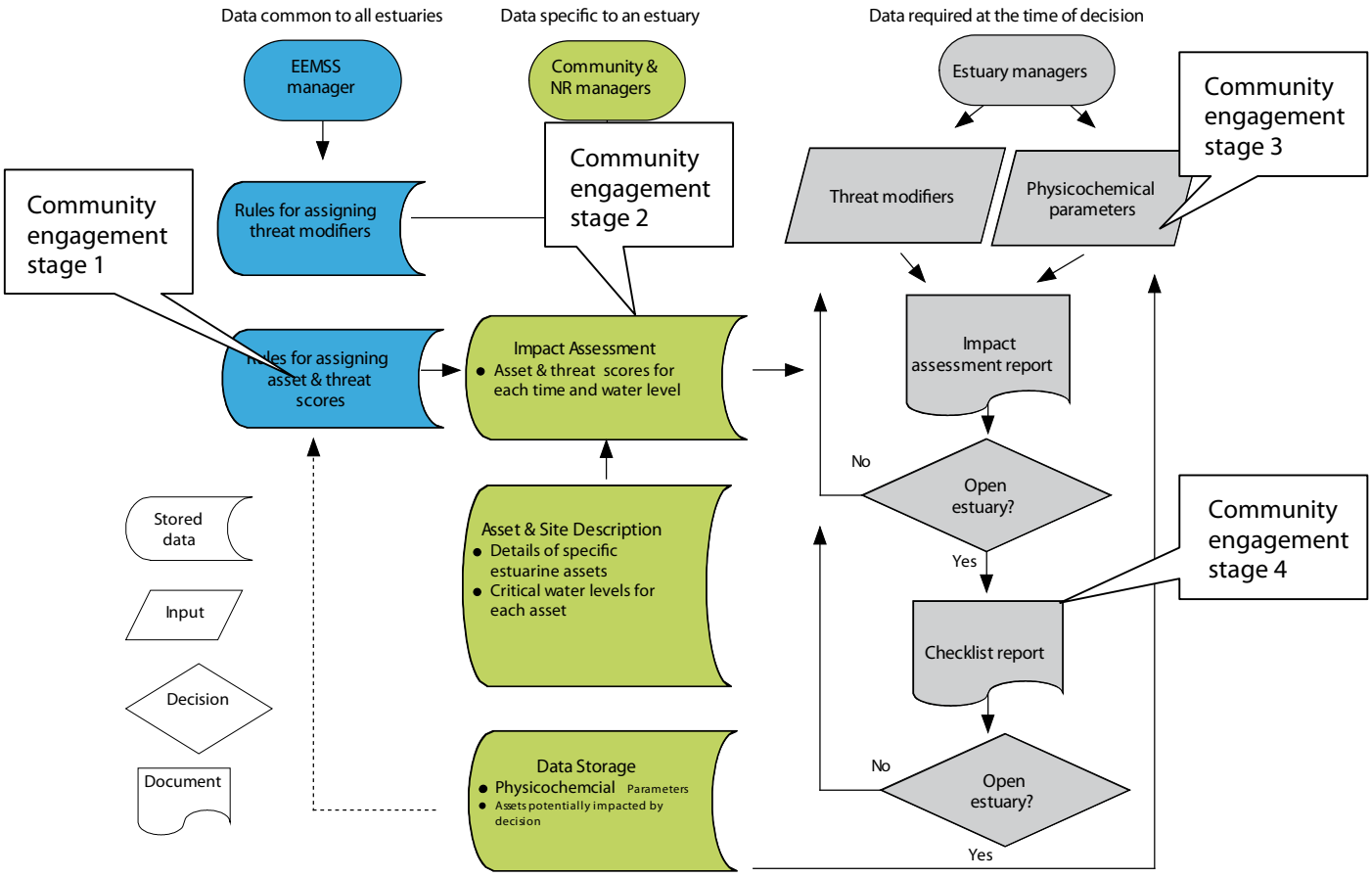
7 Comunity engagement

Stakeholder engagement is essential to not only making an informed decision but also the acceptance of that decision. The history of unlicensed estuary openings in several estuaries in south west Victoria highlighted the importance of engaging communities in all stages of the decision making process.

Community collaboration was intrinsic to the development and implementation of the EEMSS on the four trial estuaries; the Glenelg, the Eumerella (Yambuk), the Aire and the Anglesea. The database has also been designed to facilitate ongoing community involvement.

Several formal opportunities for community engagement were provided during the EEMSS development and implementation on the trial estuaries (Fig. 7.1). However, throughout the development phase there were also many informal opportunities, these included three project update leaflets, letters summarising the workshop findings, project information on CMA websites, tours of the trial estuaries with individual landholders, and many phone conversations with community members. The EEMSS provides opportunities for ongoing community engagement once it is being used on an estuary as part of the opening decision process.

Figure 7.1. Opportunities for community engagement in the EEMSS project



Community engagement stage 1 - Development of the EEMSS

The involvement of communities in the development phase is discussed in section 2.3.1

Community engagement stage 2 - Implementation of the EEMSS

The EEMSS was trialled on four estuaries. This involved collecting data about the estuarine assets of each estuary prior to the community workshops. The workshops were then used to:

- introduce the communities to the EEMSS database (importantly what it will and won't do)
- explain how the EEMSS relates to any other estuary projects
- explain how information gathered in previous workshops was incorporated into EEMSS
- outline the main features of EEMSS
- explain who provided the expert advice used to develop the rules and the rationale for the scores for environmental assets that are automatically uploaded
- populate EEMSS for each estuary. This involved the participants identifying estuarine assets specific to their estuary and assigning scores to the assets and threats to those assets.

A suggested workshop plan for the implementation of the EEMSS or other estuaries is provided in section 11.4.

Community engagement stages 3 & 4 - Use of the EEMSS

The capacity of EEMSS to both store data and produce reports provides an opportunity for further community involvement.

Data on mouth status and water level are simple to gather and can be used to model the extent and timing of inundation of areas surrounding estuaries. Community members may be in a position to make regular observations of these estuary properties. This data can be used to further refine the scores assigned to the threats of opening and not opening the estuary on the various estuarine assets.

When a manager makes a decision regarding opening an estuary, they are required to generate both an impact assessment report and a checklist report. These reports present the information used to make the decision and the manager's response to that information. Both reports should be provided to the community so the decision process is open and transparent.

8 Project learnings

An evaluation survey was presented to participants at the end of the stage 2 workshops on the four trial estuaries.

The survey assessed how well the EEMSS project addressed:

1. The project aims (see section 2.1)
2. Perceived problems with current estuary entrance management (see section 2.1)
3. The level of community engagement/involvement with the project. Specifically, does the EEMSS reflect what the community values about their estuary? Also, do community members feel they have had the opportunity to contribute to the development of the framework?

The response to EEMSS in the workshops was very positive and this is reflected in the survey results (Table 8.1). Although a similar survey was not conducted prior to the project commencement, participants at the stage 1 workshops were asked to indicate their current perception of estuary entrance management by standing on a line marked from one to ten. No participant in any of the workshops scored management prior to the introduction of the EEMSS at more than five out of ten. Many comments also reflected a high level of dissatisfaction with estuary entrance management.

The responses in the survey (n = 46) were summarised into three main themes: community engagement and understanding; function and use of EEMSS; and other outcomes.

The use of negatively phrased questions should be reviewed in further community surveys of this type. When statements in the survey were expressed as a negative, the response often seemed inconsistent with responses to other similar questions and hence the range was often greater for these questions.

The relatively large number of participants (22.6%) who were unsure about some aspects of the implementation of EEMSS would suggest a follow up survey once EEMSS has been in use for some time is warranted.

It would also be valuable to assess whether the anticipated outcomes in the 'Other outcomes from EEMSS' section are realised after the EEMSS has been in use for some time.

Table 8.1 Summary of results from EEMSS evaluation survey (n = 46). Percentages may not total 100 as a small percentage of questions were unanswered

	Agree strongly %	Agree %	Don't know %	Disagree %	Disagree strongly %
Community engagement and understanding	15.3	65.9	9.8	6.5	0.6
Examples: I understand how EEMSS will work; my ideas have been included in EEMSS	**81.1**		**9.8**	**7.1**	
Function and Use of EEMSS	18.3	54.8	22.6	2.6	0
Examples: EEMSS will be easy to use. EEMSS will ensure a consistent procedure is followed. EMSS will ensure estuary management is open and transparent	**73.1**		**22.6**	**2.6**	
Other outcomes	13.8	65.6	11.2	6.9	0.7
Examples: EEMSS will improve communication between managers and community. Impacts of artificially opening an estuary will be monitored; responsibilities for estuary management is clear	**79.4**		**11.2**	**7.6**	

The use of an independent agricultural consultant to assess properties with landholders prior to a workshop was very valuable. The landholders attending the subsequent workshop were already familiar with the process of assigning asset and threat scores, had a good understanding of the language used and were pleased to have their problems with inundation formally acknowledged. It was also an opportunity for the consultant to discuss other management options for land that is frequently inundated.

9 Technical advice & further reading

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PART 2

SECTION 4

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Further reading & references

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EVCs and RARE AND THREATENED SPECIES

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SECTION 5

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Technical advice

A Technical report was prepared for the EEMSS project by Cameron E. Webb and Richard C. Russell Department of Medical Entomology Institute of Clinical Pathology and Medical Research and University of Sydney, Westmead Hospital
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Advice on illustrations of estuarine processes provided by:

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John Sherwood. Associate Professor, School of Life and Environmental Sciences Deakin University
Julie Mondon. Lecturer, School of Life and Environmental Sciences Deakin University

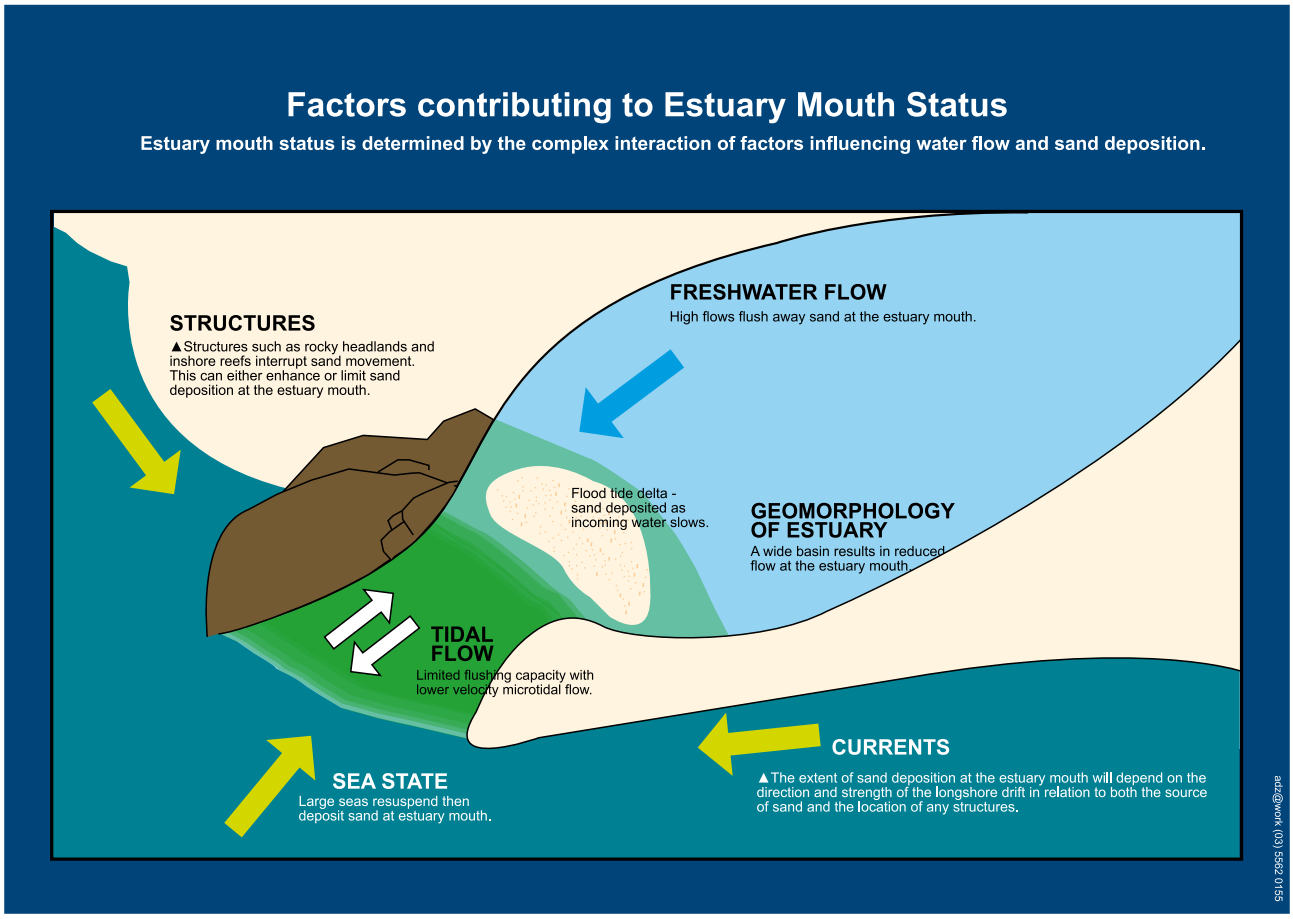
Appendix A. Factors affecting mouth status

Estuary mouth closure is a natural event for many estuaries in southern Australia. Several factors interplay to determine when an estuary closes and the length of time it remains closed. These include ebb tidal flow and freshwater discharge, which acts to remove sand from the estuary mouth and flood tides, currents and swell, which deposit sand. Many of the estuaries open directly onto the open coast and are therefore exposed to large swells which can transport large volumes of sand to the estuary mouth.

The extent and timing of estuary mouth closure will depend on the amount of water movement and the relationship between the source of sand, the prevailing current and the position of any structures which could slow water movement (Fig. A.1). Water movement in estuaries along the southern Australian coast is often not adequate to keep the estuary mouths open. The seas are mostly microtidal (i.e. tidal differences of less than 2m), so there is limited tidal flow and river discharge is also often substantially reduced, particularly during summer and early autumn.

Catchment activities such as water extraction, land use and drainage, influence both flow and timing of flow to estuaries. These activities can also potentially affect the status of the estuary mouth.

Appendix A.1



Appendix B. Seasonal hydrological cycle and estuary mouth status

Increases in freshwater flow into the estuary, often in late winter and early spring, flush away the sand bar at the estuary mouth and may also remove the marine water from the estuary (Fig. A.2). As the freshwater flow reduces, marine water gradually moves back into the estuary with flood tides. Because the marine water is denser it sinks below the fresher water, resulting in two distinct layers, called stratification.

Reduced flows during summer and autumn result in sand not being flushed from the entrance. Therefore, sand continues to be deposited and may eventually cause the estuary to close.

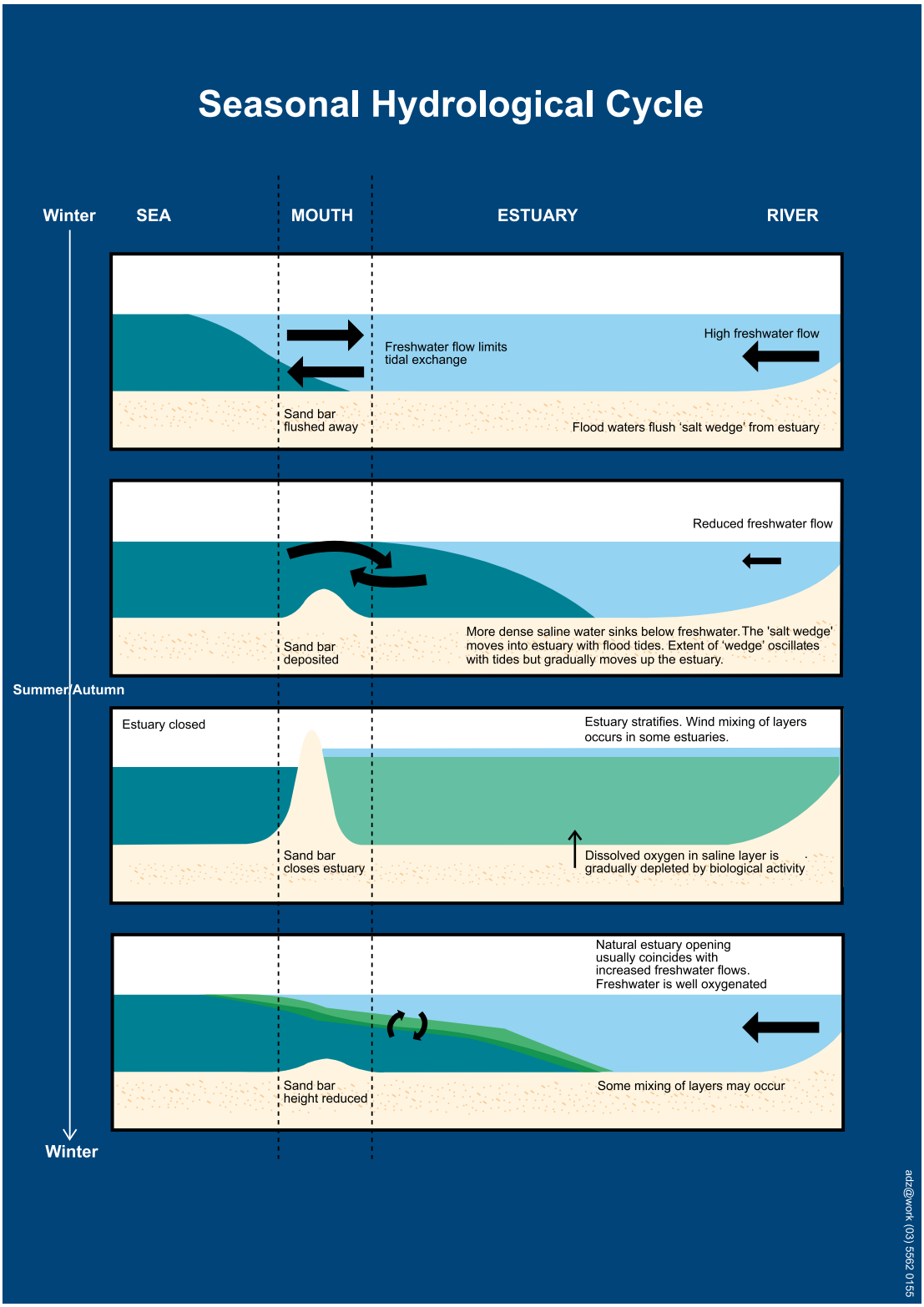
Stratification can be reduced by wind mixing, particularly in shallow estuaries with a wide basin. Orientation of the channel with respect to the prevailing winds may influence the effectiveness of wind mixing.

If there is limited mixing of the layers, dissolved oxygen levels are gradually depleted in the bottom layer by biological processes such as respiration of fish and zooplankton and the decomposition of organic matter by bacteria.

The estuary usually opens naturally once the estuary water reaches a certain level. This often coincides with an increase in freshwater flow.

It should be noted that the cycle depicted in Figure A.2 is a generalised model and the degree of stratification, as well as the extent and timing of estuary closure, varies markedly between estuaries and over time.

Figure A.2


Seasonal Hydrological Cycle
Winter
SEA
MOUTH
ESTUARY
RIVER
Freshwater flow limits tidal exchange
High freshwater flow
Sand bar flushed away
Flood waters flush 'salt wedge' from estuary
Reduced freshwater flow
Sand bar deposited
More dense saline water sinks below freshwater. The 'salt wedge' moves into estuary with flood tides. Extent of 'wedge' oscillates with tides but gradually moves up the estuary.
Summer/Autumn
Estuary closed
Estuary stratifies. Wind mixing of layers occurs in some estuaries.
Sand bar closes estuary
Dissolved oxygen in saline layer is gradually depleted by biological activity
Natural estuary opening usually coincides with increased freshwater flows. Freshwater is well oxygenated
Sand bar height reduced
Some mixing of layers may occur
Winter
adz@work (03) 5562 0155

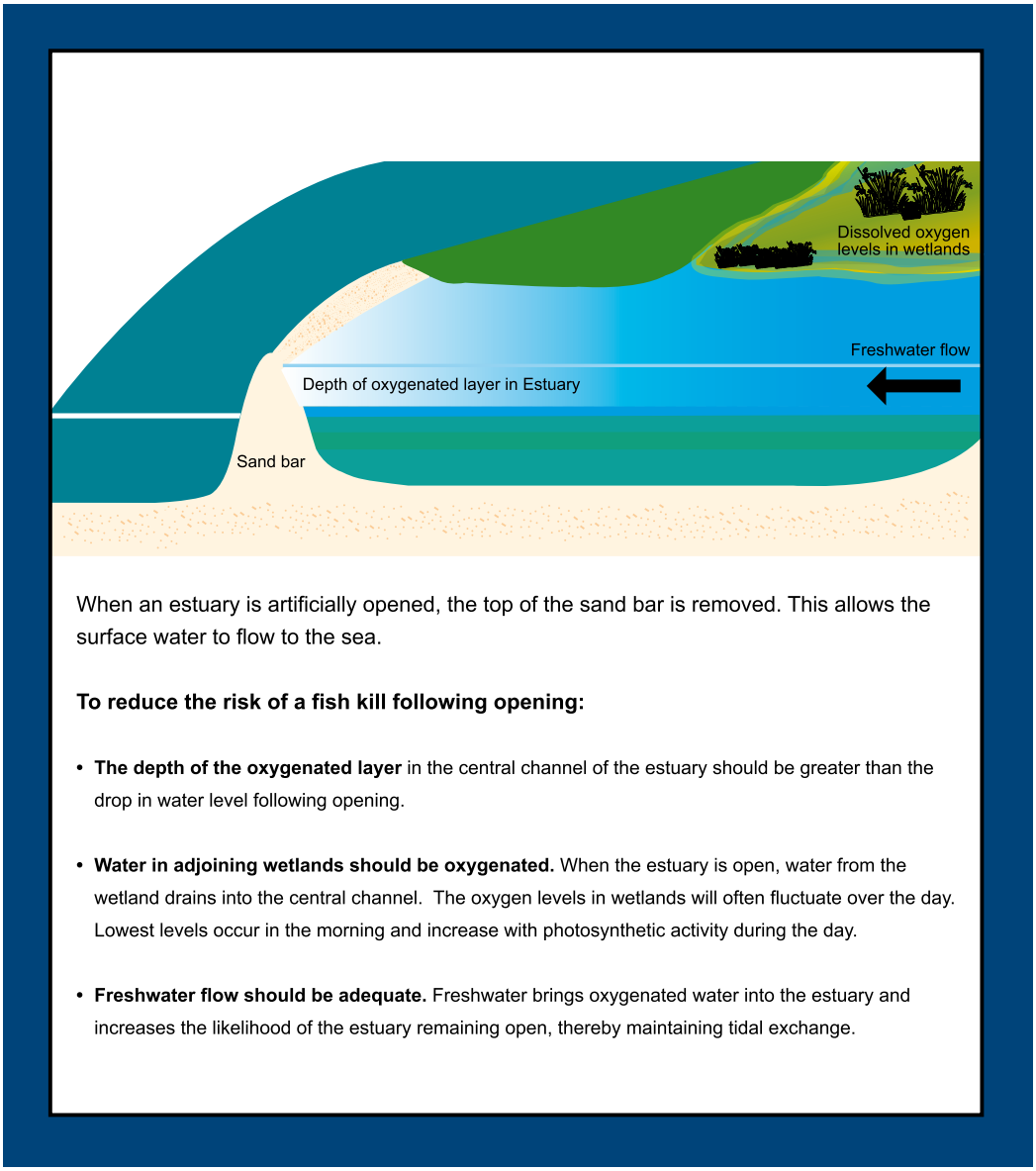
Appendix C. Fish kills in intermittently closed estuaries

Artificially opening some estuaries has resulted in large numbers of fish dying from symptoms associated with oxygen stress - termed a 'fish kill'.

A number of factors associated with opening an estuary contribute to the potential for a fish kill. These include the volume of freshwater discharge and the depth of oxygenated water in both the central channel and in any adjoining wetland (Fig A.3). Many natural openings coincide with a flush of well-oxygenated freshwater into the estuary, which reduces the likelihood of a fish kill.

If an adjoining wetland is large it can take several days for the water to drain from it. Even if there are adequate levels of dissolved oxygen in the central channel this could be replaced with water from the wetland that may not be well oxygenated.

Figure A.3 Factors contributing to 'fish kills'



Appendix D. Relevant legislation and strategies

Legislation

Fauna and Flora Guarantee Act 1988	Promotes the conservation of Victoria's native flora and fauna and the management of potentially threatening processes.
The Environment Protection and Biodiversity Conservation Act 1999.	Protects the environment, particularly matters of National Environmental Significance, and Australian biodiversity.
Heritage River Act.1992	Protects public land in particular parts of rivers and river catchment areas in Victoria which have significant nature conservation, recreation, scenic or cultural heritage attributes.
Health Act 1958.	Includes the responsibilities of municipal councils to remedy, where possible, all nuisances, which are dangerous to health or offensive.
Coastal Management Act 1995	Established the Coastal Boards. Provides for the preparation of the Victorian Coastal Strategy and the Coastal Action Plans. Requires consent for use or development of coastal crown land.
Catchment and Land Protection Act 1994	Established the Catchment Management Authorities.
Aboriginal Heritage Act 2006	Provides for the protection of Aboriginal cultural heritage in Victoria.
Aboriginal and Torres Straits Islander Heritage Protection Act 1984	Preserves and protects areas and objects in Australia that are of particular significance to Aboriginals.

Strategies and agreements

China Australia Migratory Bird Agreement (CAMBA).	Agreement between the Australia and China for the protection of migratory birds in danger of extinction and their Environment.
Japan Australia Migratory Bird Agreement (JAMBA)	Agreement between the Australia and Japan for the protection of migratory birds in danger of extinction and their Environment.
Regional Catchment Strategies	Provides a framework for integrated catchment management within each CMA region.
Victorian River Health Strategies 2002	Provides the framework for regional communities to make decisions on river protection and restoration and to find the balance between using our rivers and maintaining their ecological condition.
Victorian Coastal Strategy 2002	Prepared under the Coastal Management Act 1995. The VCS provides strategic direction for planning and management in the coast and marine environments.
Central West Victoria Estuaries Coastal Action Plan 2005.	Establishes a planning and management framework to improve protection of estuarine values through integrated management.
South West Victoria Estuaries Coastal Action Plan 2002	Establishes a planning and management framework to improve protection of estuarine values through integrated management.

Appendix E. Key to conservation status terms

Conservation status

TVF Threatened Vertebrate Fauna in Victoria

DD - Data deficient
NR - Near threatened
Vu - Vulnerable
En - Endangered
CR - Critically endangered
WX - Extinct in the wild
RX - Regionally extinct
EX - Extinct

VROT Rare or threatened plants in Victoria

x - Presumed Extinct in Victoria
e - Endangered in Victoria
v - Vulnerable in Victoria:
r - Rare in Victoria
k - Poorly Known in Victoria

FFG Flora and Fauna Guarantee Act (1988)

N - Nominated for listing
L - Listed

EPBC- Environment Protection and Biodiversity Act (1999)

CD - Conservation dependent
VU - Vulnerable
EN - Endangered
CR - Critically endangered
EX - Extinct

Appendix F. Fish species, groups and relevant ecological information

Refer to section 9 for details of references. Group symbols are explained in Table 4.1

Group	Common name	Scientific name	Comments	Spawning period	Access period		Reference
					In	Out	
1	Tommy Ruff	*Arripis georgianus*		NA			
1	Australian Salmon	*Arripis spp*		NA			
1	Eastern Australian Salmon	*Arripis trutta*		NA			
1	Red Gurnard	*Chelidonichthys kumu*		NA			
1	Blue Morwong	*Nemadactylus douglasii*		NA			
1	Tailor	*Pomatomus saltator*		NA			
1	Trevally	*Pseudocaranx dentex*		NA			
2	Australian Smelt	*Retropinna semoni*	Increase in temperature triggers spawning (15-18 ºC). Adhesive eggs on macrophtes. Diadromous populations reported but not substantiated	Sept -Nov (freshwater)			4,5
2	Southern Pygmy Perch	*Nanoperca australis*	Frequents weedy, slow-flowing or still waters. Breeding when water temperatures reach 16 to 21ºC. Eggs are scattered over the bottom, adhering to rocks and vegetation. Females may spawn several times during a season. Breeding generally in freshwater but also recorded in wetlands adjacent to Yambuk estuary (salinity 4 ppt)	Sept-Oct (mainly freshwater)			3,9
2	Yarra Pygmy Perch	*Nanoperca obscura*	Prefers slow-flowing or still waters with abundant aquatic vegetation, in lakes and small creeks. It has been collected from brackish waters.	Sept-Oct (freshwater)			3
3O	Short-finned Eel	*Anguilla australis*	Downstream migration of adults to the sea. Glass eels move into estuaries in winter and spring	NA	May-Oct	Oct-March	4
3O	Long-finned Eel	*Anguilla reinhardtii*	Downstream migration of adults to the sea. Glass eels move back into estuaries.	NA	Jan-May	unknown	4
3O	Broadfin Galaxias	*Galaxias brevipinnis*	Autumn-winter spawning in FW probably when stream is in flood. Whitebait returns to estuary in spring. Estuarine use thought to be facultative	June-July	Sept-Jan	Apr-July	2,4
3O	Australian Mudfish	*Galaxias cleveri*	Adults utilise low lying, well-vegetated swampy habitats.	July-Aug	Sept-Nov	unknown	4
3O	Common Galaxias	*Galaxias maculatus*	Adults move downstream to spawn in vegetation, on margins of estuaries, on spring tide. Eggs hatch when inundated at next spring tide. Larvae migrate to the sea and juveniles return in spring	March -June	Sept-Dec	Apr-July	2,4 TAG

Group	Common name	Scientific name	Comments	Spawning period	Access period		Reference
3O	Spotted Galaxias	*Galaxias truttaceus*	Spawning near adult habitat. Probably in freshwater when the stream is in flood.	June -July (freshwater?)	Sept-Jan	Apr-July	2, TAG
3O	Pouched Lamprey	*Geotria australis*	Migratory species with downstream migration of young adults to the sea where they mature and eventually return to freshwater to spawn.	Oct-Dec (freshwater)	Jul-Nov	Jul-Aug	4, 5
3O	Short-headed Lamprey	*Mordacia mordax*	Migratory species with downstream migration of young adults to the sea where they mature and eventually return to freshwater to spawn.	Aug -Nov (freshwater)	Aug-Dec	Aug-Nov	4 ,5
3O	Australian Grayling	*Prototroctes maraena*	Spawning triggered by temperature. Spawn in the same portion of the river they inhabit. Larvae move downstream to brackish or marine waters. About 6 months later, juveniles return to freshwater.	April - May (freshwater)	Oct-Jan	Apr-Jul	4
3O	Eastern River Garfish	*Hyporhamphus regularis*	River garfish inhabit brackish and fresh waters, from near shore in estuaries to rivers and lakes. Vegetation required for egg attachment.		Oct-Nov		TAG
3F	Yellow-eye Mullet	*Aldrichetta forsteri*	Spawning in marine waters. Juveniles and adults use estuary. Juveniles recorded from Surry estuary in all months.		Late summer-winter		TAG. 10
3F	Sea Mullet	*Mugil cephalus*	Juveniles and adults use estuary.		Feb-Aug		TAG
3F	Long-nosed Flounder	*Ammotretis rostratus*	Juveniles on sand. Recorded from shallow estuaries including lower reaches of rivers		Winter-spring		TAG, 8
3F	Greenback Flounder	*Rhombosolea tapirina*	Juveniles estuarine, often in lower reaches of rivers				8
3F	Mulloway	*Argyrosomus hololepidotus*	Adults found in offshore reefs and in estuaries. Adults utilise deep holes in estuaries. May spend early years in estuaries and then move to marine waters.			Late summer - autumn	7, TAG
3F	Southern Anchovy	*Engraulis australis*	Eggs and larvae prefer salinity of 15 ppt		Late spring-summer		TAG

Group	Common name	Scientific name	Comments	Spawning period	Access period		Reference
3F	Luderick	*Girella tricuspidata*	Adults use macrophyte beds in estuaries; spawn in marine waters				
3F	Sea garfish	*Hyporhamphus melanochir*	Estuarine dependence unknown				
3F	Striped Gudgeon	*Gobiomorphus australis*	Spawning occurs in late summer and autumn, at a water temperature of about 21oC. Juveniles found in estuaries				
3F	Cox's Gudgeon	*Gobiomorphus coxii*	Large numbers of juveniles are found in middle and lower reaches of streams. It is thought that young fish are washed downstream to later migrate upstream				3
3F	Dusky Morwong	*Dactylophora nigricans*	Juveniles use vegetation in estuary		Winter-spring		
3F	South Australian Cobbler	*Gymnapistes marmoratus*	Mainly estuarine. Juveniles found among seagrass.		Late spring-summer		8
3F	King George Whiting	*Sillaginodes punctatus*	Found over sandy areas in shallow bays and estuaries. Recruits found in seagrass late winter				8,TAG
3F	Smooth Toadfish	*Tetractenos glaber*	Large schools over sandy flats in sheltered bays and estuaries				8
3F	Dusky Flathead	*Platycephalus fuscus*	Juveniles and adults in estuary; often associated with sandy bottom		Winter		
3F	Pink Snapper	*Chrysophyrs auratus*	Juveniles in sheltered bays and estuaries; not recorded in SW Victorian estuaries		Summer		8
3F	Freshwater Herring	*Potamalosa richmondia*	Not clear whether they spawn in freshwater or estuaries.	July -Aug	Jul-Aug	Unknown	4
4	Black Bream	*Acanthopagrus butcheri*	Spawning and juvenile development in estuaries. Spawning when salinities 11-18 ppt. Planktonic eggs. Schooling species, moves to sea during floods	Oct-Feb in western Victoria, earlier in eastern Victoria.			3,8
4	Estuary Perch	*Macquaria colonorum*	Spawning at estuary mouths in salt water. Water temp 14.-19 ºC. Planktonic eggs	Aug-Dec.			3
4	Australian Bass	*Macquaria novemaculeata*	Adults migrate downstream to estuaries to spawn. Spawn in brackish water when temp. 11-18ºC	June - Dec			2,4 & 12
4	Tupong	*Pseudaphritis urvilli*	Migrates to estuaries to spawn. Juveniles remain in estuaries for 9 months. Seagrass habitat important for breeding. Downstream migration of adults April to August. Upstream movement of juveniles September to February	Sept - Dec			4, 5

Group	Common name	Scientific name	Comments	Spawning period	Access period		Reference
4	Blue-spot Goby	*Pseudogobius olorum*	Found in brackish lagoons and upper estuarine areas where there are bare muddy bottoms. Spawns on mud or silt bottom with abundant aquatic vegetation. Spawning both autumn and spring (when water temperature 20-25ºC) recorded from Swan River estuary, W.A.	Early to late spring.			3, 11
4	Lagoon Goby	*Tasmanogobius lasti*	Normally found in estuaries and bays in burrows in silty sand or mud.	Not mentioned			3
4	Bridled Goby	*Arenigobius bifrenatus*	Principally an estuarine species, also found in lower reaches of coastal streams and rivers. Prefers still or slow moving waters with a silt or mud bottom and cover of rocks, logs and aquatic vegetation. A burrowing species	Spring and summer.			3
4	Small-mouthed Hardyhead	*Atherinosoma microstoma*	Spawning in estuaries late spring-summer. Often associated with seagrass beds.	Nov- Feb			
4	Tamar Goby	*Afurcagobius tamarensis*	Primarily an estuarine species, but occasionally enters lower reaches of rivers and streams. Prefers still or slow-flowing water with mud or silt substrate and cover provided by aquatic plants, rocks or fallen logs. Little is known of the biology of this benthic, burrowing species.	Sept - Nov			3
4	Flathead Gudgeon	*Philypnodon grandiceps*	Found in a wide variety of habitats, both freshwater and estuarine. Occurs most frequently in lakes and dams where there is little or no water flow, usually where there are weedy or mud bottoms.	Late spring -early summer			3
4	Dwarf Flatheaded Gudgeon	*Philipnodon sp. Nov.*	Frequents quiet areas with little water flow where there are mud or rock bottoms with weeds. Found in brackish estuarine areas to altitudes of several hundred metres.	Not known			3
4	Pale Mangrove Goby	*Mugilogobius paludis*	Generally found in mangroves or holes in sea grass areas, sometimes entering freshwater. Able to tolerate high water temperatures and a wide salinity range.	Not mentioned			3

Appendix G. Estuarine birds: conservation status and populations

See appendix E for key to conservation status symbols. Source of population data: Waterbird Population Estimates - Third Edition http://www.wetlands.org/IWC/WPEnote.htm

Common name	Scientific name	Group	TVF	FFG	EPBC	CAMBA JAMBA	National/International population
Brown Quail	*Coturnix ypsilophora Ins*	2b	DD				no data
King Quail	*Coturnix chinensis victoiae*	2b	CR	L			no data
Musk Duck	*Biziura lobata*	1a	VU				no data
Freckled Duck	*Stictonetta naevosa*	1b	EN	L			19 000
Black Swan	*Cygnus atratus*	1b					300 000-500 000
Australian Shelduck	*Tadorna tadornoides*	2b					no data
Australian Wood Duck	*Chenonetta jubata*	2b					no data
Pacific Black Duck	*Anas superciliosa*	1b					100 000 - 1 000 000
Australasian Shoveler	*Anas rhynchotis*	1c	VU				no data
Grey Teal	*Anas gracilis*	1b					25 000-1 000 000
Chestnut Teal	*Anas castanea*	1b					no data
Pink-eared Duck	*Malacorhynchus membranaceus*	1c					no data
Hardhead	*Aytya australis*	1a	VU				100 000 - 1 000 000
Australasian Grebe	*Tachybaptus novaehollandiae*	1a					500 000
Hoary-headed Grebe	*Poliocephalus poliocephalus*	1a					500 000
Great-crested Grebe	*Podiceps cristatus*	1a					3 000-10 000
Spotless Crake	*Porzana tabuensis*	2b					no data
Black-faced Shag	*Leuoccarbo fuscescens*	1a					no data
Darter	*Anhinga melanogaster*	1a					no data
Little Pied Cormorant	*Phalacrocorax melanoleucos*	1a					no data
Pied Cormorant	*Phalacrocorax varius*	1a	NT				10 000-25 000
Little Black Cormorant	*Phalacrocorax sulcirostris*	1a					no data
Great Cormorant	*Phalacrocorax carbo*	1a					no data
Australian Pelican	*Pelecanus conspicillatus*	1b					100 000 - 1 000 000
White-faced Heron	*Egretta novaehollandiae*	2a & 2b					> 1,000 000
Little Egret	*Egretta garzetta*	2a & 2b	CR	L			no data
Great Egret	*Ardea alba*	2a & 2b	EN	L			no data on oceanic population
Intermediate Egret	*Ardea intermedia*	2a & 2b		L		CJ	25 000-1 000 000
Cattle Egret	*Ardea ibis*	2b					100000
Nankeen Night Heron	*Nycticorax caledonicus*	2a & 2b	VU			CJ	no data for Aust pop
Australasian Bittern	*Botaurus poiciloptilus*	2b	EN	L			2 000

Common name	Scientific name	Group	TVF	FFG	EPBC	CAMBA JAMBA	National/International population
Australian White Ibis	*Threskiornis molucca*	2b					<70 000
Straw-necked Ibis	*Threskiornis spinicollis*	2b					500 000
Royal Spoonbill	*Platalea regia*	2a					100 000-250 000
Terek Sandpiper	*Xenus cinereus*	2a					50 000
Yellow-Billed Spoonbill	*Platalea flavipes*	2a					25 000-1000 000
Osprey	*Pandion haliaetus*	4				CJ	no data
Whistling Kite	*Haliastur sphenurus*	4					no data
White Bellied Sea Eagle	*Haliaeetus leucogaster*	4	VU	L			no data
Swamp Harrier	*Circus approximans*	4					no data
Pacific Heron	*Ardea pacifica*	2b				C	100 000 - 1 000 000
Lewin's Rail	*Rallus pectoralis*	2b	VU	L			30 000
Australian Spotted Crake	*Porzana fluminea*	2b					no data
Magpie Goose	*Anseranas semipalmata*	2b	EN	N			>1 000 000
Purple Swamphen	*Porphyrio porphyrio*	2b					100 000 - 1 000 000
Dusky Moorhen	*Gallinula tenebrosa*	1b & 2b					no data
Black-tailed Native Hen	*Gallinula ventralis*	2b					no data
Eurasian Coot	*Fulica atra*	1a					no data
Blue-billed Duck	*Oxyura australis*	1a	VU	L			18 000
Lathams Snipe	*Gallinago hardwickii*	2b					25 000-1000 000
Bar-tailed Godwit	*Limosa lapponica*	2a & 2b					170 000
Whimbrel	*Numenius phaeopus*	2a & 2b				J	55 000
Eastern Curlew	*Numenius madagascariensis*	2a & 2b				CJ	38 000
Marsh Sandpiper	*Tringa stagnatilis*	2a				CJ	90 000
Common Greenshank	*Tringa nebularia*	2a				CJ	55 000
Common Sandpiper	*Tringa (Actitis) hypoleucos*	2a				CJ	30 000
Ruddy Turnstone	*Arenaria interpres*	5				CJ	25 000-1000 000
Great Knot	*Calidris tenuirostris*	2a	EN	L		CJ	380 000
Red Knot	*Calidris canutus*	2a				CJ	220 000
Sanderling	*Calidris alba*	5	NT			CJ	22 000
Red-necked Stint	*Calidris ruficollis*	2a				CJ	315 000
Sharp-tailed Sandpiper	*Calidris acuminata*	2a & 2b				CJ	160 000
Curlew Sandpiper	*Calidris ferruginea*	2a				CJ	180 000
Painted Snipe	*Rostratula benghalensis*	2b	CR	L	VU	CJ	<10 000
Pied Oystercatcher	*Haematopus longirostris*	2a & 5				CJ	11 000
Sooty Oystercatcher	*Haematopus fuliginosus*	2a	NT			C	4 000
Black-winged Stilt	*Himantopus himantopus*	2a					Oceanic population not included
Banded Stilt	*Cladorhynchus leucocephalus*	2a					206 000

Common name	Scientific name	Group	TVF	FFG	EPBC	CAMBA JAMBA	National/International population
Red necked Avocet	*Recurvirostra novaehollandiae*	1c					107 000
Pacific Golden Plover	*Pluvialis fulva*	2b				CJ	100 000
Grey Plover	*Pluvialis squatarola*	2b & 5				CJ	125 000
Red-capped Plover	*Charadrius ruficapillus*	2a & 5					95 000
Double-banded Plover	*Charadrius bicinctus*	5					50 000
Hooded Plover	*Thinornis rubricollis*	5	EN	L			4 500
Red-kneed Dotterel	*Erythrogonys cinctus*	2b					26 000
Masked Lapwing	*Vanellus miles*	2b					127 000
Pacific Gull	*Larus pacificus*	5	NT				4 950
Silver Gull	*Larus novaehollandiae*	5					>1 000 000
Caspian Tern	*Sterna caspia*	1a, 2a & 5	NT			C	1 000-5 000
Crested Tern	*Sterna bergii*	1a & 2a	NT			J	no data
Little tern	*Sterna albifrons sinensis*	5	VU	L		CJ	10 000-100 00
Fairy tern	*Sterna nereis nereis*	5	EN	L			2 580
Whiskered Tern	*Chlidonias hybridus*	3	NT				100 000 - 1 000 000
Blue-winged Parrot	*Neophema chrysotoma*	2b					no data
Orange-bellied Parrot	*Neophema chrysogaster*	2b	CR	L	EN		no data
Ground parrot	*Pezoporus wallicus wallicus*	2b	EN	L			no data
Azure kingfisher	*Alcedo azurea*	1a	NT				no data
Sacred kingfisher	*Todiramphus sanctus*	1a					no data
Striated Fieldwren	*Sericornis fuliginosus*	2b					no data
White-fronted Chat	*Epthianura albifrons*	2b					no data
Australian Raven	*Corvus coronoides*	4					no data
Forest Raven	*Corvus tasmanicus*	4					no data
Little Raven	*Corvus mellori*	4					no data
Welcome Swallow	*Hirundo neoxena*	3					no data
Tree Martin	*Hirundo nigricans*	3					no data
Fairy Martin	*Hirundo ariel*	3					no data
Clamorous Reed Warbler	*Acrocephalus stentoreus*	2b				CJ	no data
Little Grassbird	*Megalurus gramineus*	2b					no data
Golden-headed Cisticola	*Cisticola exilis*	2b					no data

Appendix H. Estuarine EVC descriptions

Coastal saltmarsh (EVC 009)

Defining characteristics: Low, primarily low shrubby to herbaceous or grassy vegetation of salinised coastal soils in or adjacent to tidally influenced wetland.

Habitat: Associated with tidal wetlands of sheltered embayments and estuaries.

Floristics: Coastal saltmarsh can include a number of zones of varying structure and floristics, reflecting tidal inundation and substrate character. Structurally prominent species variously include *Sclerostegia arbuscula, Sarcocornia quinqueflora, Suaeda australis* and *Samolus repens*, with *Frankenia pauciflora* a more localised component. *Gahnia filum, Disphyma clavellatum* and *Distichlis distichophylla* can be locally prominent in peripheral habitats.

Structure: Variable: herbland, grassland, shrubland to 1.5 metres.

Distribution: Scattered distribution in sheltered embayments and estuaries from Portland area to East Gippsland.

Vegetation Quality: Vulnerable to physical disturbance and water quality within estuary situations, but component species often with high potential for re-colonization. Few weeds in wetter zones, but *Spartina* spp. can be extremely serious in some wetter habitats. The outer margins of saltmarsh vegetation are potentially more species-rich, and are vulnerable to a wider range of weeds.

Comments: This variation is not simply classified into regional floristic communities. Coastal saltmarsh represents an aggregate vegetation.

Estuarine wetland (EVC 010)

Defining characteristic: Moderate height rush/sedge wetland vegetation, variously with component of small halophytic herbs, occurring on estuarine flats.

Habitat: Anaerobic peat-rich mud of estuarine flats, inundation regimes variously sustained if drainage-line outlet blocked, twice daily with tides if breached.

Floristics: Dominated by *Juncus kraussii, Bolboschoenus caldwellii* and (stunted and sub-dominant) *Phragmites australis*, with associated species including *Samolus repens, Ranunculus amphitrichus, Distichlis distichophylla, Isolepis cernua, Selliera radicans, Apium prostratum, Triglochin striata, Leptinella spp., Mimulus repens, Sarcocornia quinqueflora* and *Suaeda australis*. *Gahnia filum, Schoenoplectus pungens* and sometimes *Poa labillardierei / Poa poiformis* can be present on the outer verges towards the boundaries with other EVCs.

Structure: Rushland/sedgeland, typically <1 (–1.5 m) height, sometimes in mosaic with low herbland. Woody species generally absent, but scattered stunted shrubs (including *Leptospermum lanigerum, Melaleuca ericifolia* or *Myoporum insulare*) can occasionally be present.

Distribution: Scattered along the coast in estuarine situations, most extensive in association with larger estuarine floodplains, e.g. Snowy River, L. Tyers, upper reaches of Tamboon and Wingan Inlets, Gellibrand River, Aire River, Glenelg River, Gippsland Lakes, formerly Yarra River, well defined streams of Otway-Bellarine coast.

Vegetation quality: Vulnerable to weed invasion in disturbed areas, vulnerable to local changes in hydrological regime or water quality.

Comments: Distinguished from Estuarine reedbed by the smaller stature and reduced dominance of *Phragmites australis* (and greater diversity), from Coastal saltmarsh by the dominance of medium-sized graminoids, and from Estuarine scrub by the general absence of woody species. In parts of its range, Estuarine wetland can occur adjacent to or in mosaic with these other vegetation components.

Brackish sedgeland (EVC 013)

Defining characteristics: Sedgeland dominated by salt-tolerant sedges in association with low grassy / herbaceous ground-layer and a halophytic component.

Habitat: Mostly at least marginal wetland (including peripheral or ephemeral zones).

Floristics: Structurally prominent species include *Gahnia filum / Gahnia trifida* and *Baumea juncea*, with *Bolboschoenus caldwelli* and/or *Schoenoplectus pungens* in some wetter versions.

Structure: Medium to tall sedgeland to 1.5 metres.

Distribution: Scattered in near-coastal and western inland areas.

Vegetation Quality: Prone to invasion by *Juncus acutus*, drier versions prone to invasion by wider range of introduced species, notably annual grasses.

Comments: Extreme tidal events can be of high importance in maintaining the ecological zone in which this EVC occurs. Brackish sedgeland has larger component of species shared with non-saline situations and has limited tidal input compared to Estuarine wetland

Swamp scrub (EVC 053)

Defining characteristic: Myrtaceous shrub species (usually) shared with Swamp scrub occurring in association with ground-layer dominated by non-halophytic herbs.

Habitat: Essentially freshwater habitat, often on the outer verges of Estuarine scrub and further upstream where freshwater inputs from the creek and from groundwater are sufficient to sustain non-halophytic vegetation. Soils typically have high organic content, often silty/peaty, with a thick surface layer of organic detritus.

Floristics: The usual shrub species is *Melaleuca ericifolia* in eastern Victoria and *Leptospermum lanigerum* in western Victoria. Major species of ground-layer include *Poa labillardierei, Gahnia clarkei, Carex appressa, Goodenia humilis, Villarsia reniformis, Acaena novae-zelandiae* and *Juncus* spp. While the vegetation is often relatively species-poor as a closed scrub, more open sites are rich in small herbs.

Structure: Shrubland to scrub to 2–4 metres.

Distribution: Widely distributed in association with lower reaches of watercourses throughout Victoria but greatly cleared for agriculture and relatively little remaining.

Vegetation quality: Vulnerable to weed invasion, altered hydrology and clearing.

Comments: Potentially affected by estuary closure with prolonged inundation.

Mangrove shrubland (EVC 140)

Defining characteristic: Extremely species-poor shrubland vegetation of inter-tidal zone, dominated by mangroves.

Habitat: Mud-flats of the lower inter-tidal zone of sheltered embayments. In Victoria, confined to tidal wetland situations.

Floristics: Characteristically occurs as mono-specific stands of *Avicennia marina*. In some stands, species from adjacent Coastal saltmarsh or Sea-grass meadow can also be present.

Structure: Open to closed scrub.

Distribution: Restricted distribution in sheltered sections of coast. It can also extend inland as narrow bands along tidal creeks (e.g. around parts of Westernport Bay and Corner Inlet). The *Otways* community description applies to tiny patches along the lower rainfall section of coast (and in river estuaries) from Altona Bay to Barwon Heads. The *Gippsland* community describes the stands of Corner Inlet and can be presumed effectively equivalent to the stands of Westernport Bay.

Vegetation quality: Vulnerable to physical disturbance and impacts of pollutants.

Comments: *Avicennia* can also occur as a minor component of Coastal saltmarsh (EVC 9) (e.g. amongst Basalt rocks at Williamstown) or sometimes as a fine-scale mosaics (e.g. in parts of Corner Inlet).

Seasonally inundated sub-saline herbland (EVC 196)

Defining characteristic: Species-poor low herbland of seasonal saline wetland, dominated by *Wilsonia* spp.

Habitat: Seasonal wetland within relicts of former tidal lagoons. Salinity and water regimes fluctuate over wide range. Habitat is rarely inundated tidally and then only by diluted seawater, overland flows from the Barwon River are important.

Floristics: Herbland dominated by *Wilsonia* spp. (principally *W. humilis*).

Distribution: Extremely rare and occupying a very localised habitat (e.g. Salt Swamp in Barwon Estuary, Point Lonsdale).

Vegetation quality: Damaged by past shell grit extraction, otherwise robust and stable.

Comments: Barwon Estuary is permanently open.

Brackish herbland (EVC 538)

Defining characteristic: Low herbland dominated by species tolerant of mildly saline conditions and intermittent inundation.

Habitat: Brackish conditions associated with inland drainage-basins and lakes, and also estuarine locations. Inundation is mostly shallow and intermittent, but soils typically remain at least damp over much of the year.

Floristics: Structurally prominent species include *Lobelia irrigua, Sebaea* spp., *Ranunculus diminutis, Isolepis cernua, Schoenus nitens, Wilsonia rotundifolia*, and sometimes *Selliera radicans, Distichlis distichophylla* and/or *Samolus repens*.

Structure: Low herbland (sometimes with grassy/sedgy patches), mostly <0.15 m in height and often <0.05 m.

Distribution: Scattered in restricted habitat, recorded from Aire River.

Vegetation quality: Vulnerable to invasion by aggressive environmental weeds such as Sea wheat-grass and Spiny rush and loss of diversity with increased salinity. Sites indicative of slight natural salinity can support a range of significant flora.

Comments: Often occurs in mosaic or complex with other wetland components.

Saline aquatic meadow (EVC 842)

Defining characteristic: Submerged herbland of thin grass-like plants.

Habitat: Permanent to seasonal shallow lakes, ranging from sites becoming hypersaline when dry, to brackish (to nearly fresh) water. Elevation of sampled sites ranges from near sea-level (< 1 m) to approximately 250 m. Soils are typically anaerobic, primarily comprising various combinations of sand, silt, clay or shell-bed, with high organic content (e.g. organic silts, humic sandy soils and salinised clays).

Floristics: Characteristically extremely species-poor, comprising one or more species of *Lepilaena* or *Ruppia*. Floristic variations include the following:

- *Ruppia megacarpa* – relatively saline water-bodies (inland and near coastal), with more or less permanent inundation.
- *Lepilaena* spp. (e.g. *L. priessii, L. bilocularis, L. cylindrocarpa*) – widespread in brackish to saline sites, inland and coastal. Frequently seasonal or intermittently variable in depth and consequent salinity levels.
- *Ruppia tuberosa* – very localised, small brackish swamps, saline lakes and marshes or tidal flats of sheltered bays, mostly on the western side of Port Phillip Bay.
- *Lepilaena marina* occurs with *Zostera muelleri* and *Ruppia maritima* on intertidal mudflats of Swan Bay on western Port Phillip Bay, in vegetation transitional between Sea-grass meadow and Saline aquatic meadow - treated here as variant of Sea-grass meadow.

Structure: Submerged herbland, dying back to rootstocks when the substrate is exposed.

Distribution: Widespread within restricted suitable habitat across lowland parts of the State, principally in the Wimmera, western volcanics and coastal areas, with an ephemeral variant extending to the floors of salt pans in the southern Mallee.

Vegetation quality: Typically very species-poor, mostly appearing relatively secure provided water quality is maintained.

Sea-grass meadow (EVC 845)

Defining characteristic: A quatic meadow of sheltered shallow marine and lower estuarine habitats.

Habitat: Sheltered marine shallows, intertidal flats and estuarine inlets.

Floristics: Dominated by stands of *Zostera* and / or *Heterozostera* spp., often monospecific and sometimes in close proximity to *Avicennia marina* stands on mud flats below high-tide levels. *Zostera muelleri* extends into lower estuarine habitats, with *Heterozostera tasmanica* conspicuous on intertidal mud flats.

Structure: Herbland sward, sometimes occurring in association with Mangrove shrubland.

Distribution: Scattered along Victorian coast, with most extensive development within Corner Inlet and Westernport Bay.

Vegetation quality: Vulnerable to die-back from factors including altered water quality and pollution and in places potentially encroached by introduced cord-grass *Spartina* spp.

Comments: Sea-grass meadow unambiguously represents wetland vegetation; however this context would rarely be extended into a marine context beyond the inter-tidal zone.

Estuarine flats grassland (EVC 914)

Defining characteristic: Tussock grassland of coastal flats, beyond zone of normal tidal inundation.

Habitat: Occurs in a range of low-lying coastal sites, typically with a shallow sand layer over a heavier soil. In at least some locations, impeded drainage can result in seasonal waterlogging - while unusual, brief inundation can occur intermittently in some sites (e.g. the rear of saltmarshes and around drainage-line swamps behind barrier dunes).

Floristics: Major species include *Poa poiformis, Austrostipa stipoids*, and *Isolepis nodosa*. Comprises a mixture of salt-tolerant species such as *Disphyma crassifolium* and less tolerant species such as *Senecio pinnatifolius*.

Structure: Tussock grassland to 1 metre.

Distribution: Restricted distribution on low-lying terrain above usual inundation levels, scattered locations.

Vegetation quality: Potentially vulnerable to high disturbance levels associated with recreational activities.

Comments: Occupies an intermediate zone between dryland / dampland and wetland vegetation. Mostly represents at least marginal wetland (including peripheral or ephemeral zones).

Brackish grassland (EVC 934)

Defining characteristic: Grassland on sub-saline heavy soils, including dominants of Plains grassland (and a portion of associated herbaceous species) in association with herbaceous species indicative of saline soils. Sometimes occurs as a fringing community on the verges of saline lakes.

Habitat: Generally occurs on heavy grey to black clay basaltic soils in sites which are to some extent naturally saline. Primarily occurs in dampland complex, sometimes peripheral to wetland.

Floristics: Structurally prominent species include *Poa labillardierei, Themeda triandra, Austrodanthonia* spp., *Distichlis distichophylla, Calocephalus lacteus, Selliera radicans, Sebaea* spp., *Wilsonia rotundifolia* and *Lobelia irrigua*. Generally consists of a limited component of tussock grasses and forbs of Plains grassland in association with halophytic species such as *Distichlis distichophylla* and (some less water-requiring) forb species shared with Brackish herbland (EVC 538).

Structure: Tussock Grassland to 1 metre.

Distribution: Scattered in southern lowland and plains areas, most communities critically endangered. Extremely depleted in estuarine situations, remnants few and generally highly modified.

Vegetation quality: Generally highly modified.

Comments: Highly endangered by weed invasion, soil disturbance, urbanisation, lack of awareness by managing agencies.

Estuarine reedbed (EVC 952)

Defining characteristic: Vegetation dominated by tall reeds in association with a sparse ground-layer of salt tolerant herbs. Distinguished from Estuarine wetland by the vigour and total dominance of the reeds, as well as the absence of samphires in the ground layer.

Habitat: Estuarine reedbed occurs in sub-saline situations of coastal estuaries (sometimes periodically blocked by sand bars). The habitat is subject to surface salinity as well as flushing by freshwater (including via groundwater), but is beyond direct inundation from normal tidal inputs, at elevations of approximately 1 m ASL.

Floristics: *Phragmites australis*, with associated species including *Samolus repens, Juncus kraussii, Triglochin striatum, Bolboschoenus caldwellii, Suaeda australis, Gahnia filum* and *Crassula helmsii*.

Structure: Reedbed, typically 2–3 m in height, with sparse herbaceous ground-layer.

Distribution: Known from scattered near coastal sites between the Otways and East Gippsland, e.g. Aire River Estuary, Jack Smith Lake, Gippsland Lakes system and Snowy River Estuary.

Vegetation quality: While appearing reasonably resilient to weed invasion, potentially vulnerable to degradation where accessible by stock or subject to run-off of nutrients from agricultural land.

Comments: Represents an extension of EVC 821 Tall marsh into sub-saline habitats.

Estuarine scrub (EVC 953)

Defining characteristic: Myrtaceous shrub species (usually) shared with Swamp scrub occurring in association with ground-layer dominated by halophytic herbs.

Habitat: Sub-saline habitat, notably on the verges of Estuarine wetland (peripheral or further upstream), where freshwater inputs (in particular via groundwater) are sufficient to sustain shrubs but saline surface inputs maintain a halophytic groundlayer. Occurs at elevations of approximately 0.5–1.5 metres ASL. Soils typically have high organic content, often silty/peaty, with a thick surface layer of organic detritus. Estuaries and seepage zones at the rear of saltmarshes.

Floristics: The usual shrub species is *Melaleuca ericifolia* (in eastern Victoria), rarely with *M. lanceolata, Melaleuca gibbosa* or *Leptospermum lanigerum* in marginal sites in western Victoria. The major species of the ground-layer include *Samolus repens, Triglochin striatum* and *Selliera radicans*, variously with *Sarcocornia quinqueflora, Gahnia filum, Poa poiformis, Juncus kraussii, Disphyma crassifolium, Distichlis distichophylla* and (locally) *Juncus revolutus*. Species such as *Isolepis nodosa, Rhagodia candolleana, Tetragonia implexicoma* and *Myoporum insulare* can occur on the drier verges, but except for East Gippsland, are not characteristic of the vegetation. In East Gippsland, *Myoporum* is characteristic and *Tetragonia* waxes and wanes according to the flooding regime; it is prevalent following flooding and sustained lower water levels as occurs when estuaries open. While the vegetation is frequently relatively species-poor, some sites can be rich in small herbs.

Structure: Shrubland to scrub to 2–3 metres.

Distribution: Scattered in suitable habitat along the coast, but rare and of restricted total extent, e.g. Aire-Calder River estuary, Jack Smith Lake, Nooramunga Islands, Duck Point on Corner Inlet.

Vegetation quality: Vulnerable to weed invasion and clearing, at least in minor estuaries where more accessible to on-going agriculture.

Comments: Can grade into Coastal dune scrub, Moonah woodland and Damp melaleuca scrub, but occupies wetter and more saline habitats in comparison. Occurs in habitats ranging from wetland to dampland, but most examples would be considered to comprise at least marginal wetland or an associated fringing zone.

Mud flats [part of Non Vegetation (EVC 990)]

Defining characteristics: Low lying areas which are unvegetated (or nearly so).

Habitat: Including intertidal mud flats.

Floristics: Lacking vascular plant species.

Structure: Unvegetated.

Distribution: Scattered.

Vegetation quality: Not relevant.

Comments: Areas lacking vascular vegetation can be of high ecological value as wetland habitat.

Littoral rainforest (EVC new no number)

Defining characteristic: Rainforest with a low canopy rarely exceeding 15 m, consisting of a closed canopy with or without emergents, the composition is a mix of drought and exposure hardy species from the coast, the hinterland rainforest EVCs and the site (were it more frequently burnt). Ferns are not diverse, but the ground layer usually has a diverse array of herbs. Ground cover is rarely high except in gaps where it tends to be grassy.

Habitat: Cheniers, berms and other estuarine deposits (islands, levees). The lower elevation areas adjacent can be Estuarine scrub, Estuarine wetland or bare sand in saline areas and Swamp scrub in freshwater reaches. Soils vary according to origin and whilst not a determinant of the presence of Littoral rainforest, they can differentiate floristic communities of this EVC. Soils vary between: peat, silt, sand (and combinations of these) to in some rare instances, cobble berms (around the Gippsland Lakes).

Floristics: Emergents may or may not be present but can include Southern mahogany *E. botryoides*, Swamp gum *E. ovata*, Coast banksia *Banksia integrifolia*. The canopy is usually dominated by Common boobialla *Myoporum insulare*, Sweet pittosporum *Pittosporum undulatum* Muttonwood *Rapanea howittiana*. Less commonly, Lilly pilly *Acmena smithii* may be co-dominant. Prominent vines include Staff climber *Celastrus australis*, Forest clematis *Clematis glycinoides*, Austral sarsaparilla *Smilax australis*, Seaberry saltbush *Rhagodia candolleana*. After disturbance Dusky coral pea *Kennedia rubicunda* may be prominent as a are a range of shrubs Tree everlasting *Ozothamnus ferrugineus* and Snowy daisy-bush *Olearia lirata* and the scramblers Seaberry saltbush and New Zealand spinach *Tetragonia tetragonioides*.

Some communities of Littoral rainforest have as one of their usual disturbance regimes, periodic inundation from estuaries with saline or brackish water. Short periods see little detectable change in floristics or composition, longer periods can lead to partial or complete loss of canopy and most primary rainforest species. This is however followed by a vigorous and diverse regeneration event of secondary Littoral rainforest species and mature Littoral rainforest will regenerate on the site. The proviso here is that the flooding regimes are not altered from those that spawned the Littoral rainforest in the first instance. Also it should be noted that the grandeur of the stand is severely compromised by prolonged disturbance as the stand is reduced to a collapsing mess of fallen canopy species amongst a rampant regenerating shrub layer.

Structure: Closed forest at maturity.

Distribution: Restricted in Victoria to East Gippsland.

Warm temperate rainforest (EVC 032)

Defining characteristic: Closed forest to 25 m tall occurring along gullies and river flats. Dominated by a range of non-eucalypt canopy species above an understorey of smaller trees and shrubs and usually visually dominated by ferns and climbers.

Floristics: Canopy usually dominated by Lilly pilly *Acmena smithii*, Muttonwood *Rapanea howittiana* and Sweet pittosporum *Pittosporum undulatum*. Vines are usually very well developed.

Structure: Closed forest at maturity.

Distribution: Restricted in Victoria to East Gippsland.

Comments: For more detail refer to description of *Alluvial Terraces* Warm Temperate Rainforest in Peel (1999) *Rainforest and Cool Temperate Mixed Forests of Victoria*, Department of Natural Resources & Environment, Victoria.

Appendix I. Sources of asset information

Asset	Information required	Information details	Links
Birds	Bird species lists	Birds Australia or the DSE Atlas of Victorian Wildlife	http://www.birdata.com.au/home_top.html: http://www.viridans.com.au
Fish & economic fish	Fish species lists	DSE Atlas of Victorian Wildlife	http://www.viridans.com.au
Birds & fish	Conservation status of fish and birds	Advisory list of rare and threatened vertebrate fauna in Victoria 2003	http://www.dpi.vic.gov.au/CA256F310024B628/0/58D93F149297811DCA25710D0024AADE/$File/Advisory+List+of+Threatened+Vertebrate+Fauna+in+Victoria+-+2003.pdf
Ecological Vegetation Classes (EVC)	Map of EVCs adjacent to estuary	Department of Primary Industries website - Victoria Resources Online. A Biodiversity Interactive Map on the website allows users to display a number of vegetation themes for any area of Victoria - including Ecological Vegetation Classes (EVCs), 1750 EVCs, broad EVC Groups and Bioregional Conservation Status of EVCs. The scale at which data is represented varies across the state and further surveys may be required on some estuaries. If further detail is required, mapping of EVCs at a scale of 1:10 000 is recommended	http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/vegetation
Rare and threatened flora	Conservation status of plants	Advisory list of rare and threatened plants in Victoria 2005	http://www.dse.vic.gov.au/dse/nrenpa.nsf/LinkView/996B0477753A4204CA256DD4007F1CA528E305DE442CAC684A256DEA0024ACF6

Asset	Information required	Information details	Links
Roads/bridges	Road classification	For arterial roads see 'maps of declared roads' at Vic Roads. Local road classifications are available from the local municipal council's Register of Public Roads	http://www.vicroads.vic.gov.au/vrne/vrne5nav.nsf/childdocs/-2BBDC9EF1E56C40ACA256FD300241C3B-DC01E44F4F8C5427CA256FD300241C40-A1FA773045A99B72CA256FE10042AAEE?open
Agricultural land	Property boundaries	See 'Agricultural Land Impact Assessment Report'. Cadastral property maps are available through the DSE Corporate Geospatial Database Library	http://www.nre.vic.gov.au/land/lcnlc2.nsf/FID/-9A2C348B40DC89BC4A256CB700181D8B?OpenDocument
Stormwater	Location and size of stormwater pipes	The internal diameter of stormwater pipes that discharge to estuaries is available from local municipal councils	
Cultural heritage	Important sites	Victorian Heritage Register & Victorian Heritage Inventory. Also contact local municipal councils	http://www.heritage.vic.gov.au
Indigenous culture	Important sites	Contact details are available at Aboriginal Affairs Victoria	http://www.dvc.vic.gov.au/AAV/INDEX.HTM
Freshwater flow	Minimum freshwater inflow	Minimum river discharge required for an effective artificial river mouth opening can be determined using historical data. Victorian river discharge data is available at the Victorian Water Resources Data Warehouse.	http://www.vicwaterdata.net/vicwaterdata/home.aspx
Identify dates of major social events	Important dates	Identify any dates that will potentially affect the threat score assigned for opening or not opening the estuary	

Appendix J. Assets and critical levels (Australian height datum) required for assigning threat scores

Asset title	Details *Insert information to identify asset*	Critical AHD	AHD
EVC		Coastal saltmarsh: Lowest AHD Estuarine wetland: mid point AHD Estuarine reedbed: mid point AHD Swamp scrub: Lowest AHD Littoral rainforest: AHD 30 cm below surface of EVC Warm temperate rainforest: AHD 30 cm below surface of EVC	
Rare and threatened flora		Refer to corresponding EVC	
Agricultural land		Low land Intermediate land High land	
Boat ramps		Access affected by inundation Some problems associated with use of ramp Boat ramp unusable	
Built infrastructure		More than 50 mm above property grounds Level of the underside of the floor of the house or commercial / industrial building 100 – 300mm above the floor level of the building More than than 300mm above the floor level of the building	
Camping		Some loss of camping sites due to inundation of access tracks Some loss of camping sites due to inundation of sites Substantial loss of camping sites due to inundation of access tracks Substantial loss of camping sites due to inundation of sites	

Asset title	Details *Insert information to identify asset*	Critical AHD	AHD
Jetties		Access to jetty Jetty surface	
Recreational land		Some loss of recreational land due to inundation of access tracks Some inundation of recreational land Substantial loss of recreational land due to inundation of access tracks Substantial inundation of recreational land	
Roads and bridges		Less than 10 mm water over road or bridge 10-50 mm water over road or bridge 51-300 mm water over road or bridge Greater than 300 mm water over road or bridge	
Septic Systems		Top of septic tank Bottom of septic tank	
Stormwater		Greater than 50 mm above property grounds Level of the underside of the floor of the house or commercial / industrial building 100 – 300 mm above the floor level of the building Greater than 300 mm above the floor level of the building	
Walking tracks and bridges		Access to track affected by inundation Inundation causes some problems with use of track Track unusable	

Appendix K. The EEMSS Agricultural Land Impact Assessment Report

Property Identification

Name:

Property Location:

Property ID (Cadastral No):

Property Description

Predominant Agricultural Use **1** **2** **3** **4** **5** *Select one*

refer to 'Predominant Agricultural Use Categories'

Exceptions to single asset category land use. This section is only to be completed if the property cannot be categorised using the agricultural use descriptions provided. Please provide a description, an estimated score and a brief justification for the score assigned.

Description:

Score:

Rationale for score:

Other relevant land details

Only complete this section if the landholder has access to other non-adjoined land or leased adjoined land – Describe association to property affected by inundation. Include information such as proximity, accessibility and how land use is relevant to the property, in particular, how the land assists the landowner to mitigate loss associated with land inundation.

Land Types

Include all land utilised as part of the farming enterprise when completing the table below

Land type #	**Area(ha)**	**Percentage**	**Estuarine water level (EWL)**(m)
High land			>
Intermediate land			Between &
Low land			<

#Refer to 'Land Type Descriptions'

Monthly threat assessment

Refer to 'Threat Attributes and Scores'.*
The total threat score is the maximum of the individual threat scores assigned to each attribute

		Threat Attributes –					Comments
Month	**EWL** metres	1. % of low & intermediate land inundated	2.Capability to mitigate loss	3. Degree of restoration required	4. Loss of access to higher land	**Total threat score***	
January							
February							
March							
April							
May							
June							
July							
August							
September							
October							
November							
December							

Predominant agricultural use categories

Category 1 – Non-agricultural land

Category 2 – Dryland grazing/non irrigated pasture/forestry

These enterprises have low level use of the affected asset areas for agricultural production. The land is part of a larger extensive grazing or forestry enterprise. If stock are grazed on the land it is for short periods of time during the year. The impact of inundation is minimal as the farm is run at a low stocking rate with significant alternative grazing options.

In general this asset will be in lower rainfall areas where pasture production is less than 4 tonnes of dry matter per hectare per annum. Paddocks used on the affected areas are large (greater than 20 ha).

Category 3 – High rainfall farming/lifestyle farming

These areas are subject to more intensive productive processes. This is achieved through the greater capacity to produce pasture (4-6 tonnes dry matter per hectare per annum) due to higher rainfall. As a result there is greater stocking pressure and less alternative grazing options. The enterprise would still be considered to be extensive grazing. Paddock sizes would be smaller (less than 20ha).

Lifestyle blocks may still be used for income generation but are not considered the primary source of income for the owners. They are also of smaller area (less than 10 ha). Generally use is for small numbers of production animals, horses or bush areas. Alternative grazing area may not exist and the use of hand feeding may be required during periods of inundation.

Category 4 – Mixed grazing – possibly some irrigation

These areas have significant income generation usage. Irrigated land in this category would be land that has occasional irrigation or is part of a larger area of irrigation that is not threatened with inundation. Mixed grazing areas would run at reasonably high stocking rates and a significant (greater than 10%) area of the farming enterprise is threatened by inundation. This area would be a higher rainfall area as in Category 3 above.

Category 5 – Dairy, orchard, vineyard, intensive agriculture or urban residential – possibly significant irrigation used

These areas are used for intensive agricultural pursuits. The areas affected will usually be greater than 10% of the total enterprise area. Grazing of dairy cows is at a high stocking rate (greater than 1.5 cows per hectare of the entire milking area). Orchard and vineyard use is part of a viable enterprise that is a significant part of the farm business. These enterprises have significant areas of effected land that is capable of being used for this enterprise. eg. dairy land that is capable of growing 6 tonnes of dry matter of pasture per hectare per year or potato farming capable of producing yields similar to that of unaffected areas in the same enterprise.

Land type descriptions

A percentage figure will be used for the loss of utilisation of the assets compared to not having any inundation for the period in question. This requires an assessment of the potential production from that area of land. Potential production will be greater on some areas of land than others. For the use in the threat value assessment land areas will be assigned one of three classifications:

1. HIGH LAND – Land that is not affected by inundation at all. This classification will be assigned to give an assessment of the proportion of the farming enterprise affected by inundation.
2. INTERMEDIATE LAND – Land that is only inundated for short periods of time. These are the higher areas that are the last areas inundated and the first to have the water recede. These areas will normally have a capability for production of pasture or crops. These areas of land will be the most affected by decisions in estuary management.
3. LOW LAND – These land areas will have minimal productivity due to constant inundation. These are areas that normally have minimal productive output and are only seen as opportunistic use areas. Plant species that survive in these areas are of minimal productive use.

Threat attributes and scores

Threat score	Threat level	Threat attributes
2	Minor	1. Less than 50% of low land inundated 2. Loss can be mitigated with minimal extra inputs – eg stock can be moved to other land and no extra bought in feed is required 3. a) No renovation or extra input required to revert land to previous productivity following inundation. b) No damage to fences 4. No loss of access to other high land
3	Moderate	1. All low land is inundated and less than 20% of marginal land is inundated 2. Mitigation of losses requires minimal extra inputs – eg stock can be moved to other land and less than 10% of feed requirements need to be bought in 3. a) Minimal input required to return land to previous productivity – eg weeds sprayed with no extra seed required. b) Debris to be removed to maintain fence integrity 4. Access is restricted to less than 5% of the rest of the farming land
4	Major	1. All low land is inundated and 20-50% of intermediate land is inundated 2. Stock can be moved to non inundated land but feeding out is difficult 10-50% of feed requirements need to be brought in 3. a) Pasture renovation is achieved through drilling of appropriate seed b) Some fence rewiring required 4. Access to 5-10% of the rest of the enterprise is affected
5	Severe	1. All low land inundated and greater then 50% of intermediate land inundated 2. No suitable land is available for hand feeding and greater than 50% of stock requirements need to be brought in 3. a) All land needs to be fully renovated with cultivation and lime or gypsum treatment to address soil quality issues. b) fences need to be replaced 4. Access is lost to greater than 20% of the farm area

Threat modifiers

Duration of inundation (DI)

The effect of duration of inundation on the use of a specific agricultural asset is related to the processes of waterlogging and salinity. The assessment assumes an inundation period of less than 21 days. For periods greater than 14 days, threat attribute scores will be increased by one.

If a period of other than 14 days is recommended please complete the table below.

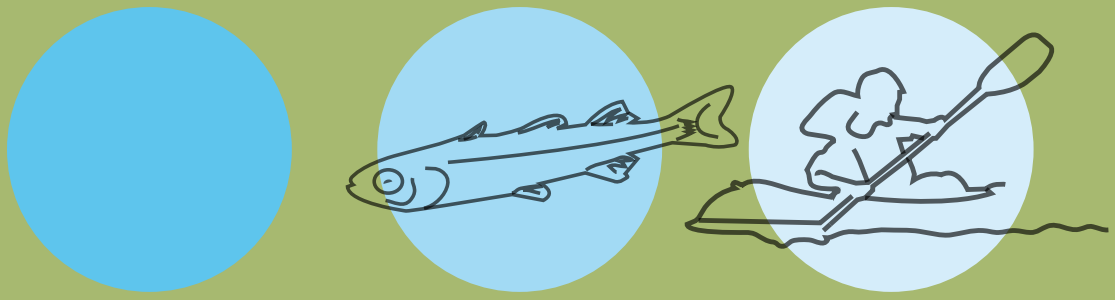
Critical duration of inundation (days) **Threat modifier rationale**

Drought (DR)

The extent of drought conditions will affect the productive capability of an asset. EEMSS will change the threat scores to reflect the increased level of threat associated with each level of drought

1. Local drought (100 km) – Causes a reduction in the productive capability of the entire farming enterprise. This will result in reduced capability to mitigate losses through decreased production of pasture from high unaffected land. Consequently increased amounts of brought in feed will be required. This will increase the threat value as assigned by one point.
2. Regional drought (1000 km) – A reduction in the supply of brought in feeds due to drought in the areas where these feeds are sourced will result in increased prices of these feeds. This will increase the threat value as assigned by 2 points
3. Continental drought (5000km) - Feed prices will be more severely affected by continental drought. The effect of a regional drought would be increased costs of transportation of feed from distant areas Continental drought would result in feed prices being related to the cost of importation of feed from overseas. A continental drought will increase the assigned threat value by 3 points.

The EEMSS will add the threat modifier scores to the total threat score and will not have the capacity to add the modifier to the individual attribute scores. Therefore, if both modifiers are applicable, that is the property is experiencing drought and some land has been inundated for greater than the given period, both modifiers will be added to the threat score.



USER MANUAL












EEMSS

estuary entrance management support system

10 Installing the EEMSS on your computer

EEMSS Database is a Microsoft Access™ built application. The system has been custom designed and built. Users do not need Microsoft Access™ training, but will need to know how to use the EEMSS application.

Current version

Microsoft Access™ 2000
EEMSS_8.mdb

EEMSS can be accessed by Microsoft Access™ 2000 or higher. The user must only open the correct version of EEMSS, depending on which version of Microsoft Access™ they are using. If using Microsoft Access™ 2003 the user must convert the database to that version if they wish to make edits. If using Microsoft Access™ 2000, the user will not have to make any database conversions at all.

System requirements

For best use of the EEMSS Database Application, the user should have the following settings on their PC.

PCs using Windows 98, 2000, Me, XP or Windows NT® 4.0
Pentium® 11 MHz or faster processor
256 MB RAM minimum
The following settings can be adjusted via the control panel > display settings.

Display Settings	1024 x 768 pixels
Colour Settings	High Colour (16 bit) or True Colour (32 bit)

Loading the EEMSS onto your PC

To open the EEMSS database, insert the CD and then double click the EEMSS.mdb file as you would any Microsoft application such as Word or Excel.

11 Implementing the EEMSS

There are three major phases involved in implementing EEMSS as a decision making tool for a particular estuary:

Data acquisition & input phase

This involves:

- Identifying assets
- scoring environmental assets
- scoring threats to environmental assets

Information needs to be collected about all assets that are potentially impacted by the opening decision. Forms are provided in the EEMSS to guide collection of this data.

Community consultation phase

This is an essential step in the application of the EEMSS as it is the stage at which community acceptance and adoption of the EEMSS as a management tool is facilitated by the estuary manager. Direct community input to the EEMSS is required to:

- identify and score socio/economic and cultural assets
- identify and score the threats to those assets.

Decision phase

At the time of making an opening decision the manager is required to:

- input data on current estuary conditions
- assess the impact assessment and checklist reports
- communicate the decision and its rationale to the community.

11.1 Asset descriptions

Data acquisition

The following is a step by step guide to loading your estuary's asset information into EEMSS. This is done prior to community consultation. The more complete and up to date the data set entered into EEMSS the better the impact assessment report will reflect the true impact of the decision.

1. Identify assets on the estuary	The **'Data requirements'** sheet in the EEMSS includes three forms. Use these as a guide when collecting data for inclusion in the database. (see STEP 1). Use the **'Information sources'** form (Appendix I) to compile a complete list of socioeconomic, cultural and environmental assets for inclusion in the description section of the EEMSS.
2. Identify AHDs at which assets are impacted by raised water levels	Complete **'Critical AHDs'** form (Appendix J). If all relevant AHDs are known, this will ensure that assigning threat scores is a simple procedure to complete in the workshop. If all relevant AHDs are not known, then further work may be required to collect any missing data.
3. Investigate solutions, other than artificially opening the estuary, to protect inundated assets	This is an essential step. Inclusion of some assets in EEMSS may be required in the short term while options are investigated. Other solutions could include: floating jetties & boardwalks; realigning or raising road levels; moving septics or installation of sewerage systems; raising stormwater drain outlets or reticulating stormwater; and return of wetlands on flood affected land.
4. Undertake flood impact assessments of agricultural land	Assessment of the impact of flooding on agricultural land needs to be undertaken in consultation with the affected landholder. Landholders only need to participate if they want their property included on the Impact Assessment report (and therefore factored into the final decision to open or not open the estuary mouth). Use of an independent agronomist to do these assessments is recommended. An **'Agricultural land impact assessment proforma'** (Appendix K) is provided by the system for this purpose. Asset and threat scores are assigned to each property affected by inundation. Property IDs are used to identify each property in the EEMSS. The consultant will need to be provided with aerial maps showing property boundaries and if possible contours indicting the extent of inundation at various EWLs. The scores assigned are strictly confidential. A fictitious property should be included for demonstration purposes in the workshop. See section 6.11
5. Contact Cultural Heritage Officer	The options for including Indigenous cultural values in the EEMSS should be presented to the Cultural Heritage Officer See section 5.1.

Asset data input

Locate your estuary by selecting the ‘estuary listing’ button (Step 2). New estuaries can be included by adding a row to the bottom of the list. Relevant CMA details are added on the ‘estuary management’ sheet in the ‘description’ section.

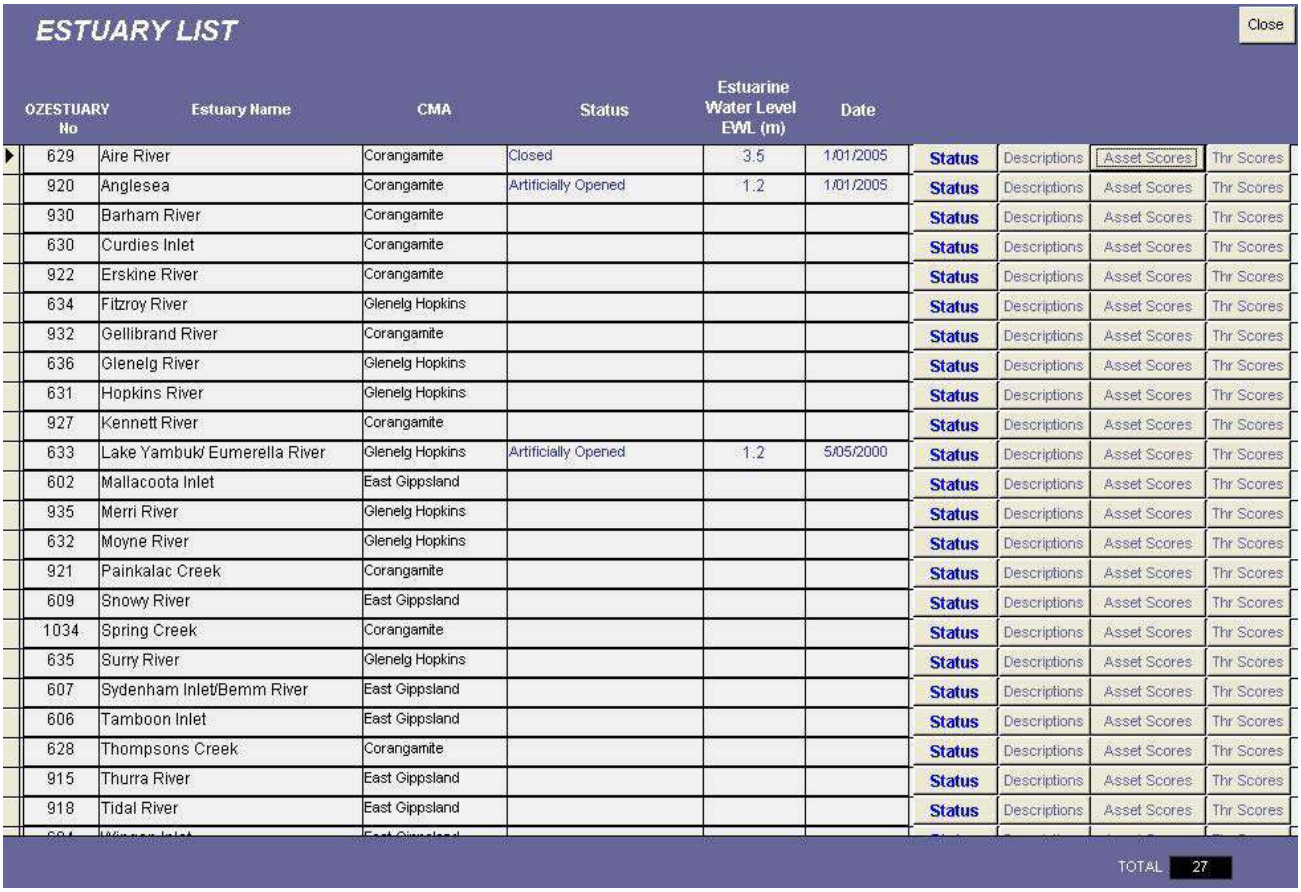
Step 1

Click on the Data Requirements tab to display forms that indicate the information required prior to impact assessments

Step 2

Click Estuary on the Main Menu to go to the Estuary Listing Screen to view all estuaries in your database.

Three files are provided to guide data collection.



ESTUARY LIST

Close

OZESTUARY No	Estuary Name	CMA	Status	Estuarine Water Level EWL (m)	Date				
629	Aire River	Corangamite	Closed	3.5	1/01/2005	Status	Descriptions	Asset Scores	Thr Scores
920	Anglesea	Corangamite	Artificially Opened	1.2	1/01/2005	Status	Descriptions	Asset Scores	Thr Scores
930	Barham River	Corangamite				Status	Descriptions	Asset Scores	Thr Scores
630	Curdies Inlet	Corangamite				Status	Descriptions	Asset Scores	Thr Scores
922	Erskine River	Corangamite				Status	Descriptions	Asset Scores	Thr Scores
634	Fitzroy River	Glenelg Hopkins				Status	Descriptions	Asset Scores	Thr Scores
932	Gellibrand River	Corangamite				Status	Descriptions	Asset Scores	Thr Scores
636	Glenelg River	Glenelg Hopkins				Status	Descriptions	Asset Scores	Thr Scores
631	Hopkins River	Glenelg Hopkins				Status	Descriptions	Asset Scores	Thr Scores
927	Kennett River	Corangamite				Status	Descriptions	Asset Scores	Thr Scores
633	Lake Yambuk/ Eumerella River	Glenelg Hopkins	Artificially Opened	1.2	5/05/2000	Status	Descriptions	Asset Scores	Thr Scores
602	Mallacoota Inlet	East Gippsland				Status	Descriptions	Asset Scores	Thr Scores
935	Merri River	Glenelg Hopkins				Status	Descriptions	Asset Scores	Thr Scores
632	Moyne River	Glenelg Hopkins				Status	Descriptions	Asset Scores	Thr Scores
921	Painkalac Creek	Corangamite				Status	Descriptions	Asset Scores	Thr Scores
609	Snowy River	East Gippsland				Status	Descriptions	Asset Scores	Thr Scores
1034	Spring Creek	Corangamite				Status	Descriptions	Asset Scores	Thr Scores
635	Surry River	Glenelg Hopkins				Status	Descriptions	Asset Scores	Thr Scores
607	Sydenham Inlet/Bemm River	East Gippsland				Status	Descriptions	Asset Scores	Thr Scores
606	Tamboon Inlet	East Gippsland				Status	Descriptions	Asset Scores	Thr Scores
628	Thompsons Creek	Corangamite				Status	Descriptions	Asset Scores	Thr Scores
915	Thurra River	East Gippsland				Status	Descriptions	Asset Scores	Thr Scores
918	Tidal River	East Gippsland				Status	Descriptions	Asset Scores	Thr Scores

TOTAL 27

The Estuary List screen displays many Victorian estuaries. Estuaries can be added to the bottom of the list. The list can be sorted using any field. For example, to sort estuaries by CMA, click on a CMA in the list then right click and choose ‘sort ascending’.

The most recent entry of mouth status, EWL and date is also displayed on this page (see Step 15).

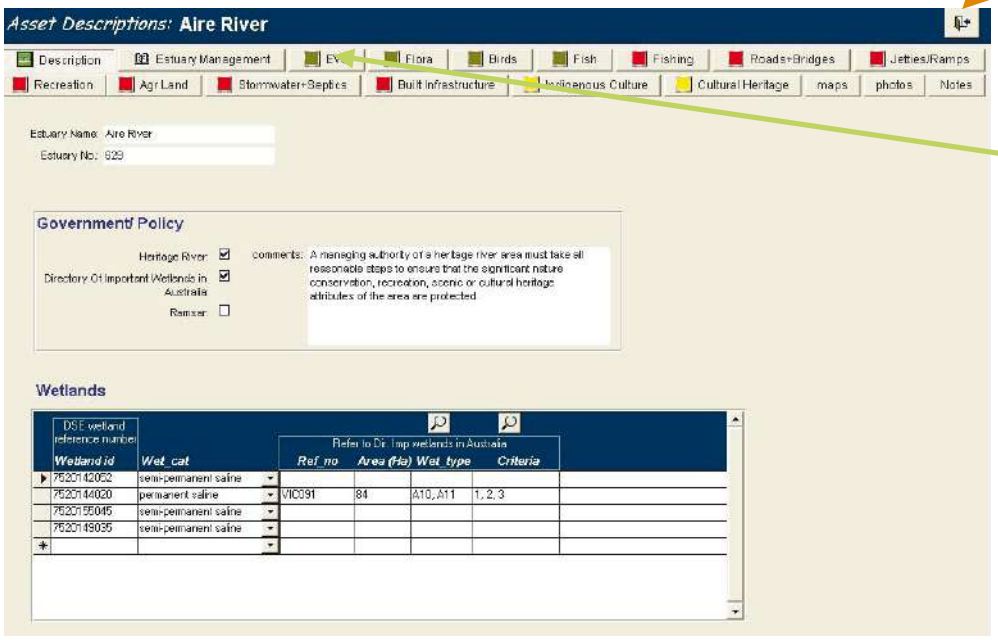
Information about the environmental, socioeconomic and cultural assets of an estuary is stored in the 'description' section of the EEMSS.

Step 3

Click Descriptions Button to select the estuary descriptions section.

TIP

Click on the 'folder' icon to close section.

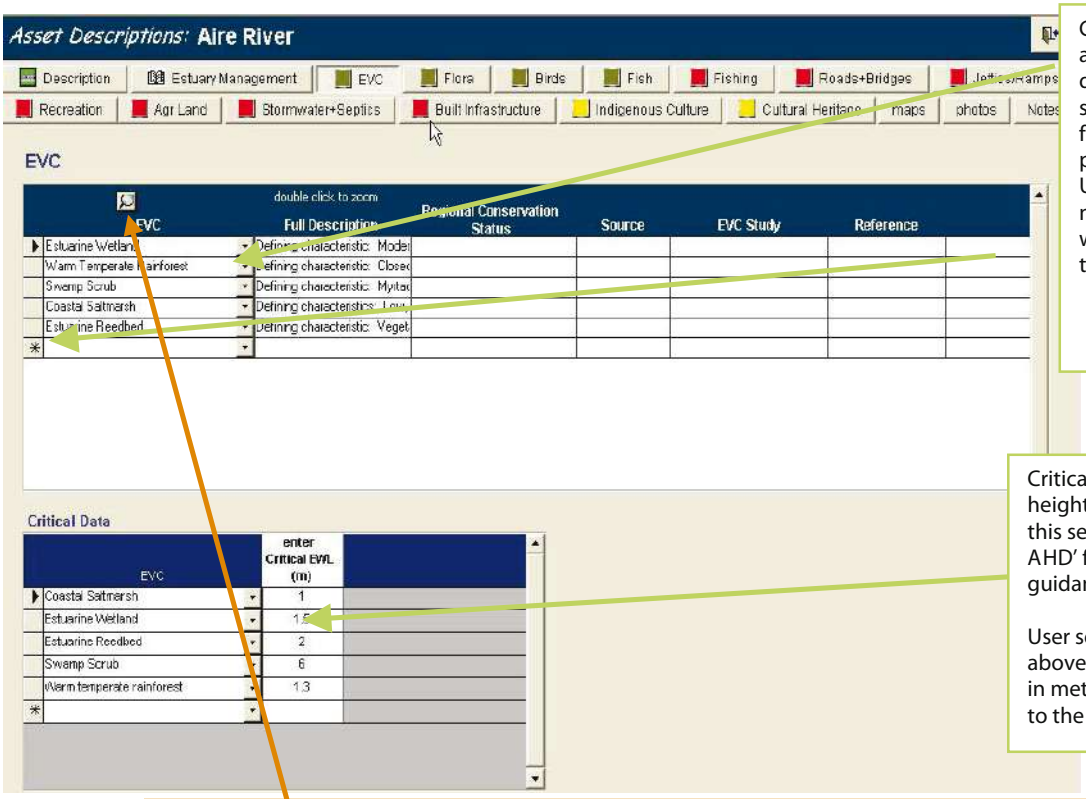


Step 4

Click tabs to enter separate screens for environmental, socioeconomic and cultural data.

Example 1. Input of EVC data

THE list of EVCs was determined by the technical advisory group. The critical EWL to enter is explained in the 'Critical AHD sheet



Step 5

Click down arrow on drop down box to select an EVC from the predefined list. User can add new records where they see the asterix.

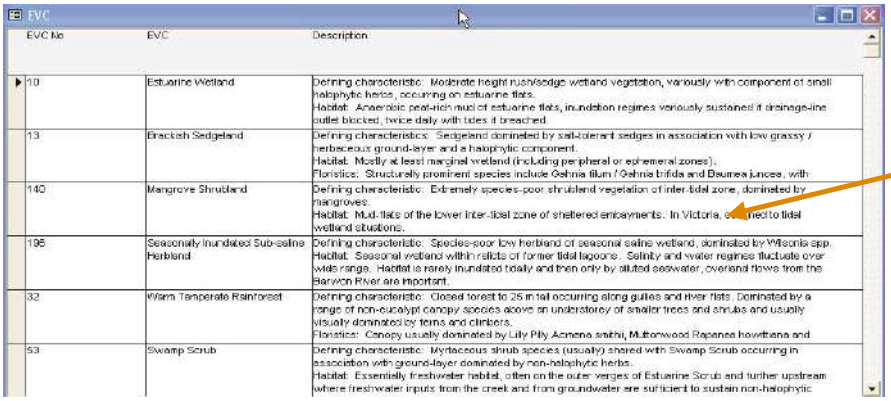
Step 7

Critical estuarine water level heights must be entered in this section. Refer to 'Critical AHD' form (Appendix G) for guidance

User selects the EVC as above and then enters EWL in metres in the field directly to the right.

TIPS

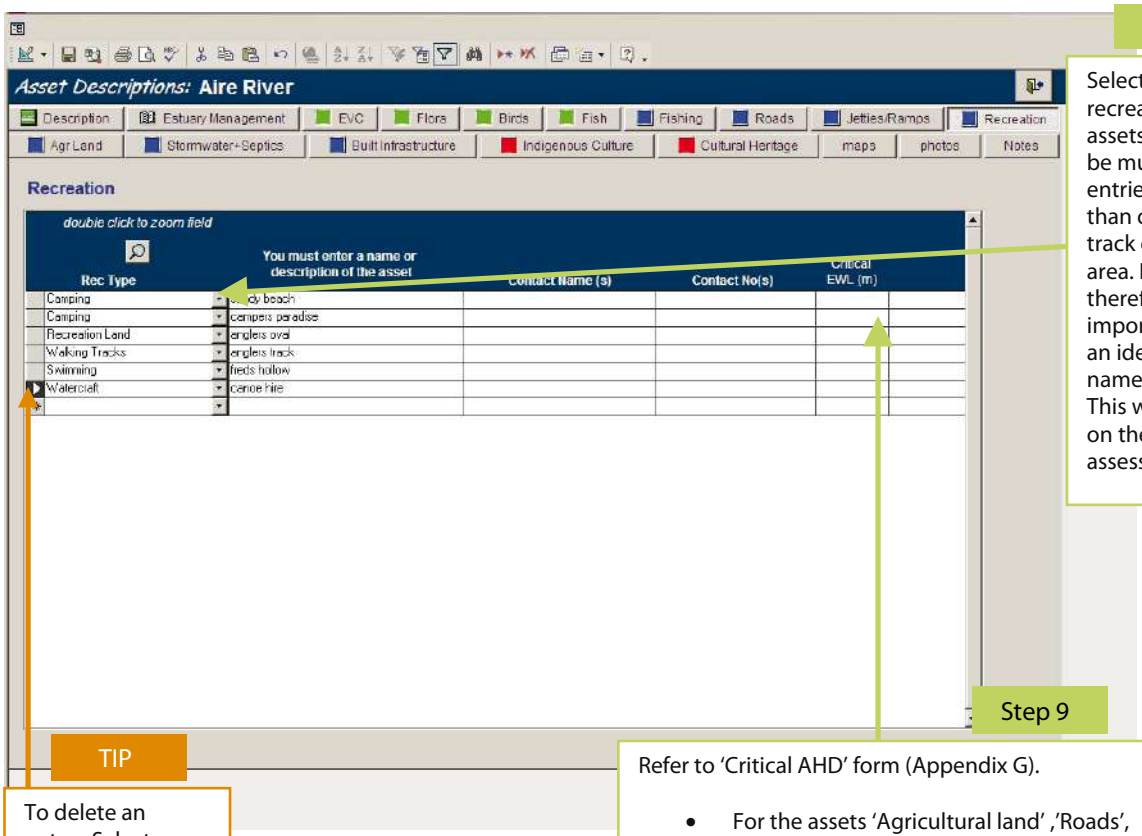
- User can view further information in the "Lookups" by clicking the magnifying glass wherever it appears. A screen appears with the "Lookup table" that can be viewed by the user.
- On the EVC page further information can be also be viewed by double clicking on a cell in the 'Full Description' column
- The user may add to the Lookup table by scrolling to the bottom of the screen and entering data besides the new record asterix. However, this list is pre-determined by the project team and should only be edited following careful consultation with the team.



TIP

EVC lookup table displays all the EVC's available to select in the database.

Example 2. Input of recreational assets



Step 8

Select relevant recreational assets. There can be multiple entries. e.g more than one walking track or camping area. It is therefore important to enter an identifying name for each. This will appear on the impact assessment report

Step 9

Refer to 'Critical AHD' form (Appendix G).

- For the assets 'Agricultural land' ,'Roads', 'Septics' and 'EVCs', it is critical that a single EWLs is entered in metres.
- Not all recreational assets require an EWL. For those assets that do, this information is used only to guide the threat assessment. Therefore, all the relevant information from Appendix B can be entered here or a summary, such as the range of water levels.

TIP

To delete an entry : Select asset then right click on mouse. Choose 'cut'. You will be asked to confirm you want to delete the record, select OK

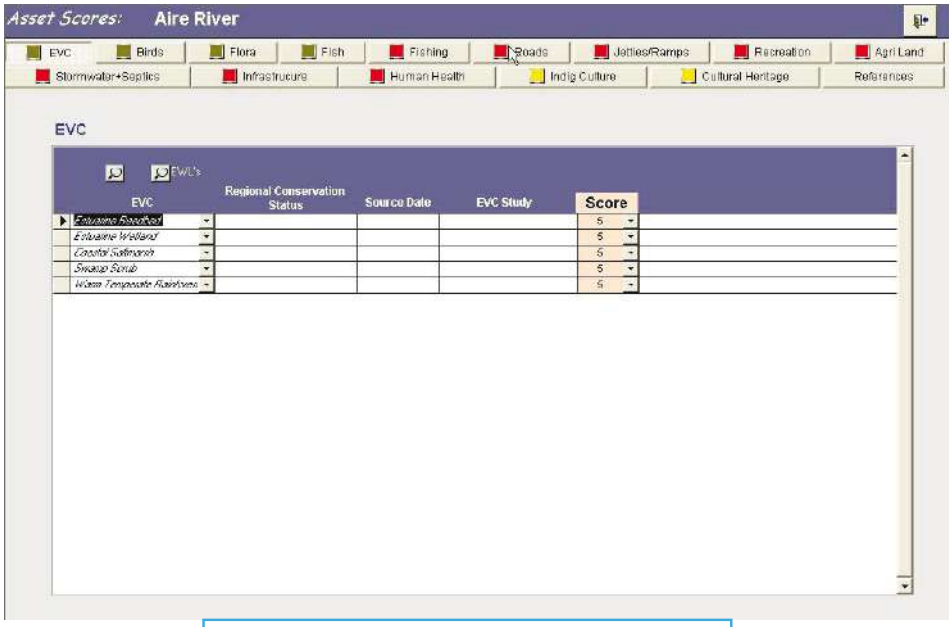
11.2 Assets scores

Once the data assets have been entered at the description phase, they are then scored. Please note that you cannot add new assets here. Only assets that you want to appear on the impact assessment report have to be scored. For further information about assigning asset and threat scores refer to Section 11.4 'Community consultation' and also relevant sections on each asset in Part 2 of the report.

Step 8

Go to the Estuary List. Click on 'Asset Scores' Button.

Example 1. Assigning asset score to EVCs



Step 9

Asset Scores screen appears. Simply click on each tab to go to desired asset. Then go to score field to enter scores

Note

Some scores like those for EVCs, birds, fish & roads are automatically entered for you and are set by the administrator.

Example 2. Assigning asset scores to birds

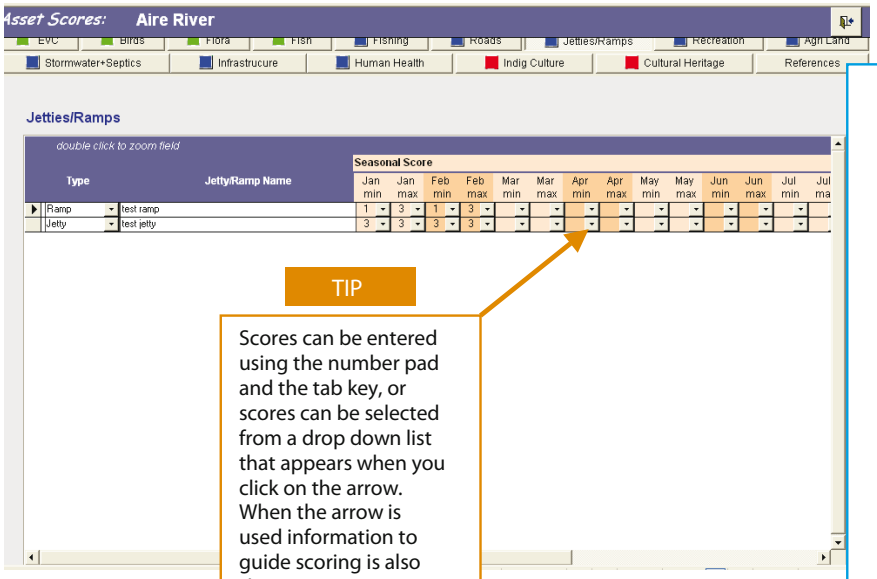
Step 10

The bird group summary shows a summary of the bird species entered and also includes automatically calculated scores provided by the administrator. It is recommended that managers use the groups assigned, rather than individual species, to avoid lengthy impact assessment reports.

Managers may choose to score individual bird species. This would be appropriate if a species has a conservation status of near threatened or greater or is a species that the community identifies as important. Each asset attribute should be scored i.e. conservation status, habitat use and population score. The maximum of the three scores is used in the impact assessment.

For some attributes there is the capacity to enter minimum and maximum scores. For most scores there will probably be consensus, but it is important to capture any variation in opinion. A range of opinions often highlights that further data is required before a score can be confidently assigned. The ability to enter a range of scores also helps avoid conflict in the community workshops when scoring recreation and other socioeconomic assets.

Example 3. Assigning asset scores to jetties and boat ramps



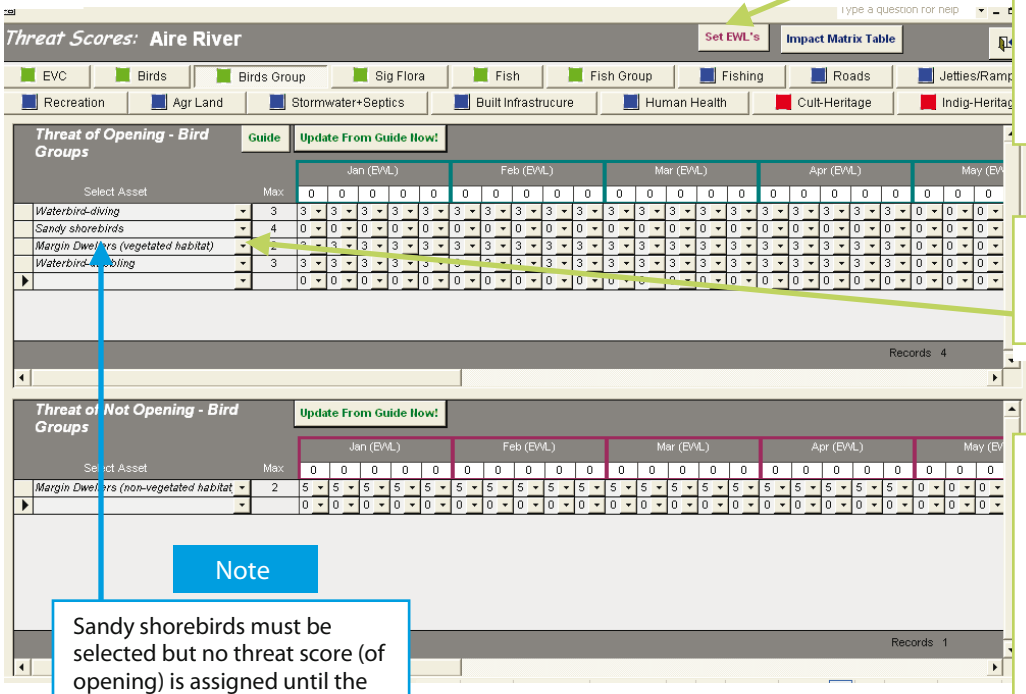
TIP

Scores can be entered using the number pad and the tab key, or scores can be selected from a drop down list that appears when you click on the arrow. When the arrow is used information to guide scoring is also shown.

Note

- Socioeconomic asset scores are assigned during community consultation (see section 11.4).
- If a minimum and maximum score is allocated only the maximum score is automatically used for the impact assessment
- To reflect the change in use level of the 'Recreation' assets and 'Jetties' and 'Boat ramps', a different asset score can be assigned for each month. Use scroll bar at the bottom of the page to move to new month

11.3 Threat scores



Step 11

Go to Estuary List. Click on Threat Scores Button.

Step 12

Note: It is important to first set water levels (EWLs) for your estuary. They will then be automatically displayed. Click on 'Set EWLs' Button. See step 11 in section 11.4

Step 13

Click on the arrow to select all relevant groups.

Step 14

Score the threat of opening or not opening at each water level and for each month.

For assets with pre-determined scores, the user can choose to click on 'Update from guide now' to automatically assign scores to environmental assets.

Note

Sandy shorebirds must be selected but no threat score (of opening) is assigned until the input of threat modifiers.

11.4 Community consultation

Workshops were an effective means of providing information about the EEMSS to the community and assigning scores to the socioeconomic assets and threats to those assets. (See section 7 Community engagement).
A suggested workshop plan is included below. It is important the agenda is tailored to suit each estuary.
It is recommended that a professional facilitator be employed and the workshops run for a maximum of 3 hours including a break.

Aerial photos or maps with all assets denoted are useful to guide discussion in the community workshops. Information regarding location of these can be stored in the **'maps'** and **'photos'** sheets in the asset description section.

WORKSHOP STEPS	COMMENTS
1. Provide information about the potential impact of artificial estuary mouth opening on the natural values of an estuary	The workshop is an opportunity to provide information about why estuary mouths close, the seasonal hydrological cycle factors contributing to fish kills and the potential impact of artificially breaching the entrance on the environmental values of an estuary.
2. Briefly outline the main features of the EEMSS	The main components are an Impact assessment, a checklist and data storage. The impact assessment requires assigning asset scores and threat scores.
3. Describe how information gathered in earlier community workshops was incorporated into the EEMSS	Some community members will have attended workshops during the development of EEMSS. It is important to note that the information community members provided forms the basis of the asset list in the EEMSS and has also been used to develop the monitoring sections and the checklist report.
4. Explain how the rules were developed and who provided the expert advice	Technical advisory groups and consultants were used to provide expert advice for some socioeconomic and all environmental assets. The rationale for the fish, bird and plant groups used, and the environmental scores that are automatically uploaded, need to be included.
5. Introduce the communities to the EEMSS database importantly (what it will and won't do)	The EEMSS program will not make the decision whether or not to open an estuary but it will assist managers when making that decision by ensuring a consistent decision process is followed so socioeconomic, cultural and environmental assets are considered and openings are safe and effective.
6. Explain how the EEMSS relates to any other estuary projects	It should be stressed that management of the estuary mouth is just one component of estuary and catchment management. Potential projects identified when investigating options other than artificially opening the mouth could also be mentioned here.

WORKSHOP STEPS	COMMENTS
7. Include **Descriptions of assets**. Confirm the list of assets on the estuary that should be included in the EEMSS	Assets previously identified should already be in the database. Confirm that all the uses & functions of the estuary and surrounding area that are impacted by mouth status are included **STEPS 4 -7**
8. Confirm AHD at which assets are affected	If all AHDs are not known, this can be refined with further monitoring
9. Assign **Asset scores**: Environmental Assets	Note these automatically upload **STEPS 8-10**
10. Assign asset scores to socioeconomic assets	Because data entry is time consuming, choose one or two critical assets to score and include in EEMSS for demonstration in the workshop. For others, note the score levels for each month on butcher paper or white board and include later.
11. Determine range of EWLS to use for threat scores	Up to five EWLs can be selected. The Critical AHD form will provide a guide to the range of EWLs to use. Graphing the asset and the critical height may help to identify some key EWLs. The highest EWL should be within the 'natural opening range' the lowest is usually the height of the lowest infrastructure. The level will also depend on the minimum water level at which the estuary can be successfully opened without extensive excavation. Factors such as the width and height of the beach berm will determine this level. **STEPS 11-12**
12. **Score threats** to assets for each month and EWL	Only assets selected for assigning threat scores will appear on the impact assessment report. Review those already included and add in threats to social assets **STEPS 13-14** **See relevant asset in sections 4-6**
13. Run scenarios to show how the information changes with different water levels and times of the year	Input various modifiers and physicochemical to demonstrate how they change impact assessment reports and checklist reports
14. Identify opportunities for further community involvement	Community involvement could include monitoring physicochemical parameters such as mouth status and EWL. It might also be appropriate to monitor estuarine assets that were identified as potentially impacted by mouth status. **See section 3.3**. A method for distributing the impact assessment and checklist reports to the community should also be established.

11.5 Physicochemical data input

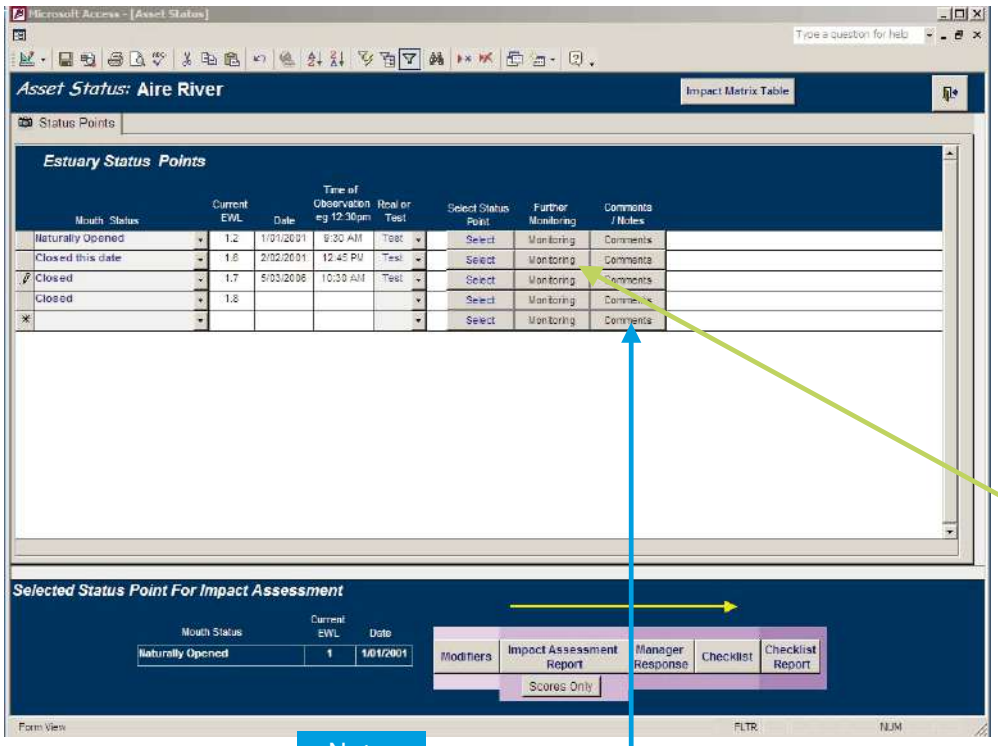
Estuary managers should regularly enter data regarding mouth status and EWLs on the estuary status page. The most recent entry is shown on the 'Estuary list' page (See Section 3.3) for further details.

Step 15

Select 'Status' from Estuary list page

Step 16

Data input must be in the recommended format. For mouth status select carefully from drop down list. The 'naturally opened' and 'artificially opened' options refer to openings on the date entered, after that date just the 'open' option should be used. EWL is in metres. Date and time must be entered in the format shown.



Step 17

Physiochemical profiles are entered on the 'water quality' sheet in the monitoring section. Other numerical data can be stored on the 'other data' sheet in this section.

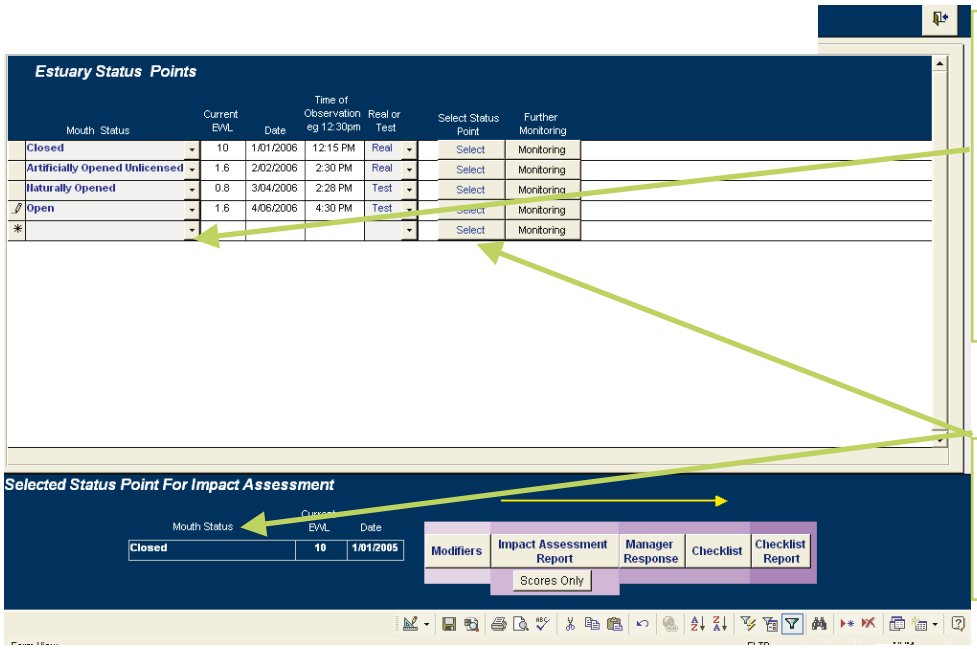
Note

- General observations and any information specific to a date can be recorded in the 'Comments' section.
- Links to the pictorial information can be included on the maps and photos sheets in the 'Asset description' section.

11.6 Making the decision

Prior to making the decision whether or not to open an estuary the manager needs to:

- collect physicochemical profiles, including dissolved oxygen levels, from several sites in both the estuary channel and in any adjoining wetlands. The results are entered in the monitoring section. A subset of these parameters is presented in the checklist report;
- input modifiers and review the impact assessment report; and
- complete the checklist report.



Step 17

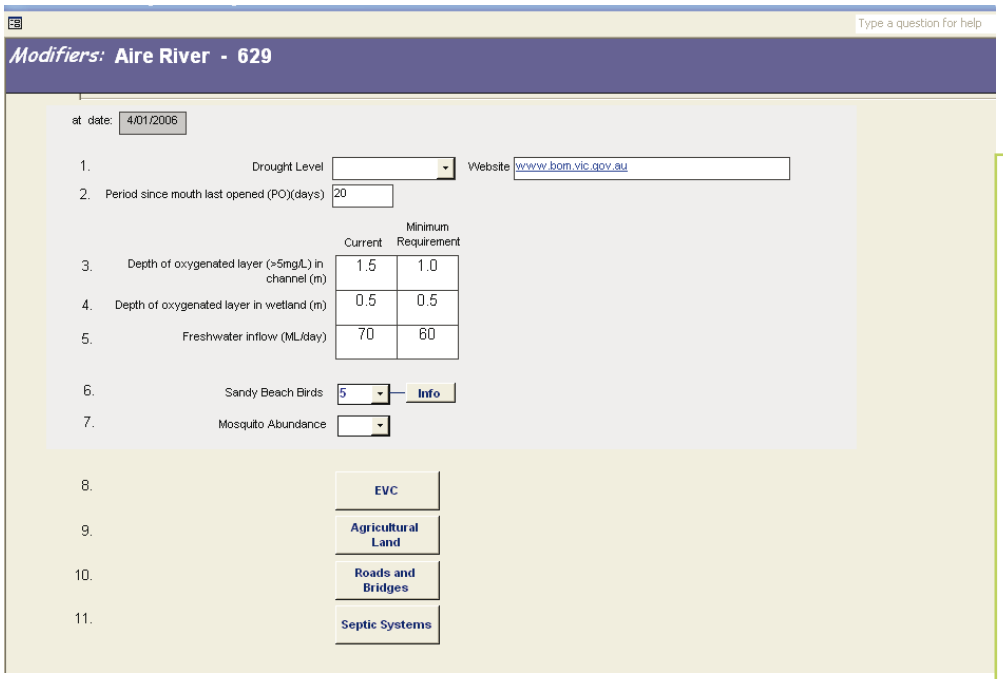
Go to a new row to enter a status point.

Enter mouth status date, EWL, and time and select 'real'.

The test mode is used for scenario testing. Data is not saved if the test button is selected.

Step 18

Press the select button for that day to be selected for the impact assessment.

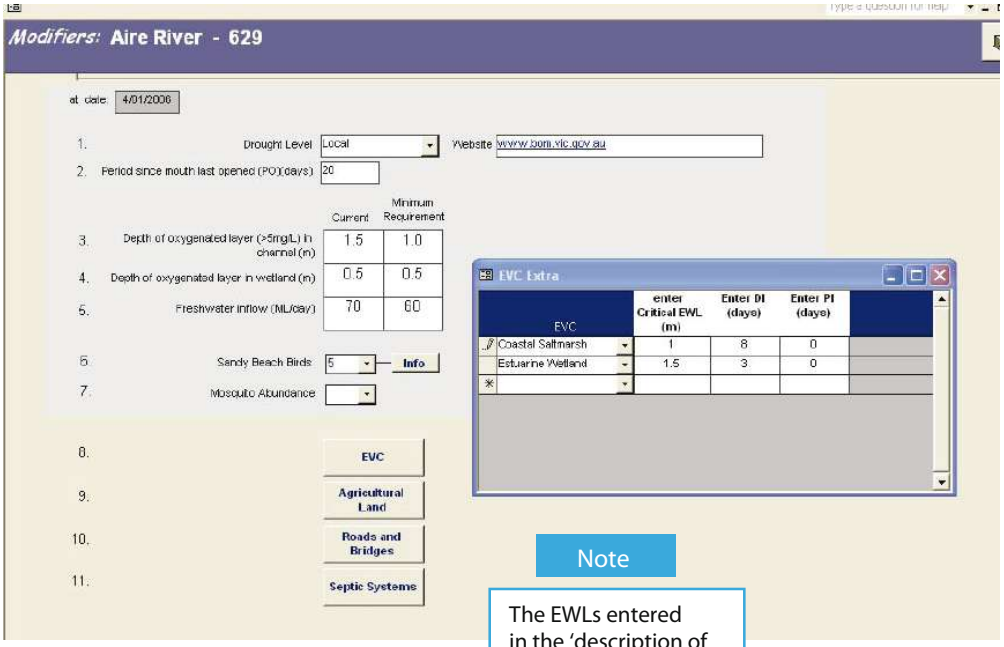


Step 19

Enter relevant threat modifiers.

The threat modifiers required will depend on the particular assets that were assigned threat scores for each estuary.

A survey of the estuary mouth is needed to determine if the area is being utilized by shorebirds, such as terns, for breeding or foraging. The threat score assigned relates to opening the estuary.



Step 20

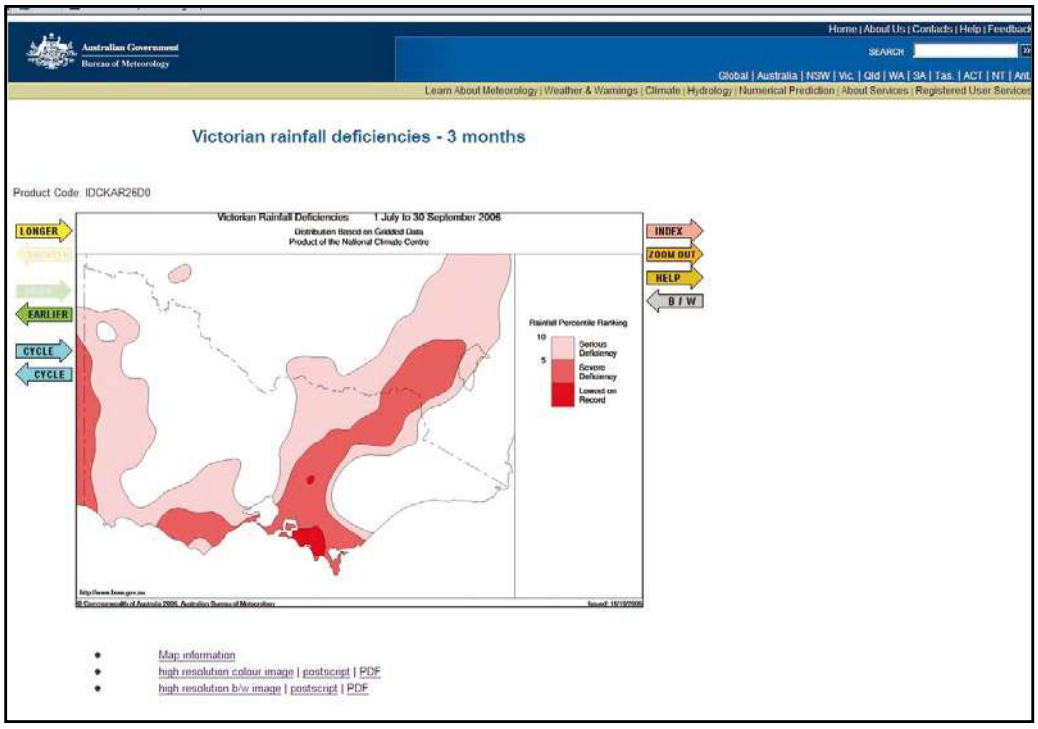
For some assets Duration of inundation (DI) and/or period since an asset was last inundated (PI) is required. Because most EVCs will be inundated when the estuary is closed, PI will usually be zero

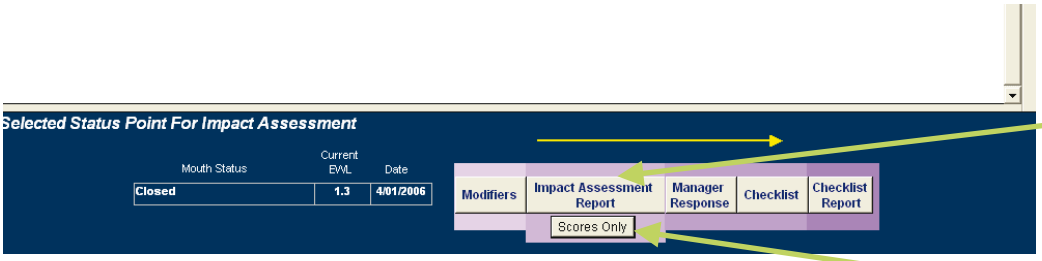
Note

The EWLs entered in the 'description of assets' will automatically be displayed here

Drought modifier

Drought in the EEMSS is defined as a rainfall deficiency that is below the 10th percentile (lowest 10% of records) for the previous three months. This information is available at the Bureau of Meteorology website. www.bom.gov.au. A local drought refers to a spatial scale of approximately 100 km, regional 1000 km and continental 5000 km.





Step 21

Press the 'Impact Assessment Report' to see the results of your impact assessment in print preview.
The 'Scores Only' button displays the threat scores assigned previously plus any relevant modifiers. Some scores can therefore be greater than 5.

Review impact assessment report

The impact assessment report summarises the impact of both opening and not opening the estuary on the assets of a particular estuary at various water levels and in the month entered **(see section 3.1.)**. The impact of opening and not opening the estuary is displayed on different pages. Some modifier information such as drought level, oxygen levels and period since the mouth was last open (PO) are also shown. Although they are not threat modifiers, both the presence of wetlands listed in the Directory of Important Wetlands and Heritage River status are displayed and should be considered by the manager when making their decision.

The manager can clearly see at what EWLs, infrastructure such as walking tracks, roads etc will be affected. This alerts the manager to take action if required and/or contact the responsible agencies. A range of actions could be contemplated depending on the assets potentially impacted; these include, placement of signs to close jetties, warning signs on walking tracks and roads and development of monitoring programs to assess the condition of EVCs.

In the example impact assessment report, the impact on sandy shorebirds of opening the estuary is very high this reflects the threat score of 5 (substantial loss of breeding habitat) assigned in step 19. A 'local' level of drought was entered in the modifier stage, if this was increased to regional or continental then the impact of opening on the 'waterbird' margin dwellers' bird groups would automatically increase to reflect the importance of the estuary as a drought refuge.

The impact of opening on the fish group, 'estuarine permanent' is also considered to be very high; this reflects the potential for egg and larvae loss at this time of year. Estuary perch is in the group estuarine permanent therefore the impact on the Fishing asset 'estuary perch' is the same as for that fish group. If the depth of oxygenated water in either the channel or wetlands was less than the minimum requirement the impact of opening on all fish groups would all change to very high.

The threat of not opening on the 'seasonal obligate' fish group is moderate. However, if the period since the estuary was last open (PO) entered in the modifiers was greater than 365 days, the threat score and hence impact score would increase to reflect the impact of restricting access between the estuarine and marine environments for species in this group.

The manager includes their response ('Input Manager's Response') after considering the impact of opening and not opening the estuary on the various assets, and other factors such as heritage river status, presence of listed wetlands and comments from the indigenous community. Although not explicitly included as part of the impact assessment, the status of adjacent estuaries and previous decision about the estuary could also be considered at this time. For example, if adjacent estuaries, which are thought to be more important as bird refuge areas, are closed this may change the weight you give to the bird asset in this report. Or if all adjacent estuaries are open, then the impact score assigned for not opening the estuary on the seasonal fish group may not have the same influence on a decision. Similarly, if in previous years to protect a road from inundation, the estuary was artificially opened at a critical time for fish breeding, the greater weight given to the impact score for the asset 'fish' this year, because of those historical decisions, could be mentioned in the 'managers response'.

Example impact assessment report

(note all information displayed is for demonstration purposes only)

EEMSS - Impact Assessment March ***Aire River ozestuary no. - 629***

Current : Closed

Manager:

Decision Justification:

As At date : 5/03/2006
Time : 10:30 AM
Current Water Level : 1.7 m
Period since mouth last open : 0 days
Drought Level :

Heritage ☑
Dir Imp Wetlands ☑

	Current	Minimum
Depth of oxygenated layer (>5mg/L) in channel above mean sea level (m):	1.5	1.0
Depth of oxygenated layer in wetland (m):	0.5	0.5
Freshwater inflow (ML/day):	70	60

Asset Type	Name	Asset Score	Estuary Water Levels 0.8	1	1.2	1.4	1.6
Not Opening							
Not Opening – Bird groups							
	Margin dwellers (non-vegetated)	2	*High*	*High*	*High*	*High*	*High*
Not Opening – EVC							
	Coastal Saltmarsh	5	*High*	*High*	*High*	*High*	*High*
	Estuarine Reedbed	5	*Mod*	*Mod*	*Mod*	*Mod*	*Mod*
Not Opening – Fish groups							
	Estuarine Seasonal Obligate	4	*Mod*	*Mod*	*Mod*	*Mod*	*Mod*
Not Opening – Jetties							
	Main jetty	5	*Mod*	*Mod*	*Mod*	*V High*	*V High*
Not Opening – Ramps							
	Main ramp	3	*Low*	*Low*	*Low*	*Low*	*Mod*
Not Opening – Recreation							
	Camping - campers retreat	3	*Low*	*Low*	*Mod*	*Mod*	*Mod*
	Walking Tracks - Anglers track	5	*Low*	*Mod*	*Mod*	*V High*	*V High*
Not Opening – Roads							
	Main Rd	4	*Mod*	*Mod*	*Mod*	*Mod*	*High*
	Sand Rd	2	*Low*	*Low*	*Mod*	*Mod*	*High*

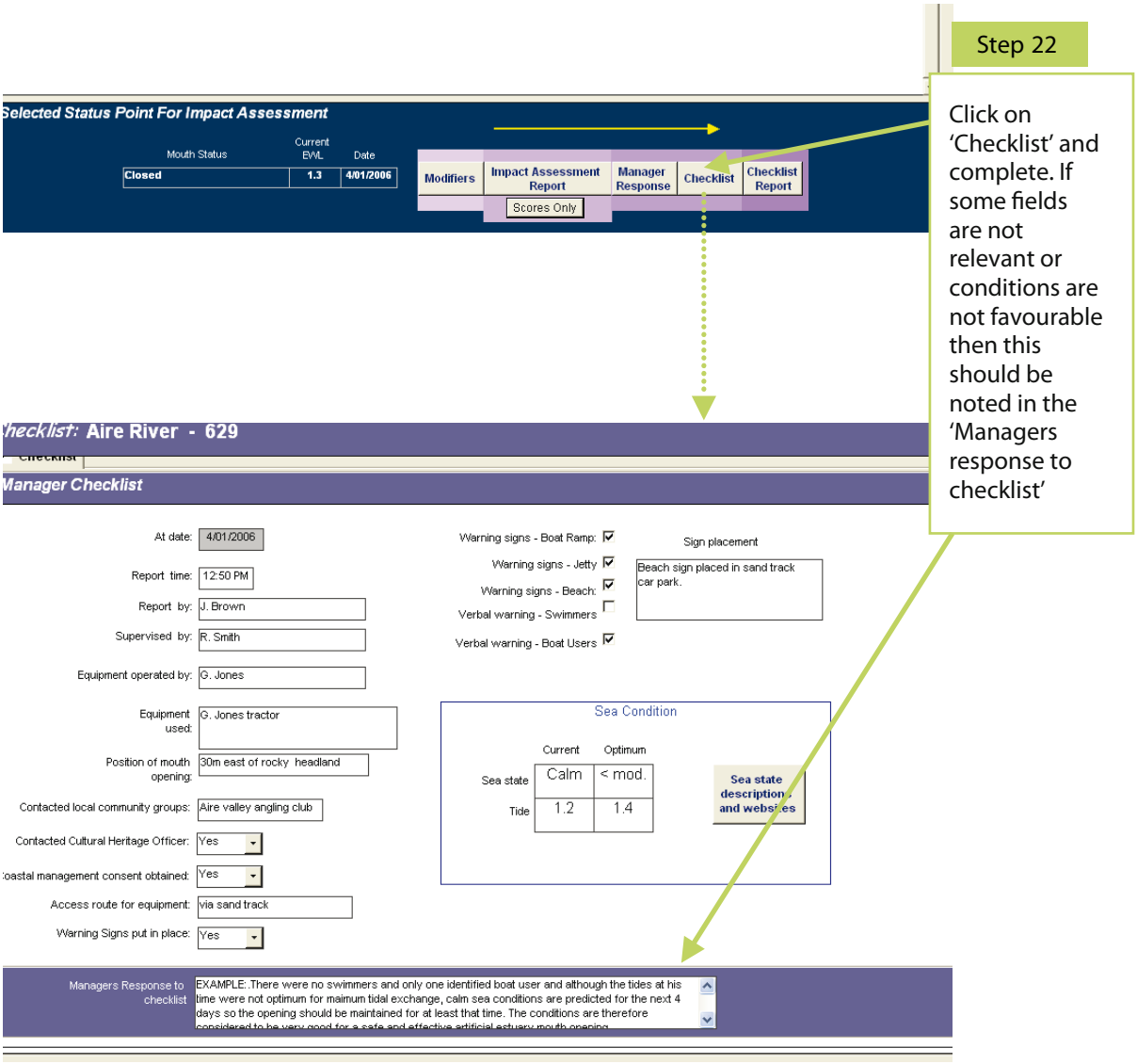
Asset Type	Name	Asset Score	Estuary Water Levels 0.8	1	1.2	1.4	1.6
Opening							
Opening – Bird Groups							
	Margin dwellers (vegetated)	2	*Mod*	*Mod*	*Mod*	*Mod*	*Mod*
	Sandy shorebirds	4	*V High*	*V High*	*V High*	*V High*	*V High*
	Waterbird - dabbling	3	*High*	*High*	*High*	*High*	*High*
	Waterbird- diving	3	*High*	*High*	*High*	*High*	*High*
Opening – EVC							
	Coastal Saltmarsh	5	*Mod*	*Mod*	*Mod*	*Mod*	*Mod*
	Estuarine Reedbed	5	*Mod*	*Mod*	*Mod*	*Mod*	*Mod*
	Estuarine Seasonal Obligate	5	*Mod*	*Mod*	*Mod*	*Mod*	*Mod*
Opening – Fish							
	Australian mudfish	4	*Mod*	*Mod*	*Mod*	*Mod*	*Mod*
Opening – Fish Groups							
	Estuarine Permanent	4	*V High*	*V High*	*V High*	*V High*	*V High*
	Estuarine Seasonal Obligate	4	*Mod*	*Mod*	*Mod*	*Mod*	*Mod*
	Non-estuarine marine	1	*Low*	*Low*	*Low*	*Low*	*Low*
Opening – Fish							
	Estuary perch	4	*V High*	*V High*	*V High*	*V High*	*V High*
Opening – Recreation							
	Beach Use - Smith's Beach	4	*Mod*	*Mod*	*Mod*	*Mod*	*Mod*

Impact of opening an estuary on indigenous cultural values:

A statement form the local indigenous community can be included here

Checklist report

If after viewing the impact assessment report the manager decides that the estuary should be opened then the checklist is completed. The decision to open an estuary is also dependent on the requirements of the checklist report being met **(See section 3.2)**.



The ‘Checklist report’ presents the information entered in the checklist and also the results of water quality monitoring entered in the ‘Monitoring section’ for that day. The depths of the oxygenated layer in the central channel and wetland are threat modifiers and therefore are also included on the impact assessment report

EEMSS - Manager Checklist *Aire River*

Status:	**Closed**	Status	**2/02/2001**
Report by:	**J.Smith**	Report	**12:30 PM**

Report by:	J.Smith	Warning Signs put in place:	Yes
Supervised by:	J.Brown		
Equipment operated by:	L.Jones	Warning signs ☑	Sign
Equipment used:	L.Jones’ backhoe	Warning signs ☑	Beach signs placed in main car park and at end of beach access track.
Position of mouth opening:	20m east of rocky headland	Warning signs ☑	No swimmers were using the estuary.
Contacted local community groups:	Aire River Anglers Club	Verbal swimmers ☐	
Contacted Cultural Heritage Officer:	Yes	Verbal boat users ☑	
Coastal management consent obtained:	Yes		

	Current	Optimum
Sea State	Calm	< Mod
Tide	1.2	1.4

Managers response to checklist

The sea state conditions are predicted to be calm for the next 4 days and although tidal conditions are currently not ideal for maximum marine water exchange, maximum tidal heights are increasing. There are currently very few recreational users of the estuary. Conditions are therefore considered to be very good for a safe and effective artificial mouth opening.

Water Quality Data

Collected date:	Site:	Time	Ewl (m)	Depth (m)	Salinity (ppt)	Dissolved oxygen (mg/L)	Temperature (°C)
1/02/2001	Site 1 Bridge	10:30 AM	1.2	0	4	9	19
			0	0.5	4	8	18
			0	1	5	8	17
			0	1.5	5	8	17
			0	2	20	6	16
1/02/2001	Site 2 - Browns	10:45 AM	1.2	0	4	9	19
			0	0.5	4	9	18
			0	1	5	8	17
			0	1.5	6	8	17
			0	2	21	6	16
			0	2.5	23	6	16

Monday, 2 February 2001 2:31:58 PM Page 1 of 2

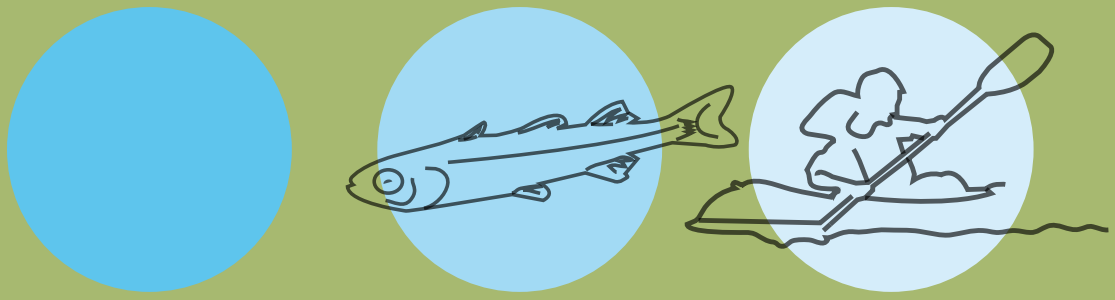
Both reports, including the manager’s response to both outputs, ensure the decision process is open and transparent. A method for making both reports available to the community should be investigated.

11.7 Saving data

It is essential that the manager ensures that all files are regularly saved. The most appropriate back up system needs to be discussed with the IT manager within each agency using the EEMSS.

11.8 Improving the EEMSS

Further refinements to the EEMSS database will be identified following its use in estuary opening decisions. It is important that all suggestions are captured so they can be incorporated in later versions of the EEMSS. The 'notes' page in the 'Description' section of the EEMSS can be used to record any recommendations. This should be made available to future reviews of the EEMSS



EEMSS

Estuary Entrance Management Support System

further information

For further information about the EEMSS project contact your local catchment management authority.

acknowledgements

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