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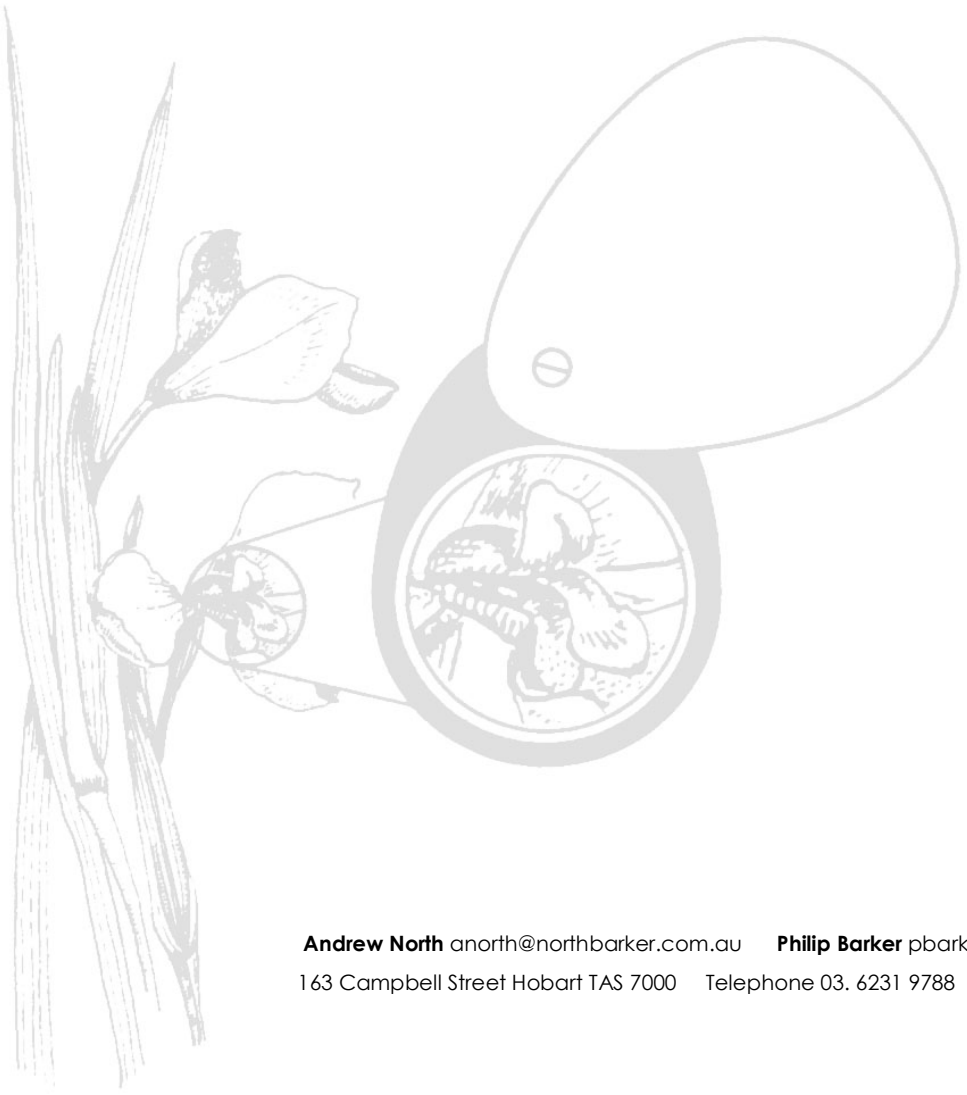
ECOSYSTEM SERVICES

Cataract Gorge Environmental Flow

Impact on Threatened Flora

30th Nov 2010

For Hydro Tasmania



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SUMMARY AND RECOMMENDATIONS

A number of stakeholder interests including water quality, visual appearance and recreation have been represented to Hydro Tasmania with a desire to increase the environmental flow in Cataract Gorge. In response to these representations Hydro Tasmania is considering options for potentially increasing the environmental flow released from the Trevallyn Dam into Cataract Gorge.

There is a statutory minimum flow requirement of 0.43 cumecs. The existing flow release from the dam is 1.5 cumecs which was introduced in 2003. The four options under consideration are:

1. 3 cumecs throughout the gorge
2. 2.5 cumecs throughout the gorge
3. 0.5 cumecs in reaches 2 and 3 and 3 cumecs in reaches 1 and 4
4. 0.5 cumecs in reaches 2 and 3 and 2.5 cumecs in reaches 1 and 4

The 0.5 cumecs flow in options 3 and 4 would controlled by an off take at Deadmans Hollow and feeding a mini hydro power station at Duck Reach where the balance of the flow would be released into Reach 4. If the mini hydro is not viable the flow may be the same in all reaches, however, this document assumes it will be implemented.

Four surveys were undertaken with the aim determining the location and abundance of threatened flora species that may be affected by changes to the environmental flow. The distribution of Declared weeds within the flood channel is also considered. Survey 1 was undertaken in October 2009 after a large flood in August, survey 2 was undertaken in April 2010 with a flow of 1.5 cumecs; survey 3 was undertaken in April 2010 with a flow rate of 3 cumecs and survey 4 was completed in May with a flow rate of 0.5 cumecs.

There are a number of records of threatened flora species that predate the dam and some of these species are now considered to be extinct from the gorge. There are numerous records of threatened flora species that predate the environmental flow implemented in 2003. However, the records do not record the locations in relation to the flow level at that time and so it cannot be determined if the sites have been inundated by the instatement of a 1.5 cumec environmental flow in 2003.

There are also records from 2003-2010, including a recent extensive survey by DPIPWE, but none record the height above the environmental flow. As such, our surveys represent the baseline for the extent and abundance of threatened flora for this project in Cataract Gorge.

Prioritisation of areas to be surveyed, based on access and resources, allowed us to assess suitable habitat on Reaches 1-4 fairly comprehensively. Nevertheless the distribution of records and number of plants recorded is a sample.

Four surveys were undertaken; two to establish baseline abundance of threatened flora and two to measure the change in flow height of the 3 cumecs and 0.5 cumecs options. The change in flow height of the 2.5 cumec flow was extrapolated.

The baseline surveys recorded 13 threatened flora species between the water level at 1.5 cumecs and the riparian zone above flood level. This is more than 5 m above the current flow level. In total we recorded 1886 plants.

It was estimated that a 3 cumec flow would change the water level by more than 20 but less than 30 cm throughout the gorge. This level is consistent between the basins and the narrower reaches. We have selected the midpoint at 25 cm for data analysis. We have assumed that the 2.5 cumec flow would change the water by about 10 cm less than the 3 cumec flow; ie about 1/3 of the change between the 1.5 and the 3 cumec flow. So we have selected 15 cm for data analysis.

The threatened flora species that occur within the gorge are listed in the table below. The table indicates the percentage of plants inundated in Reaches 1 to 4 for a 3 cumec and 2.5 cumec flow (options 1 and 2) and in Reaches 1 and 4 for a 3 cumec and 2.5 cumec flow (options 3 and 4). In options 3 and 4 no inundation is proposed in Reaches 2 and 3 where the proposal is for a 0.5 cumec flow.

Reach 1 and 4	**3 cumec**	**2.5 cumec**	**Total # plants recorded in reaches 1,2,3,4.**
Scientific Name	**% inundated**	**% inundated**	
Alternanthera denticulata	22 - 12	14 - 8	524
Centipeda cunninghamii	25 - 0	25 - 0	4
Lycopus australis	100 - 92	100 - 92	13
Lythrum salicaria	80 - 55	71 - 53	184
Mentha australis	7 - 7	4 - 4	180
Persicaria decipiens	97 - 97	86 - 86	134
Persicaria subsessilis	50 - 40	38 - 32	348
Callitris oblonga subsp. *oblonga*	0	0	16
Centipeda cunninghamii	0	0	3
Doodia caudata	0	0	33
Epacris exserta	0	0	32
Hovea tasmanica	0	0	6
Prostanthera rotundifolia	0	0	191
Ranunculus sessiliflorus var. sessiliflorus	0	0	200
Spyridium vexilliferum var. *vexilliferum*	0	0	18
Total number	597	469	1886

For most species affected by a change in flow, the largest portion of the loss is incurred by the 2.5 cumec flow with a relatively small additional increment lost to the 3 cumec flow. Three species, *Lycopus australis* (92), *Persicaria decipiens (86),* and *Lythrum salicaria* (53) incur more than 50 % loss to any modified flow option. These impacts would be considered to be significant losses in the context of local populations and the conservation status of these endangered and vulnerable species.

It is likely that a permanent change to the environmental flow would eventually result in the re establishment of plants near the new water level. The potential for this to occur is evident in the distribution of *Lythrum, Lycopus* and both *Persicaria* species. A significant portion of each of these species occurs at water level and are assumed to have established since the application of the 1.5 cumec flow in 2003. The production of seed locally should be sufficient to provide for the regeneration of these species at the new water level.

A reduction in flow in Reaches 2 and 3, to provide water to the Duck Reach Power Station, results in a significant drop in the water level. We estimated this to be in the order of 30-60 cm depending on the cross section of the channel. It was evident that the 0.5 cumec flow exposed a considerable area of habitat that is suited to the species affected by the environmental flow options. As this habitat currently exists within the river, some 30-60 cm below the water level, it is a sedimentary environment characterised by the accumulation of silt deposited on the flood tail and organic matter. Although the sediments exposed by a 0.5 cumec flow would be scoured by flood flows, the remaining substrate would be little different from that currently

occupied by these plants. As such it is probable that this new habitat would be colonised by these species.

The instatement of a 0.5 cumec flow would add a dimension of spatial flow variability that is not currently present in the Cataract gorge. This spatial dimension is likely to result in more rather less habitat suitable for these species simply due to the exposure of more river bed. The impact of drought as a result of the 0.5 cumec flow is difficult to determine. However, the establishment of healthy mature plants of most species up to 2 m above the 1.5 cumec flow, throughout the gorge, suggests that precipitation and inflows are adequate to sustain them.

Willow, blackberry and gorse are declared weeds that appear to invade open rocky habitat within the flood zone. Extended periods of low flow, due to the current environmental flow release and extended drought may have favoured weed establishment in the river channel. However, the presence of patches of old infestations above the general flow level is the main determinant of the rate of invasion as they provide the propagules.

Willow has proven to be the most invasive while blackberry and gorse appear to be kept in check by flood flows. Where willow occurs as scattered plants, control is possible by herbicide stem injection.

Conclusion and recommendations:

1. The 2.5 cumec flow is estimated to inundate marginally fewer plants than the 3 cumec flow.
2. Plants of all species except *Lycopus australis* are likely to re establish near the water level of either the 2.5 or 3 cumec flow (options 1 and 2).
3. If the flow rate is increased *Lycopus australis* should be collected and reintroduced to suitable habitat.
4. All of the potential losses due to inundation and the collection of *Lycopus australis* would require a Permit under the *Threatened Species Protection Act 1999*.
5. No impact is anticipated on species listed under the EPBC and so a referral under this Act is not necessary.
6. 0.5 cumecs in Reaches 2-3 adds spatial variability that could provide more habitat and may result in more plants.
7. Inundation of willows may result in some willow deaths and flood debris.
8. All weeds will continue to establish between the environmental flow and flood flow levels.
9. Smaller willows above the flow should be controlled with poison.

ACKNOWLEDGMENTS

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Report: Philip Barker

GIS: Susan Jungalwalla

CONTENTS

1. INTRODUCTION

1.1 BACKGROUND AND AIMS

A number of stakeholder interests including water quality, visual appearance and recreation have been represented to Hydro Tasmania with a desire to increase the environmental flow in Cataract Gorge. In response to these representations Hydro Tasmania is considering options for potentially changing the environmental flow released from the Trevallyn Dam into Cataract Gorge. The current flow is 1.5 cumecs. A survey design to determine the potential impacts on threatened flora values within the gorge was developed and approved by Hydro Tasmania.

The aim of the survey was to determine the location and extent of threatened flora species within the impact range of 3 different options for flows that may be implemented within the gorge.

The flow options are:

5. 3 cumecs throughout the gorge
6. 2.5 cumecs throughout the gorge
7. 0.5 cumecs in reaches 2 and 3 and 3 cumecs in reaches 1 and 4
8. 0.5 cumecs in reaches 2 and 3 and 2.5 cumecs in reaches 1 and 4

The third and fourth options include considering the impact of reducing flow to 0.5 cumecs in Reaches 2 and 3 of the gorge if the Duck Reach hydro electric scheme were to be recommissioned.

Finally the invasion of Declared weeds within the flood zone of the gorge was considered due to a concern that some woody weeds are invading the gorge; particularly willow.

A survey was initially undertaken in October 2009, however, severe floods in August 2009 defoliated most of the vegetation and identification of threatened flora was not possible. As a result, the study area was resurveyed in April 2010 in conjunction with a series of trial flow releases (0.5 and 3.0 cumecs). Regrowth over the summer was spectacular.

1.2 THE STUDY AREA

The study area is the lower South Esk River within the Cataract Gorge. The gorge is located between the Trevallyn Dam and the estuary of the Tamar River. The total length of the study area is about 5 km and it is divided into Reaches 1-5 from the dam to the estuary (Figure 1). Reach 5 is tidal.

The dam was commissioned in the 1950's and a base flow of 0.425 cumecs was maintained below the dam until it was increased to an environmental flow of 1.5 cumecs in 2003. The flow was raised at that time in part to provide for the needs of a rare aquatic snail. A number of small weirs exist at the Duck Reach Power Station inlet (Deadmans Hollow), downstream of Duck Reach (Reach 4) and at First Basin. These weirs have the effect of creating small pools behind them that permanently inundated the "riparian" habitat. As a result of the dam and weirs and the consequently altered flow, riparian and instream plant habitat within Cataract Gorge is now highly modified.

The flood flows and environmental flow regime have been measured and are represented in Figure 2 for First Basin. These diagrams indicate that the environmental flow occurs between 60-90 % of the time in winter versus summer and that flood flows exceeding 100 cumecs occur about 5% of the time. The diagrams

also illustrates that the environmental flow or less would have occurred naturally for about 5% of the time overall and 10% through summer. The majority of dam spills occur during the winter.

The geology of the Gorge is Jurassic dolerite. For most of its length, flow through the gorge is bedrock controlled and is a sediment throughput zone. The dam has modified the supply of sediment and restricted it to mud and suspended clay. Colluvium, including boulder, gravel and sand, continues to be input from the walls of the gorge and the local catchment supplies small amounts of fluvial sediments.

At and above the current flow height, mixed sediments (including gravel, sand and mud that normally form the substrates that riparian and semi aquatic plants grow in) are now restricted to a few protected sites. The loss of sediments from the system is evident in the armouring of the bed where it is exposed below the dam wall and scour pools that are empty of sand and gravel.

The study area includes the channel and riparian zone on both sides of the river. However, there is no riparian zone between the "river bank" and major flood level but rather a broad, generally unvegetated area characterised by large colluvial boulders and extensive bedrock slabs. The river bank, or edge of the main channel, is smaller boulder and bedrock slabs.

The study area has an altitude range from 0 m at the estuary to 100 m at the base of the dam wall. It is situated in the moist, subhumid cool climatic zone and the rainfall is in the 600 to 800 mm per annum zone.

Flora surveys of the gorge were undertaken by Ratkowski *et al* 1993 and North Barker in 2001, the year before the increase in base flow. An extensive survey was also undertaken by DPIPWE just weeks before the current work in 2010. No previous surveys recorded the height above the environmental flow.

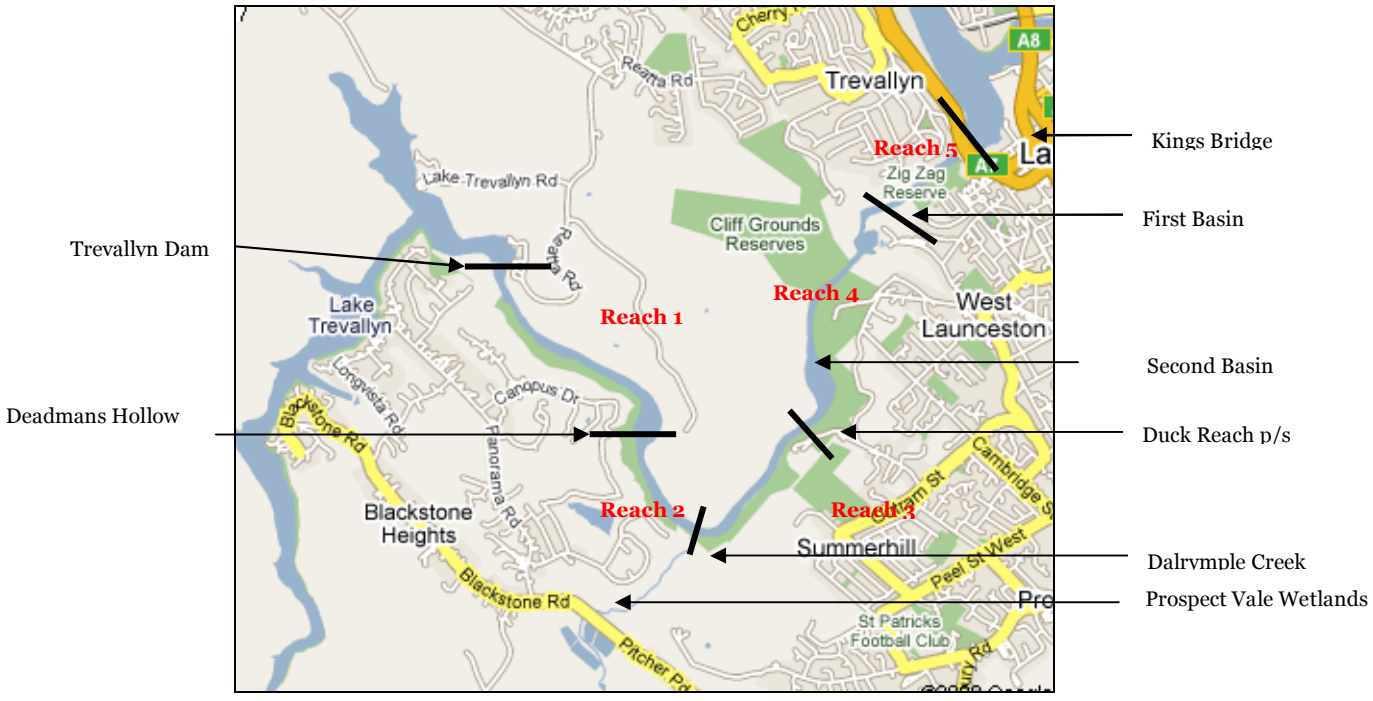
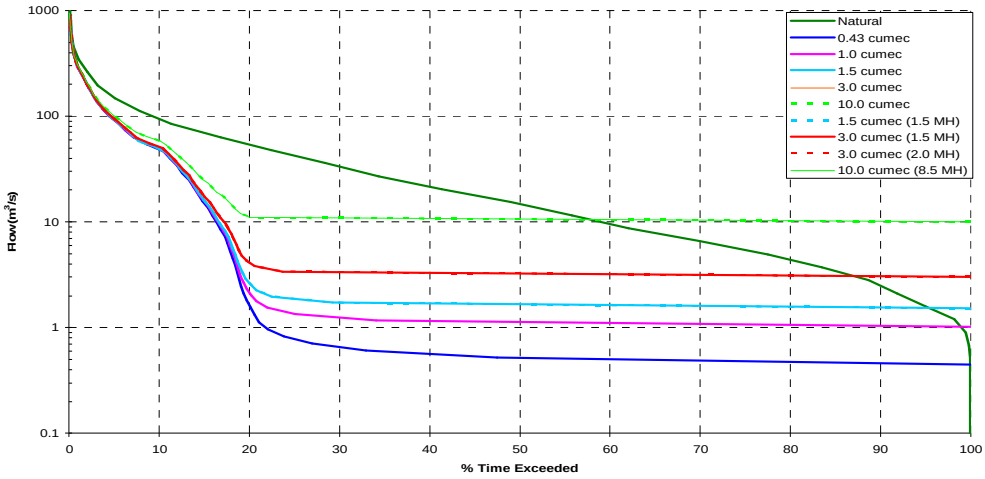
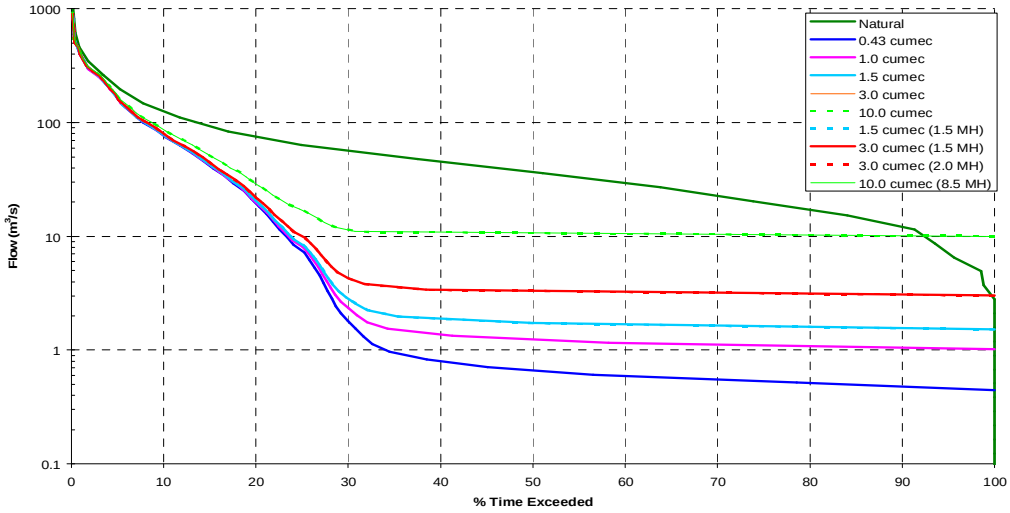


Figure 1 – The extent of the study area.

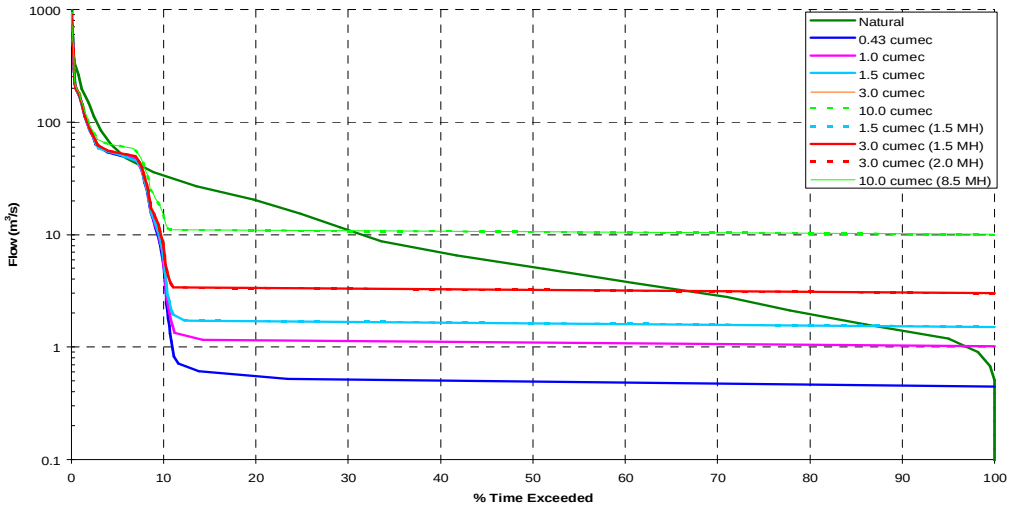
(from Hydro Tasmania 2009)



Annual flow duration



Winter flow duration



Summer flow duration

Figure 2 – Seasonal flow duration curves for First Basin.

(from Hydro Tasmania 2009)

2. METHOD - THREATENED FLORA AND WEED ASSESSMENT

2.1 BACKGROUND RESEARCH

The following sources were used for biological records from the region:

- Natural Values Atlas [1] - This database includes records from previous surveys;
- Tasveg Digital Data – Tasveg 2.0 as of February 2010- This is a vegetation layer; and,
- Listing Statements and/or DPIPWE note sheets for all flora previously recorded in the gorge.

2.2 LIMITATIONS

It should be noted that no plant survey can guarantee that all vascular flora will be recorded during a single visit due to the limitations of the sampling technique, seasonal and annual variation in abundance and the possible absence of fertile material for identification. Additional species are likely to occur which may be recorded by repeated visits over several years and in different seasons. However, all significant species known to occur in the vicinity (5 km radius) of the study area were considered in this report. Non threatened flora were not recorded. Non declared weeds were not recorded.

The flora surveys were undertaken in October 2009 and April and May 2010.

Note that the number of NVA records reported in Table 1 refers only to those with precision of 500 m or better. Furthermore, it should be noted that within the number reported in some instances many are either very close or are in effect duplicates. As such the NVA records should be considered to be the number of observations and not the number of populations, for example there are 97 records of *Doodia caudata* with better than 500 m precision but the listing statement records only 4 locations.

The number of plants reported is a sample of those present in the gorge that reflects the survey coverage. River banks not surveyed are illustrated in Figure 4d. The coverage is in the order of 60% of the river bank. However, there are extensive sections of habitat that are unsuitable adjacent to weirs. In the order of 80% of suitable habitat was surveyed.

Limitations of GPS accuracy have resulted in some mapped data being imprecise. However, the corresponding height above flow level and estimate of numbers is correct for these records.

2.3 ASSESSMENT OF CONSERVATION SIGNIFICANCE

Methods of assessing conservation significance of flora have been developed and are detailed in Appendix 1. The conservation significance of species is determined at a state and federal level by legislation (Tasmanian *Threatened Species Protection Act 1995*[2] (TSPA) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA)), the implications of which are considered below in for relevant species.

[1] GIS Unit, DPIPWE

[2] This report addressed Threatened species as per the list on the Tasmanian Legislative database www.thelaw.tas.gov.au.

2.4 Survey

Four surveys were undertaken with the aim of determining the location and abundance of threatened flora species that may be affected by changes to the environmental flow (See Appendix 5 for extent of survey). The distribution of declared weeds within the flood channel is also considered. Survey 1 was undertaken in October 2009 after a large flood in August. The flood consisted over a spill over more than 1000 cumecs in August and 6 others of more than 300 cumecs between July and September. Survey 2 was undertaken in April 2010 with a flow of 1.5 cumecs; survey 3 was undertaken in April 2010 with a flow rate of 3 cumecs and survey 4 was completed in May with a flow rate of 0.5 cumecs.

Survey 1. October 2009, flow 1.5 cumecs: The locations of all previous records of threatened flora in Reaches 1 to 4 were visited.

The 2009 survey determined which threatened flora species are unlikely to be affected by any of the proposed flow options. These are species that normally occur well above the existing flow and are often above flood flows as well. As such in the second survey in April 2010 we were able to focus on the species that occur closer to the rivers edge.

Survey 2. April 2010, flow 1.5 cumecs: The locations of all previous records of threatened flora in Reaches 1 to 4 were visited. Between known records of species the survey route meandered from the left to right bank to maximise the traverse of what appeared to be suitable habitat. As such the survey is a sample of the habitat. In the order of 60% of the length of both banks was surveyed. The largest omission was the banks of the pool behind the weir at Deadmans Hollow (Reach 1) as this was inaccessible. It is also likely to have fewer threatened flora than other sections due to presence of the weir pool which has flooded suitable habitat.

The location of each species encountered was recorded by GPS. The height of the plant(s) above the 1.5 cumec flow was estimated to within 10 cm and the number of plants at that height also recorded.

In each Reach a number of plants and other fixed objects were flagged and the height above the 1.5 cumec flow measured. This allowed us to estimate the changes in flow height at 0.5, 2.5 and 3 cumecs.

Survey 3. April 2010, flow 3 cumecs: During the release period we revisited flagged plants and other features in each Reach and estimated the change in the height of the flow. One feature was the gauge below Trevallyn Dam.

Survey 4. May 2010, flow 0.5 cumecs: We visited Reaches 2-3 to evaluate potential impacts if flow is reduced in this section in order to provide water to the Duck Reach Power Station. Here we estimated the fall in the level of the flow and observed the nature of the habitat that was exposed by the reduced flow.

Botanical nomenclature follows the current Census of Tasmanian plants [3].

Declared Weeds

The location and descriptions of extent of all weeds listed on the Tasmanian *Weed Management Act 1999* were recorded using GPS.

2.5 Data analysis

All data were entered into a spread sheet. The data were sorted by height above the 1.5 cumec flow. The data were classed into three classes. (see results)

Class 1. Those plants less than 15 cm above 1.5 cumecs. (inundated by 2.5 cumec flow)

[3] Buchanan, 2009

Class 2. Those plants 15 - 25 cm above 1.5 cumecs. (inundated by 3 cumec flow)

Class 3. Those plants greater than 25 cm above 1.5 cumecs. (above 3 cumec flow)

3. RESULTS AND DISCUSSION

3.1 HISTORY OF RECORDS OF THREATENED FLORA

Table 1 provides habitat details and notes on the susceptibility of each habitat to changes in flow for all flora species previously collected from within 50m of the river in Reaches 1-5 (Appendix 3). Note that the number of NVA records reported in Table 1 refers only to those with precision of 500 m or better. Furthermore, it should be noted that within the number reported in some instances many are either very close or are in effect duplicates. As such the NVA records should be considered to be the number of observations and not the number of populations, for example there are 97 records of *Doodia caudata* with better than 500 m precision but the listing statement records only 4 locations.

Appendix 3 does not include the recent DPIPWE (2010) data other than the previously unrecorded *Lycopus australis*, simply because it was collected so close in time to the current study that it doesn't add value to the historic context. Plates 1-10 in Appendix 4 illustrate the range of habitats present within Cataract Gorge and some of the substrate characteristics and species.

Eleven species in Table 1 have been coloured yellow to indicate that at least part of their habitat is less than one metre above the current flow level. Those that only occur above 1 m are not coloured and presumably will not be affected by any future environmental flow options. Table 1 also indicates that those species within the inundation area often occur in sediment habitats; although some have been recorded in rock crevices and between boulders.

It appears that an organic / sandy mud substrate at water level is susceptible to loss during major flood flows, such as August 2009, and that it reforms in the absence of high flows. This dynamism is typical in the disturbance regime of rivers, however, the preference for this habitat by some species eg *Lythrum salicaria, Lycopus australis* and *Persicaria decipiens* renders them at higher risk of significant reduction in numbers due to a broad scale loss of their habitat. That is, widely distributed plants are more likely to persist on habitat remnants that remain after flood disturbance and are then able to recolonise between major floods.

The distribution of the previous records of *P. subsessilis* and *Alternanthera denticulata* and the description of abundance included in North Barker (2001) suggests that they were sparsely distributed. A spill of 450 cumecs occurred in January preceding this survey. In comparison to the 1000 cumecs and 6 other spills over 300 cumecs between July and October 2010 it is unlikely to have had the same defoliating impact on the plants and so the records probably provide a reasonable impression of abundance at the time.

Lythrum salicaria, *Mentha australis* and *Xerochrysum bicolor* each have only one record more recent than 2001 and may have been very rare in the gorge, at least since sometime after the construction of the dam, and may have always been rare.

Utricularia australis and *Isoetes elatior* are true aquatics and each have only one or two records, having not been recorded in the gorge for more than 160 years. It is possible that their habitats were dependent on pre dam exposure to very low summer flows in shallow water.

Appendix 3 indicates a large number of records of plants from the gorge over a very long period of time. Some are now considered to be extinct i.e. not recorded for more than 50 years, despite searches. These include *Boronia gunnii*, *Xerochrysum*

bicolor, Utricularia australis and Isoetes elatior. The probability of finding these plants is low, although from time to time species are rediscovered following some type of regenerative stimulus or recolonisation or may simply have been overlooked due to their rarity. For example, while *Lycopus australis* had not previously been recorded in the gorge prior to 2010, it has, almost certainly, always been present.

The terrestrial, semi aquatic and aquatic plants have different ecological needs. The habitats of each occur in a range of locations in respect to flow height and habitat quality eg rock crevice or sediment. Each species varies in its abundance. As such the response of each species to an increase or decrease in flow is likely to be different. Therefore the only statement that can easily be justified is the quantum of impact of each flow option due to permanent inundation.

Table 1: Flora species listed on the TSPA (endangered - e, vulnerable – v, rare-r, and EPBCA (Endangered – E and Vulnerable V- V) previously recorded within 50 m of the river channel, height above 1.5 cumec flow, substrate of habitat and context.

Species name	TSPA/EPBCA	Height (m)	Substrate	Context
Alternanthera denticulata lesser joyweed	e	0 – 1.0	Boulder crevice and probably gravel and sand	Damp grassland, swamp forest and boulder gaps in river channels. Nine Tasmanian locations two in reserves. 524 plants recorded along Reaches 1 – 4.
Arthropodium strictum chocolate lily	r	> 10	Soil	Dry forest and woodland on dolerite. Not a riparian species and occurs above the flood level.
Boronia gunnii river boronia	v V	1-5	Boulder, gravel and sand	Riparian scrubs in flood zone. Considered to be extinct from the gorge, last record 1961.
Callitris oblonga ssp. *oblonga* South Esk pine	v E	6-7	Boulder, gravel and sand	Riparian forests generally on flood plain above minor flood level (pers ob) also in rocky fire refuges. Known from two locations in the gorge both above environmental flow options.
Centipeda cunninghamii Common sneezeweed	r	0-5	Boulder, gravel and sand	Known from a wide variety of soil types in soaks subject to flooding and at the margins of drying lagoons and wetlands. No NVA records within 50 m of river but reference made to occurrence along the river in Third Basin by Olsen in 1937. Recorded by DPIPWE in 2010. 4 plants below the diversion weir at beginning of Reach 2. Four additional imprecise records.
Cynoglossum australe coast houndstongue	r	> 10	soil	Generally a species of sand and sand stone but occasionally known from dry dolerite sites. Not a riparian species and restricted to slopes of the gorge above flood level.

Species name	TSPA/EPBCA	Height (m)	Substrate	Context
Discaria pubescens spiky anchorplant	e	<1	Boulder gravel and sand	Occurs on flood plains and in minor flood channels in gravel and boulder deposits. About 12 Tasmanian records. Only one previous record (Burbury 1911) from First Basin but has not been relocated. Potentially within the range of environmental flow options. No records from this survey.
Doodia caudata small raspfern	e	> 5	Bedrock crevice	This fern was recorded from one location in Reach 2 in a rock crevice above the range of environmental flow options (North 2001). It has 97 NVA records (3 in reserves) but is recorded as occurring at only 4 places in the DPIPWE Listing Statement 2010.
Epacris exserta south esk heath	e Pen	3-10	Boulder, gravel and sand	A riparian species that normally occurs in river bank, heaths and forest. In Cataract Gorge this species occurs above the range of environmental flow options.
Gyrostemon thesioides broom wheelfruit	r	> 10	Soil	Occurs on dry dolerite slopes below *Allocasuarina* forest. This habitat is above the flood zone.
Hovea tasmanica rockfield purplepea	r	> 10	Colluvium and soil	Occurs on dry dolerite slopes and colluvial talus slopes. This habitat is above the flood zone.
Isoetes elatior tall quillwort	r	- 0.1	Water, mud, silt and gravel	An aquatic fern ally with about 25 Tasmanian records. One record from below First Basin in 1842. Grows in the silt and mud on the bed of rivers. The impact of the dam on sediments would not favour the persistence of this species. If still present the habitat would be rare and the species would be unlikely to "find" suitable habitat depth and substrate if the environmental flow were raised significantly.
Lycopus australis	e	< 1		Not previously recorded in the gorge until 2010. Eight populations in northern Tasmania support in the order of 1500 plants (Listing Statement DPIPWE 2010). Five other records elsewhere in Tasmania presumed extinct. Thirteen plants recorded in the gorge in March 2010 by Richard Schahinger (DPIPWE).

Species name	TSPA/EPBCA	Height (m)	Substrate	Context
Lythrum salicaria purple loosestrife	v	< 1	Boulder, gravel and sand	The habitat is swamps, stream banks. 52 NVA records (4 reserved) predominantly in the central north but otherwise widespread in the east of Tasmania. The species has the ecological potential to colonise new suitable habitat. Some of the habitat is within the range of environmental flow options. 184 plants recorded in Reaches 2-4.
Mentha australis river mint	e	<1	Boulder, gravel and sand	Occurs in riparian habitats in the ecotone between the channel and thicker vegetation. Known from 5 locations of which it is presumed to be extinct at two. This survey 180 sq m occupied in Reaches 1-4. Most of its habitat is above the range of environmental flow options.
Persicaria decipiens slenderwaterpepper	v	< 1	Boulder, gravel and sand and organic mat.	Occurs in riparian and swampy habitat with about 18 Tasmania records. Recorded once from First Basin in 1993. This study recorded 134 plants in Reach 4.
Persicaria subsessilis bristly waterpepper	e	< 1	Boulder gravel and sand	Occurs in swamp forest and rocky wet places. Three Tasmanian locations. This study recorded 348 plants in Reaches 2-4.
Poa mollis soft tussockgrass	r	> 10	soil	Rocky dolerite soils. Historic records and its habitat are above the flood level.
Prostanthera rotundifolia roundleaf mintbush	v	> 5	Colluvium and soil	Rocky dolerite soils and riparian scrubs. Historic records and its habitat are above the range of environmental flow options.
Ranunculus sessiliflorus var. *sessiliflorus* rockplate buttercup	r	> 10	Soil and rock plate	An annual plant of dolerite soils. Not riparian. Historic records and its habitat are above the flood level..
Spyridium eriocephalum heath dustymiller	e	> 5	Soil and gravel	Only known from one population near Hobart on mudstone. Cataract Gorge population now presumed extinct. If present its habitat is likely to be above the range of environmental flow options.

Species name	TSPA/EPBCA	Height (m)	Substrate	Context
Spyridium vexilliferum var. *vexilliferum* helicopter bush	r	> 5	Boulder, gravel and sand.	Dry granite and dolerite soils in heathy vegetation. Common on granite near Coles Bay, also along the South Esk River as well as isolated populations in the Northern Midlands and North west coast near Couta Rocks. Found in association with *Epacris exserta* and *Callitris oblonga* in First Basin and Second Basin. Its habitat is likely to be above the range of environmental flow options. Also known from east coast, midlands and northwest.
Utricularia australis yellow bladderwort	r	0	Water, mud, sand silt and gravel	An aquatic plant of marshes in stationary or slow flowing water. Three tasmanian locations. Only one previous record from 1842 from First Basin. Potential habitat is very rare and restricted to the backwaters of First Basin. If still present the species would be unlikely to "find" suitable habitat depth and substrate if the environmental flow were raised significantly.
Velleia paradoxa spur velleia	v	> 10	soil	Dry dolerite soils in grassy woodland. Its habitat is above the flood level.
Veronica plebeia Trailing speedwell	r	> 5	Soil	Dolerite soils in forest and woodland. Its habitat is above the flood level.
Xerochrysum bicolor eastcoast everlasting	r	0	Gravel, sand and silt.	Swampy riparian vegetation. About 50 locations in Tasmania. One record from 1937 in First Basin. Potential habitat is very rare and probably restricted to the backwaters of First Basin. Potential habitat may be within the range of environmental flow options.

3.2 Impact of inundation

The threatened flora species that were recorded within the gorge are listed in Table 2. The table indicates the number of plants recorded below the inundation levels of 2.5 and 3 cumecs. The number of plants recorded is a sample that reflects the survey coverage and so represents a minimum. Appendix 5 (Figures 4a-d) illustrate the distribution of records collected within the current surveys extent. The records are coded to indicate the different species and the three inundation classes.

Non threatened flora were not recorded. A number of none threatened species do occur within the proposed inundation area. Any loss of these plants is highly unlikely to indirectly effect the outcome for the threatened flora. This is because the plants are generally sparse herbaceous plants or graminoids which do not have a major role in

bank stability because the effected environment is predominantly boulder and is well below the riparian vegetation. Where the graminoids dominate the threatened flora are sparse to absent.

***Surveys 1 and 2*. Baseline (1.5 cumecs) October 2009/April 2010.**

The baseline survey recorded 13 threatened flora species between the water level at 1.5 cumecs and the riparian zone above flood level. In total 1882 plants were recorded. This includes an assumption of 1 plant per square m in the area occupied by *Mentha australis* and 13 *Lycopus australis* a and 3 *Centipeda cunninghamii* recorded by DPIPWE. The 1 plant per sq m assumption is arbitrary and based on the likelihood that each patch supports more than 1 plant.

***Survey 3*. Inundation by 3 and 2.5 cumec flows (Options 1 and 2) April 2010**

Observations of flagged plants and features indicate that a 3 cumec flow would change the water level by more than 20 but less than 30 cm throughout the gorge. This level is consistent between the basins and the narrower reaches. We have selected the midpoint at 25 cm for data analysis. Within the inundated area of the 3 cumec flow 597 plants of seven threatened flora species exist (Table 2).

We have estimated that the 2.5 cumec flow would reduce the water level by about 10 cm compared to the 3 cumec flow; ie about 1/3 of the change between the 1.5 and the 3 cumec flow. So we have selected 15 cm for data analysis. Within the inundated area of the 2.5 cumec flow 469 plants of six threatened flora species exist (Table 2).

Both measures of change reflect the precision of our measure of the height that plants are above water level and the estimated change in flow height.

Table 3 indicates the percentage of the total number of plants recorded that will be inundated by the various flow options.

For most species, the largest portion of the loss is incurred by the 2.5 cumec flow (option 2) with a relatively small additional increment lost to the 3 cumec flow (option 1) (Table 3). Three species, *Lycopus australis* (92), *Persicaria decipiens (86),* and *Lythrum salicaria* (53) incur more than 50 % loss to any modified flow option. These impacts would be considered to be significant losses in the context of local populations and the conservation status of these endangered and vulnerable species (Table 4).

The population of *Lycopus australis* known in the gorge is limited to 13 plants. Twelve of the 13 plants would be inundated by options 3 or 4 and all by options 1 or 2. If only one remained under options 3 or 4 there is an increased risk of local extinction.

For the other species, it is more likely that a permanent change to the environmental flow would eventually result in the re establishment of plants near the new water level. The potential for this to occur is evident in the distribution of *Lythrum,* and both *Persicaria* species. A significant portion of each of these species occurs near water level and are assumed to have established since the application of the 1.5 cumec flow in 2003. The production of seed locally should be sufficient to provide for the regeneration of these species at the new water level.

3.3 Impact of reduced flow between Deadmans Hollow and Duck Reach

***Survey 4*. Reduction of flow to 0.5 cumecs in Reaches 2 and 3 – Options 3 and 4.**

The recommissioning of the Duck Reach Power Station would result in a reduction in the water flow through Reaches 2 and 3. The reduced flow would be in the order of

0.5 cumecs. Water would continue to enter Reach 3 from the waste water released into Dalrymple Creek which enters the gorge below the Duck Reach intake.

If the Duck Reach Power Station is recommissioned then the 2.5 or 3 cumec flows will be restricted to Reaches 1 and 4 (options 3 and 4). In addition to plants above the 3 cumec inundation level in Reaches 1 and 4 all plants in Reaches 2 and 3 would not be inundated.

Five species occur along Reaches 2 and 3 that have been recorded at or near the current flow level:

1. *Alternanthera denticulata*
2. *Centipeda cunninghamii*
3. *Lycopus australis*
4. *Lythrum salicaria*
5. *Persicaria subsessilis*

A reduction in flow in Reaches 2 and 3 results in a significant drop in the water level. We estimated this to be in the order of 30-60 cm depending on the cross section of the channel.

In the event that the environmental flow was reduced to 0.5 cumecs, other than the input from Dalrymple Creek, plants above this level would be dependent upon water from rain and spills over Trevallyn dam. While these spills occur primarily in winter, they also occur sporadically in the summer months. The existing distribution of many plants away from the current flow suggests that plants already survive on precipitation and spills for their water needs.

It was evident that the 0.5 cumec flow exposed a considerable area of habitat that is suited to species affected by the environmental flow options. As habitat currently exists within the river, some 30- 60 cm below the water level, it is a sedimentary environment characterised by the accumulation of silt deposited on the flood tail and organic matter. Although the sediments exposed by a 0.5 cumec flow would be scoured by flood flows, the remaining substrate would be little different from that currently occupied by these plants. As such, it is probable that this new habitat would be colonised if flows were reduced in Reaches 2 and 3.

The instatement of a 0.5 cumec flow along these Reaches would add a dimension of spatial flow variability that is not currently present in the Cataract Gorge. This spatial dimension is likely to result in more habitat; simply due to the exposure of more river bed. The increase in habitat area is likely to be suitable for most of the species that are potentially inundated in Reaches 1 and 4 and in particular the five species listed above.

Table 2: The threatened flora species that were recorded within each Reach showing the number of plants recorded below the inundation levels of 2.5 (0-15 cm) and 3 cumecs 15-25 cm) and those not predicted to be inundated > 25 cm..

Reach	**1**				**2**				**3**				**4**				
Inundation class	0 - 15	15 - 25	> 25	**Total**	0 - 15	15 - 25	> 25	**Total**	0 - 15	15 - 25	> 25	**Total**	0 - 15	15 - 25	> 25	**Total**	**Grand Total**
Scientific name																	
Alternanthera denticulata	22	3	81	**106**	20	12	66	**98**	13	12	149	**174**	16	19	111	**146**	**524**
Callitris oblonga subsp. *oblonga*															16	**16**	**16**
Centipeda cunninghamii					1		3	**3**									**4**
Doodia caudata						8	5	**13**		5	15	**20**					**33**
Epacris exserta			4	**4**							1	**1**			27	**27**	**32**
Hovea tasmanica															6	**6**	**6**
Lycopus australis	12			**12**					1			**1**					**13**
Lythrum salicaria					30		37	**67**	4	1	6	**11**	97	4	5	**106**	**184**
Mentha australis	8		57	**65**			3	**3**			3	**3**		5	104	**109**	**180**
Persicaria decipiens													115	15	4	**134**	**134**
Persicaria subsessilis					10	5	28	**43**	9	13	54	**76**	112	26	91	**229**	**348**
Prostanthera rotundifolia			23	**23**											168	**168**	**191**
Ranunculus sessiliflorus var. *sessiliflorus*							200	**200**									**200**
Spyridium vexilliferum var. *vexilliferum*															18	**18**	**18**
Grand Total	42	3	165	**210**	60	25	339	**424**	27	31	228	**286**	340	69	550	**959**	**1882**

Table 3. The percentage of plants inundated in Reaches 1 to 4 for a 3 cumec and 2.5 cumec flow (options 1 and 2) and in Reaches 1 and 4 for a 3 cumec and 2.5 cumec flow (options 3 and 4).

Reach 1 and 4	**3 cumec**	**2.5 cumec**	**Total # plants recorded in reaches 1,2,3,4.**
Scientific Name	**% inundated**	**% inundated**	
Alternanthera denticulata	22 - 12	14 - 8	524
Centipeda cunninghamii	25 - 0	25 - 0	4
Lycopus australis	100 - 92	100 - 92	13
Lythrum salicaria	80 - 55	71 - 53	184
Mentha australis	7 - 7	4 - 4	180
Persicaria decipiens	97 - 97	86 - 86	134
Persicaria subsessilis	50 - 40	38 - 32	348
Total number	597	469	1383

3.4 CONTEXT OF SPECIES THAT WILL BE INUNDATED

Table 1 describes the habitat for each species that will be inundated by the environmental flow options and the number of populations recorded elsewhere in Tasmania. The Tasmanian distributions (note the data limitations on the map) of those species affected by inundation are illustrated in Figure 3.

In combination, the number of plants known in the gorge, the number of plants proposed to be inundated, and the population statistics of the broader Tasmanian distributions, demonstrate the relative impact on each species at a state wide scale. Abundance data are limited to the survey sample in the gorge and are not available for all other Tasmanian locations for all species and so a complete quantification of the impact is not possible. However, Table 4 provides a tabulated summary of the population data for each affected species. All species have one or more populations reserved (Figure 3).

Table 4. A summary of population (pops) data in Tasmania, the number of plants recorded in Cataract Gorge and the estimated loss for a 3 cumec and 2.5 flow in options 1 and 2 and options 3 and 4.

Scientific Name	NVA records[4]	# Pops[5]	# Pops Reserved	Population size range and max estimate	Cataract Gorge[6]	# plants lost to options 1-2, 3-4.
Alternanthera denticulata	9	5	2	2->1500, 2560	>1500	117 -71 60 - 38
Centipeda cunninghamii	9	5	2	4 - 50 ?	4	1-1 0-0
Lycopus australis	33	7	2	10-600, 1680	13	13-13 12-12
Lythrum salicaria	52	8[7]	2	?	184	136-131 101 - 97
Mentha australis	10	5	1	120000 m^2 2-40 patches	180 m^2 40 patches	8-13 m^2 2 patches
Persicaria decipiens	87	14[8]	2	?	134	130 - 115
Persicaria subsessilis	4	3	2	10-1000, 2130	348	175 - 131 138 - 112

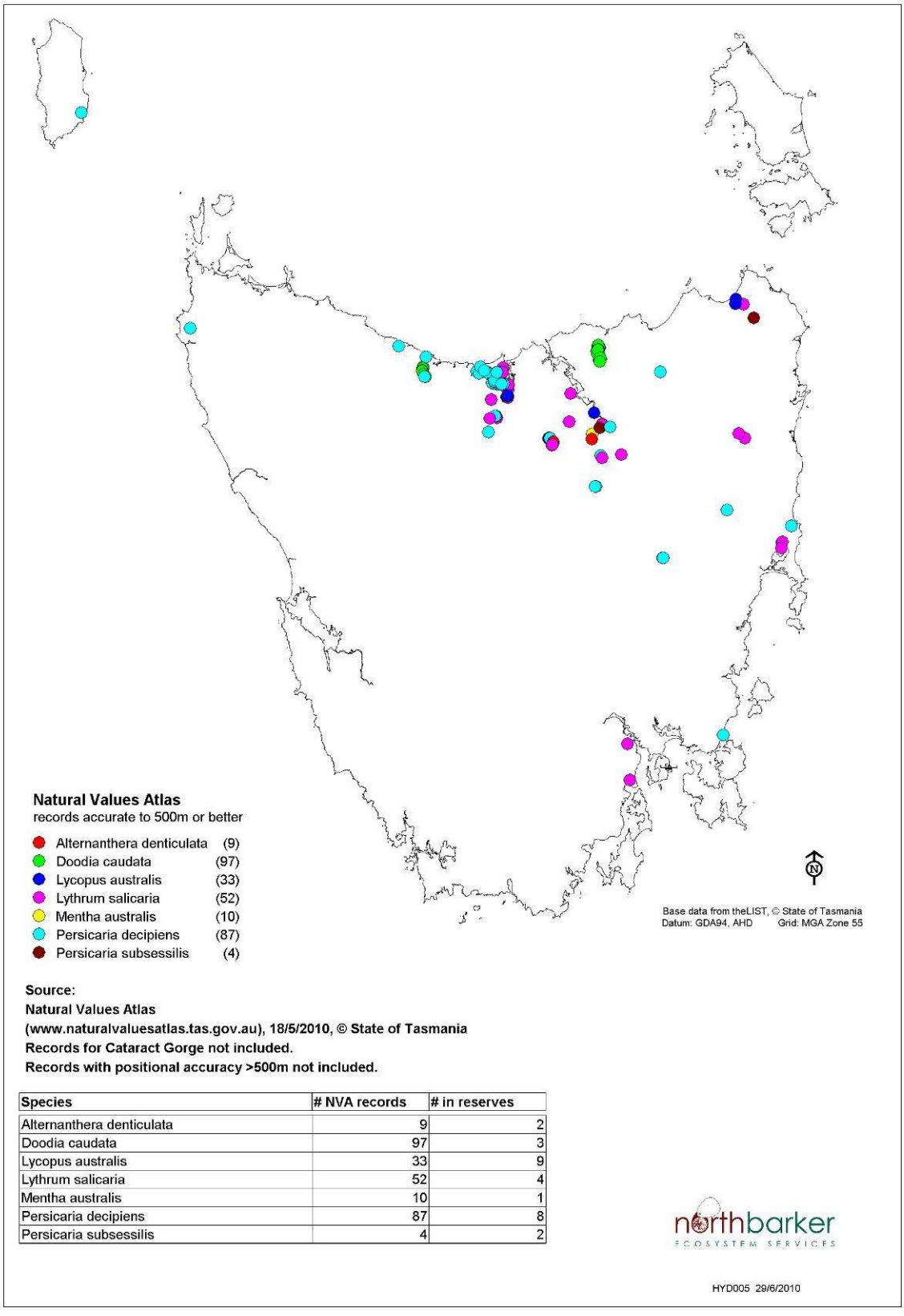
[4] NVA records with precision 500 m or better.

[5] Number of populations reported as extant in DPIPWE Listing Statements.

[6] Max number from Threatened Species Section and North Barker Surveys 2010.

[7] Distinct locations mapped in DPIPWE note sheets.

[8] Distinct locations



Species	# NVA records	# in reserves
Alternanthera denticulata	9	2
Doodia caudata	97	3
Lycopus australis	33	9
Lythrum salicaria	52	4
Mentha australis	10	1
Persicaria decipiens	87	8
Persicaria subsessilis	4	2

Figure 3 – The Tasmanian distribution of species affected by inundation.

3.5 Regeneration Triggers

The threatened plant species that will be inundated by any flow option have all persisted and regenerated in Cataract Gorge under the current flow and sediment regime. Nevertheless, it is worth considering if the regeneration triggers will persist if any of the options is implemented.

Vegetation communities are made up of a few to many flora species which may have different ecological attributes in terms of physical tolerances, growth forms and regeneration strategies. Clearly, successful regeneration from time to time is a prerequisite of persisting as part of a community. The triggers for germination are important in this replacement cycle.

In many examples the germination of soil or canopy stored seed is triggered by a specific event like fire or soil disturbance such as induced by floods. The disturbance induces germination by breaking a physiological dormancy which is sensitive to, for example, heat or exposure to light. For some species, there may be a need for a more complex interaction of a range of variables, for example, physiological maturation of the seed over time, low temperature stratification, light quality, mechanical or chemical scarification and more e.g. Insausti et al (1995).

In riparian and riverine habitats it is generally assumed that germination is triggered by factors associated with flood disturbance. However, even between plants existing in the same flood prone community there is experimental evidence that species differ in their germination rates under different flood periods and that some are even inhibited by flood (Pierce and King 2007). Sedimentation deposit rates can also effected germination rates.

Voesenek and Blom (1992) showed that two wetland Rumex species were characterised by spring germination, a persistent seed bank, flood tolerant seeds and multiple post flood germination cohorts. They argue that these traits are consistent with a their habitat of predictable winter floods and erratic summer floods. This is a similar flood regime to the South Esk River. However, we do not know what the ecological attributes of any of the species of interest are.

The disturbance caused by flooding often produces gaps in the vegetation and exposes soils or sediments. It is these gaps that are often colonised by regenerating plants adapted to respond to the changed conditions. Insausti et al (1995) demonstrated that for *Ambrosia tenuifolia* germination in gaps only followed adequate exposure to suitable light quality and after exposure to a specific temperature regime. Another species may respond to a different temperature signal or have no need for the light signal.

The triggers that are often associated with flood prone environments can be quite varied among co existing species. As such within the same environment species, may germinate at different times, at different rates and in response to floods of different periods.

Cataract Gorge has a highly modified sediment regime but the modified flood regime is still within the range of what might be described as normal, i.e. winter floods and occasional summer floods with considerable variation in size. The proposal is to potentially raise or reduce the base flow by a very small amount and not to change the existing flood regime. This proposal is highly unlikely to change the potential for germination of any of the plants under consideration from that which exists now.

Specific knowledge of each species germination triggers is unlikely to be able to be translated into either practical, effective or manageable flow regimes. This is simply because they are most likely to be associated with large floods or attributes that cannot be controlled in the landscape eg light quality. Notwithstanding that the Cataract Gorge is a modified environment, the flood regime should be sufficient to cause the prerequisite disturbances typical of flood related ecologies.

3.6 DECLARED WEEDS

Five weeds listed on the Tasmanian *Weed Management Act 1999* are present in the gorge. None Declared herbaceous weeds were not considered.

The weeds are:

1. *Asparagus asparagoides* (bridle creeper)
2. *Salix fragilis* (willow)
3. *Rubus fruticosus* (blackberry)
4. *Ulex europaeus* (gorse)
5. *Chrysanthemoides monilifera* (boneseed)

North Barker mapped the infestations of weeds in 2001. The extent today is essentially the same but with the addition of scattered plants that were not previously mapped. Appendix 5 indicates the current extent of declared weeds. A number of other weed species are present but other than *Crataegus monogyna* (hawthorn) none present a particular threat of permanent broad scale infestation.

Bridle creeper, blackberry, gorse and boneseed all generally occur away from the waters edge and so will not be affected by the proposal.

Willow is the main weed that is affected by the flow in the river. The largest areas of habitat that are well suited to willow are already occupied. In addition numerous small or young plants are scattered along the length of the gorge in less favourable habitat such as rock crevices.

The extended periods of low flow will tend to favour the expansion of willow and once established a willow plant is unlikely to be removed by a flood. Beyond the major infestations the control of willow scattered in the gorge is relatively straight forward. Control using stem applied glyphosate is simple and quick. Once dead, the small "saplings" would be unlikely to cause any hazard when washed through the gorge during flood.

Any change to flow within the range of the environmental flow options would not alter the infestation rate of willow significantly; simply because it involves a small area. The greatest change would be in the additional river bed habitat exposed in Reaches 2 and 3 in the reduced flow options 3 and 4.

Blackberry is less prevalent than willow reflecting that the habitat in the gorge is less conducive to this species. It is unlikely to ever infest the gorge to the same degree as willow. Any change to flow within the range of the environmental flow options would not alter the infestation rate of blackberry significantly.

Both gorse and boneseed occur beyond the range of the environmental flow options. Both require soil to establish significant infestation and so tend to be most prevalent above the flood level on the lowest slopes of the gorge. The range of these species is therefore practically unaffected by the river height.

Numerous herbaceous weeds are also present but are not considered here.

3.7 MITIGATION

The current distribution of plants at or near water level reflects the adaptation of the plants to the most recent modification to water flow, ie the 2003 instatement of a 1.5 cumecs "environmental" flow. The instatement of that flow would almost certainly have inundated plants that existed at or near the previous base flow. It is

therefore reasonable to assume that the distribution would also "adapt" to any of the proposed flow options by colonising the new habitat at the waters edge.

With the exception of *Mentha australis*, virtually every plant recorded in Survey 1 was either in flower or had flowered profusely over the summer of 2010. If flowering and the production of seed is generally successful each year I would anticipate that there would be sufficient seed to allow colonisation to occur at the new waters edge. *Mentha australis* is generally well above the inundation level.

The largest population of *Lycopus australis*, supporting 12 of 13 plants known in the gorge exists within the range of inundation of all options. If only one remains there is an increased risk of local extinction. The probability of successful recolonisation is related to the abundance of seed available and opportunities to recolonise. Clearly if all the plants of a species are inundated then both of these factors are locally eliminated.

Lycopus australis seed should therefore be collected and juveniles transplanted to a nursery to produce seed and rhizome (perenating root material). The rhizome of adults should also be collected. Once a new flow level is in place, seeds and rhizomes should be reintroduced. Two hundred rhizomes should be established in a nursery and translocated at 4 locations; two near existing locations and two additional locations. One on Reach 1 and one at First Basin. After planting any dead plants should be replaced for two years.

Where small weirs in Reach 4 are no longer of use then decommissioning them by breaching the walls would increase the area of habitat available to species affected by inundation.

Flow variability is a central plank of environmental flow considerations. In this case the options 3 and 4 add to the existing variability by introducing two flow rates in different places that have similar ecological characteristics and species composition. The introduction of further variability in flow rates in impractical for the operators. Flow variability in moderate to very high flows (exceeding about 75 cumecs) approaches the natural duration as illustrated in Figure 2.

3.8 MONITORING

Colonisation:

The colonisation of the edge of the flow should be measured. The aim is to determine if the number of plants within 25 cm of the imposed flow level increases over time; that is, do the plants of each species that is inundated colonise the edge of the new flow level.

The existing data are sufficient to be used as a baseline. The northern shore of Reach 1 and the perimeter of First Basin in Reach 4 should be the samples and remeasured after 5 years and 10 years. The remeasurement should take place in March.

No response is proposed if colonisation does not occur.

Translocation:

The success of translocation of *Lycopus* should be measured. The aim is to determine if the translocated plants establish and produce seed.

Fifty plants each near the existing locations and 50 at Reach 1 and 50 at First Basin should be monitored. The number of survivors should be counted after 12 months and 2 years.

If overall survival is less than 10 percent after 2 years the effort should be repeated at new locations.

4. LEGISLATIVE IMPLICATIONS

4.1 IMPLICATIONS FOR COMMONWEALTH *ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999*

Three listed flora species recorded from the gorge are:

1. *Boronia gunnii* -Vulnerable, considered to be extinct from the gorge;
2. *Callitris oblonga* - Vulnerable, is very rare, occurring at only two locations as a small stand in First Basin and a single tree in Second Basin. No impact anticipated; and,
3. *Epacris exserta* - Endangered, is also rare but occurs sporadically along the walls of the gorge at flood level and at First Basin. No impact anticipated as occurs above the potential environmental flow options .

None of these species is affected by the environmental flow options nor a reduced flow option through Reaches 2 and 3 (Table 2). None of the criteria applied under the EPBC for determining if a development proposal or land use change will cause a significant impact will be met. Therefore it is not anticipated that the proposal would significantly affect any flora species listed on the EPBC. Consequently, any intention to change the flow regime would not normally require referral to the Commonwealth Minister.

4.2 IMPLICATIONS FOR TASMANIAN *THREATENED SPECIES PROTECTION ACT 1995*

Five species listed as endangered *Alternanthera denticulata, Doodia caudate, Lycopus australis, Persicaria subsessilis* and *Mentha australis* may be inundated by an increased environmental flow. Two species listed as vulnerable *Lythrum salicaria* and *P. decipiens* may be inundated by an increased environmental flow.

Permanent inundation would require a Permit under the TSPA (See Appendix 2). A Permit application requires an estimate of the quantum of the impact and details of attempts to minimise the impact. The estimates provided here comply with the DPIPWE guidelines on population estimates.

4.3 IMPLICATIONS FOR THE TASMANIAN *WEED MANAGEMENT ACT 1999*

The Act requires that landowners prevent declared weeds from spreading to the habitat of species listed on the TSPA. As such declared weeds within the gorge should be controlled to prevent them from occupying further habitat at the expense of the threatened species.

5. CONCLUSIONS

The riparian and in stream flora habitat within the Cataract Gorge has been dramatically modified by the placement of the Trevallyn Dam. Possibly the most important change has been the reduction in sediment input. The sediment starved flood flows that pass through the gorge erode sediment based habitats. As a result it is likely that the gorge now supports a significantly reduced extent of suitable habitat for riparian, semi aquatic and aquatic flora.

The abundance of threatened flora species within the gorge is likely to have been reduced in proportion to the reduction in the extent of suitable habitat. There are a number of records of threatened flora species that predate the dam and some of these species are now considered to be extinct from the gorge.

There are numerous records of threatened flora species that predate the environmental flow implemented in 2003. However, the records do not record the locations in relation to the flow level at that time and so it cannot be determined if the sites have been inundated by the rise in flow height in 2003.

The current survey has recorded all of the species reasonably expected to still occur in the gorge. The number of locations and the number of plants recorded far exceeds any previous survey. One species not previously recorded, *Lycopus australis*, was located by DPIPWE staff at about the same time as this work.

For most species affected by a change in flow, the largest portion of the loss is incurred by the 2.5 cumec flow with a relatively small additional increment lost to the 3 cumec flow. Three species, *Lycopus australis* (92), *Persicaria decipiens (86),* and *Lythrum salicaria* (53) incur more than 50 % loss to any flow option. These impacts would be considered to be significant losses in the context of local populations.

The largest known population of *Lycopus australis* in the gorge supports 12 plants and exists within the range of options 1 and 2. If only one plant remained under options 3 and 4 there is an increased risk of local extinction.

The impact of reducing the flow to Reaches 2 and 3 (options 3 and 4) is difficult to predict. However, the 0.5 cumec flow would add a spatial element of variation to the flow in Cataract Gorge that does not currently exist. It would also expose additional habitat that is likely to be colonised by at least some of the semi aquatic threatened flora that are present in the gorge.

Willow, blackberry and gorse are the declared weeds that appear to invade open rocky habitat within the flood zone. Extended periods of low flow, due to the low environmental flow and extended drought, may have favoured weeds establishment in the channel. However, the presence of patches of old infestations is the main determinant of the rate of invasion as they provide the propagules.

Willow has proven to be the most invasive while blackberry and gorse appear to be kept in check by flood flows. Where willow occurs as scattered plants control is possible by herbicide stem injection.

Recommendations:

Mitigation:

1. If the flow rate is increased *Lycopus australis* seed should be collected and juveniles transplanted to a nursery to produce seed and rhizome (perenating root material). The rhizome of adults should also be collected. Once a new flow level is in place seeds and rhizomes should be reintroduced.

2. Where small weirs in Reach 4 are no longer of use then decommissioning them by breaching the walls would increase the area of habitat available to the species currently affected by inundation.

Management:

1. Willow control should be undertaken. A plan is required that considers the timing and priority of areas and should consider the fate of dead willows and role of other land managers. It is recommended that control be by stem injection or frilling and pasting with glyphosate.

Monitoring:

1. Establish the monitoring proposal for recolonisation of the shore and the establishment of translocated *Lycopus australis*.

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APPENDIX 1 - DEFINITIONS OF CONSERVATION VALUES OF PLANT AND ANIMAL SPECIES

SPECIES OF NATIONAL SIGNIFICANCE

Listed in Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

The *EPBC* Act has six categories of threat status for species:

1. **Extinct -** If at a particular there is no reasonable doubt that the last member of the species has died
2. **Extinct in the wild -** If it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or If it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form
3. **Critically endangered** - If at a particular time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria
4. **Endangered** - If it is not critically endangered; and it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria
5. **Vulnerable** - If at a particular time it is not critically endangered or endangered; and it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
6. **Conservation dependent -** If, at that time, the species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years

SPECIES OF STATE SIGNIFICANCE

Listed in Tasmanian *Threatened Species Protection Act 1995* (TSP Act)

Threatened flora and fauna species in Tasmania are listed in Schedules 3 (extinct or endangered), 4 (vulnerable) or 5 (rare). These three categories are defined in Section 15 of the Act.

1. **Extinct** - If no occurrence of the taxon in the wild can be confirmed during the past 50 years
2. **Endangered -** If it is in danger of extinction because long-term survival is unlikely while the factors causing it to be endangered continue operating.
3. **Vulnerable** - If it is likely to become an endangered taxon while the factors causing it to be vulnerable continue operating.
4. **Rare** - If it has a small population in Tasmania that is not endangered or vulnerable but is at risk."

Species that have been nominated and approved by the Scientific Advisory Committee for listing in the Act

SPECIES OF REGIONAL OR GENERAL SIGNIFICANCE

The following definitions are from three publications: Flora Advisory Committee 1994, Vertebrate Advisory Committee 1994, Invertebrate Advisory Committee 1994

Flora only - Species listed as rare but not necessarily 'at risk' (**r3**)

Fauna only – Species requiring monitoring (**m**)

Both – Species of unknown risk status (**k**) in Tasmania, or thought to be uncommon within region, or a species having a declining range or populations within the area.

Species considered to be outside its normal range or of an unusual form as determined and justified in the body of the report.

Species identified in regional studies as being of conservation significance that are not listed in current legislation

Species that have been recognised but have not been formally described in a published journal that are thought to significant as determined and justified in the body of the report.

Plant species that are not known to be reserved. To be so it must be known to exist in at least one secure Reserve. Secure reserves include reserves and parks requiring the approval of both Houses of Parliament for their revocation. They include: National Parks, Aboriginal Sites, Historic Sites, Nature Reserves, State Reserves, Game Reserves, Forest Reserves, Wellington Park, and insecure reserves in the World Heritage Area which is protected by international agreement under the World Heritage Convention.

APPENDIX 2 - LEGISLATIVE IMPLICATIONS OF THREATENED SPECIES

Tasmanian State Legislation Affecting Threatened Species

Threatened Species Protection Act 1995

Threatened flora and fauna species in Tasmania are listed in Schedules 3 (endangered) and 4 (vulnerable) of the Threatened Species Protection Act, 1995. Rare species that are considered to be 'at risk' are listed in Schedule 5 of the Act. These three categories are defined in Section 15 of the Act.

1. "An extant taxon of native flora or fauna may be listed as **endangered** if it is in danger of extinction because long-term survival is unlikely while the factors causing it to be endangered continue operating.

2. A taxon of native flora or fauna may be listed as **vulnerable** if it is likely to become an endangered taxon while the factors causing it to be vulnerable continue operating.

3. A taxon of native flora or fauna may be listed as **rare** if it has a small population in Tasmania that is not endangered or vulnerable but is at risk."

The Act provides mechanisms for protecting these species from threatening processes the implementation of 'recovery plans', 'threat abatement plans', 'land management plans', public authority agreements', and 'interim protection orders'.

Section 51 (a) of the TSPA states that: "A person must not knowingly, without a permit - take, trade in, keep or process any listed flora or fauna". The Act defines 'take' as including: "kill, injure, catch, damage, destroy and collect. A land manager is therefore required to obtain a permit from the Tasmanian Department of Primary Industries, Water and Environment (DPIWE) to carry out management that may adversely affect any of the species listed in the Act

Commonwealth of Australia Legislation Affecting Threatened Species

Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act establishes a process for assessing actions that are likely to have impacts of *national environmental significance*. Such impacts include World Heritage Areas, RAMSAR Wetland sites of international importance, migratory species protected under international agreements, nuclear actions, the Commonwealth marine environment and **nationally threatened species and communities.**

Threatened species are defined in several categories:

1. Extinct

- If at a particular there is no reasonable doubt that the last member of the species has died

2. Extinct in the wild

- If it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or
- If it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form

3. Critically endangered

- If at a particular time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria

4. Endangered

- If it is not critically endangered; and it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria

5. Vulnerable

- If at a particular time it is not critically endangered or endangered; and it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.

6. Conservation dependent

- If, at that time, the species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years

An action that is likely to affect species that are listed in any of the above categories may require ministerial approval unless the Commonwealth Environment Minister has granted an exemption. The Act establishes a **referral process** to Environment Australia to determine whether an action requires a formal **approval** and thus would be required to proceed through the **assessment and approval process**.

A referral must provide sufficient information to allow the Minister to make a decision. The Minister is then required to make a decision within 20 business days of the referral. The Minister may decide an approval is not necessary if the action is taken in a specified manner. The action may not require approval but may require a **permit** if undertaken on Commonwealth land. If an approval is required then an **environmental assessment** must be carried out. In such instances the environmental assessment approach will be determined by the Minister and may vary from preliminary documentation to a full public inquiry depending on the scale and complexity of the impact.

APPENDIX 3: PREVIOUS RECORDS OF SPECIES FROM WITHIN 50 M OF THE SOUTH ESK RIVER IN CATARACT GORGE.

Scientific name	Common	E GDA	N GDA	Precision	Date	Name	TSPA	EPBCA
Alternanthera denticulata	lesser joyweed	509912	5411683	200	26/03/1993	A.Ratkowsky	e	
Alternanthera denticulata	lesser joyweed	508212	5410133	50	25/07/2001	A.North	e	
Alternanthera denticulata	lesser joyweed	508362	5409783	50	25/07/2001	A.North	e	
Alternanthera denticulata	lesser joyweed	509512	5410313	100	30/08/2001	A.North	e	
Alternanthera denticulata	lesser joyweed	509512	5410323	100	30/08/2001	A.North	e	
Alternanthera denticulata	lesser joyweed	509412	5410333	100	30/08/2001	A.North	e	
Alternanthera denticulata	lesser joyweed	509212	5410083	100	30/08/2001	A.North	e	
Alternanthera denticulata	lesser joyweed	508362	5409883	100	30/08/2001	A.North	e	
Alternanthera denticulata	lesser joyweed	508262	5410183	100	30/08/2001	A.North	e	
Alternanthera denticulata	lesser joyweed	507212	5411383	100	30/08/2001	A.North	e	
Alternanthera denticulata	lesser joyweed	509012	5409783	100	30/08/2001	A.North	e	
Alternanthera denticulata	lesser joyweed	509919	5411873	100	12/02/2003	M.Baker	e	
Arthropodium strictum	chocolate lily	509857	5411447	500	27/11/1938	A.Olsen	r	
Arthropodium strictum	chocolate lily	509812	5411283	100	1/11/1984	J.Kirkpatrick	r	
Arthropodium strictum	chocolate lily	510302	5412043	500	25/10/1992	A.Ratkowsky	r	
Boronia gunnii	river boronia	510112	5411983	500	14/10/1937	A.Olsen	v	VU
Boronia gunnii	river boronia	510112	5411983	500	24/10/1959	H.King	v	VU
Boronia gunnii	river boronia	510112	5411983	500	25/10/1961	T.Burns	v	VU
Boronia gunnii	river boronia	509612	5410683	200		T.Carr	v	VU
Boronia gunnii	river boronia	510112	5411983	500		C.Stuart	v	VU
Boronia gunnii	river boronia	510112	5411983	500		S.Hannaford	v	VU
Boronia gunnii	river boronia	510112	5411983	500		R.Gunn	v	VU
Callitris oblonga	south esk pine	509912	5411683	200	19/01/1938	A.Olsen	v	EN
Callitris oblonga	south esk pine	510302	5412043	500	12/09/1953	D.Paton	v	EN
Callitris oblonga	south esk pine	510012	5411783	100	1/01/1985	S.Harris	v	EN
Callitris oblonga	south esk pine	509912	5411783	100	3/09/1996	P.Barker	v	EN
Callitris oblonga	south esk pine	509512	5410783	100	26/07/2001	A.North	v	EN
Callitris oblonga	south esk pine	509512	5410783	100	30/08/2001	A.North	v	EN

Scientific name	Common	E GDA	N GDA	Precision	Date	Name	TSPA	EPBCA
Cynoglossum australe	coast houndstongue	509512	5410283	100	30/08/2001	A.North	r	
Discaria pubescens	spiky anchorplant	509912	5411683	200	1/09/1911	F.Burbury	e	
Doodia caudata	small raspfern	509212	5410083	100	30/08/2001	A.North	e	
Doodia caudata	small raspfern	510112	5411983	5000	17/12/1844	R.Gunn	e	
Epacris exserta	south esk heath	509912	5411683	200	10/07/1981	A.Moscal	e	PEN
Epacris exserta	south esk heath	507212	5411383	200	3/11/1983	R.Crowden	e	PEN
Epacris exserta	south esk heath	507212	5411383	200	16/10/1987	R.Crowden	e	PEN
Epacris exserta	south esk heath	509612	5410683	100	1/01/1990	K.Williams	e	PEN
Epacris exserta	south esk heath	509912	5411783	100	1/01/1990	K.Williams	e	PEN
Epacris exserta	south esk heath	507212	5411333	100	9/06/1996	D.Keith	e	PEN
Epacris exserta	south esk heath	509982	5411603	100	9/06/1996	D.Keith	e	PEN
Epacris exserta	south esk heath	507212	5411283	50	24/07/1996	D.Keith	e	PEN
Epacris exserta	south esk heath	507212	5411283	100	24/07/1996	D.Keith	e	PEN
Epacris exserta	south esk heath	509812	5411883	50	27/08/1996	M.Ilowski	e	PEN
Epacris exserta	south esk heath	508212	5410683	100	24/07/2001	A.North	e	PEN
Epacris exserta	south esk heath	509512	5410433	100	30/08/2001	A.North	e	PEN
Epacris exserta	south esk heath	508212	5410683	100	30/08/2001	A.North	e	PEN
Epacris exserta	south esk heath	507912	5410883	100	30/08/2001	A.North	e	PEN
Epacris exserta	south esk heath	509512	5411313	200	26/11/2003	R.Schahinger	e	PEN
Epacris exserta	south esk heath	509212	5410083	100	19/08/2005	R.Schahinger	e	PEN
Epacris exserta	south esk heath	510302	5412043	500	01/01/1836	R.Gunn	e	PEN
Epacris exserta	south esk heath	510302	5412043	500	01/09/1878	A.Simson	e	PEN
Epacris exserta	south esk heath	509857	5411447	500	01/09/1878	A.Simson	e	PEN
Epacris exserta	south esk heath	509112	5409883	3000	23/09/1842	R.Gunn	e	PEN
Epacris exserta	south esk heath	507212	5411333	100		D.Keith	e	PEN
Epacris exserta	south esk heath	509982	5411603	100		D.Keith	e	PEN
Gyrostemon thesioides	broom wheelfruit	510302	5412043	500	1/09/1911	F.Burbury	r	
Gyrostemon thesioides	broom wheelfruit	509857	5411447	500	14/01/1937	A.Olsen	r	
Gyrostemon thesioides	broom wheelfruit	509812	5411583	100	19/12/1985	F.Duncan	r	
Gyrostemon thesioides	broom wheelfruit	510302	5412043	500	01/01/1800	L.Rodway	r	
Gyrostemon thesioides	broom wheelfruit	510302	5412043	500	01/01/1833	R.Lawrence	r	
Hovea tasmanica	rockfield purplepea	510302	5412043	1000	15/09/1911	F.Burbury	r	
Hovea tasmanica	rockfield purplepea	508412	5410283	2000	28/09/1972	S.Jarman	r	
Isoetes elatior	tall quillwort	509112	5409883	3000	15/03/1842	R.Gunn	r	
Lycopus australis	Australian gypsywort	509162	5409970	5	10/03/2010	Viscoiu	e	
Lycopus australis	Australian gypsywort	508328	5419457	5	18/03/2010	Schahinger	e	
Lythrum salicaria	purple loosestrife	508262	5410133	50	25/07/2001	A.North	v	

Scientific name	Common	E GDA	N GDA	Precision	Date	Name	TSPA	EPBCA
Mentha australis	river mint	509627	5410445	10	27/02/2009	R.Skabo	e	
Mentha australis	river mint	510302	5412043	1000	01/12/1886	Unknown	e	
Persicaria decipiens	slenderwaterpepper	509912	5411683	200	25/02/1993	A.Ratkowsky	v	
Persicaria decipiens	slenderwaterpepper	509912	5411683	200	26/03/1993	A.Ratkowsky	v	
Persicaria subsessilis	bristly waterpepper	509112	5409883	3000	1/12/1937	A.Olsen	e	
Persicaria subsessilis	bristly waterpepper	509512	5411033	50	26/07/2001	A.North	e	
Persicaria subsessilis	bristly waterpepper	509512	5410323	100	30/08/2001	A.North	e	
Persicaria subsessilis	bristly waterpepper	509412	5410333	100	30/08/2001	A.North	e	
Persicaria subsessilis	bristly waterpepper	509162	5409983	100	30/08/2001	A.North	e	
Persicaria subsessilis	bristly waterpepper	508262	5409983	100	30/08/2001	A.North	e	
Persicaria subsessilis	bristly waterpepper	508463	5409599	2500	11/01/2005	R.Scabo	e	
Poa mollis	soft tussockgrass	509792	5411623	25	16/02/2005	M.Wapstra	r	
Prostanthera rotundifolia	roundleaf mintbush	509302	5410278	500	1/10/1911	L.Rodway	v	
Prostanthera rotundifolia	roundleaf mintbush	509112	5409883	3000	1/01/1980	A.North	v	
Prostanthera rotundifolia	roundleaf mintbush	509712	5410483	100	4/09/1995	F.Duncan	v	
Prostanthera rotundifolia	roundleaf mintbush	509912	5411783	100	3/09/1996	P.Barker	v	
Prostanthera rotundifolia	roundleaf mintbush	509512	5410323	100	30/08/2001	A.North	v	
Prostanthera rotundifolia	roundleaf mintbush	508262	5410683	100	30/08/2001	A.North	v	
Prostanthera rotundifolia	roundleaf mintbush	507912	5410883	100	30/08/2001	A.North	v	
Prostanthera rotundifolia	roundleaf mintbush	507312	5411283	100	30/08/2001	A.North	v	
Ranunculus sessiliflorus	rockplate buttercup	509712	5411483	100	16/08/1995	F.Duncan	r	
Ranunculus sessiliflorus	rockplate buttercup	507362	5411283	100	30/08/2001	A.North	r	
Spyridium eriocephalum	heath dustymiller	510302	5412043	500	01/01/1800	A.Simson	e	
Spyridium eriocephalum	heath dustymiller	510302	5412043	500	01/01/1800	A.Simson	e	
Spyridium eriocephalum	heath dustymiller	510302	5412043	500	21/10/1800	A.Simson	e	
Spyridium eriocephalum	heath dustymiller	509857	5411447	1000	22/09/1878	R.Johnson	e	
Spyridium vexilliferum	helicopter bush	509912	5411783	100	3/09/1996	P.Barker	r	
Utricularia australis	yellow bladderwort	510302	5412043	500	01/01/1800	W.Curtis	r	
Utricularia australis	yellow bladderwort	510302	5412043	500	26/03/1846	R.Gunn	r	
Velleia paradoxa	spur velleia	509012	5409883	500	24/12/1938	A.Olsen	v	
Xerochrysum bicolor	eastcoast everlasting	509912	5411683	200	14/01/1937	A.Olsen	r	

APPENDIX 4: PLATES 1-10

A low energy backwater at First basin.

Callitris oblonga habitat at First Basin.

Epacris exserta below Trevallyn Dam (Reach 1).

Root of *Epacris exserta* exposed by erosion at First Basin.

Cataract Gorge during August 2009 flood.

Bed load 0.5 m above environmental flow below Trevallyn Dam.

Deep scour hole with pebble but no sand. Pebbles remain in hole if vertical energy is insufficient to remove them.

Vegetated alluvial deposits below a local inflowing drainage line. Gravel and boulder (rear) and sand (foreground).

A weir at the intake for the Duck Reach Power Station.

The "pool" behind the weir in Reach 4.

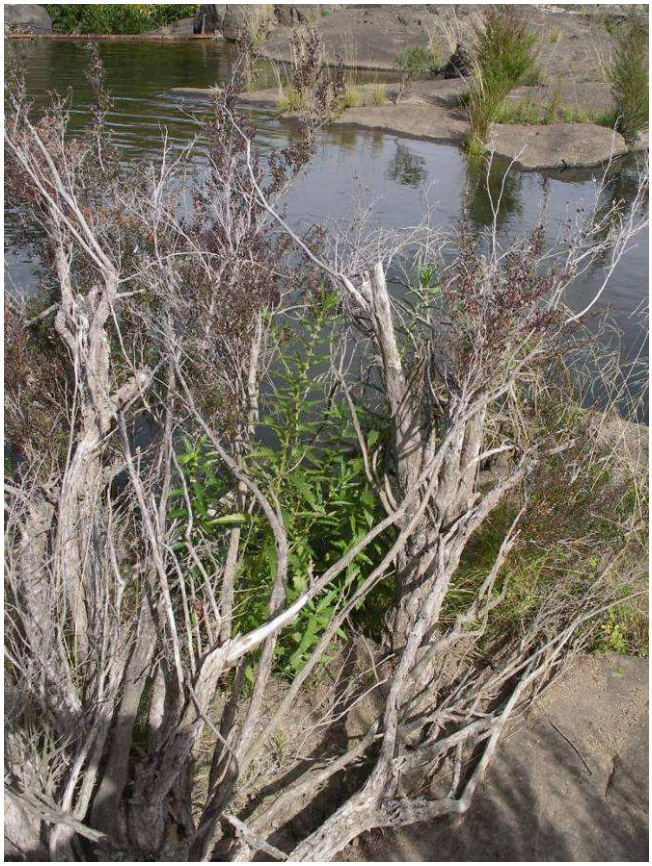
Mentha australis 3 m above water level.

Persicaria subsessilis at water level.

Mentha australis in flood debris.

Young willows scattered near water level.

Lythrum salicaria



Lycopus australis (R. Schahinger)

Appendix 5 - Figure 4a - Reach 1
Distribution of threatened flora that are subject to inundation

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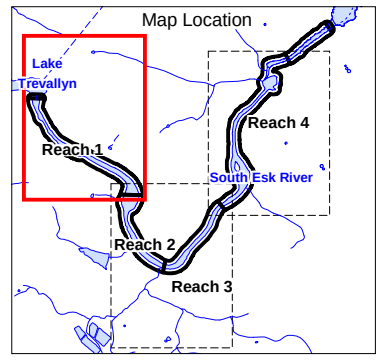


Threatened Flora observations for Reach 1

Inundation class
height above water (cm), flow rate

- 0 - 15cm, 2.5/3 cumecs
- 15 - 25cm, 3cumecs
- > 25cm, above flow options

Threatened Flora Species - Reach 1

Ad	Alternanthera denticulata	(55)
Ee	Epacris exserta	(1)
La	Lycopus australis	(1)
Ma	Mentha australis	(8)
Pr	Prostanthera rotundifolia	(2)

Labels indicate species; colour indicates flow rate at which inundation occurs.
The number of observations for each species is indicated in the species list.
The map is indicative of the frequency because some labels overlap at this scale.

Observations are from October 2009 (North Barker)
and March/April 2010 (NVA and North Barker) surveys.

The mapping has been undertaken using a hand held GPS and subjective interpretation.
Consequently it should be considered indicative only.

N

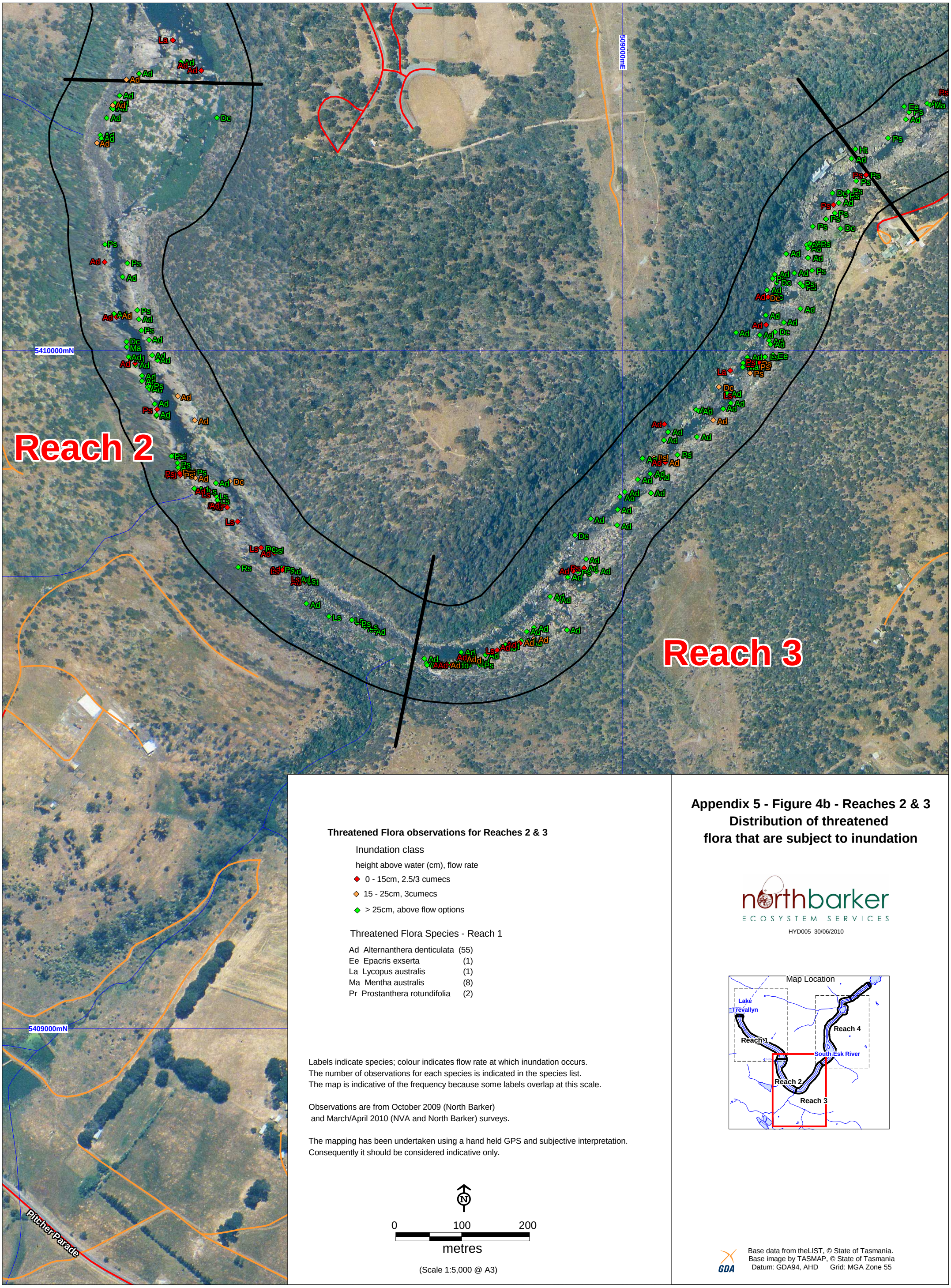
0 100 200
metres

(Scale 1:5,000 @ A3)

GDA

Datum: GDA94, AHD Grid: MGA Zone 55

Lake Trevallyn Road
Reatta Road
Duck Reach Road
Zenith Court
Canopus Drive
5412000mN
5411000mN
508000mE
Reach 1



Threatened Flora observations for Reaches 2 & 3

Inundation class

height above water (cm), flow rate

- 0 - 15cm, 2.5/3 cumecs
- 15 - 25cm, 3cumecs
- > 25cm, above flow options

Threatened Flora Species - Reach 1

Ad	Alternanthera denticulata	(55)
Ee	Epacris exserta	(1)
La	Lycopus australis	(1)
Ma	Mentha australis	(8)
Pr	Prostanthera rotundifolia	(2)

Labels indicate species; colour indicates flow rate at which inundation occurs.
The number of observations for each species is indicated in the species list.
The map is indicative of the frequency because some labels overlap at this scale.

Observations are from October 2009 (North Barker)
and March/April 2010 (NVA and North Barker) surveys.

The mapping has been undertaken using a hand held GPS and subjective interpretation.
Consequently it should be considered indicative only.

N

0 100 200

metres

(Scale 1:5,000 @ A3)

Appendix 5 - Figure 4b - Reaches 2 & 3 Distribution of threatened flora that are subject to inundation

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5412000mN

510000mE

Basin Road

Sinclair Street

Cambridge Street

Corin Street

Reach 4

Appendix 5 - Figure 4c - Reach 4
Distribution of threatened flora that are subject to inundation

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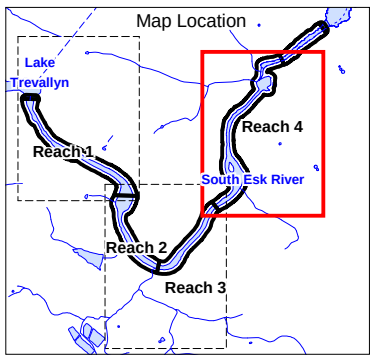


Threatened Flora observations for Reach 4

Inundation class

height above water (cm), flow rate

- 0 - 15cm, 2.5/3 cumecs
- 15 - 25cm, 3cumecs
- > 25cm, above flow options

Threatened Flora Species - Reach 1

Ad	Alternanthera denticulata	(55)
Ee	Epacris exserta	(1)
La	Lycopus australis	(1)
Ma	Mentha australis	(8)
Pr	Prostanthera rotundifolia	(2)

Labels indicate species; colour indicates flow rate at which inundation occurs.
The number of observations for each species is indicated in the species list.
The map is indicative of the frequency because some labels overlap at this scale.

Observations are from October 2009 (North Barker)
and March/April 2010 (NVA and North Barker) surveys.

The mapping has been undertaken using a hand held GPS and subjective interpretation.
Consequently it should be considered indicative only.

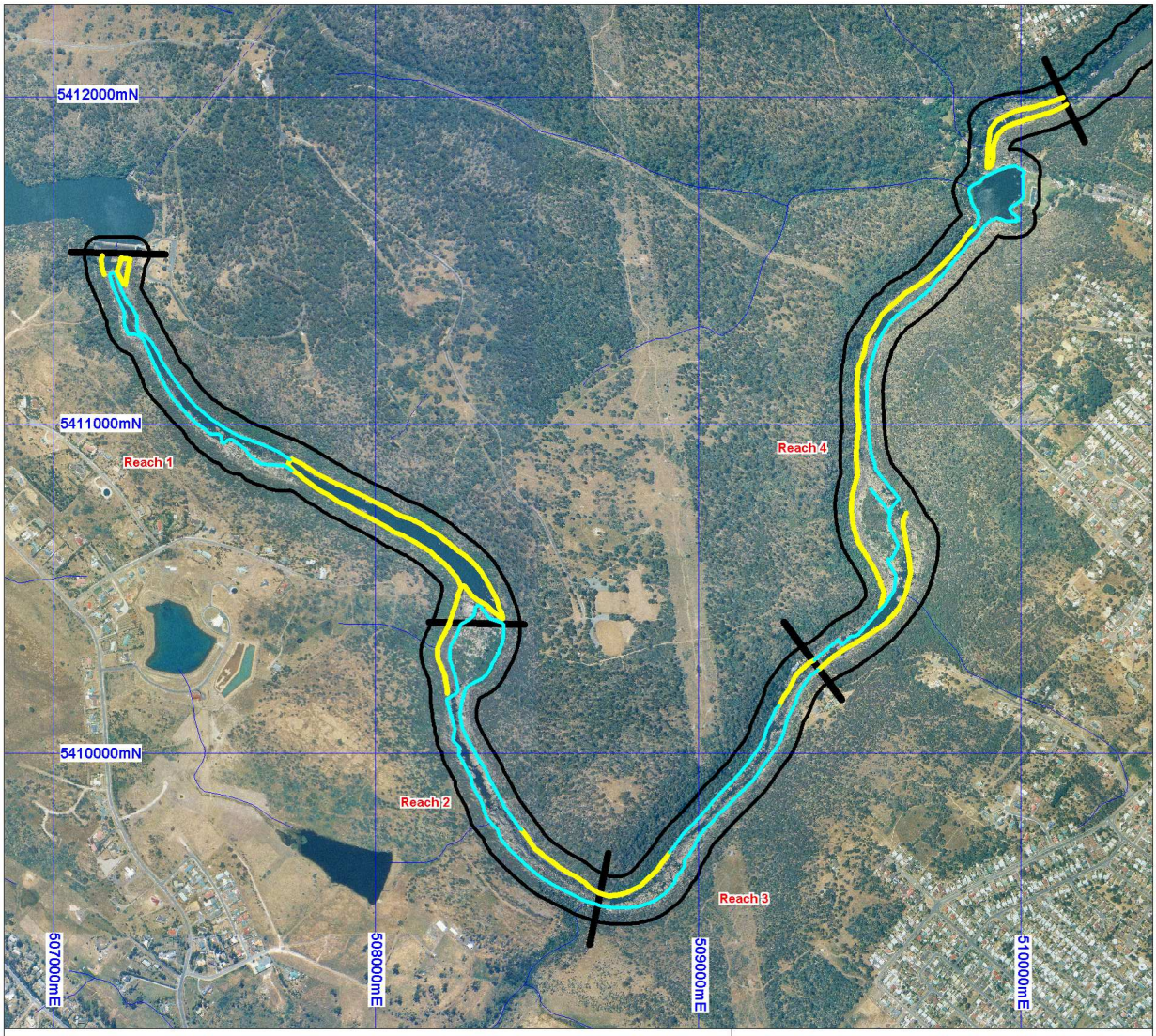
N

0 100 200
metres

(Scale 1:5,000 @ A3)

GDA

Datum: GDA94, AHD Grid: MGA Zone 55



Survey Status

North Barker Ecosystem Services

river bank NOT searched in survey 2 (5.7 km)

river bank searched in survey 2 (7.8 km)

The mapping has been undertaken using a hand held GPS and subjective interpretation. Consequently it should be considered indicative only.

Base image by TASMAP, © State of Tasmania
Datum: GDA94, AHD Grid: MGA Zone 55

GDA

0 250 500m
metres

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HYD005 28/9/2010

Lake Trevallyn Road
Reatta Road
Duck Reach Road
South Esk River
Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Zenith Court
Canopus Drive
Panorama Road
Glover Avenue
Neptune Drive

The mapping has been undertaken using a hand held GPS and subjective interpretation. Consequently it should be considered indicative only.

Declared Weeds

- w, willow, extensive
- bb, blackberry, scattered
- bs, boneseed, scattered
- g, gorse, scattered
- w, willow, scattered

Base data from theLIST, © State of Tasmania
Datum: GDA94, AHD Grid: MGA Zone 55

GDA

Figure 5 - Distribution of weeds

0 250 500m
metres

(Scale 1:10,000 @ A3)

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HYD005 30/06/2010