

## The Green and Golden Bell Frog Key Population at Sussex Inlet – Swan Lake



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# 1. BACKGROUND

## 1.1 Introduction

The Green and Golden Bell Frog (GGBF, Figure 1) *Litoria aurea* is a relatively large, muscular species. Adult sizes range from approximately 45 mm to 100 mm with most individuals being in the 60-80 mm class. The colouration of the back is quite variable, being a vivid pea green splotched with almost metallic brass brown or gold. The backs of some individuals may be almost entirely green whilst in others the golden brown markings may almost cover the whole dorsal surface (DEC 2005).

The Green and Golden Bell Frog was formerly distributed from the NSW north coast near Brunswick Heads southwards along the NSW coast to Victoria, where it extended into East Gippsland, and west to Bathurst, Tumut and the Australian Capital Territory (DEC 2005). In the 1960s, the species was considered widespread, abundant and commonly encountered (Mahony, 1996; Osborne *et al.*, 1996). Today, the species exists as a series of isolated populations within its former range.

The Green and Golden Bell Frog (GGBF) is listed as an endangered species under Schedule 1 of the NSW *Threatened Species Conservation Act 1995*. At the national level, the species is listed as Vulnerable under Schedule 1 Part 2 of the *Environment Protection and Biodiversity Conservation Act 1999*.

As a consequence of being listed under both state and national legislation a recovery plan has been prepared for the GGBF (Department of Environment and Conservation 2005). This plan of management (PoM) has been prepared to satisfy Action 11.3.4 of the draft GGBF Recovery Plan developed in accordance with the *Threatened Species Conservation Act 1995*. Action 11.3.4 calls for the NSW Department of Environment and Climate Change (DECC) to prepare and implement a GGBF Management Plan for each key population on its own land and liaise with other landowners as necessary (e.g. local councils, industry, residents) to prepare and implement site specific Management Plans across the extent of the species distribution in NSW.

Where GGBF occur on public land, local councils are, under the Local Government Act, required to refer to the recovery plan for this species in any management plans. It is therefore envisaged that this Management Plan will satisfy this requirement of Shoalhaven City Council (with respect to the Sussex Inlet population which occurs on private and public land). The Shoalhaven local government area has been identified in the draft GGBF Recovery Plan (DEC 2005) as supporting eight of the 42 Key Populations. This Management Plan is also intended to provide guidance, direction and coordination for other stakeholders, land owner/managers within this area where the frog and/or its habitat occurs.

The Southern Rivers Catchment Management Authority (CMA) has developed a Catchment Action Plan (CAP) that identifies a number of targets for managing natural resources. Biodiversity Catchment Target number 2 within the CAP is supported by the actions undertaken and proposed within this Management Plan (PoM).

## 1.2 Objectives of the Management Plan (MP)

The Sussex Inlet Management Plan covers GGBF and their habitat occurring within the catchment of Swan Lake (including the Sussex Inlet sewerage treatment plant, Springs Road, Conjola National Park and Sussex Inlet Golf Course). This Management Plan has been prepared to ensure that the population is managed and monitored such that the species continues to persist at the location and that measures of the population's viability are maintained or improved over time.

The objectives of this plan are to:

1. Identify and where possible ameliorate threats and other factors affecting, or likely to impact on, the conservation of the species within the Sussex Inlet study area.
2. Manage the species in accordance with the strategies outlined within the draft GGBF Recovery Plan (DEC 2005).
3. Conduct assessments of habitat at sites where the frog has been detected in recent times.
4. Facilitate community consultation, including workshops and information days.
5. Co-ordinate habitat protection, restoration and enhancement measures.
6. Collate recent records of the species within the area covered in this management plan.

Appendix A details five strategies that aim to achieve the above objectives, including detailed actions assigned to each strategy, potential funding sources, and the agencies responsible for implementing each action.



**Figure 1.** Green and Golden Bell Frog *Litoria aurea* at Sussex Inlet Sewerage treatment plant

## 2. THE SUSSEX INLET POPULATION

### 2.1. Location and Land Ownership

The Sussex Inlet – Swan Lake key population is currently known to centre around a breeding site within the Sussex Inlet Sewerage Treatment Plant (STP) (35°10' S, 150°34' E), which is managed by Shoalhaven Water. The frogs have been known from this site since March 1998 when 15 road-killed juvenile frogs and three live frogs were observed on The Spring Road within 100 metres of a water easement east of the STP (G. Daly, pers. obs.). Frogs were observed as they crossed the road and dispersed downslope along the sedgeland (Thomson Street wetland). The frogs were concentrated within the area of the sedgeland that had higher moisture levels than the surrounding vegetation. Subsequent surveys detected adult and juvenile frogs within the STP. The area east of The Springs Road where the frogs were dispersing is Crown and freehold land. Green and Golden Bell Frogs have also been heard calling from a wetland in Conjola National Park (NP) (D. Stevenson, pers. comm.) and a dam in Sussex Inlet Golf Course (Anon pers. comm.).

The frogs occur on both private and public land. The public land includes the foreshores of Swan Lake (SCC/DECC) and Conjola National Park (NP) and is managed by Shoalhaven City Council (SCC - including Shoalhaven Water) and the Department of Environment and Climate Change (DECC). Habitat for the frogs is also found on private land in the area which includes the Sussex Inlet Golf Club (record from the mid 1990's).

### 2.2 Habitat

The GGBF within the STP are associated with two overflow ponds, herein termed ponds A and B (Gaia Research 1998). Pond A measures 47 x 155 metres in size and is up to 1.5 metres deep. It is ephemeral and fills after rain, or when water is discharged into it from other ponds in the plant. The water is generally clear and the pond supports a large variety of aquatic plants including Cumbungi *Typha orientalis*, Spikerush *Eleocharis sphacelata*, Water Couch *Paspalum paspalodes*, and Twig Rush *Baumea juncea*. The pond is not shaded by trees, but the surrounding vegetation includes a woodland termed Scribbly Gum *Eucalyptus sclerophylla* / Red Bloodwood *Corymbia gummifera* woodland.

Pond B is 47 x 110 metres in size and can, at times, be up to 1.5 metres deep. It is permanent but the depth varies with the volume of rain received. The water level of Pond B may be augmented from an adjoining settling pond. This pond has only a small area of Spikerush and the water is green from algae growth indicative of a high nutrient content.

Fish are absent from the ponds. However, the Long-necked Turtle *Chelodina longicollis* is common and has been observed in both ponds during periods when they contained substantial water. Other potential predators of frogs at the site include the Red Fox *Vulpes vulpes*, White-faced Heron *Egretta novaehollandiae* and Red-bellied Black Snake *Pseudechis porphyriacus*. Carnivorous aquatic insects, such as dragon fly larvae were abundant in pond B. These insects colonise pond A when it is filled.

To the east of the STP is a sedgeland swamp that drains into a culvert that reticulates water under The Springs Road. The waterway drains through bushland towards the town of Sussex Inlet. Cumbungi occurs within this wetland. No large pools are present; however, the lip of the intake pipe of the culvert is such that water banks to a depth of 0.3 m prior to flowing through the pipes. Green and Golden Bell Frogs are regularly detected crossing this road as they move along the sedgeland swamp.

Approximately one kilometre to the south-west of the STP is Swan Lake. This lake is termed an ICOLL (intermittently closing and opening lake or lagoon) because it intermittently closes and opens to the sea. One swamp located 300 metres west of the village of Cudmirrah is adjacent to

Swan Lake and supports dense stands of the plants 'Snow in Summer' *Melaleuca linariifolia* and a shrublayer of Swamp Melaleuca *M. ericifolia* and Sawsedge *Gahnia sieberana*. On 14 July 2005, approximately twenty GGBF were heard calling from this swamp (D. Stevenson pers. comm.). There are additional areas of Melaleuca wetland and sedgeland around Swan Lake and these offer potential breeding habitat for GGBF.

The habitat that the frogs use for refuge, breeding, foraging and dispersal is varied. The vast majority of observations of GGBF in this area have been from Sussex STP, where the species breeds. However, few frogs have been detected at this site during periods of reduced rainfall, and the refuge sites used by the GGBF outside breeding events has yet to be determined. Refuge sites are of critical importance to the species survival in the area.

### 2.3 Species status

Twenty two surveys for GGBF have been conducted at the Sussex Inlet STP during summer and autumn, from 1999 to 2007 (Appendix B). No surveys were conducted between 2003 and 2005. During most surveys, more frogs were detected around Pond A than around Pond B. Pond A seems highly suitable for the species, as the substrate is sandy, the water body ephemeral, and the pond receives a high level of direct sunlight and has emergent aquatic vegetation (Pyke and White 2001). Conversely, Pond B is permanent and has a relatively small area of emergent aquatic vegetation. More GGBF were found at Pond B when pond A was dry, or when it held a very small volume of water.

The number of GGBF detected during different survey periods ranged from 0 to 42. GGBF were rarely detected during periods of drought. The largest number of adults (42) was found after a large rain event (125 mm fell over three days prior to the survey). This indicates that other counts may have constituted a small portion of the total population. The maximum number of adult GGBF detected during a single survey at the STP was ten (during the 2006-2007 season).

Successful breeding (metamorphlings) was recorded in 1999, 2000 and 2001. No breeding has been observed since then.

In July 2005, approximately twenty GGBF were heard calling from a swamp within Conjola NP (D. Stevenson, pers. comm.). During 1999, diurnal surveys were conducted for GGBF within Sussex Inlet Golf Course (G. Daly unpub. data). Although the area had several dams and emergent aquatic vegetation no GGBF were detected. However, discussions with groundsmen at that time indicated that GGBF had been seen around one dam.

### 2.4 Chytrid status of the GGBF population

Nineteen swab samples were taken from GGBF at the Sussex Inlet STP during the 2006-2007 season (Gaia Research 2007). The samples were analysed for the presence of chytrid, at the CSIRO laboratory in Geelong Victoria. Of the remaining samples, one tested positive for chytrid, with 42 zoospores present. However, during the first analysis, no clear result could be obtained for twelve samples, due to inhibition of the control reagent. Of these, nine were re-analysed at 1/100 dilution, either individually or as a batch of four samples. This re-analysis indicated another sample was positive for chytrid (no zoospore count given). In summary, these results indicate that chytrid is present in at least parts of the Sussex Inlet GGBF population.





**Figure 2.** Sites where GGBF have been detected in the Sussex Inlet area



**Figure 3.** Sussex Inlet STP and environs

### 3. THREAT ASSESSMENT

A management plan for the Sussex Inlet GGBF population in the STP area was completed in the year 2000 (Gaia Research 2000). It proposed several management actions for the STP ponds and associated septic ponds, including the road crossing (The Springs Road) and Crown Land east of The Springs Road. As a result of that management plan, Shoalhaven City Council has undertaken the following actions:

1. Overflow Pond A is allowed to dry out and fill naturally to a depth of one metre.
2. Sludge from the STP is no longer pumped into Pond B.
3. Emergent aquatic vegetation within Pond A is infrequently slashed and the areas of Cumbungi on the south-east and north-east corner are retained.
4. Herbicides are not used to control emergent aquatic plants.
5. Shoalhaven Water has funded additional monitoring and research. Twenty two surveys have been conducted at the site during summer and autumn from 1999 to 2007.

The following additional threats to the Sussex Inlet population have been identified:

1. Loss of habitat. The GGBFs occupy and utilise a wide variety of habitat types within the areas identified above. There is continuing pressure to further modify bushland for urban and agricultural development. This has led to loss of areas that provide habitat for the GGBF, i.e. within the water easement to the east of The Springs Road, and to loss of connectivity between foraging and breeding sites. Loss of habitat can also be as a result of weed invasion, particularly Bitou Bush *Chrysanthemoides monilifera rotundata* (Listed as a Key Threatening Process under the *TSC Act 1995*).
2. Introduced predators that include Plague Minnow – *Gambusia holbrooki* (Listed as a Key Threatening Process under the *TSC Act 1995*). Plague Minnow are not present in Swan Lake. To reduce the risk of Plague Minnow colonising the wetland there must be a concerted effort to educate landowners within the catchment on the problems associated with this exotic predator. Fortunately the majority of the catchment of Swan Lake is within the DECC reserve system.
3. Disease. Frog Chytrid *Batrachochytrium dendrobatidis* - is listed as a Key Threatening Process under the *TSC Act* and *EPBC Act*. This disease may be the most serious threat to GGBF limiting population recovery. The hygiene protocol for the control of disease in frogs (Wellington and Haering 2001) should be adhered to at all times.
4. Feral and Domestic Cats - *Felis catus* and Red Fox (Listed as a Key Threatening Process under the *TSC Act 1995*) are both known to prey on adult or juvenile GGBF.
5. Predation of GGBF from native predators may also be a threat to the species because the population has declined to such an extent that it is not robust. Native predators include Eels *Anguilla* spp., Red-bellied Black Snake *Pseudechis porphyriacus*, Eastern Tiger Snake *Notechis scutatus* and Ibis *Threskiornis* spp.
6. Water quality. Runoff including sediments and chemicals from urban and agricultural areas may pollute GGBF habitat such as wetlands and drainage areas. Pollution can also be a result of inappropriate application of chemicals (Glyphosate) for weed control.
7. Anthropogenic climate change (Listed as a Key Threatening Process). Rises in sea level and changes in rainfall patterns may impact on where, and if, GGBF can utilise some breeding sites.
8. Inappropriate Management. GGBF populations may be negatively affected by the use of herbicides and pesticides, the opening and closing, or emptying, of water bodies, as well as inappropriate fire frequency and intensity (Listed as a Key Threatening Process under the *TSC Act 1995*).
9. GGBF can be killed or negatively affected by direct human impact, such as mowing or collisions with motor vehicles (The Springs Road).

## **4. ON-GOING AND FUTURE MANAGEMENT ACTIONS**

Appendix A lists several Management Actions which aim to (a) maintain the existing GGBF population; (b) increase the population; and (c) improve the habitat for GGBF in the Sussex Inlet area. These actions arise from discussions at a recent stakeholder meeting (see 4.1. below) and are also based on Gaia Research (2000), which lists several desirable conservation measures. They can be assigned to the following five strategies:

1. Community consultations and education to build awareness of the GGBF;
2. On-ground actions such as removal of invasive weeds, creation of potential breeding habitat, fox baiting and providing a frog underpass on The Springs Road;
3. Improvement of habitat within the broader catchment of Swan Lake;
4. Reduction of external threats to GGBF; and
5. Monitoring and research to better understand the extent and dynamics of the GGBF population.

### **4.1 Community consultations**

A stakeholder workshop was facilitated by Gaia Research Pty Ltd to identify the above threats and possible management actions as a basis for preparing the PoM. The workshop was held on 5 March 2007 with representation from local residents, Shoalhaven City Council, Shoalhaven Water, councillor, Forests NSW and DECC. A draft of this plan was then distributed to these stakeholders for comment. Further comments are welcome and should be submitted to DECC, Metro (details on inside cover).

An interview with G. Daly was broadcasted on the local ABC on 14 March 2007 dealing with the plight of GGBF. However, the follow up of reported sightings did not reveal any new records in the Sussex Inlet area.

### **4.2 Habitat restoration**

There have been no specific habitat restoration works conducted in the immediate area where the GGBF exist. There is opportunity to create additional breeding habitat on land managed by SCC adjacent to the STP. Currently, this land is a refuse depot, but decommissioned areas could have shallow multipurpose dams dug to capture sediment and provide breeding habitat for GGBF.

DECC could consider partially filling the channel that drains the wetland in Conjola NP where GGBF have been found. The works should allow water to pool in the wetland for longer periods and would hence better cater for the breeding requirements of frogs.

The most expensive proposal for conservation of the Sussex Inlet GGBF would be to provide underpasses for The Springs Road by the provision of concrete box culverts to facilitate the movement of frogs along the sedgeland to the east of the STP. If a series of culverts were installed in conjunction with other movement barriers, then the frogs could move through the underpass and reduce the likelihood of road kills.

### **4.3 Habitat acquisition and conservation**

The majority of the catchment of Swan Lake lies within Conjola NP. There is a small settlement to the west of the STP and light industrial land to the north. The bushland that is within existing conservation reserves provides secure habitat for the dispersal of frogs west from the STP to the lake. The habitat in the wetland/sedgeland to the east of the STP is not within a conservation reserve, and its long-term conservation is thus not secured.

### **4.4 Fox baiting**

Fox baiting is conducted by the National Parks and Wildlife Service in Conjola NP. Foxes do forage in the Sussex Inlet STP (scats observed) and there is an opportunity for Shoalhaven City Council to implement a baiting regime within the confines of the STP.

## 4.5. Monitoring and research

Two transects around the perimeter of Swan Lake were surveyed for GGBF in 2007 (Gaia Research 2007). No GGBF were detected during these searches. Most records of GGBF in the area were obtained from the STP. These surveys were limited to the STP, but provide valuable information on the occurrence of GGBFs in the area. This work should continue.

Chytrid fungus *Batrachochytrium dendrobatidis* is listed on the TSC Act as a key threatening process to amphibians within many countries including Australia (Berger *et al.* 1998, Hyatt *et al.* 2007). The disease has been implicated in amphibian deaths, population declines and extinction in some species of Australian frog. The disease is widespread in many different environments; and is implicated in the decline and local extinction of the GGBF. Nineteen samples taken from GGBF at Sussex Inlet STP were tested for the presence of chytrid. Two of these were positive for chytrid. However, recent studies indicate that chytrid is either being destroyed or attenuated in waters with a certain water quality, including waters with a certain degree of bacterial activity. It could be that that GGBF persist at Sussex Inlet STP because certain water contaminants attenuate or suppress chytrid. However, this theory warrants further monitoring and research.

## 5. DURATION

This plan will be implemented from early July 2007 to end June 2010.

### REVIEW

A review of the plan is required after 2.5 years as a basis for its next iteration after three years. Informal review of the plan is also encouraged both within organisations and through networks and partnerships. All recommendations to improve the plan should be directed to the DECC contact given in the inside cover of this plan.

### FROG HYGIENE PROTOCOL

Individuals studying or surveying frogs often travel and collect samples of frogs from multiple sites and, without implementing the hygiene protocol, may be a cause for the spread of the chytrid disease. Green and Golden Bell Frogs can be particularly sensitive to the introduction of infectious pathogens, such as the frog chytrid fungus. Therefore, it is important that frog workers recognise the boundaries between sites and undertake measures, to reduce the likelihood of spreading infection. The detailed procedures and measures are provided in the Hygiene protocol for the control of disease in frogs (NPWS 2001), which can be obtained from the Department of Environment and Climate Change, or downloaded from: <http://www.nationalparks.nsw.gov.au/pdfs/hyprfrog.pdf>

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## Appendix A. Implementation plan

### Strategy 1: Education and communications to build awareness of the GGBFs and encourage further on-ground actions

Action	Recovery plan links	Responsibility	Cost	Funding source	Timeframe
1.1 Shoalhaven Water/SCC conduct training for staff on fox control baiting	Actions 10.3.1, 14.3.2	Shoalhaven Water, SCC	In-kind	Shoalhaven Water	2007-2010
1.2 Prepare, distribute, and report on, a community survey seeking GGBF observations	Actions 12.3.1, 14.3.2	Consultants, Shoalhaven City Council Environment groups	\$2,000 (advertising, printing). Environment groups distribute/collect and collate	DECC/ Shoalhaven City Council	2007-2009
1.3 Liaise with Illawarra Department of Education & Training (DET) to develop and implement GGBF education programs in local schools	Action 14.3.2	DECC DET	In-kind DET; educational consultants \$1,500	Environmental Trust	2007-09
1.4 Develop a forum (e.g. email list) through which the community can access information about the local GGBF population and frog-friendly activities	Action 14.3.1	DECC, Consultant Other stakeholders	DECC Threatened Species website		2008-2009
1.5 Liaise with local media (print, radio, TV) to encourage them to regularly report on GGBFs and the roll out of management actions in this plan	Action 14.3.1	DECC, Gaia Research, Consultants, Other stakeholders	In-kind	In-kind by Gaia Research & DECC (e.g. interviews and media releases)	Initiated in 2007 by Gaia Research but ongoing
1.6 Use or stage local community events to highlight GGBFs and encourage frog-friendly actions	Action 14.3.2	Shoalhaven City Council DECC	\$3,000 (production of static display for events)	SCC and Local sponsors	2007-2009
1.7 Raise community awareness through field demonstration days, information brochures and other community education programs	Action 14.3.2	Shoalhaven City Council DECC, consultants	\$1,000	DECC/ Shoalhaven City Council	2007-2009

**IMPLEMENTATION PLAN (continued)****Strategy 2: Further development of GGBF breeding habitat on public and private lands**

<b>ACTION</b>	<b>RECOVERY PLAN LINKS</b>	<b>RESPONSIBILITY</b>	<b>COST</b>	<b>FUNDING SOURCES</b>	<b>TIMEFRAME</b>
2.1 Create breeding habitat at decommissioned refuse site	Action 11.3.3	Shoalhaven City Council and consultants	> \$5,000	NHT/NSW Environmental Trust Grants/ Council/ Threatened Species Network Community Grants	2007-09
2.2 Install plastic breeding troughs at appropriate locations with approvals	Action 11.3.3	DECC	\$5,000	NHT/NSW Environmental Trust Grants/CMA devolved grants	2007-10

**Strategy 3: Improvement of habitat within and between the GGBF sub-populations**

<b>ACTION</b>	<b>RECOVERY PLAN LINKS</b>	<b>RESPONSIBILITY</b>	<b>COST</b>	<b>FUNDING SOURCES</b>	<b>TIMEFRAME</b>
3.1 Investigate opportunities for improving sub-population connectivity between STP and east of The Springs Road (link with Action 5.1)	Actions 10.3.1, 11.3.3	DECC	to be determined (same budget as for Action 5.1)	CMA devolved funding/NSW Environmental Trusts/local sponsors	2007-10



## IMPLEMENTATION PLAN (continued)

### Strategy 4: Reduction of external threats to GGBFs

ACTION	RECOVERY PLAN LINK	RESPONSIBILITY	COST	FUNDING SOURCES	TIMEFRAME
4.1 Promote responsible cat ownership in relation to GGBFs through education (link with Actions 1.4, 1.5, 1.6)	Actions 11.3.2, 14.3.2	DECC, Consultants, Shoalhaven City Council 1	As required	In-kind, council and industry work budget in liaison with DECC	2007-10
4.2 Control feral predators; Initiate fox baiting programs at Sussex STP and Conjola NP.	Actions 11.3.2, 11.3.6	Shoalhaven City Council DECC	As required	Council and industry works budgets in liaison with DEC	2007-10
4.3 Minimise stormwater impacts on GGBFs and their habitats through stormwater plans and actions	Action 11.3.1	Shoalhaven City Council DECC	As required	Stormwater plan budgets	2007-10
4.4 Investigate mechanism to reduce road toll on GGBF on The Springs Road. Link with Action 3.1	Actions 11.3.2,	Shoalhaven City Council	As required		2007-10
4.5 Liaise with landowners (Council, industries, residents) to encourage best practices (e.g. mowing, landscaping, maintaining wet areas) related to GGBF habitat (link with Actions 1.1, 1.4, 1.6, 1.7). Create guidelines for best practices.	Actions 11.3.1, 14.3.2	DECC	See other Actions		2007-10

**IMPLEMENTATION PLAN (continued)****Strategy 5: Monitoring and research to better understand the extent and dynamics of the Coomonderry Swamp, Sussex Inlet and Crookhaven floodplain GGBF populations**

<b>ACTION</b>	<b>RECOVERY PLAN LINKS</b>	<b>RESPONSIBILITY</b>	<b>COST</b>	<b>FUNDING SOURCES</b>	<b>TIMEFRAME</b>
5.1 Map and identify existing and potential habitat across the broader Sussex Inlet area (link with Action 3.1)	Action 11.3.4, 12.3.2	DECC and consultants	\$20,000 (same budget as Action 3.1)	CMA devolved funding/NSW Environmental Trusts	2007-09
5.2 Continue the systematic surveys to determine baseline population numbers and location. Reconcile with historic records	Action 12.3.1	DECC and consultants	\$30,000	CMA devolved funding/NSW Environmental Trusts/local sponsors	2007-10
5.3 Monitor effectiveness of management actions against baseline data from Action 5.2. Report findings to DECC, Shoalhaven Water and community (link with Action 1.5)	Action 12.3.1	DECC	\$5,000	CMA devolved funding/NSW Environmental Trusts/local sponsors	2008-10
5.4 Undertake sampling of frogs and water at different locations to see if frog chytrid is present. Link in with national Threat Abatement Plan (TAP) for chytrid.	Actions 11.3.5, 12.3.2	DECC	\$15,000	CMA devolved funding/NSW Environmental Trusts/local sponsors/TAP funds, DEC,	2007-10

## Appendix B. Records of GGBF at Sussex Inlet STP

**Note:** a = adults and j = juveniles, nr = not recorded

Date	Survey Period (min.)	Number of GGBF	Temp air °C	Temp water °C	Comment on rain
7.10.99	31	0	18.1	22.0	No rain for 20 days
19.10.99	30	1a	14.0	20.0	No rain for 32 days
27.10.99	90	9a	17.0	21.8	44 mm fell on 24.10.99
30.10.99	30	2a	20.6	22.0	44 mm fell on 24.10.99
9.12.99	90	6a	24.5	20.5	23 mm fell on that day
20.12.99	60	7a, 20j	19.7	21.3	10 mm fell over previous 2 days
30.12.99	70	10a	20.7	23.8	85 mm fell over previous 4 days
14.2.00	40	3a, 6j	18.5	20.7	4 mm fell on previous day
25.2.00	40	8a, 7j	20.7	23.8	0.8 mm fell over previous two days
21.1.01	38	5j	26.7	Nr	43 mm fell 3 days before
28.1.01	60	1a	26.6	21.0	21 mm fell 2 days before
1.2.01	135	6a	26.7	Nr	11 mm fell on day
5.2.01	120	8a	23.6	22.2	30 mm fell on day
10.12.01	120	8a, 1j	19.1	23.2	7 mm fell previous 3 days
16.1.02	60	0	21.2	19.7	36 mm fell on day
25.1.02	60	1a	22.2	23.0	42 mm fell on day
7.2.02	66	42a	17.4	19.9	125 mm fell over previous 3 days
12.4.02	30	4a	Nr	Nr	No rain for 12 days
16.10.06	72	10a	Nr	Nr	Region in drought
3.1.07	Nr	0	Nr	Nr	Shallow pools – prior rain had fallen
13.2.07	35	8a	18.7	19.1	60 mm rain GGBF around Pond B only
28.2.07	40	5a	22	23.1	Nr