Murrumbidgee to Googong Water Transfer:

Aquatic Ecology Monitoring Plan

Version 1

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Certificate of approval for issue of documents

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1	Marco Bottari	September 2013	Consolidation of Burra Creek Environmental Management Plan, Ecological Monitoring Sub Plan and Geomorphologic Monitoring Sub Plan.	28 Jan 14

Contents

Acronyms

ACT	Australian Capital Territory
AEMP	Aquatic Ecology Management Plan
AFDM	Ash Free Dry Mass
ARI	Average Recurrence Interval
AUSRIVAS	Australian River Assessment System
BEMP	Burra Creek Environmental Management Plan
DECC(W)	NSW Department of Environment, Climate Change (and Water) – now NSW Office of Environment & Heritage and NSW Office of Water
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPA	Environment Protection Authority
GMP	Geomorphology Management Plan
M2G	Murrumbidgee to Googong Water Transfer
MEMP	Murrumbidgee Ecological Management Plan
ML	Mega Litre
NSW	New South Wales
OEMP	Operation Environmental Management Plan
RBA	Rapid Bio-assessment
SFWQMP	Stream Flow & Water Quality Management Plan

Register of significant changes/additions to previous version(s) or previous relevant document(s)

Previous relevant documents:

- Burra Creek Environmental Management Plan, Version 1.1, November 2011
- Ecological Monitoring Plan, Version 4, September 2010
- Geomorphologic Monitoring Plan, Version 5, December 2010

Table 1.1 Significant changes/additions to previous version(s) or previous relevant document(s)

Subject	Description of change/addition	Addressed within:
Terrestrial Ecology	All references to terrestrial ecology monitoring and commitments have been omitted from this amalgamated plan. The omissions relate predominately to section 1.3, 5, 7.3 and 8.2 of the Ecological Monitoring Plan (2010).	Landscape Rehabilitation and Terrestrial Ecology Management Plan
Flow & Water Quality	All reference to stream flow and water quality monitoring and commitments have been omitted from this amalgamated plan. The omissions relate to section 3 of the Burra Creek Environmental Management Plan (2011).	Stream Flow and Water Quality Monitoring Plan
Compliance Tracking Program	Detail within the Compliance Tracking Program – Operations section noted in the Burra Creek Environmental Management Plan (2011) and the Geomorphologic Monitoring Plan (2010) has been omitted from this amalgamated plan and replaced with a reference to the corresponding sections in the Operation Environmental Management Plan.	Operation Environmental Management Plan
Roles & Responsibilities	Detail within the Roles and Responsibilities section noted in the Ecological Monitoring Plan (2010) and the Geomorphologic Monitoring Plan (2010) has been omitted from this amalgamated plan and replaced with a reference to the relevant sections in the Operation Environmental Management Plan.	Operation Environmental Management Plan
Reporting	The reporting section noted in the Ecological Monitoring Plan (2010) and the Geomorphologic Monitoring Plan (2010) has been omitted from this amalgamated plan.	Operation Environmental Management Plan
Auditing	The Auditing section noted in the Geomorphologic Monitoring Plan (2010) has been omitted from this amalgamated plan.	Operation Environmental Management Plan
Integrated Annual Report	Commitment to produce an integrated annual report noted in section 6 of the Ecological Monitoring Plan (2010) has been reworded to reflect our commitment to perform longer term assessments at appropriate intervals.	Aquatic Ecology Monitoring Plan
Geomorphology	Monitoring frequencies and management actions have been amended to reflect current operational status and monitoring approach/design.	Aquatic Ecology Monitoring Plan

Subject	Description of change/addition	Addressed within:
General Text	Multiple changes have been made, whilst maintain the intent of the plan. The operating mode word ‘shutdown’ replaced with ‘suspension’ to have consistent terminology with Section 10.2.7 of AS 2885.3 2012 ‘Pipelines - Gas and liquid petroleum-Operation and maintenance’.	Aquatic Ecological Monitoring Plan
Fish	Monitoring frequencies altered to reflect current operational status and recommendations made in previous monitoring reports.	Aquatic Ecological Monitoring Plan

1. Introduction

1.1 Purpose

The Ecological Monitoring Plan (EMP 2010; NSW approval condition) has been redrafted to incorporate the Burra Creek Environmental Management Plan (BEMP 2011; Commonwealth approval condition) and the Geomorphologic Monitoring Sub Plan (GMP 2010; NSW approval condition). This revised document will be known as the Aquatic Ecology Monitoring Plan (AEMP) and sits beneath the overarching Operation Environment Management Plan (OEMP) for the Murrumbidgee to Googong Water Transfer (M2G) project.

The purpose of the AEMP is to:

- Describe monitoring programmes, schedules and techniques;
- Establish triggers to alert operators to possible unsafe periods of abstraction from the Murrumbidgee River or discharge to Burra Creek;
- Establish review procedures and management actions that should be initiated if triggers are exceeded; and
- Ensure no adverse change to the physical, chemical or biological condition of waters affected by the water transfer.

It details how:

- The aquatic ecology in the Murrumbidgee River and Burra Creek is monitored in order to assess ecological impact of the scheme;
- The impact of the scheme on the geomorphology of Burra Creek at the pipeline outlet and downstream to Googong reservoir and Murrumbidgee River near the abstraction point is monitored; and
- To adaptively manage any adverse impacts that may arise from the operation of the pipeline.

The AEMP is closely linked to:

- The OEMP;
- The Stream Flow and Water Quality Monitoring Plan;
- The Construction Environment Management Plan (2012); and
- The Landscape Rehabilitation and Terrestrial Ecology Management Plan.

The monitoring plans supply important information back to the water transfer managers about observed performance compared to environmental and operational standards or triggers. They are a key part of the adaptive management process, which is formalised in the OEMP.

1.2 Objectives

This Aquatic Ecological Monitoring Plan aims to determine the baseline Murrumbidgee River and Burra Creek condition prior to water abstraction, and then to continue monitoring after commencement to determine what changes are taking place that are attributable to abstraction from Angle Crossing and subsequent discharge into Burra Creek.

The key objectives of this monitoring program are:

- To determine water transfer management actions by assessing whether and to what extent water abstraction at Angle Crossing is affecting aquatic ecosystems in the Murrumbidgee River.

- To determine water transfer management actions by assessing whether and to what extent water abstraction at Angle Crossing and subsequent discharge into Burra Creek is affecting aquatic ecosystems in Burra Creek.
- To assist water transfer management actions by assessing stream geomorphologic impact within Burra Creek and at the abstraction point on Murrumbidgee River.

Initiation and regulation of water transfer depends both on information about the state of aquatic ecology and geomorphology in both the Murrumbidgee River and Burra Creek (this Plan), and the stream flow and water conditions in the Murrumbidgee River and Burra Creek (see Stream Flow and Water Quality Plan).

The results of this plan, when combined with the outcomes of the Stream Flow and Water Quality Monitoring Plan will also support the adaptive management framework and the underpinning *2011 Environmental Flow Guidelines*.

Following Australian experiences in river health monitoring, the river and creek will be examined using several ecological indicators. Sampling will occur at a range of sites in the upper Murrumbidgee River upstream and downstream of Angle Crossing, as well as upstream and downstream of the Burra Creek discharge outlet. This monitoring program forms part of a larger ACTEW program, known as the Murrumbidgee Ecological Monitoring Program (MEMP).

The indicators for the overall monitoring program are:

- Streamflow (hydrological) characteristics
- Water quality parameters (physico-chemical)
- Aquatic ecology (macroinvertebrates and periphyton)
- Freshwater fish assessment
- Bank (riparian) and in-stream vegetation characteristics
- Bed (geomorphological) and sediment characteristics
- Water levels in Googong reservoir.

These indicators are linked to the other OEMP plans.

The program is designed to be adaptive. Information gained from monitoring will be fed back to the Murrumbidgee to Googong (M2G) water transfer operators and the Environmental Reference Group so that appropriate management actions can be initiated as required. This will enable the operation to undergo continual improvement to ensure objectives are maintained over time and the best possible outcomes are achieved.

The Murrumbidgee to Googong pipeline is complete and with Googong reservoir near full supply level there is currently no requirement to run the pipeline for continuous water transfer and this is likely to be the case for the next few years. During this time the pipeline is only required to be operated on a routine basis for short periods to maintain the pumps and to ensure the pipeline remains fully operational. With this in mind the pipeline can be in one of three modes; Suspension, Standby and Operating. These modes influence the geomorphologic monitoring program (section 3.4).

2. Ecological monitoring program - Murrumbidgee River

The primary monitoring focus of this program is the local abstraction reach of the Murrumbidgee River at Angle Crossing. Much of the monitoring information and methodology described below is already in place in ACTEW's current Murrumbidgee Ecological Monitoring Program (MEMP).

The relevant questions targeted by the monitoring are shown in a framework in Appendix B. This framework responds primarily to ACT Government stakeholders and provides a mechanism for evaluating the causes and extents of changes in the river ecosystem; these will be traced through various indicators that reflect the existing ecological condition in the river.

In this monitoring, the potential effects of abstraction are to be quantified, and where possible, compared to existing and future stressors of the river. Thus, the focus is on the current aquatic/riparian ecosystem conditions and the impacts of future abstraction at Angle Crossing, using a variety of ecological indicators.

The information generated by the monitoring will allow the ACT Environment Protection Authority (EPA) to monitor the outcomes of the *2011 Environmental Flow Guidelines* and ACTEW's licence on the river and riparian ecology; and allow both ACTEW and the ACT EPA to better understand appropriate limits to abstraction, any impact thresholds on the riverine ecosystem, and to undertake an adaptive management approach for the future.

2.1 Key monitoring elements

The key monitoring objectives of the program will be able to identify and provide qualitative and quantitative data on changes occurring in the Murrumbidgee River with regard to:

- How abstraction at Angle Crossing affects the maintenance of healthy aquatic ecosystems, in terms of biota; and
- If the abstraction at Angle Crossing creates flow variations that impact on sediment movement and deposition.

The key elements of the monitoring program are:

- Monitor ecological indicators (macroinvertebrates and periphyton) at select locations with Rapid Bioassessment (AUSRIVAS) sampling, to establish species composition and abundance, combined with quantitative physical habitat assessments;
- Monitoring the fish biota in the river with quantitative sampling, at select locations, to establish composition, abundance and life cycle stages of species; and
- Monitoring of the riverine vegetation, at the macroinvertebrate monitoring locations, to establish floristic compositions, abundance of native and non-native species, recruitment and resilience to change.

2.2 Ecological Indicators - Macroinvertebrate and periphyton

2.2.1 Key monitoring elements

- To establish a knowledge base of the condition of macroinvertebrate communities at test and control sites to assist in the monitoring of riverine ecosystem health and the potential impacts of abstraction.
- To establish seasonal and annual variation of the composition and abundance of the organic constituent of the periphyton at control and reference sites and to assist in the monitoring of the riverine ecosystem health and the potential impacts of abstraction.

2.2.2 Rationale

Macroinvertebrates and periphyton are two of the most commonly used biological indicators used in river bio-assessment. Macroinvertebrates are commonly used to provide a general characterisation of the health of a stream ecosystem because they represent a continuous record of preceding environmental, chemical and physical conditions at a given site.

The potential for impacts to arise during the implementation of the Murrumbidgee to Googong Water Transfer are dependent upon the pumping regime and the environmental flow rules implemented. Potential effects may include modifications to the stream substrate through sedimentation, loss of riffle zones, changes in water chemistry and periphyton accumulation. These processes in turn may influence the composition of macroinvertebrate communities downstream of the abstraction point.

To monitor for any potential impacts, macroinvertebrates will be sampled in two meso-habitats, riffle and pool edges, and organisms identified to family/genus level, to characterise each site; while periphyton will be sampled in the riffle zones at each site and analysed for chlorophyll-a and ash free dry mass (AFDM), which will provide estimates of the algal (autotrophic) biomass and total organic mass respectively (Biggs and Kilroy, 2000).

2.2.3 Macroinvertebrate Sampling

Macroinvertebrate sampling and physical habitat assessments will be conducted using the ACT AUSRIVAS protocols. Under ACTEW's MEMP program, sampling commenced in spring 2008 and has subsequently been conducted in autumn and spring each year.

2.2.4 Periphyton Sampling

The six sites selected, given in Table 2.1, will be sampled for periphyton in autumn and spring in each year in conjunction with macroinvertebrate sampling. All periphyton samples- adnate and loose forms of periphyton, as well as organic/inorganic detritus in the periphyton matrix, will be collected using the in situ syringe method similar to Loeb (1981), as described in Biggs and Kilroy (2000). Parameters that are investigated include Ash Free Dry Mass (AFDM gm2) and chlorophyll-a.

2.2.5 Method

Rapid bioassessment (RBA) methods (i.e. AUSRIVAS) will occupy the main component of this program. The RBA will provide an overview of the system that will indicate, on a broad scale whether there are notable changes.

This data will also be necessary for compliance monitoring as part of ACTEW's water abstraction licence (Licence No. WU67) and will provide information and a vital link between current and long term trends since there is now a comprehensive historical dataset containing AUSRIVAS assessments from previous programs.

The Australian Rivers Assessment System (AUSRIVAS) is a rapid, standard method for assessing the ecological health of freshwaters through biological monitoring and habitat assessment (Coysh et al., 2000). The "Licence to Take Water" (No. WU67) requires the appropriate AUSRIVAS model, accompanying scores and bandings to be utilised, in order to detect any changes in observed and expected macroinvertebrate communities within the studied sites (Table 2.1). This program will implement the ACT AUSRIVAS approach to incorporate ecological health assessments based on riffle and edge habitats,

The AUSRIVAS protocols will involve taking two replicate kicknet samples from each habitat at each site. The residue from each of the two samples will be sub-sampled three times according to the ACT AUSRIVAS protocols (Coysh et al., 2000), resulting in a total of six replicated samples for each habitat and each site. Taxa will be identified to genus level. This expansion of the family level requirements of the AUSRIVAS protocols should allow better detection of subtle changes in the system; and thereby facilitate in the early detection of any potential impacts, which may allow rapid remediation before any potential problem(s) escalate. The sampling regime shall be reviewed through assessment of the data as indicated later in this plan.

Habitat assessments will be undertaken twice annually in spring and autumn, concurrently with each sampling event. Habitat and site information will be collected on ACT AUSRIVAS data sheets. This will assist in the interpretation of the biological information and will also compliment data obtained from the geomorphology component.

2.2.6 Site Selection

The selected sites for the monitoring of macroinvertebrates and periphyton are given in Table 2.1 and are depicted in Appendix A. Three of the sites are upstream of Angle Crossing and three are downstream. All of the selected sites are characterised by good riffle and edge zones. The sites are also accessible by staff without compromising safety.

Table 2.1: Site locations for macroinvertebrate and periphyton monitoring

Site	Site code	Location	Monitoring	Latitude	Longitude
1	MUR 15	Approximately 30 km U/S of Angle Crossing; near Colinton; riffle zone is in a narrow side channel	M,P,W	S 35.8681	E 149.1344
2	MUR 16	U/S Angle Crossing; good riffle zones and access	M,P,W	S 35.7634	E 149.1382
3	MUR 18	U/S Angle Crossing; Within 1 km of the abstraction site; good riffle zone; good macrophyte beds	M,P,W,G	S 35.5878	E 149.1093
4	MUR 19	D/S Angle Crossing; directly below abstraction site with good riffle; monitor macrophytes in island in middle of river	M,P,W,G	S 35.5829	E 149.1094
5	MUR 23	D/S Angle Crossing; at Point Hut; good riffle. Narrow stretch and suitable substrate for periphyton sampling	M.P,W	S 35.4502	E 149.0749
6	MUR 28	Approximately 33 km D/S Angle Crossing; U/S Cotter River confluence; river narrow; good riffle zone with cobble substrate suitable for periphyton sampling	M,P,W	S 35.3244	E 148.9504

M = macroinvertebrates; P= periphyton; G= geomorphology; W = water quality
U/S = upstream; D/S = downstream

2.2.7 Data analysis

Prior to abstraction the analyses focused on assessing the similarities and differences between the biological signatures at different reaches of the upper Murrumbidgee and temporal differences and trends. These analyses have formed an understanding of the underlying environmental factors responsible for observed trends and will better allow for the effects of operations to be identified from nature variation.

The main analyses of these data will involve both univariate and multivariate techniques including, but not limited to the following:

2.2.8 Univariate analyses

Univariate analysis will be used to determine the magnitude of differences between sites and sampling occasions (e.g. Analysis of Variance, ANOVA or the non-parametric analog) for the periphyton data and where applicable, biological metrics (see below).

2.2.9 Biological metrics

Certain biological measurements (metrics) will be derived from the collected data as to best describe river "health" at a given site. These will include, but are not limited to:

- AUSRIVAS O/E scores
- Taxonomic richness
- PET taxa Index
- SIGNAL-2 (weighted tolerance scores)
- Community stability (turnover), to be undertaken prior to continuous operation

2.2.10 Multivariate analyses

Multivariate techniques will be applied to macroinvertebrate data to describe and illustrate spatial and temporal trends and associations between the sites in this program. These techniques may include, but are not limited to:

- Ordination (Non-metric Multi-Dimensional Scaling – NMDS);
- The ANOSIM (ANalysis Of SIMilarity) routine - used to determine if the differences between groups of sites observed within the ordination plots are significantly different;
- The SIMPER procedure - used to investigate the taxa responsible for any observed temporal and spatial changes in macroinvertebrate community structure between and within sites;
- BVSTEP – used to determine the best combination of environmental variables proportion of macroinvertebrate assemblages, explained by measured environmental variables (e.g. land-use practices, habitat variables etc) can be calculated using the BVSTEP routine; and
- PERMANOVA – a non-parametric procedure using permutation that allows hypothesis testing to be conducted on studies involving multivariate data sets (i.e. macroinvertebrate communities) in single or multi-factorial designs.

2.2.11 Methodology and sampling review

It is the intention of the program to be dynamic and adaptive. Conditions prevailing at the time of sampling, and analysis results from previous sampling runs, shall be used to modify the methodologies as required to best suit improvement to the outcomes of the program.

The sampling regime undertaken at the commencement of the program is designed to provide a suitable baseline of information to enhance existing data sets and reduce information gaps in future monitoring regimes.

If the information gathered from the current regime (for example, high replication and genus level taxonomic resolution) shows similar results and patterns when compared to reduced levels of replication and higher taxonomic resolution (i.e. family level), then recommendations will be made to scale down the sampling and processing components of this monitoring program.

Recommendations to adapt the scale/extent of the monitoring program may also be initiated in response to the level of M2G operation (i.e. long periods of high volume pumping, compared to long periods of maintenance flows only).

Consultation of this element of the program may be sort from a principle aquatic ecologist independent of the project, before such recommendations are finalised.

2.3 Fish monitoring

2.3.1 Aim

- To obtain ongoing fish population status to assist in the monitoring of the riverine ecosystem and potential impacts associated with operating the pipeline.

2.3.2 Rationale

The Murrumbidgee River provides habitat for a number of native (including several threatened species) and alien fish species.

Known key ecological values of the upper Murrumbidgee River include the provision of important habitat for a number of iconic and threatened fauna species, including:

- Trout Cod (Maccullochella macquariensis);
- Macquarie Perch (Macquaria australasica);
- Murray Cod (Maccullochella peeli peeli); and
- Murray River Crayfish (Euastacus armatus).

Angle Crossing, along with a number of other sites in the upper Murrumbidgee, has also been used as a site for the stocking of Trout Cod, as part of the Trout Cod Recovery Plan.

Fish are widely used in the monitoring of river condition, particularly related to flow changes. Fish also have relatively well known biology and environmental requirements, many components of which are flow dependent. The collection of fish and determining their taxonomy to species level is also relatively inexpensive and rapid. Fish are also at the apex of the aquatic food web and react to degradation or improvement in their habitat.

Pumping from Angle Crossing has the potential to affect fish populations above and below the abstraction point. Impacts that have the potential to affect fish populations include: increasing fine sediment deposition; exacerbation of low flow periods; and loss of temporal change of small and medium flow peaks. Such effects may influence spawning cues and movement; cause changes in habitat through sedimentation and loss of riffle zones.

Fish data already exists for the Murrumbidgee River in reaches upstream and downstream of Angle Crossing. These data will be used in the establishment of a knowledge base.

2.3.3 Sampling

The ACT Government (TAMS Conservation Planning and Research group) has been undertaking regular fish surveys of the Murrumbidgee River every two years since 1994. This information will provide a solid foundation for establishing current fish populations in the region of Angle Crossing.

Whilst the pipeline is in 'Standby' mode (section 2.4), a fish survey will be undertaken biennially to coincide with TAMS's sampling program. When the pipeline is operated for water supply (Operating mode) sampling will be conducted annually for a period time, the length of which is to be determined.

2.3.4 Methods

The fish monitoring involves:

- A general fish survey, focused on riverine habitat types and current monitoring sites, upstream and downstream of Angle Crossing.

The general fish survey has determined the current fish community prior to abstraction, and will enable comparison with conditions after abstractions and/or additional releases of flow.

A site upstream of Angle Crossing will act as a control site should no or minimal flow be released from Tantangara Dam. The sites below Angle Crossing enable an assessment of the potential impacts of flow variations and abstraction.

2.3.5 Sampling sites

Fish monitoring will be undertaken at three (3) sites upstream of the abstraction point at Angle Crossing and three (3) sites downstream of Angle Crossing on the Murrumbidgee River. The selected sites are known to have fish biota representative of the fish community in the reach.

The sites upstream of Angle Crossing are:

- Boat Hole (Angle Bend) - approximately 500m upstream
- Lawler Road – approximately 13.5km upstream
- Kissop's Flat – approximately 95km upstream

The sites downstream of Angle Crossing are:

- Tharwa Sandwash – approximately 7km downstream;
- Point Hut Crossing – approximately 15km downstream; and
- Kambah Pool – approximately 30km upstream.

Each site is between 500m and 1000m of river length, and has flow-dependent habitat features, such as riffles, gorge or sand slugs and permanent pools of water. The sites are also relatively accessible, and some have previous long-term data.

2.3.6 Data analysis

Fish caught will be identified to species level and measured to the nearest mm (CFL or TL). Where large numbers of small fish are encountered, a sub sample (~25) from each year type will be measured and the remainder counted.

Fish will be examined for external abnormalities, such as lesions or infection by the external copepod parasite Lernaea sp.

Some large bodied fish, including Trout Cod, Macquarie Perch and Carp may be tagged with PIT tags to enable future identification and assist in future monitoring of fish movement in the ACT.

Some of the parameters and indices that will be examined include:

- Community composition
- Nativeness index: the proportion of native species by number and potentially by biomass if length/weight tables are available
- Fish abundance
- Catch per unit effort for selected methods (Fish per shot or fish per net night)
- Length frequencies for selected species
- External parasite loads.

2.4 Geomorphology Monitoring Program

2.4.1 Aim

- To monitor geomorphologic condition upstream and downstream of the abstraction point on Murrumbidgee River.

Pipeline modes

The Murrumbidgee to Googong pipeline is complete and with Googong reservoir near full supply level there is currently no requirement to run the pipeline for continuous water transfer and this is likely to be the case for the next few years. Currently the pipeline is only required to be operated on a routine basis for short periods to maintain the pumps and to ensure the pipeline remains fully operational.

The pipeline may be in one of three modes:

- **Suspension**: parts of system may be decommissioned requiring lead time before start up. No water can be transferred.
- **Standby**: ready to run, all components in place and being operated routinely for maintenance purposes (see SFWQMP for more detail).
- **Operating**: operating in earnest, transferring to increase Googong reservoir storage levels.

During ‘Operating’ mode the system may be parked due to out of specification water, plan triggers or maintenance.

2.4.2 Key monitoring elements

The key monitoring objectives of the program are to collect quantitative and semi-quantitative data that will assist the program to identify any changes occurring, and to determine whether or not the abstraction from Murrumbidgee creates flow variations that impact on erosion, sediment deposition and movement.

The zones of geomorphological monitoring are identified and prioritised adaptively, in response to the information that is gathered through the life of the program. Sites are expected to change in response to natural flood events that will occur in the Murrumbidgee River.

The key elements of the monitoring program are:

- Monitoring sediment transportation and deposition changes to determine changes in bed and bank erosion, armouring and deposition, and effects on vegetation structure.

2.4.3 Rationale

Stream flow is a major determinant of stream form and channel morphology, it also dictates the capacity of which a stream can transport sediment. As such, stream flow may strongly influence the composition of aquatic flora and fauna. The structural adjustment of channel units, such as channel widening and redistribution of channel material may result in short and long term changes to water quality, and to riparian and aquatic habitat conditions.

2.4.4 Method – Suspension

Monitoring requirements will be negotiated with the stakeholders of this plan if the pipeline is placed in ‘Suspension’ mode. It is likely that monitoring would be significantly reduced during this time and then reinstated prior to the pipeline being recommissioned.

Method – Standby

- Annual visual inspections (by a geomorphologist or suitably qualified hydraulic engineer) at key sites, upstream and downstream of the abstraction point.
- Prior to the pipeline commencing in Operating mode for continuous water transfer to improve Googong water storage capacity, surveyed transects and site observations should be undertaken to re-establish and confirm baseline condition.

Method – Operating

To provide ongoing geomorphologic data on the channel structure, detailed mapping of a selection of channel units is required, upstream and downstream of the abstraction point on Murrumbidgee River.

For this monitoring program, two sites have been selected for the Murrumbidgee;

- The pool area just upstream of the Murrumbidgee River abstraction point
- Two sites approximately 300m and 500m downstream of Angle Crossing

The reaches will be described and channel units will be mapped according to the classifications set out in Table 2.2. The features of each channel type are given in Table 2.3.

Mapping will involve the use of both remotely sensed and field data. Transects will be surveyed by GPS and/or Dumpy Level to provide detailed data on channel form. Finally, field validation of all sites will occur to ensure accuracy of site description and mapping.

The design of the intake structure is not expected to create any sediment scour or deposition issues for Murrumbidgee River, however specific inspections shall be undertaken every three months for the first two years of relatively-continuous water transfer operation to confirm there is no scouring or deposition occurring near the intake structure or eductors as a result of the water abstraction.

2.4.5 Data analysis

Appropriate analysis and reporting of the data will be carried out with reference to the channel form units present, flow-channel structure, sediment loads and movements and establishing the method for monitoring 'change over time' in those units.

The analysis will include the following:

- A description of the current river channel morphology and sediment beds;
- Visual representation of the site data; and
- Comparisons of the current dataset (where possible) with historical changes in the river.

Table 2.2: Chanel unit classification

Slow water	Anabranch	Backwater	Pool	River edge	Slack edge	Sand bed	
Fast water	Riffle	Rapid	Step	Cascade	Fall	Chute	Run

Table 2.3: Diagnostic features of riffles, rapid, step and cascade channel units

Channel Unit Type[1]	Fluvial environment	Range of hydraulic characteristics	Dominant substrate
Riffle	Shallow part of the River bed with moderately steep water surface profile	Rippled, unbroken standing waves; 5-10% water surface area in supercritical flow (white water); >5-10% water surface area in supercritical flow, but finer substrate and more gradual slope than rapid	Gravel and cobble
Rapid	Deeper (than riffle) part of the River bed with steep or stepped water	15-50% water surface area in supercritical flow	Cobble and boulder

Channel Unit Type[1]	Fluvial environment	Range of hydraulic characteristics	Dominant substrate
	surface profile; No pool formation either upstream or downstream		
Step	Point of rapid change in grade (greater than rapid); Backwater pool upstream and plunge pool downstream	>50% water surface area in supercritical flow. Vertical drops of water lower than the bankfull channel depth	Boulder or bedrock or log
Cascade	Steep channel units of closely spaced step-pool sequences	>50% water surface area in superficial flow; Flow cascades	Boulder or bedrock
Fall	Flow obstruction commonly found in bedrock, cascade and step-pool river reaches	Vertical drops of water higher than the bankfull channel depth	Generally bedrock

[1]Fast water channel units listed in increasing order of longitudinal grade change, and critical flow.

Data reporting

When the pipeline is in Operating mode an annual report will be provided and will include a summary and trend analysis, with reference to specific high flow events if they occur. Reporting will include an assessment of the need to alter the frequency or nature of the monitoring program. When in Standby a brief annual report will be produced summarising visual inspections performed during the year, noting any significant changes to the creeks geomorphology.

2.5 Riverine vegetation

2.5.1 Aim

To monitor riverine vegetation before and after water abstractions, at key sites on the Murrumbidgee River to determine changes occurring as a result of water abstraction at Angle Crossing.

2.5.2 Rationale

The quality, condition and extents of riparian vegetation including instream vegetation, are closely linked to the riverine environment – usually in a predictable pattern. Changes in flow can lead to changes in species composition and dominance of some species over others resulting in a decrease in diversity. The relative influence and importance of vegetation to each of the above processes will vary along a river valley, as will the importance of the vegetation associations occurring on various geomorphic units and the strata and growth forms found within them.

Along different channel types, changes in stream flow affect bank area exposure in different ways, potentially leading to encroachment or inundation. These effects may reduce the quality of the vegetation through loss of native species and/or increases in non-native, invasive species. An understanding of the condition of vegetation associated with reaches of the Murrumbidgee River immediately upstream and downstream of Angle Crossing will contribute to assessing whether or not the abstractions have a negative impact on the system as a whole.

2.5.3 Method

The assessment at each site (100m reaches) will be based on obtaining information from three locations, which cover the riverine vegetation along each bank. The location of each site will be determined by GPS coordinates for ease of identification in future monitoring.

Sites will be located generally in areas of high species diversity, and within relatively undisturbed vegetation (i.e. not immediately adjacent to access tracks, disturbed areas or within major weed infestations, such as blackberry). Furthermore, to facilitate data comparisons, sites will cover the range of geomorphic features evident along the channel, namely: sand beds, pools, and cobble/boulder bars and riffles.

Each site will comprise two floristic zones:

- channel edge
- bank edge

All terrestrial and emergent plant species growing in or extending over plots set up in the floristic zones will be recorded and assigned a visually assessed cover/abundance value based on the modified five-point Braun-Blanquet scale (Table 2.4).

Each site will also be photographed to represent the site and location of sites and plots. The photographs will be catalogued and documented and also maintained in digital format.

2.5.4 Sampling sites and timing

Sites selected for vegetation assessments upstream and downstream of Angle Crossing are the same as the macroinvertebrate and periphyton component given in Table 2.1. The preferable time for sampling is during flowering which is generally in spring. This assists in determination and cataloguing of rare and difficult to find species

2.5.5 Data analysis

Appropriate analysis and reporting of the data will be carried out with reference to establishing the vegetation at each monitoring site, with a view to monitoring changes that could occur over time.

The data analysis and reporting will include the following:

- Discussion of threatened or otherwise significant flora species and communities within the study areas that might be affected by modified flow conditions;
- Visual representation of the plot data;
- Comprehensive lists of plant species, cover, and abundance within each of the floristic zones
- ANalysis Of VAriance (ANOVA) routines to assess significant differences between plot data within each of the floristic zones;
- Evaluation of flow velocities and depth characteristics of each transect in relation to the in-channel vegetation recorded at each site, and

- Comparison of the current dataset (where possible) will be made with the data collected during a past monitoring program.

Table 2.4: Modified Braun-Blanquet scale

Cover abundance score	Species coverage within transect
1	Sparse <5% (3 or less individuals)
2	Common <5% (Consistent / many individuals throughout plot)
3	5-25%
4	25-50%
5	50-75%
6	75-100%

3. Ecological Monitoring Plan - Burra Creek

The primary focus of this monitoring component will be the local discharge reach of Burra Creek, downstream of the discharge point. The framework for this program is similar to the Angle Crossing abstraction and provides a mechanism for evaluating the causes and extents of changes in the river ecosystem; these will be traced through various indicators that reflect the existing ecological condition in the river.

In this monitoring program, the potential effects of discharging water from the Murrumbidgee River into Burra Creek are to be quantified, and where possible, compared to existing and future stressors likely to affect Burra Creek. Thus, the focus is on the current aquatic/riparian ecosystem conditions and the impacts of future water discharges from the Angle Crossing pump station, using a variety of ecological indicators.

3.1 Key monitoring elements

The key monitoring objectives of the program are to collect quantitative and semi-quantitative data that will assist the program to identify changes occurring in Burra Creek with regard to:

- How the discharge into Burra Creek from the Murrumbidgee River affects the maintenance of healthy aquatic ecosystems in terms of biological communities, including fish biota; and
- Whether or not the discharges into Burra Creek creates flow variations that impact on erosion, sediment deposition and movement.

The potential zone of monitoring covered by this program is:

- Upstream of the discharge point on Burra Creek to Cassidy's Creek; and
- Downstream of the discharge point to approximately 1km downstream of the Burra Creek confluence on the Queanbeyan River, where Googong Reservoir levels permit.

The key elements of the monitoring program are listed below:

- Monitoring ecological indicators (macroinvertebrates and periphyton) at select locations with Rapid Bioassessment (AUSRIVAS) sampling, to establish species composition and river health bands, combined with quantitative physical habitat assessments; and estimates of algal biomass from periphyton samples;
- Regular qualitative monitoring of riverine vegetation, both lower riparian and 'in-stream' vegetation, at the macroinvertebrate monitoring locations, to establish floristic compositions and relative abundances of native and non-native species. Macrophyte inundation of the creek bed will also be considered in the surveys; and
- Monitoring fish biota in Burra Creek with quantitative sampling at select locations.

3.2 Ecological Indicators - Macroinvertebrate and periphyton

3.2.1 Aims

- To establish a knowledge base of the condition of macroinvertebrate communities at test and control sites to assist in the monitoring of riverine ecosystem health and the potential impacts of discharge.
- To establish seasonal and annual variation of the composition and abundance of the organic constituent of the periphyton at control and reference sites and to assist in the monitoring of the riverine ecosystem health and the potential impacts of discharge.

3.2.2 Rationale

Macroinvertebrates and periphyton are two of the most commonly used biological indicators used in river bio-assessment. Macroinvertebrates are commonly used to provide a general characterisation of the health of a stream ecosystem because they represent a continuous record of preceding environmental, chemical and physical conditions at a given site.

The potential for impacts to arise during the implementation of the Murrumbidgee to Googong Water Transfer are dependant upon the pumping regime and the environmental flow rules implemented. Potential effects may include modifications to the stream substrate through sedimentation, loss of riffle zones, changes in water chemistry and periphyton accumulation. These processes in turn may influence the composition of macroinvertebrate communities downstream of the discharge point.

To monitor for any potential impacts, macroinvertebrates will be sampled in two meso-habitats, riffle and pool edges, and organisms identified to family/genus level, to characterise each site; while periphyton will be sampled in the riffle zones at each site and analysed for chlorophyll-a and ash free dry mass (AFDM), which will provide estimates of the algal biomass and total organic mass respectively (Biggs and Kilroy, 2000).

3.2.3 Macroinvertebrate Sampling

The methodology and sampling techniques for Burra Creek shall be the same as for Murrumbidgee River as described in section 2.2 for AUSRIVAS and periphyton assessment. Sampling sites are indicated in Table 3.1.

3.2.4 Periphyton sampling

The six active sites selected, given in Table 3.1, will be sampled for periphyton in autumn and spring in each year of the monitoring program. Periphyton sampling will be conducted in conjunction with macroinvertebrate sampling. All periphyton - adnate and loose forms of periphyton, as well as organic/inorganic detritus in the periphyton matrix, samples will be collected using the in situ syringe method similar to Loeb (1981), as described in Biggs and Kilroy (2000). Parameters that will be investigated include Ash Free Dry Mass (AFDM gm2) and chlorophyll-a.

3.2.5 Method

Rapid bioassessment (RBA) methods (i.e. AUSRIVAS) will occupy the main component of this program. The RBA will provide an overview of the system that will indicate, on a broad scale whether there are notable changes. These data will also be necessary for compliance monitoring as part of ACTEW's abstraction licence (Licence No. WU67) and will provide information and a vital link between current and long term

trends since there is now a comprehensive historical dataset containing AUSRIVAS assessments from previous programs.

3.2.6 Site selection

The selected sites for the monitoring of macroinvertebrates and periphyton are given in Table 3.1 and locations shown in Appendix A. Sites may be changed in response to changes in stream condition (i.e. changes occurring from large natural flood events) or other issues such as land access constraints. The current (2013) monitoring sites are located on the Queanbeyan River: one upstream of the Burra Creek confluence. A further five sites are located on Burra Creek: two upstream of the discharge point and three downstream. All of the selected sites are accessible by staff without compromising safety.

Table 3.1: Site locations for the macroinvertebrate and periphyton monitoring

Number	Site Code	Site Location	Purpose	Monitoring	Latitude	Longitude
1	**BUR 1a**	**Burra Creek U/S of Cassidy creek Confluence**	**Control**	M,P,W,G	**S 35.7996**	**E 148.6761**
2	**BUR 1c**	**Burra Creek U/S Williamsdale Road**	**Control**	M,P,W,G	**S 35.5563**	**E 149.2212**
3	**CAS 1**	**Cassidy Creek U/S Burra Creek Confluence**	**Control, Historical**	M,P,W	**S 35.5977**	**E 149.2280**
4	**BUR 2a**	**Burra Creek D/S Williamsdale Bridge**	**Impact**	M,P,W,G	**S 35.8262**	**E 148.8031**
5	**BUR 2b**	**Burra Creek D/S Burra Road Bridge**	**Impact**	M,P,W	**S 35.5416**	**E 149.2302**
6	**BUR 2c**	**Burra Creek U/S London Bridge**	**Impact**	M,P,W,G	**S 35.5178**	**E 149.2615**
7	**BUR 3**	**Burra Creek D/S London Bridge arch**	**Impact, Historical**	M,P,W	**S 35.8262**	**E 148.8031**
8	**QBN 1**	**Queanbeyan River ~ 3km U/S Burra Creek Confluence.**	**Control**	M,P,W	**S 35.5138**	**E 149.2874**
9	**QBN 2**	**Queanbeyan River ~1km D/S Burra Creek Confluence.**	**Impact, Historical**	M,P,W	**S 35.4974**	**E 149.2663**

M = macroinvertebrates; P= periphyton P= periphyton; G= geomorphology; W = water quality
U/S = upstream; D/S = downstream

3.3 Fish monitoring

3.3.1 Aim

- To obtain ongoing information with regard to the status of fish populations and recruitment to assist in the monitoring of the riverine ecosystem and potential impacts associated with operating the pipeline.

3.3.2 Rationale

Burra Creek flows intermittently and when flowing contains pool sections between the discharge point and Queanbeyan River that currently are habitat for only alien fish species. There is potential for native fish species to populate Burra Creek over time (particularly if long periods of pumping occur).

Impacts resulting from the discharge of Murrumbidgee water into Burra Creek have the potential to affect fish populations through:

- Increases in fine sediment transport and deposition
- Exacerbation of medium flow periods with a change in temporal variability between small and medium flow peaks.

Such effects may influence spawning cues and movement; and cause changes in habitat through sedimentation and loss of riffle zones. The changes may advantage some alien species such as trout or carp dependant upon the timing and thermal effects of the release. It is also likely that the discharges will improve the available habitat for many species of fish in this system by decreasing the in-stream temperatures and increasing the depth of pools and riffle zones.

It is expected that the likely detrimental impacts to the fish following the discharges may be that bank stability is compromised and scouring may result (thus smothering spawning habitat and the infilling of deep pools).

3.3.3 Sampling

Fish monitoring will be undertaken in Burra Creek biennially (likely toward the end of spring to coincide with higher natural flows), to determine which species are living in the available pools.

A key site for the fish survey will be the large pool near London Bridge. This pool is the most resilient to drought conditions (i.e. is likely to still have water in it after prolonged drought; whereas other pools are likely to become dry).

3.3.4 Methods

The fish monitoring will involve sampling of fish in deep pools with fyke nets if possible, and in the shallower areas (riffles and runs) using electro-fishing techniques.

The methods will allow a comprehensive assessment of the current status of the fish populations in terms of community structure (species diversity and abundances) and provide a knowledge base from which it will be possible to determine rates of recruitment under natural (pre discharge) and altered (post discharge) flow regimes.

Since flow in Burra Creek is highly variable and ceases during drought conditions, the viability of undertaking the fish monitoring shall be dependent on the available water within the pools and shall be determined immediately prior to the sampling period.

3.3.5 Sampling sites

The fish monitoring will be undertaken with a similar design that is outlined for the general survey in the Murrumbidgee River. In Burra Creek, if possible due to increased natural flow conditions, two sites are recommended to be monitored downstream of the discharge point, and one upstream. These sites are BUR 2a, BUR 2b and BUR 3 as shown in Appendix A. If flows remain low then it is possible that London Bridge may be the only suitable site.

3.3.6 Data analysis

Fish caught will be identified to species level and measured to the nearest mm. Where large numbers of small fish are encountered, a sub sample from each gear type will be measured and the remainder counted.

Fish will be examined for external abnormalities, such as lesions or infection by the external copepod parasite Lernaea sp.

Some of the parameters and indices that will be examined include:

- Community composition
- Nativeness index: the proportion of native species by number and potentially by biomass if length/weight tables are available
- Fish abundance
- Catch per unit effort for selected methods (fish per shot or fish per net night)
- Length frequencies for selected species
- External parasite loads

3.4 Geomorphology Monitoring Program

The primary monitoring focus of the program will be the local discharge reach in Burra Creek as well as areas identified during the life of the monitoring program as having a moderate risk of impacting on bank stability. Burra Creek has a current 1 in 2 year Average Recurrence Interval (ARI) flow rate of 1830 ML/d, and a 1 in 3 month flow of approximately 950ML/d (ACTEW, 2008) so the proposed Murrumbidgee to Googong Water Transfer flow rate of 100ML/d should have a minor impact by comparison.

However, the duration of the abstraction flow is significantly higher than typical durations of natural flow events. As the creek banks become saturated there is potential for bank collapse in easily erodible material, as well as riparian vegetation changes. This program is designed to monitor potential impact and trigger

appropriate management responses. Input and collaboration with local community groups shall be encouraged.

3.4.1 Aim

- To monitor geomorphologic condition upstream and downstream of the discharge location to assist in monitoring any potential changes caused by discharges of Murrumbidgee River water into Burra Creek.

3.4.2 Pipeline modes

The Murrumbidgee to Googong pipeline is complete and with Googong reservoir near full supply level there is currently no requirement to run the pipeline for continuous water transfer and this is likely to be the case for the next few years. Currently the pipeline is only required to be operated on a routine basis for short periods to maintain the pumps and to ensure the pipeline remains fully operational.

The pipeline may be in one of three modes;

- **Suspension**: parts of system may be decommissioned requiring lead time before start up. No water can be transferred.
- **Standby**: ready to run, all components in place and being operated routinely for maintenance purposes (see SFWQMP for more detail).
- **Operating**: operating in earnest, transferring to increase Googong reservoir storage levels.

During 'Operating' mode the system may be parked due to out of specification water, plan triggers or maintenance.

3.4.3 Key monitoring elements

The key monitoring objectives of the program are to collect quantitative and semi-quantitative data that will assist the program to identify any changes occurring, and to determine whether or not the discharge into Burra Creek creates flow variations that impact on erosion, sediment deposition and movement.

The zones of geomorphological monitoring are identified and prioritised adaptively, in response to the information that is gathered through the life of the program. Sites are expected to change in response to natural flood events that will occur in the Burra Creek.

The key elements of the proposed monitoring program are:

- Monitoring of sediment transportation and deposition changes, to determine changes in bed and bank erosion; armouring and deposition and effects on vegetation structure
- Conducting appropriate geomorphology surveys upstream and downstream of the discharge site, to establish the current condition which will allow for the detection of future changes in channel and structure morphology and form that could occur as a result of flows and sediment movement.

3.4.4 Rationale

Stream flow is a major determinant of stream form and channel morphology, it also dictates the capacity of which a stream can transport sediment. As such, stream flow will strongly influence the composition of aquatic flora and fauna. The structural adjustment of channel units, such as channel widening and redistribution of channel material may result in short and long term changes to water quality, and to riparian and aquatic habitat conditions. Due to the magnitude of the probable discharge compared to the current baseflow regime, there is potential for changes in the geomorphology to the creek.

Based on assessments presented in the EA/EIS there are no anticipated direct impacts to the London Bridge Natural Arch as a consequence of the project. There is not expected to be any impact on the structural integrity of London Bridge. It has had to endure significant floods in the past and the nominal 100ML/d flow is a very small percentage of its capacity. The increased duration of flowing water is also not likely to affect the natural bridge structure as the pool of water at the structure has rarely dried out.

3.4.5 Sites selection

The current (2013) monitoring sites are;

- Upstream of the discharge point on Burra Creek, near Cassidy's Ck and also just upstream of the proposed discharge point at Williamsdale Bridge
- Immediately below the discharge point on Burra Creek
- At the change of direction in Burra Ck approximately 1.5km downstream of the discharge point (BUR 2a)
- Pool 50, approximately 200m upstream of Lagoon Road Crossing
- Below Willows Crossing approximately 500m upstream from London Bridge (just upstream of BUR 2c)
- Downstream of the Burra Creek confluence on the Queanbeyan River, when water levels permit.

3.4.6 Method – Suspension

Monitoring requirements will be negotiated with the stakeholders of this plan if the pipeline is placed in 'Suspension' mode. It is likely that monitoring would be significantly reduced during this time and then reinstated prior to the pipeline being recommissioned.

3.4.7 Method – Standby

- Monitor water level at London Bridge via a water level sensor with an inbuilt logger to provide information on existing and future water level fluctuations. The data shall be downloaded during routine site visits to the ACTEW Upstream Googong stream flow monitoring site (410781).
- Annual visual inspections (by a geomorphologist or suitably qualified hydraulic engineer) at key sites during a pump maintenance run where the maximum maintenance flow is approximately 50ML/d
- Prior to the pipeline commencing in Operating mode for continuous water transfer to improve Googong water storage capacity, surveyed transects and site observations should be undertaken to re-establish and confirm baseline condition.

3.4.8 Method – Operating

Once Murrumbidgee to Googong Water Transfer enters an Operating mode and pumping commences in earnest, the potential impact on Burra Creek shall be much more significant than on the Murrumbidgee River due to the difference in flow regimes.

To provide ongoing geomorphologic data on the channel structure, detailed mapping of a selection of channel units is required, upstream and downstream of the Burra Creek discharge point.

For this monitoring program, six sites have been selected on Burra Creek. The reaches will be described and channel units will be mapped according to the classifications set out in Table 2.2. The features of each channel type are given in Table 2.3**.**

Mapping will involve the use of both remotely sensed and field data. Transects will be surveyed by Differential GPS and/or Dumpy Level at each site to provide detailed baseline data on channel form. Finally, field validation of all sites will occur to ensure accuracy of site description and mapping.

The following specific monitoring shall be undertaken on Burra Creek during Operating mode:

- For a period of two months from the commencement of Operating mode, inspections shall be undertaken at potential erosion sites weekly when pumping increases above 50ML/d, and twice weekly during continuous flows above 90ML/d. Any initial erosion problems shall be immediately directed to ACTEW for review of the flow regime. Potential erosion sites, referred to below as key sites, shall be locations shown to have moderate or high erosion potential as indicated by the most recent geomorphological assessment undertaken in accordance with the MEMP, at the time Operating mode commences.
- After the two months of intense monitoring the following program shall be undertaken and then reviewed at six monthly intervals for a period of two years from the commencement of operation;
    - Areas of erosion identified through the life of the monitoring program will be monitored at two monthly intervals for the first two years of Operation and after large rainfall runoff events (approximately 1 in 2 yr ARI events).
    - Burra Creek Riffles - Key sites as determined by a geomorphologist or suitably qualified person, monitoring at two monthly intervals for bank erosion and deposition of fine sediment.
    - Burra Creek Pools - With increased sediment movement likely, the potential formation of sand bars when water velocity slows along a channel shall be assessed during the visual inspections. These could also form a chain of ponds in the flatter regions of Burra Creek. Photographic records shall be utilised where possible to indicate spatial and temporal variability.
    - Burra Creek Pools - Surveyed channel transects will be repeated at 6 monthly intervals during the first two years of operation.
    - Burra Creek Pools - Visual inspections at two monthly intervals during the first two years of operation or following natural flow events greater than a 3 month ARI rainfall event (> 950ML/d).
    - Burra Creek Pools - Visual inspections and a review of monitoring results by a geomorphologist or suitably qualified person at 6 monthly intervals or following a large natural flow event (1 in 2 yr ARI or greater, >1830ML/d).

- Burra Creek Banks - Banks with a high potential for erosion will have visual inspections at 6 monthly intervals, and monitored after natural flow events greater than a 3 month ARI rainfall event (>950ML/d).
- London Bridge - Visual inspections at 6 monthly intervals will be performed. Any significant change to the immediate upstream sediment deposition and channel vegetation encroachment will be recorded.

3.4.9 Data analysis

Appropriate analysis and reporting of the data will be carried out with reference to the channel form units present (pre-abstraction), flow-channel structure, sediment loads and movements and establishing the method for monitoring 'change over time' in those units.

The analysis will include the following:

- A description of the current river channel morphology and sediment beds
- Visual representation of the site data
- Comparisons of the current dataset (where possible) with historical changes in the creek.

3.4.10 Data reporting

When the pipeline is in Operating mode an annual report will be provided and will include a summary and trend analysis, with reference to specific high flow events if they occur. Reporting will include an assessment of the need to alter the frequency or nature of the monitoring program. When in Standby a brief annual report will be produced summarising visual inspections performed during the year, noting any significant changes to the creeks geomorphology.

3.5 Riverine vegetation

3.5.1 Aim

To monitor riverine vegetation at key sites on Burra Creek to determine whether there are changes to the community composition of riparian vegetation and macrophyte beds and whether there are changes of encroachment or inundation in response to the increased flows downstream of the discharge point.

3.5.2 Rationale

The quality, condition and extents of riparian vegetation including in-stream vegetation, are closely linked to the riverine environment – usually in a predictable pattern. Changes in flow regime can lead to changes in species composition and dominance of some species over others resulting in a decrease in diversity.

Along different channel types, changes in stream flow affect bank area exposure in different ways, potentially leading to encroachment or inundation and scour. These effects may reduce the quality of the vegetation

through loss of native species and/or increases in non-native, invasive species. An understanding of the condition of vegetation associated with reaches of Burra Creek immediately upstream and downstream of the discharge point will contribute to assessing whether or not the discharge will have positive or negative impacts on the system as a whole.

3.5.3 Method

General surveys of the vegetation will be conducted at each nominated site at the time of the macroinvertebrate and periphyton sampling. The general surveys will follow the quantitative protocols outlined in the ACT AUSRIVAS field sampling sheets (Coysh et al., 2000) and will include but not limited to, assessments of:

- Percent cover of riparian vegetation;
- In-stream vegetation (percent cover, composition);
- Vegetation types in the riparian zone;
- Percent shading, and;
- Distribution, diversity and relative abundance or density of native and exotic vegetation on the banks of Burra Creek.

In addition to these qualitative measures, extent of predominant vegetation types shall be determined and permanent photographic markers will be established to assist in recognising trends of encroachment and/or inundation, invasion of exotics, and potential gains or losses of species.

A detailed survey shall also be undertaken for an area to approximately 200m downstream of the discharge point on Burra Creek. The survey will be based on obtaining information from three transects (approximately 50-100m apart), which cross the river channel from one bank to the other. The location of each transect will be determined by GPS coordinates for ease of identification in future monitoring.

3.5.4 Data analysis

Appropriate analysis and reporting of the data will be carried out with reference to establishing the vegetation at each monitoring site, with a view to monitoring changes that could occur over time.

The data analysis and reporting will include the following:

- Discussion of threatened or otherwise significant flora species and communities within the study areas that might be affected by modified flow conditions;
- Visual representation of the site data; and
- Descriptive statistics showing relative abundances of key taxa and percent coverage of in-stream habitat by macrophytes; and
- The diversity, distribution, abundance or density of weeds on the banks of Burra Creek.

3.5.5 Platypus habitat

In conjunction with the riparian vegetation surveys, habitat assessment and geomorphology components, general observations will be made regarding the suitability of platypus habitat in all reaches of this monitoring program.

Sighting or signs of platypus activity in Burra Creek will be recorded on field sheets. Based on the outcomes of this monitoring, a more formal monitoring program may be considered.

4. Entrainment of Aquatic Species

The pipeline intake structure at the abstraction point at Angle Crossing is designed with a filter screen system to exclude fish eggs from being able to be transferred or entrained in the pipeline pumping chamber. The system has been designed to prevent operation should the screens not be functioning properly. Operations and maintenance training is undertaken and procedures have been established to maintain system integrity.

The screens have the objective of excluding all material greater than 0.5 mm in thickness and have been constructed to ensure effective operation over the long-term.

The screen mounting design is such that only screened water is able to reach the pumps and hence transferred across to the Burra Creek for discharge down to Googong Reservoir.

The screens have an exclusion system whereby any material unable to pass through the screen is cleaned off and returned to the Murrumbidgee River.

The design also ensures that the pump chamber remains sealed during any bypassing of the screens in flood events when the whole of the intake and pumping station is submerged. It is designed to continue operating under these submerged conditions.

The screens will be managed and maintained in accordance with the manufacturers specifications; thereby ensuring that entrainment of aquatic species to Burra Creek does not occur.

5. Data analysis and reporting

The data collected for the macroinvertebrate and periphyton monitoring component will be integrated into two, six-monthly monitoring reports (fish, riverine vegetation and geomorphological parameters are reported annually only). These reports will be delivered following analysis of spring and autumn macroinvertebrate sampling. Due to the timeframe required to undertake the macroinvertebrate and periphyton analyses it may take up to six months for the reports to be produced and finalised after sampling is completed.

Reports will relate the bandwidths determined by AUSRIVAS ACT models to observational data, which will include current land-management activities; and water quality data, which will be considered in relation to ANZECC (2000) water quality guidelines. These reports will also include any correlated impacts of water abstraction and other catchment conditions and activities, and any significant emerging short and long term trends.

The reports will include relevant information such as:

- Information and comparisons with the previous autumn and spring sampling periods
- Summary of monitoring data analysed and assessed, providing a knowledge base that can be used to identify changes potentially arising from water abstraction/discharge
- An assessment and characterisation of sites, and an assessment of the similarities and differences between sites using results from the monitoring data
- Discussion of the suitability of the selected sites and the suitability of the methods used and implications for future monitoring and recommendations based on these implications, and the relevance of the sampling results to ecological functioning of the river.

An integrated discussion of all monitoring results with respect to each other (e.g. macroinvertebrates and periphyton, riverine vegetation, flow, and river-channel geomorphic changes) including any correlated impacts of water abstraction and other catchment conditions and activities, and long term trends will be performed at appropriate intervals.

The monitoring reports will be available to the public and regulators via the ACTEW website.

5.1 Quality assurance/quality control, reporting and adaptive management

5.1.1 Quality assurance and quality control

All monitoring work will be undertaken in accordance with the relevant Australian quality assurance /quality control standards.

Data collected for this program will be analysed using the most appropriate statistical techniques to answer the specified hypotheses. The monitoring program will be independently reviewed periodically to ensure the methodology remains relevant and effective.

5.1.2 Adaptive management

This program is designed to be adaptive, as outlined in the OEMP Compliance Tracking.

Through the peer review process, stakeholder liaison and preliminary data evolution and analysis it may become apparent that changes are necessary to enhance the effectiveness of the current design, or changes applied to the operating rules.

5.1.3 Periodic Reporting

The periodic reporting requirements that relates to this plan are detailed in the OEMP.

6. Triggers and Management Actions

6.1 Murrumbidgee River

6.1.1 Aquatic Ecology

Assessments of aquatic ecology along the Murrumbidgee River commenced in 2008 in preparation for assessing potential impacts of ACT Water Security Projects. The ACT AUSRIVAS assessment has produced health assessments for various locations upstream and downstream of the abstraction point.

Table 6.1 below provides the Murrumbidgee AUSRIVAS Band Levels. For more detail and information refer to the individual MEMP spring and autumn reports.

Table 6.1: Murrumbidgee AUSRIVAS riffle and edge Bank Levels used for Angle Crossing, from the MEMP project

Site	Site code	Location	Spring 2008		Autumn 2009		Spring 2009		Autumn 2010		Spring 2010		Autumn 2011		Spring 2011		Autumn 2012		Spring 2012		Autumn 2013	
		Upstream	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge
1	MUR15	~30 km U/S of Angle Crossing near Colinton;	NS	NS	B	B	NRA*	B	B	B	A	NRA*	A	B	A	A	B	B	A	A	A	A
2	MUR16	Just U/S Angle Crossing	NS	NS	B	B	B	B	A	B	A	C	A	B	A	A	B	B	B	A	A	B
3	MUR18	~500m above abstraction site	NS	NS	B	B	B	B	B	B	B	NRA*	B	A	B	B	B	B	B	A	B	A
4	MUR19	D/S Angle Crossing; directly below causeway	A	A	B	B	B	B	B	B	B	C	A	A	A	A	B	B	B	A	A	A
5	MUR23	D/S Angle Crossing; at Point Hut;	A	A	B	C	B	B	B	B	A	B	B	B	A	A	B	B	A	A	A	A
6	MUR28	~33km D/S Angle Crossing; U/S Cotter River confluence;	A	B	B	B	B	B	B	B	NS	NS	A	B	B	B	B	B	B	B	A	A

NRA - No Reliable Assessment due to the high variability obtained in the site replicates*
NS – Not sampled due to high or no flow

Triggers for the aquatic ecology in Murrumbidgee River are difficult to define since the flow change variability will be much higher than the M2G water abstraction rate. Macroinvertebrates in the MEMP are analysed at genus level at potential impact sites. This higher taxonomic resolution will enable the program to detect subtle changes in the macroinvertebrate communities that the coarser, family level data may not detect. This information shall assist in future flow management options.

The AUSRIVAS modelling to date has shown that the sites in the immediate proximity of the abstraction point are BAND B (Table 6.1), meaning that some of the taxa expected to occur at these sites are missing compared to reference data. Note that these data relate to sampling conducted prior to abstraction commencing or during a period when the pipeline was only run for short periods of time for maintenance purposes.

Based on these data, the trigger level for Murrumbidgee aquatic ecology shall be results below BAND B. Deviations below this BAND will require closer scrutiny of the data and close assessment of the available biological and physico-chemical data to ascertain the cause of the change. Such a change may occur from seasonal variation (which has been known to occur in other ACT catchment assessments), as a result of M2G abstraction, or as a result of another influencing factor, or a combination thereof.

Should the change be considered to be related to natural or upstream changes unrelated to the Murrumbidgee to Googong Water Transfer then the monitoring shall continue or be adjusted to obtain better information. The operational regime may be altered to take into account the changes.

If the cause is M2G related, in addition to the specific measures outlined in Table 6.3, management action may include modifying the Stream Flow & Water Quality Plan (i.e. environmental flow protection conditions) to mitigate impact and adapting monitoring programs to suit, including consideration of immediate action to temporarily adjust abstraction until impact is mitigated or managed to an acceptable level.

In the event that deviations from the trigger levels cannot be determined from the available data, or prolonged impacts are likely, the proposed options for mitigation will be referred to an expert panel.

6.2 Burra Creek

6.2.1 Aquatic Ecology

The trigger levels outlined below are relevant to all M2G operating modes. Assessments of aquatic ecology within Burra Creek commenced in autumn 2009 to provide baseline information in preparation for assessing potential impacts of discharge water from the proposed Murrumbidgee to Googong pipeline. The ACT AUSRIVAS assessment has produced health assessments for various locations upstream and downstream of the proposed abstraction point.

Table 6.2 below provides the current Burra AUSRIVAS Band Levels. For more detail and information refer to the individual MEMP spring and autumn reports.

Table 6.2: Burra AUSRIVAS riffle and edge Bank Levels from MEMP project

Site	Site code	Location	Autumn 2009		Spring 2009		Autumn 2010		Spring 2010		Autumn 2011		Spring 2011		Autumn 2012		Spring 2012		Autumn 2013	
			Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge
1	**BUR1**	Burra Creek U/S of Cassidy Creek confluence	NS	NS	NS	A	C	B	B	B	B	B	A	B	C	B	B	A	NS	NS
2	**BUR1c**	Burra Creek ~300m U/S Discharge Point	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	C	A	B	B	B	A	B	B
3	**BUR2a***	Burra Creek D/S Williamsdale Rd	NS	NS	NS	B	NS	B	NS	B	C	B	A	NRA*	B	A	A	A	B	B
4	**BUR2b***	Burra Creek D/S Burra Road bridge	NS	NS	NS	C	NS	B	NS	B	B	B	B	A	C	B	B	B	B	B
5	**BUR2c***	Burra Creek ~100m U/S London Bridge arch	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	B	A	B	B	A	A	A	A
6	**BUR3***	Burra Creek D/S London Bridge arch	NS	NS	B	B	B	B	B	A	NS	B	NS	NS	NS	NS	NS	NS	NS	NS
7	**QBN1**	Queanbeyan River ~ 3km U/S Burra Creek confluence.	B	A	B	A	B	B	B	B	B	B	A	A	B	A	A	X	B	B
8	**QBN2***	Queanbeyan River ~1km D/S Burra Creek confluence.	C	B	B	B	B	B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
9	**CAS1**	Cassidy Creek U/S Burra Creek confluence	NS	NS	NS	B	NS	B	NS	B	NS	B	NS	NS	NS	NS	NS	NS	NS	NS

** Sites impacted by the M2G discharge. Other sites are used as Control sites. QBYN 2 may not be a viable location as Googong Reservoir fills. When Googong exceeds 80% storage the confluence with Burra Creek becomes inundated.*

NRA - No Reliable Assessment due to the high variability obtained in the site replicates.*

NS – Not sampled due to high or no flow.

Note: If the AUSRIVAS Band for Riffle and Edge differ then the Band used for the site is taken as the lower assessment of the two.

Triggers for the aquatic ecology in Burra Creek are also difficult to define as the modified flow regime from M2G is likely to change the structure and distribution of the macroinvertebrates communities.

Analyses of macroinvertebrates through the MEMP project are determined at genus level which will enable the program to detect subtle changes in the macroinvertebrate communities that the coarser, family level data may not detect. This information will assist management options in determining whether the impact is caused by M2G, natural hydrologic variability, or other local catchment condition.

Triggers that will be used for further investigation are:

- Reduction in AUSRIVAS Band outside of natural variation
- An associated change in SIGNAL scores due to sensitive taxa
- Significant changes to the riverine vegetation composition (e.g. loss of natives / increase in weeds and changes in river channel flora).

Management action for a change in AUSRIVAS Band level shall be to initiate a closer scrutiny of the data and close assessment of the genus level information to ascertain the cause of the change.

Should the change be considered to be related to natural or upstream changes unrelated to the Murrumbidgee to Googong Water Transfer then the monitoring shall continue or adjusted to obtain better information. The operational regime may be altered to take into account the changes.

If the cause is M2G related, in addition to the specific measures outlined Table 6.3, management action may include modifying the Stream Flow & Water Quality Plan to mitigate impact and adapting monitoring programs to suit, including consideration of immediate action to temporarily adjust flows until impact is mitigated or managed to an acceptable level.

Table 6.3: Aquatic Ecology Trigger Level Summary

Trigger Condition	Trigger Value	Management Action
AUSRIVAS Band change at impact sites	If AUSRIVAS Band decreases outside of natural variation, or in relation to upstream control sites	Evaluate data results leading to the change in Band Level to determine cause and whether potentially related to the M2G project or due to other conditions. Adjust Stream Flow & Water Quality Plan if required.
Loss of sensitive taxa. from HESS or AUSRIVAS	Change in taxa abundance and diversity. Loss of flow sensitive taxa. Loss of sensitive taxa as a consequence of changes in water quality.	Correlate whether cause is M2G related. If cause is M2G related, modify Stream Flow & Water Quality Plan to mitigate impact and adapt monitoring programs to suit.
Recurrent trigger value change from HESS or AUSRIVAS	Change or impact continuing over 2 AUSRIVAS monitoring periods	Scrutinise data, resample if possible. Thorough site assessment and referral to expert panel.
Change to riverine vegetation structure	A change in community structure from pre-abstraction monitoring assessment, outside of expected natural variability	Determine extent of change and document. Initiate a more regular monitoring assessment in consultation with expert panel. If change is having a negative impact on riverine health, review Stream Flow & Water Quality Plan.

Trigger Condition	Trigger Value	Management Action
Changes in fish communities	Loss of native species Invasion of non-natives A reduction in native species abundance Increase in threatened fish species utilising Burra Ck for spawning	Undertake a detailed monitoring assessment to determine whether changes to M2G pumping regime are required, in consultation with an expert panel.

6.2.2 Geomorphology

Geomorphological monitoring will identify significant changes to riffle, pool and bank conditions, particularly those exacerbated by M2G operations. Should detrimental conditions be developing in pool, banks and/or riffles, mitigation measures will be investigated.

Any detected scouring or erosion along the riffles, pools, or banks of Burra Creek shall trigger an investigation into the cause of the impact as soon as possible. If the cause is due to the operating regime, or if the project continuing to operate could potentially result in an elevated level of impact, steps shall be considered to mitigate and alleviate the problem. Any mitigation works shall be undertaken in consultation with adjacent landowners and stakeholders.

Mitigation measures may include:

- changes to the Stream Flow & Water Quality Management Plan;
- structural intervention such as rock toe protection along the banks or bank reshaping and revegetation structural measures; and
- rock ramp bed control structures located within the downstream riffle zones to maintain pool integrity.

The range of adjustments to flow would depend on the impact and could include ceasing discharge into Burra Creek until any significant impacts have been mitigated or managed to an acceptable level.

Any detected geomorphologic impact on London Bridge will prompt investigation and discussion with stakeholders to determine appropriate management actions.

Actions undertaken shall be documented in the resultant reports of this plan.

6.2.3 Fish

Currently (2013) no native fish reside in Burra Creek. Should the fish monitoring program detect native fish in Burra Creek, and if M2G discharge was not able to follow the correct step down procedures, and stopped flow abruptly, then monitoring of fish in Burra Creek should take place to identify any episodes of native fish stranding. If native fish stranding is observed then rescue procedures must be initiated.

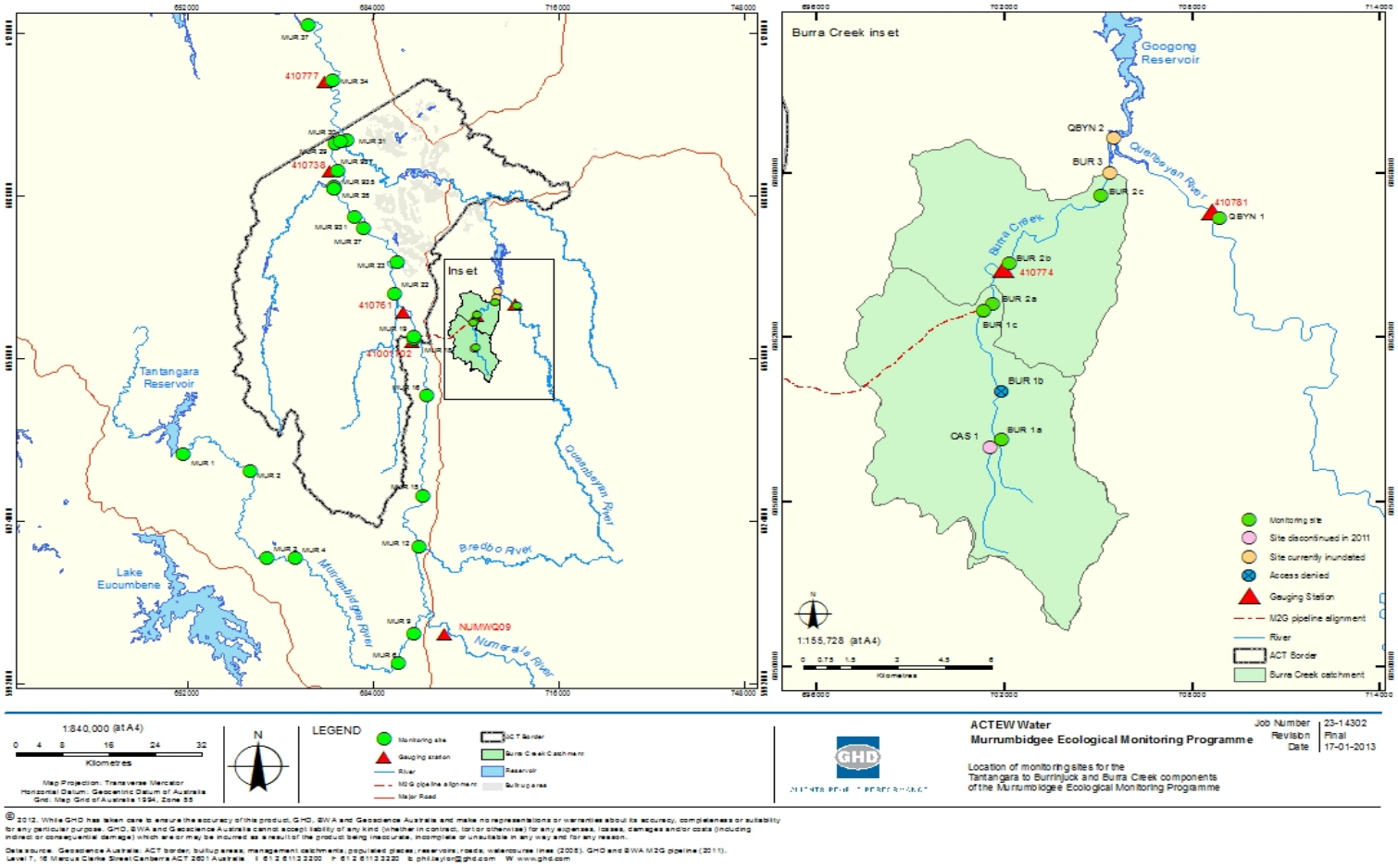
7. Roles and Responsibilities

The roles and responsibilities relating to this plan can be found in the OEMP.

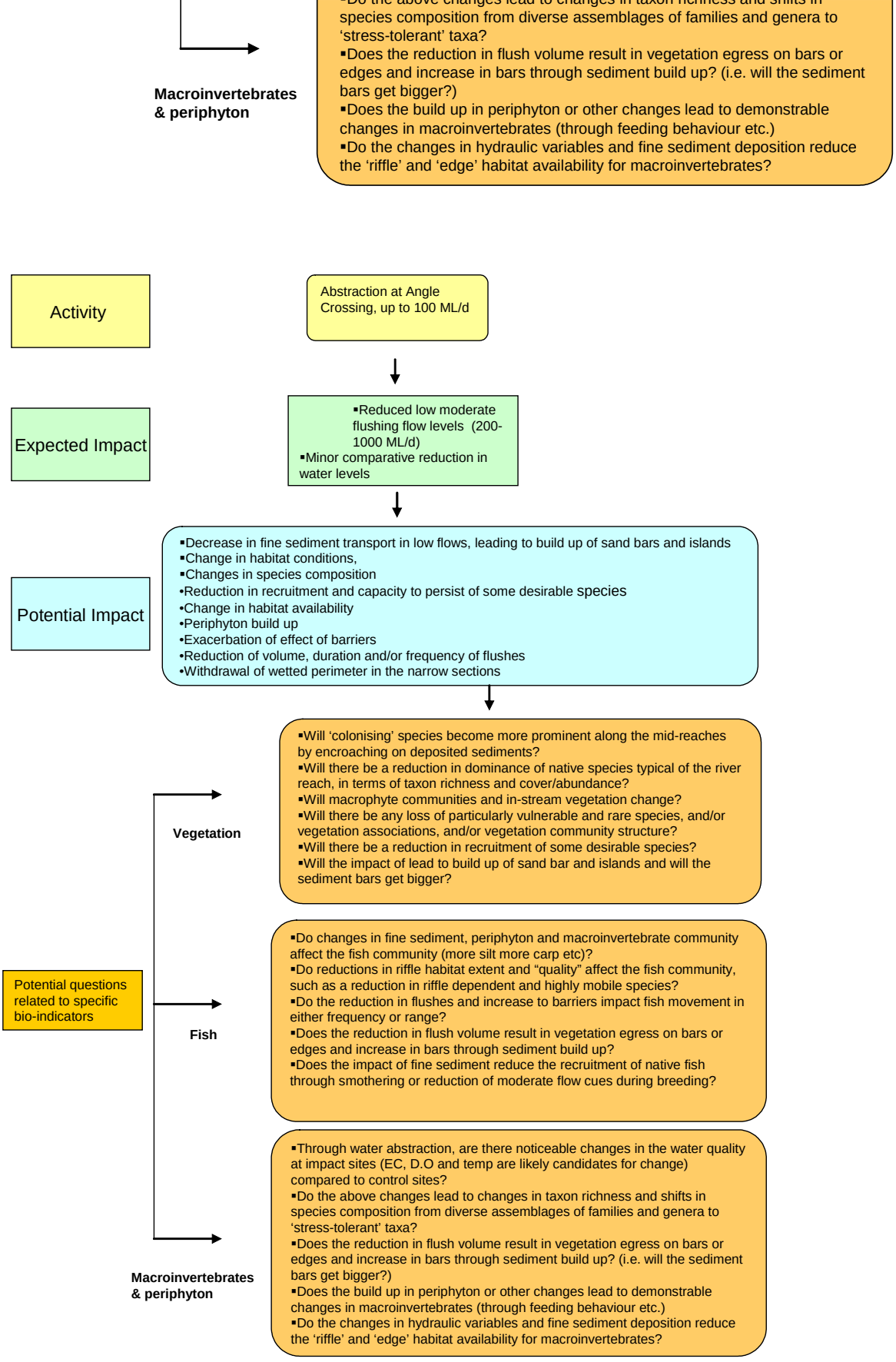
8. Compliance Tracking Program - Operations

The compliance tracking program and auditing requirements that relates to this plan can be found in the OEMP.

Appendix A – Ecological Monitoring Site Location Maps



Map A1: Monitoring sites of ecological indicators



Appendix C – Legislative & Regulatory Compliance

Table C1: Legislation relating to Burra Creek environmental management

Legislative Jurisdiction	Relevant Act
Territory (ACT)	*Nature Conservation Act 1980* *Environment Protection Act 1997* *Fisheries Act 2000* *Pest Plants and Animals Act 2005* *Water Resources Act 2007*
New South Wales	*Environmental Planning and Assessment Act 1979* *Protection of the Environment Operations Act (POEO Act) 1997.* *Fisheries Act 1935* *Fisheries Management Act (1994) and Amendment 2009* *Water Management Act (2000)* *Noxious Weeds Act 1993* *Catchment Management Authorities Act 2003* *Native Vegetation Act 2003*
Commonwealth	*Environment Protection and Biodiversity Conservation Act 1999* *Australian Capital Territory (Planning and Land Management) Act 1998* *Water Act 2007* *Canberra Water Supply (Googong Dam) Act 1974*

Appendix D – Environmental Commitments and Approval Conditions

Table D1: EIS Commitments (taken from Table 28.1, Ch 28, EIS)

Table 28.1 ref	Operational Commitment	Reference
2	Regular review of geomorphologic monitoring results for any trends toward significant impacts in Murrumbidgee River, Burra Creek or Googong Reservoir. The monitoring and adaptive management plan will include actions required to address any identified trends in a timely manner.	AEMP
11*	Maintenance of flow transfers where possible during the fish breeding season to protect any spawning populations of threatened fish species (if present). If flows need be altered, then the step up/down operating regime in the relevant OEMP subplan will be utilised to allow fish to exit the creek. *amended commitment based on Consistency Review by NGH Environmental (October 13)	AEMP
13	Regular review of the results of the aquatic monitoring program and the development of management actions that may be required to address any observed impacts.	AEMP Section 5
14*	Design measures into the scheme, to prevent the spread of invasive fish species including: • 0.5 mm aperture mesh on intake screen to prevent transfer of fish and eggs; • Provide continuous filtering and monitoring of transfer flows at the outlet into Burra Creek; and • Use filters year round, rather than only during the spawning season. • *amended commitment based on Consistency Review by NGH Environmental (October 13)	AEMP
16	Regular review of aquatic ecology monitoring results for any trends toward significant impacts in Murrumbidgee River, Burra Creek or Googong Reservoir. The monitoring and adaptive management plan will include actions required to address any identified trends in a timely manner.	AEMP Section 4 & 5
26	Impacts to the London Bridge karst formations and sites along Burra Creek will be undertaken as part of the on-going monitoring and adaptive management work that the proponent will undertake.	AEMP

Table D2: Part 3A Planning Approval Conditions (NSW)

Project Aspect	Commitment	Reference
2.1	The Proponent shall comply with section 120 of the Protection of the Environment Operations Act 1997 which prohibits the pollution of waters.	
2.3*	The Proponent shall design, construct, operate and maintain the project to avoid impacts on bank stability within the Burra Creek riverine corridor and Googong Reservoir outlet and does not increase local flooding risk. **Please note: pending regulator approval, ACTEW is intending to change this commitment to: "The Proponent shall design, construct, operate and maintain the project to avoid impacts on bank stability within the Burra Creek riverine corridor."*	
2.4	The Proponent shall not transfer water when Burra Creek is in flood based on a one in two year event or greater nor should the Proponent operate the pipeline where it results in water levels in Burra Creek being greater that the one in two year flood level.	
2.11	The Proponent shall implement the aquatic ecology management measures committed to in the documents set out in condition 1.1c) or elsewhere in these conditions of approval, including; a) monitoring and subsequent maintenance of flow transfer volumes to reasonably and feasibly mimic the natural flow regime based on the stochastic data refined in the Preferred Project Report of Burra Creek during the native fish breeding season in order to protect any spawning populations of threatened fish species; b) design measures to prevent the spread of invasive fish species; c) design measures for the protection of natural ponding habitat. If the current natural ponds along Burra Creek are lost as a result of increased flows, the Proponent is required to re-establish natural ponding habitat and d) regular review of aquatic ecology monitoring results for any trends toward significant impacts in Burra Creek or Googong Reservoir.	
3.3	Prior to the commencement of construction, the Proponent shall prepare and implement an **Ecological Monitoring Program** to monitor the impact of the project on the ecology that may be impacted by the proposal. The program shall be developed in consultation with the DECCW and Department of Industry and Investment NSW and shall include but not necessarily be limited to: a) set out monitoring requirements as detailed in the documents referred to in condition 1.1 c), in order to assess the impact of the project on Ecology present along the easement and at Burra Creek at the pipeline outlet location and downstream including the Googong Reservoir; b) baseline monitoring prior to the introduction of flows through Burra Creek in order to establish any ecological changes resulting from the project. d) provisions for monitoring during construction, operational and non-operational phases; e) mechanisms for immediately investigating any anomalous monitoring results; f) mechanisms for the management and mitigation of any impacts on the waterways including cessation of flows where necessary; and g) details of how the monitoring results will be reported to the Director-General	

Project Aspect	Commitment	Reference
	and the DECCW and the Department Industry and Investment NSW.	
3.1	Prior to the commencement of construction the Proponent shall prepare and implement a **Geomorphologic Monitoring Program** to monitor the impact of the project on the present morphology of Burra Creek at the pipeline outlet location and downstream to Googong Reservoir. The Program shall be developed in consultation with the DECCW and shall include but not necessarily be limited to: a) Set out monitoring requirements in order to assess the impact of the project on the present geo-morphology of Burra Creek at the pipeline outlet location and downstream to Googong Reservoir. b) Baseline monitoring prior to the introduction of flows through Burra Creek in order to establish any geomorphologic changes resulting from the project. c) Provisions for monitoring during construction, operational and non-operational phases; d) Mechanisms for immediately investigating any anomalous monitoring results; e) Mechanisms for the management and mitigation of any impacts on the waterways including cessation of flows where necessary; and f) Details of how the monitoring results will be reported to the Director-General and the DECCW.	OEMP, AEMP

Table D3: M2G DA Conditions (ACT)

Project Aspect	Condition	Reference
E20	The licence to extract water will be in keeping with environmental flow guidelines. This commitment was made by the proponent during the preparation of the EIS. The condition must take into account the effects of extraction on, and by, downstream users. It should also consider any new information which may be forthcoming as a result of ecological investigations that may be used to maintain or enhance the ecological values of the Murrumbidgee River in an adaptive management forum.	

Table D4: Commonwealth Conditions of Approval

Project Aspect	Commitment	Reference
4	The person taking the action must submit a **Burra Creek Environmental Management Plan** to the Minister for Approval that establishes a statistically valid ecological monitoring program to detect and manage any environmental harm to the ecological elements of Burra Creek or increase in the weeds problem in Burra Creek. The plan must include: a) Indicators, parameters and criteria to be used in measuring changes in the aquatic and riparian ecological elements of Burra Creek; b) Criteria to be used in measuring the diversity, distribution,	

Project Aspect	Commitment	Reference
	abundance or density of weeds along the banks of Burra Creek; c) Protocols for on-going reporting of adverse changes to the ecological elements of Burra Creek, or an increase in the diversity, distribution, abundance or density of weeds along the banks of Burra Creek; d) The proposed location of monitoring sites; and e) Management triggers and actions. The approved plan must be implemented.	

Appendix E – River ecosystem framework and questions for ecological monitoring at Angle Crossing