Public Works
Project Management

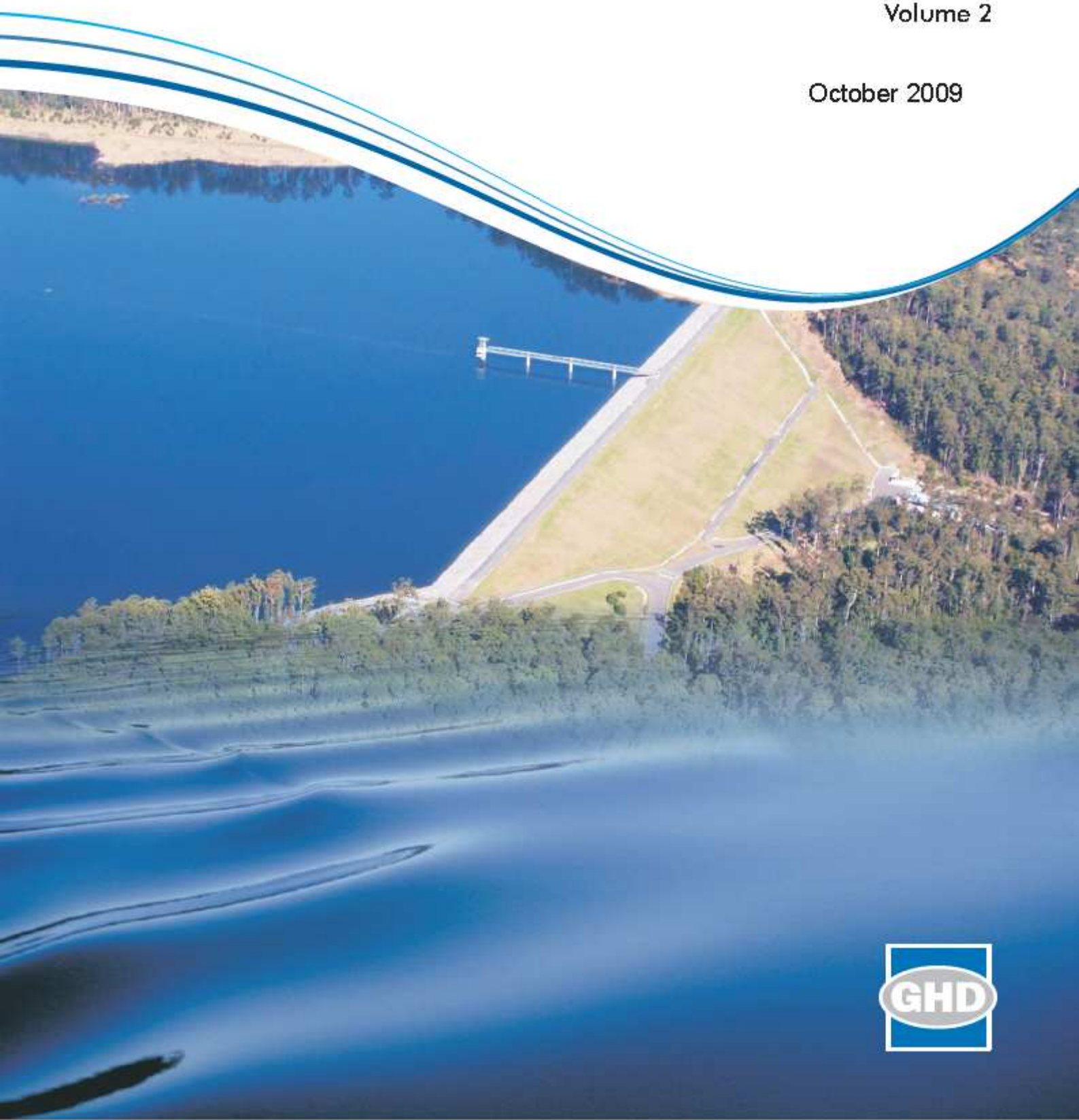
Nambucca District Water Supply Augmentation

Bowraville Off-River Storage & Associated Works

Environmental Impact Statement

Volume 2

October 2009



GHD

Contents

Appendices

Appendix A

Director Generals Requirements and Government Consultation

NSW GOVERNMENT
Department of Planning

Contact: Swati Sharma
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Fax: (02) 9228 6355
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Our Ref: S08/00546

Mr Vincent Joseph
Regional Projects Coordinator
NSW Department of Commerce
PO Box 63 J
COFFS HARBOUR NSW 2450

Dear Mr Joseph

Director-General's Requirements – Bowraville Off River Storage and Associated Works, Nambucca Local Government Area.

I refer to your request on behalf of Nambucca Shire Council, for the Director-General's requirements for the preparation of an Environmental Impact Statement in relation to the above proposal. The Director-General requires the matters detailed below to be addressed as part of the Environmental Impact Statement (EIS). Should the EIS not be exhibited within 2 years from the date of issue of the Director-General's requirements, under clause 231 (e) of the Regulation, the proponent is required to re-consult with the Director-General.

You have indicated that the proposal is permissible without development consent. As such, the Department has issued these requirements under Part 5 of the *Environmental Planning and Assessment Act 1979*. However, the EIS must clearly outline the statutory planning provisions that apply to all components of the proposal.

Form of the Environmental Impact Statement
The Department advocates the preparation of concise, accessible and justified EISs, focussing on the proposed activity, its likely environmental impacts and the mitigation of those impacts. All EISs should be prepared to allow government agencies and the public to fully comprehend the environmental implications of the proposed activity.

Mandatory Issues
Clauses 229 – 231 of the *Environmental Planning and Assessment Regulation 2000* (see Attachment No 1) provide those issues that must be included in any Environmental Impact Statement. You should ensure that each of these issues is detailed to the extent necessary and relevant to the environmental impact assessment of the activity.

Description of the Proposal
The EIS must include a full description of the proposal including its operation, clearly identifying the site, the proposed activity and the duration of construction and operation. The EIS should provide details of the proposed expansion of the bore field along the Nambucca River and South Creek, the off-river storage facility and the infrastructure and works associated with this proposal (access roads, pumping stations, transfer pipelines, transport of material for the off-river storage construction, need for any power supply upgrades, etc). All licences and approvals required by the

project must also be outlined. The EIS must also include supporting maps/plans to clearly show the various components of the proposal and their location.

Justification of the Proposal
The EIS must include a detailed justification of the proposal, and how it is associated with other activities or development in the area. This should include a description of the existing water supply system, its proposed augmentation and proposed storage volume including the effect on the region's growth in response to increased water supply. Consideration of alternative demand management measures and other alternatives so as to address water demand should be included.

Environmental Planning Instruments and Strategic Planning Documents
The EIS must assess the proposal against the relevant provisions of the *State Environmental Planning Policy (Infrastructure) 2007*, *Nambucca Local Environmental Plan 1995*, parts 7, 8, 9 and 10 of the *Draft Mid North Coast Regional Strategy* (NSW DoP 2006) and Clauses 12 and 15 of the *North Coast Regional Environmental Plan*.

Key Project Specific Issues
The EIS must assess the impacts on local residents, the Nambucca River, flora and fauna, agricultural and forestry areas in the vicinity of the proposal and Aboriginal areas of significance. The EIS must also assess potential land use conflicts with adjacent land uses.

The Department has identified that the following issues are likely to be of key significance to the environmental planning and assessment of the proposed activity. These issues do not relieve the Proponent from assessing any other key issues that it may identify during the preparation of the EIS. The EIS must include for construction and operation of the activity, as appropriate, the following matters and describe what measures would be implemented to avoid, minimise, mitigate, offset, manage and/or monitor these potential impacts:

Flora and Fauna
- Assessment of flora and fauna impacts including a detailed description land to be cleared for the storage inundation area and any other proposed clearing of land. The assessment must take into consideration impacts on any threatened species, populations, ecological communities, any critical habitat, impacts on any groundwater dependent ecosystems and the establishment and dispersal of environmental weeds. This assessment shall justify the need for any clearing of native vegetation and/or habitat features and should identify proposals for any compensating habitat/biodiversity offsets.

Hydrology, Soil and Water
- Assessment of the impacts of the activity (both construction and operation) on surface water and groundwater, including hydrology and geomorphology, water quality and quantity.
- Details of land to be inundated during a range of scenarios, including at normal full supply and during flood periods.
- Details of impacts of proposed works on soil erosion and sedimentation, including mitigation measures during construction through to permanent site stabilisation and any revegetation.
- Assessment of soil quality, in particular potential disturbance and subsequent management of Acid Sulfate Soils (ASS) or Potential ASS during construction.
- Assessment of impacts on waterways and wetlands.

Other
- Analysis of the construction impacts including: noise and vibration; general management of construction works; pollution controls; any road closures and/or traffic diversions; potential site rehabilitation measures; and locations and design of any access tracks or roads.
- Details of the implications resulting from loss of forestry land.
- Assessment of waste management, particularly the generation of solid and liquid wastes during construction and operation, and how this waste would be reduced, reused, recycled or disposed of, in accordance with the DECC guideline *Assessment, Classification and Management of Liquid and Non-liquid Waste*.

Consultation

During the preparation of the EIS, you must consult with the NSW Department of Water and Energy (DWE), Department of Environment and Climate Change (DECC), Department of Primary Industries (Fisheries), the Northern Rivers Catchment Management Authority and the Local Aboriginal Land Council. You must also consult with any other relevant local, State and Commonwealth government authorities, service providers, surrounding landowners/occupiers and community groups, and address any issues they may raise in the EIS. Details of the consultations carried out and issues raised must be included in the EIS.

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

If your proposal includes any actions that could have significant impact on matters of National Environmental Significance, it will require an additional approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This approval would be in addition to any approvals required under NSW legislation and it is your responsibility to contact the Department of the Environment, Water, Heritage and the Arts to determine if an approval under EPBC Act is required for your proposal (6274 1111 or http://www.environment.gov.au).

Please note that the Commonwealth Government has accredited the NSW environmental assessment process for assessing impacts on matters of National Environmental Significance. As a result, if it is determined that an approval is required under the EPBC Act, please contact the Department immediately.

Further Information

Please contact Swati Sharma on (02) 9228 6221 or swati.sharma@planning.nsw.gov.au should you have any enquiries regarding the Director-General's Requirements for the EIS.

Yours sincerely

Scott Jeffries
Director
Major Infrastructure Assessments
As delegate of the Director-General

DEPARTMENT OF PLANNING

Attachment No. 1

STATUTORY REQUIREMENTS FOR THE PREPARATION AND EXHIBITION OF AN ENVIRONMENTAL IMPACT STATEMENT UNDER PART 5 OF THE ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979

In accordance with the *Environmental Planning and Assessment Act 1979* (the Act), an environmental impact statement (EIS) must meet the following requirements.

Content of EIS

Pursuant to Schedule 2 and clause 230 of the *Environmental Planning and Assessment Regulation 2000* (the Regulation), an EIS must include:

1. A summary of the environmental impact statement.
2. A statement of the objectives of the development or activity.
3. An analysis of any feasible alternatives to the carrying out of the development or activity, having regard to its objectives, including the consequences of not carrying out the development or activity.
4. An analysis of the development or activity, including:
   (a) a full description of the development or activity, and
   (b) a general description of the environment likely to be affected by the development or activity, together with a detailed description of those aspects of the environment that are likely to be significantly affected, and
   (c) the likely impact on the environment of the development or activity, and
   (d) a full description of the measures proposed to mitigate any adverse effects of the development or activity on the environment and
   (e) a list of any approvals that must be obtained under any other Act or law before the development or activity may lawfully be carried out.
5. A compilation, (in a single section of the environmental impact statement) of the measures referred to in item 4(d).
6. (1)The reasons justifying the carrying out of the development or activity in the manner proposed, having regard to biophysical, economic and social considerations, including the following principles of ecologically sustainable development:
   (a) the **precautionary principle**, namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

       In the application of the precautionary principle, public and private decisions should be guided by:

       (i) careful evaluation to avoid, wherever possible, serious or irreversible damage to the environment, and
       (ii) an assessment of the risk-weighted consequences of various options,

   (b) **inter-generational** equity, namely, that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations,

   (c) **conservation of biological diversity and ecological integrity**, namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration,

   (d) **improved valuation pricing and incentive mechanisms**, namely, that environmental factors should be included in the valuation of assets and services, such as:

       (i) polluter pays, that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,
       (ii) the users of goods and services should pay prices based on the full life cycle of costs of

providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste,

(iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

Note

The matters to be included in item (4)(c) might include such of the following as are relevant to the development or activity:

(a) the likelihood of soil contamination arising from the development or activity;
(b) the impact of the development or activity on flora and fauna;
(c) the likelihood of air, noise or water pollution arising from the development or activity;
(d) the impact of the development or activity on the health of people in the neighbourhood of the development or activity;
(e) any hazards arising from the development or activity;
(f) the impact of the development or activity on traffic in the neighbourhood of the development or activity;
(g) the effect of the development or activity on local climate;
(h) the social and economic impact of the development or activity;
(i) the visual impact of the development or activity on the scenic quality of land in the neighbourhood of the development or activity;
(j) the effect of the development or activity on soil erosion and the silting up of rivers or lakes;
(k) the effect of the development or activity on the cultural and heritage significance of the land.

An environmental impact statement referred to in Section 112(1) of the Act shall be accompanied by the information specified in clause 229 of the Regulation.

The EIS must also take into account any matters required by the Director-General pursuant to clause 231 of the Regulation, which may be included in the attached letter. A copy of the Director-General's requirements should be included as an appendix to the EIS.

Attention is also drawn to clause 283 of the Regulation regarding false or misleading statements in EISs.

Nominated Determining Authority

Where there are a number of determining authorities (as defined under Part 5 of the Act), Section 110A of the Act provides for the Minister to make one of them the nominated determining authority. This avoids duplication of certain procedures and simplifies the exhibition of the EIS.

It is recommended that you discuss with the other determining authorities which one should become the nominated determining authority and advise the Department accordingly. Normally it is the proponent agency that becomes the nominated determining authority. The written agreements of all other determining authorities must be forwarded with the request to be made the nominated determining authority.

It should be noted that the onus is on the proponent agency to identify all other potential determining authorities.

Public Exhibition

When the EIS has been completed, four (4) copies should be forwarded to the Director-General (Attention: Director, Major Infrastructure Assessment) pursuant to Section 112(2) of the Act, together with details of the exhibition period and public display locations.

This should occur prior to public exhibition of the EIS in order that simultaneous exhibition of the EIS occurs in the offices of the Department and determining authority as required by Section 113 of the Act and clause 235 of the Regulation.

It is requested that an electronic copy of the EIS also be supplied. Procedures for public exhibition of the EIS are set down in clauses 234 and 235 of the Regulation.

Note

Should the EIS not be exhibited within 2 years from the date of issue of the Director-General's requirements, under clause 231 (e) of the Regulation the proponent is required to re-consult with the Director-General.

Representations
Any representations made in response to public exhibition of the EIS should, as soon as practicable and not less than 21 days before determining the activity, be forwarded to the Director-General in accordance with Section 113(3) of the Act.

Seeking the Minister's Approval
If a Species Impact Statement (SIS) has been prepared, the Proponent must have complied with Sections 112B and/or 112C of the Act (i.e. concurrence and/or consultation requirements) before seeking the Minister's approval.

The Department's *Best Practice Guidelines* encourage proponents when seeking approval to provide:

- a comprehensive report which addresses in detail its consideration of issues raised in representations;
- any proposed changes to the activity, and any further measures to mitigate impacts; and,
- all relevant technical information relating to the proposed activity.

– ✧ –

Northern Rivers CMA CATCHMENT MANAGEMENT AUTHORITY

JOB No.			
ENTERED TO DATABASE			
INITIAL			DATE
DATE			REF. No.
NAME	INIT	DATE	ACTION
SL		26/11	

Your Ref: 22/14133/12973
Our Ref: IN08/1461

Shaun Lawer
Senior Planner
GHD Pty Ltd
PO Box 1340
Coffs Harbour NSW 2450

Dear Shaun

Bowraville Off-river Storage and Associated Works- Requirements for EIS

Thank you for your letter of 22 October 2008 with the opportunity to comment on the development of the EIS for this activity.

In considering such projects, The Northern Rivers Catchment Management Authority's (NRCMA) primary concern is that natural resource condition is maintained or improved. This is a large scale project, and has the capacity to significantly influence its surrounding environment. The NRCMA has the following comments in relation to the proposal.

Native Vegetation

NRCMA has the role of implementing advisory, assessment and approval aspects of the Native Vegetation Act (NVA) for clearing proposals.

Unless the vegetation being cleared is an EEC or in an over-cleared Mitchell Landscape, the NVA assessment process for the clearing of native vegetation usually requires assessment of an existing patch of native vegetation to serve as an "offset" to be managed mainly for conservation purposes. The vegetation being assessed as an offset must be of equal or greater conservation status (based on extent of clearing of the forest ecosystems in question). It is our experience in applying the NVA assessment tools on the North Coast that the offset area usually needs to be at 10x greater than the area being cleared (often 20x or more) to achieve the object of the Act to "improve or maintain environmental outcomes".

It is however understood that this proposal will be considered under Part 5 of the EPA Act. In this case, it is advised that s25 of the NVA provides legislative exclusions where the NVA does not apply. Specifically in this case excluded clearing consists of:

- s25(g)- any clearing that is, or is part of, an activity carried out by a determining authority within the meaning of Part 5 of the EPA Act if the determining authority has complied with that Part,
- s25(h)- any clearing that is, or is part of, an activity carried out in accordance with an approval of a determining authority within the meaning of Part 5 of the EPA Act if the determining authority has complied with that Part,

If the Bowraville Off-River Storage proposal meets these criteria (or another sub-section of s25) NVA approval may not be required. However, the NRCMA does recommend that the proponents consider compensatory / offset areas consistent with the "improve or maintain" principle."

Riverine Management

It has been identified that the ground water source is highly connected to the Nambucca River surface water system. The NRCMA recommend that the proposal fully quantify the threats to the groundwater system due to possible changes to the river system. Recommendations emanating from the recent Geomorphic Assessment of Bowraville Borefield need to be integrated into the overall proposal.

Northern Rivers
CMA CATCHMENT MANAGEMENT AUTHORITY

JOB No. 2214183			
ENTERED TO DATABASE SC 25/11			
INITIAL			DATE
DATE 25/11/08			REF. No.
NAME	INIT	DATE	ACTION
PP	PP	25/11	
SC		25/11	
TR			
JM			

24 November 2008

Shaun Lawer
Senior Planner
GHD Pty Ltd
PO Box 1340
Coffs Harbour NSW 2450

Dear Shaun

Bowraville Off-river Storage and Associated Works- Geomorphic Assessment of Bowraville Borefield

The NRCMA has reviewed the report by Hydralex and offers the following comments.

- Support is given for the recommendation to augment the pipeline crossing with the construction of a bed control structure incorporating a fish ladder.
- Support is given to the generic designs provided for addressing the bank erosion, nick point, low lying terrace, causeway & culvert management options.
- A recommendation exists for the construction of one additional bed control structure downstream of the pipeline crossing. It would be beneficial to see such structures recommended for the reach upstream of the pipeline crossing in addition. The study reach has been subject to a history of geomorphic disturbance with planform change and bed level adjustments. Bed control structures provide stable points to encourage channel recovery processes, and will also help in maintenance of the groundwater system.
- There is no mention of the maintenance of the existing lateral migration restoration site lying between PB9 & PB10. Work was undertaken in partnership with Council, Nambucca Valley Landcare, NRCMA & the landholder within the last two years. This site still provides a major potential threat. It is important that future management of the site is integrated into the management of the borefields.
- A formal landholder agreement process needs to be considered in the on-ground implementation of any of the recommendations of the study.
- The recommendations of this study need to be converted into a more detailed River Management Plan for the area incorporating post event monitoring and updating.

If you wish to discuss these issues further, please contact Peter Corlis, Catchment Coordinator, on 6653 0115.

Yours sincerely

Peter Corlis
Catchment Coordinator

All Correspondence to the General Manager – PO Box 618 GRAFTON NSW 2460
Tel: 02 6642 0622 - Fax: 02 6642 0640
Email: northern@cma.nsw.gov.au Web site: www.northern.cma.nsw.gov.au

Your reference : 22/14133/12973
Our reference : FIL08/15789; DGR IDA No.301038
Contact : Ian Greenbank, 66402510

JOB No. 22141330			
ENTERED TO DATABASE			
INITIAL			DATE
DATE 1/12/08			REF. No.
NAME	INIT	DATE	ACTION
PP		1/12	
SL		1/12	
TR			

27 NOV 2008

Shaun Lawer
GHD Pty Ltd
PO Box 1340
COFFS HARBOUR NSW 2450

Dear Mr Lawer

PART 5 EIS REQUIREMENTS - BOWRAVILLE OFF-RIVER STORAGE

Thank you for your letter of 22 October 2008 concerning the requirements for the Environmental Impact Statement (EIS) for the Bowraville Off-River Storage and associated works.

The DECC has considered the details of the proposal and has identified the information it recommends be included in the EIS. We note that a number of residential dwellings are located within close proximity to the proposed dam site. These dwellings may be subject to unacceptable impacts (particularly relating to dust & noise) if not appropriately managed.

We also note that "threatened fauna" and "key habitat" have been recorded on the proposed site. The proponent must clearly demonstrate how they intend to manage these and all other issues to ensure that there are no unacceptable impacts on the environment and nearby residences.

In addition, DECC notes the existence of sixteen (16) registered Aboriginal sites in the immediate locality. These include the massacre sites, burial sites, Aboriginal Reserves, modified trees and isolated artefacts. We recommend the proponent consider any potential impacts on the traditional Aboriginal custodians and any relationship that may exist between these sites and any Aboriginal cultural values of the project area.

DECC's requirements are detailed in Attachment 'A'. In summary, the DECC's key information requirements for the proposal include an adequate assessment of:

a) Air quality impacts, particularly relating to dust management;
b) Noise impacts (assessment as per NSW Industrial Noise Policy);
c) Soil & water management;
d) Flora and fauna;
e) Aboriginal cultural heritage; and
f) Estuary management.

The guidelines provided in Attachment A are designed for environmental impact assessment documents and therefore their content is relevant to the EIS. They address DECC's responsibilities relating to environmental management & pollution control, flora, fauna, cultural heritage and threatened species, populations, ecological communities and their habitats. It should

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be noted that these are only guidelines and it is up to the proponent (and later the determining authority after appropriate consultation) to determine the detail and comprehensiveness of the surveys and level of assessment required to form legally defensible conclusions regarding the impact of the proposal. The scale and intensity of the proposed development should dictate the level of investigation. It is important that all conclusions are supported by adequate data.

The EIS should also assess the development in relation to the requirements of Section 5A of the *Environmental Planning and Assessment Act 1979,* and determine whether a permit to disturb Aboriginal objects under Part 6 s87, or whether a licence to destroy, deface or damage Aboriginal objects may be required under Part 6 s90, of the *National Parks and Wildlife Act 1974.*

Statutory Matters

To assist DECC in assessing the EIS it is requested that the EIS follow the format of Department of Planning's EIS guidelines and addresses DECC's specific EIS requirements as outlined in the following attachments. If the necessary information is not adequately provided in the EIS then delays in the development application process may occur.

If the proposed development is to extract greater than 30 000 tonnes per annum of material for reuse on the site then the operation will be scheduled under the *Protection of the Environment Operations Act (1997)*, and will therefore require an Environment Protection Licence to carry out a scheduled activity. The applicant will need to make a separate application to DECC to obtain this licence. General information on licence requirements can be obtained from DECC's *Environment Line* on 131555 or on DECC website at

http://www.environment.nsw.gov.au/licensing/whoneeds.htm.

DECC requests that the applicant provide 2 copies of the EIS. These documents should be lodged at DECC's Grafton office - PO Box 498 GRAFTON NSW 2460 and marked to the attention of the Regional Manager.

If you have any queries regarding this matter please contact the Grafton Office on 6640 2500.

Yours sincerely,

GRAEME BUDD
Head Waters & Catchments Unit
Environment Protection and Regulation

ATTACHMENT A: EIS Requirements for the proposed Bowraville Off-River Storage – Lots 183, 185, 190, 308 & 309 DP755549 and Lots 3 & 6 DP1076377, Bowraville

A. Executive summary

The executive summary should include a brief discussion of the extent to which the proposal achieves identified environmental outcomes.

B. The proposal

1. Objectives of the proposal

2. Location & Description of the proposal

The proponent must provide location details along with an accurate description of the proposal which addresses the following:

- General overview of site – context setting
- Air quality
- Noise & Vibration
- Water Quality
- Soil Management
- Waste & Chemicals
- Flora & Fauna
- Aboriginal Cultural Heritage
- Ecologically Sustainable Development
- Rehabilitation
- Justification for the proposal

In preparing the site description the proponent should consider:

- Using map(s) showing the locality of the proposed development in a regional and local context. Local context maps should be based on 1:25 000 topographic plans. Photographs of the site's key attributes may provide useful documentation.
- The area subject to development should be clearly identified on an appropriately scaled plan. This includes all ancillary works such as buildings and other structures, parking areas, loading/processing/treatment areas, access roads, and material stockpiling areas.
- The applicability or otherwise of Local Environment Plans (LEP), Regional Environment Plans (REP) and State Environmental Planning Policies (SEPP) and Regional Vegetation Management Plans (RVMPs) to the site should be determined and detailed. In particular, your attention is drawn to SEPP No. 14 - Coastal Wetlands, SEPP No. 26 - Littoral Rainforest, SEPP No. 44 - Koala Habitat Protection and the Native Vegetation Conservation Act 1997.

C. The environmental issues

1. General

- The potential impacts identified in the scoping study need to be assessed to determine their significance, particularly in terms of achieving environmental outcomes, and minimising environmental pollution.

- Identify gaps in information and data relevant to significant impacts of the proposal and any actions proposed to fill those information gaps so as to enable development of appropriate management and mitigation measures. This is in accordance with Ecologically Sustainable Development principles.

  Note: The level of detail should match the level of importance of the issue in decision making which is dependent on the environmental risk.

Describe baseline conditions

- Provide a description of existing environmental conditions for any potential impacts.

Assess impacts

- For any potential impacts relevant for the assessment of the proposal provide a detailed analysis of the impacts of the proposal on the environment including the cumulative impact of the proposal on the receiving environment especially where there are sensitive receivers.
- Describe the methodology used and assumptions made in undertaking this analysis (including any modelling or monitoring undertaken) and indicate the level of confidence in the predicted outcomes and the resilience of the environment to cope with the predicted impacts.
- The analysis should also make linkages between different areas of assessment where necessary to enable a full assessment of environmental impacts eg assessment of impacts on air quality will often need to draw on the analysis of traffic, health, social, soil and/or ecological systems impacts; etc.
- The assessment needs to consider impacts at all phases of the project cycle including: exploration (if relevant or significant), construction, routine operation, start-up operations, upset operations and decommissioning if relevant.
- The level of assessment should be commensurate with the risk to the environment.

Describe management and mitigation measures

- Describe any mitigation measures and management options proposed to prevent, control, abate or mitigate identified environmental impacts associated with the proposal and to reduce risks to human health and prevent the degradation of the environment. This should include an assessment of the effectiveness and reliability of the measures and any residual impacts after these measures are implemented.
- Proponents are expected to implement a 'reasonable level of performance' to minimise environmental impacts. The proponent must indicate how the proposal meets reasonable levels of performance. For example, reference technology based criteria if available, or identify good practice for this type of activity or development. A 'reasonable level of performance' involves adopting and implementing technology and management practices to achieve certain pollutant emissions levels in economically viable operations. Technology-based criteria evolve gradually over time as technologies and practices change.
- Use environmental impacts as key criteria in selecting between alternative sites, designs and technologies, and to avoid options having the highest environmental impacts.
- Outline any proposed approach (such as an Environmental Management Plan) that will demonstrate how commitments made in the EIS will be implemented. Areas that should be described include:

  a) operational procedures to manage environmental impacts
  b) monitoring procedures
  c) training programs
  d) community consultation
  e) complaint mechanisms including site contacts

f) strategies to use monitoring information to improve performance
g) strategies to achieve acceptable environmental impacts and to respond in event of exceedences.

2. Air

Describe baseline conditions

- Provide a description of existing air quality and meteorology, using existing information and site representative ambient monitoring data.

Assess impacts

- Identify all pollutants of concern and estimate emissions by quantity (and size for particles), source and discharge point.
- Estimate the resulting ground level concentrations of all pollutants. Where necessary (eg potentially significant impacts and complex terrain effects), use an appropriate dispersion model to estimate ambient pollutant concentrations. Discuss choice of model and parameters with the DECC.
- Describe the effects and significance of pollutant concentration on the environment, human health, amenity and regional ambient air quality standards or goals.
- Describe the contribution that the development will make to regional and global pollution, particularly in sensitive locations.
- Reference should be made to *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (EPA, 2001); *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW* (EPA, 2001).

Describe management and mitigation measures

- Outline specifications of pollution control equipment (including manufacturer's performance guarantees where available) and management protocols for both point and fugitive emissions. Where possible, this should include cleaner production processes.

3. Noise and vibration

A number of residences surround the proposed site, with several being close to the proposed boundary and could be subject to unacceptable noise impacts if not managed appropriately.

A Noise Impact Assessment (NIA) for the proposal must be conducted by an appropriately qualified acoustics consultant. The NIA must be conducted in accordance with the State Government's *"Industrial Noise Policy" (EPA, 2000)* and address the potential impacts of the quarry operations on the nearby residents including the following:

Describe baseline conditions

- Determine the existing background (L_{A90}) and ambient (L_{Aeq}) noise levels in accordance with the *"Industrial Noise Policy" (EPA, 2000)*.
- Determine the existing road traffic noise levels in accordance with the *"NSW Environmental Criteria for Road Traffic Noise"*, where road traffic noise impacts may occur.
- The noise impact assessment report should provide details of all monitoring of existing ambient noise levels including:

  a) details of equipment used for the measurements
  b) a brief description of where the equipment was positioned

c) a statement justifying the choice of monitoring sites, including the procedure used to choose the sites, having regards to the definition of 'noise sensitive locations(s)' and 'most affected locations(s)' described in Sectior 3.1.2 of the "*Industrial Noise Policy" (EPA, 2000)*
d) details of the exact location of the monitoring site and a description of land uses in surrounding areas
e) a description of the dominant and background noise sources at the site
f) day, evening and night assessment background levels for each day o the monitoring period
g) the final Rating Background Level (RBL) value
h) graphs of the measured noise levels for each day should be provided
i) a record of periods of affected data (due to adverse weather and extraneous noise), methods used to exclude invalid data and a statement indicating the need for any re-monitoring under Step 1 in Section B1.3 of the "*Industrial Noise Policy*" (EPA, 2000).
j) determination of L_{Aeq} noise levels from exsting industry.

Assess impacts

- Determine the Project Specific Noise levels for the site. For each identified potentially affected receiver, this should include:
  a) determination of the intrusive criterion for each identified potentially affected receiver
  b) selection and justification of the appropriate amenity category for each identified potentially affected receiver
  c) determination of the amenity criterion for each receiver
  d) determination of the appropriate sleep disturbance limit.
- Maximum noise levels during night-time perod (10pm-7am) should be assessed to analyse possible affects on sleep. Where $L_{A1(1min)}$ noise levels from the site are less than 15 dB above the background L_{A90} noise level, sleep disturbance impacts are unlikely. Where this is not the case, further analysis is required. Additional guidance is provided in Appendix B of the *NSW Environmental Criteria for Road Traffic Noise*
- Determine expected noise level and noise character (eg tonality, impulsiveness, vibration, etc) likely to be generated from noise sources durng:
  a) site establishment
  b) construction
  c) operational phases
  d) transport including traffic noise generated by the proposal
  e) other services.

  Note: The noise impact assessment report should include noise source data for each source in 1/1 or 1/3 octave band frequencies including methods for references used to determine noise source levels. Noise source levels and characteristics can be sourced from direct measurement of similar activities or from literature (if full references are provided).
- Determine the noise levels likely to be received at the most sensitive locations (these may vary for different activities at each phase of the development). Potential impacts should be determined for any identified significant adverse meteorological conditions. Predicted noise levels under calm conditions may also aid in quantifying the extent of impact where this is not the most adverse condition.
- The noise impact assessment report should include:
  a) a plan showing the assumed location of each noise source for each prediction scenario
  b) a list of the number and type of noise sources used in each prediction scenario to simulate all potential significant operating conditions on the site
  c) any assumptions made in the predictions in terms of source heights, directivity effects, shielding from topography, buildings or barriers, etc

d) methods used to predict noise impacts including identification of any noise models used. Where modelling approaches other than the use of the ENM or SoundPlan computer models are adopted, the approach should be appropriately justified and validated
e) an assessment of appropriate weather conditions for the noise predictions including reference to any weather data used to justify the assumed conditions
f) the predicted noise impacts from each noise source as well as the combined noise level for each prediction scenario under any identified significant adverse weather conditions as well as calm conditions where appropriate
g) for developments where a significant level of noise impact is likely to occur, noise contours for the key prediction scenarios should be derived
h) an assessment of the need to include modification factors as detailed in Section 4 of the "*Industrial Noise Policy*" (EPA, 2000).

- Discuss the findings from the predictive modelling and, where relevant noise criteria have not been met, recommend additional mitigation measures.
- The noise impact assessment report should include details of any mitigation proposed including the attenuation that will be achieved and the revised noise impact predictions following mitigation.
- Where relevant noise/vibration criteria cannot be met after application of all feasible and cost effective mitigation measures the residual level of noise impact needs to be quantified by identifying:
  a) locations where the noise level exceeds the criteria and extent of exceedance
  b) numbers of people (or areas) affected
  c) times when criteria will be exceeded
  d) likely impact on activities (speech, sleep relaxation, listening, etc)
  e) change on ambient conditions
  f) the result of any community consultation or negotiated agreement.
- For the assessment of existing and future traffic noise, details of data for the road should be included such as assumed traffic volume; percentage heavy vehicles by time of day; and details of the calculation process. These details should be consistent with any traffic study carried out in the EIS.
- Where blasting is intended an assessment in accordance with the *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (ANZECC, 1990) should be undertaken. The following details of the blast design should be included in the noise assessment:
  a) bench height, burden spacing, spacing burden ratio
  b) blast hole diameter, inclination and spacing
  c) type of explosive, maximum instantaneous charge, initiation, blast block size, blast frequency.

Describe management and mitigation measures

- Determine the most appropriate noise mitigation measures and expected noise reduction including both noise controls and management of impacts for both construction and operational noise. This will include selecting quiet equipment and construction methods, noise barriers or acoustic screens, location of stockpiles, temporary offices, compounds and vehicle routes, scheduling of activities, etc.
- For traffic noise impacts, provide a description of the ameliorative measures considered (if required), reasons for inclusion or exclusion, and procedures for calculation of noise levels including ameliorative measures. Also include, where necessary, a discussion of any potential problems associated with the proposed ameliorative measures, such as overshadowing effects from barriers. Appropriate ameliorative measures may include:
  a) use of alternative transportation modes, alternative routes, or other methods of avoiding the new road usage

b) control of traffic (eg: limiting times of access or speed limitations)
c) resurfacing of the road using a quiet surface
d) use of (additional) noise barriers or bunds
e) treatment of the façade to reduce internal noise levels buildings where the night-time criteria is a major concern
f) more stringent limits for noise emission from vehicles (i.e. using specially designed 'quite' trucks and/or trucks to use air bag suspension
g) driver education
h) appropriate truck routes
i) limit usage of exhaust breaks
j) use of premium muffles on trucks
k) reducing speed limits for trucks
l) ongoing community liaison and monitoring of complaints
m) phasing in the increased road use.

4. Water

Describe baseline conditions

- Describe existing surface and groundwater quality – an assessment needs to be undertaken for any water resource likely to be affected by the proposal and for all conditions (e.g. a wet weather sampling program is needed if runoff events may cause impacts).

  Note: Methods of sampling and analysis need to conform with an accepted standard (e.g. Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC 2004) *or be approved and analyses undertaken by accredited laboratories).*

- Provide site drainage details and surface runoff yield.

- State the ambient Water Quality and River Flow Objectives for the receiving waters. These refer to the community's agreed environmental values and human uses endorsed by the Government as goals for the ambient waters. These environmental values are published on the website: www.environment.nsw.gov.au/ieo. The EIS should state the environmental values listed for the catchment and waterway type relevant to your proposal. NB: A consolidated and approved list of environmental values is not available for groundwater resources. Where groundwater may be affected the EIS should identify appropriate groundwater environmental values and justify the choice.

- State the indicators and associated trigger values or criteria for the identified environmental values. This information should be sourced from the ANZECC 2000 *Guidelines for Fresh and Marine Water Quality* (http://www.deh.gov.au/water/quality/nwqms/volume1.html)(Note that, as at 2004, the NSW Water Quality Objectives booklets and website contain technical criteria derived from the 1992 version of the ANZECC Guidelines. The Water Quality Objectives remain as Government Policy, reflecting the community's environmental values and long-term goals, but the technical criteria are replaced by the more recent ANZECC 2000 Guidelines). NB: While specific guidelines for groundwater are not available, the ANCECC 2000 Guidelines endorse the application of the trigger values and decision trees as a tool to assess risk to environmental values in groundwater.

- State any locally specific objectives, criteria or targets, which have been endorsed by the government e.g. the Healthy Rivers Commission Inquiries (www.hrc.nsw.gov.au) or the NSW Salinity Strategy (DLWC, 2000) (www.dlwc.nsw.gov.au/care/salinity/#Strategy).

- Where site specific studies are proposed to revise the trigger values supporting the ambient Water Quality and River Flow Objectives, and the results are to be used for regulatory purposes (e.g. to assess whether a licensed discharge impacts on water quality objectives), then prior agreement from the DECC on the approach and study design must be obtained.

- Describe the state of the receiving waters and relate this to the relevant Water Quality and River Flow Objectives (i.e. are Water Quality and River Flow Objectives being achieved?).

Proponents are generally only expected to source available data and information. However, proponents of large or high risk developments may be required to collect some ambient water quality / river flow / groundwater data to enable a suitable level of impact assessment. Issues to include in the description of the receiving waters could include:

a) lake or estuary flushing characteristics
b) specific human uses (e.g. exact location of drinking water off take)
c) sensitive ecosystems or species conservation values
d) a description of the condition of the local catchment e.g. erosion levels, soils, vegetation cover, etc
e) an outline of baseline groundwater information, including, but not restricted to, depth to watertable, flow direction and gradient, groundwater quality, reliance on groundwater by surrounding users and by the environment
f) historic river flow data where available for the catchment.

Assess impacts

- No proposal should breach clause 120 of the *Protection of the Environment Operations Act* 1997 (i.e. pollution of waters is prohibited unless undertaken in accordance with relevant regulations).
- Identify and estimate the quantity of all pollutants that may be introduced into the water cycle by source and discharge point including residual discharges after mitigation measures are implemented.
- Include a rationale, along with relevant calculations, supporting the prediction of the discharges.
- Describe the effects and significance of any pollutant loads on the receiving environment. This should include impacts of residual discharges through modelling, monitoring or both, depending on the scale of the proposal. Determine changes to hydrology (including drainage patterns, surface runoff yield, flow regimes, wetland hydrologic regimes and groundwater).
- Describe water quality impacts resulting from changes to hydrologic flow regimes (such as nutrient enrichment or turbidity resulting from changes in frequency and magnitude of stream flow).
- Identify any potential impacts on quality or quantity of groundwater describing their source.
- Identify potential impacts associated with geomorphological activities with potential to increase surface water and sediment runoff or to reduce surface runoff and sediment transport. Also consider possible impacts such as bed lowering, bank lowering, in stream siltation, floodplain erosion and floodplain sitation.
- Identify impacts associated with the disturbance of acid sulfate soils and potential acid sulfate soils.
- Containment of spills and leaks shall be in accordance with the technical guidelines section 'Bunding and Spill Management' of the *Authorised Officers Manual* (EPA, 1995) (http://www.environment.nsw.gov.au/mao/bundingspill.htm) and the most recent versions of the Australian Standards referred to in the Guidelines. Containment should be designed for no-discharge.
- The significance of the impacts listed above should be predicted. When doing this it is important to predict the ambient water quality and river flow outcomes associated with the proposal and to demonstrate whether these are acceptable in terms of achieving protection of the Water Quality and River Flow Objectives. In particular the following questions should be answered:

  a) will the proposal protect Water Quality and River Flow Objectives where they are currently achieved in the ambient waters; and

b) will the proposal contribute towards the achievement of Water Quality and River Flow Objectives over time, where they are not currently achieved in the ambient waters.

Note: The assessment of water quality impacts needs to be undertaken in a total catchment management context to provide a wide perspective on development impacts, in particular cumulative impacts.

- Where a licensed discharge is proposed, provide the rationale as to why it cannot be avoided through application of a reasonable level of performance, using available technology, management practice and industry guidelines.
- Where a licensed discharge is proposed, provide the rationale as to why it represents the best environmental outcome and what measures can be taken to reduce its environmental impact.
- Reference should be made to *"Managing Urban Stormwater- Soils and Construction"* (Landcom, 2004), *"Guidelines for Fresh and Marine Water Quality"* (ANZECC, 2000).

Describe management and mitigation measures

A Soil & Water Management Plan should be developed which outlines all management and mitigation measures relating to stormwater management and erosion control. The Soil & Water Management Plan should:

- Outline stormwater management to control pollutants at the source and contain them within the site. Also describe measures for maintaining and monitoring any stormwater controls.
- Outline erosion and sediment control measures directed at minimising disturbance of land, minimising water flow through the site and filtering, trapping or detaining sediment. Also include measures to maintain and monitor controls as well as rehabilitation strategies.
- Describe wastewater treatment measures that are appropriate to the type and volume of wastewater and are based on a hierarchy of avoiding generation of wastewater; capturing all contaminated water (including stormwater) on the site; reusing/recycling wastewater; and treating any unavoidable discharge from the site to meet specified water quality requirements.
- Outline pollution control measures relating to storage of materials, possibility of accidental spills (eg preparation of contingency plans), appropriate disposal methods, and generation of leachate.
- Describe hydrological impact mitigation measures including:
  a) site selection (avoiding sites prone to flooding and waterlogging, actively eroding or affected by deposition)
  b) minimising runoff
  c) minimising reductions or modifications to flow regimes
  d) avoiding modifications to groundwater.
- Describe groundwater impact mitigation measures including:
  a) site selection
  b) retention of native vegetation and revegetation
  c) artificial recharge
  d) providing surface storages with impervious linings
  e) monitoring program.
- Describe geomorphological impact mitigation measures including:
  a) site selection
  b) erosion and sediment controls
  c) minimising in-stream works
  d) treating existing accelerated erosion and deposition
  e) monitoring program.
- Any proposed monitoring should be undertaken in accordance with the *"Approved Methods for the Sampling and Analysis of Water Pollutants in NSW"*, (DEC 2004).

5. Soils and contamination

Describe baseline conditions

- Provide any details (in addition to those provided in the location description - Section C) that are needed to describe the existing situation in terms of soil types and properties and soil contamination.

Assess impacts

- Identify any likely impacts resulting from the construction or operation of the proposal, including the likelihood of:
  a) disturbing any existing contaminated soil
  b) contamination of soil by operation of the activity
  c) subsidence or instability
  d) soil erosion
  e) disturbing acid sulfate or potential acid sulfate soils.
- Reference should be made to *"Contaminated Sites – Guidelines for Consultants Reporting on Contaminated Sites"* (EPA, 1997); *"Contaminated Sites – Guidelines on Significant Risk of Harm and Duty to Report"* (EPA, 1999).

Describe management and mitigation measures

- Describe and assess the effectiveness or adequacy of any soil management and mitigation measures during construction and operation of the proposal including:
  a) erosion and sediment control measures
  b) proposals for site remediation – see *"Managing Land Contamination, Planning Guidelines SEPP 55 – Remediation of Land"* (Department of Urban Affairs and Planning and Environment Protection Authority, 1998)
  c) proposals for the management of these soils – see *"Assessing and Managing Acid Sulfate Soils"*, (EPA, 1995) (note that this is the only methodology accepted by the DEC).

6. Waste and chemicals

Describe baseline conditions

- Describe any existing waste or chemicals operations related to the proposal.

Assess impacts

- Assess the adequacy of proposed measures to minimise natural resource consumption and minimise impacts from the handling, transporting, storage, processing and reprocessing of waste and/or chemicals.
- Reference should be made to *"Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes"* (EPA, 1999).

Describe management and mitigation measures

- Outline measures to minimise the consumpton of natural resources.
- Outline measures to avoid the generation of waste and promote the re-use and recycling and reprocessing of any waste.
- Outline measures to support any approved regional or industry waste plans.

7. Flora & Fauna Impacts

Flora

An assessment of vegetation on the site must include:

- A comprehensive description of the vegetation on the site. This will include an assessment of the condition of the plant communities present, including the designation of conservation significance at a local, regional and State level, and an assessment of the likely occurrence of any threatened species, populations or ecological communities listed under Schedules 1 or 2 of the "*Threatened Species Conservation Act 1995*" and any Rare or Threatened Australian Plant (ROTAP) species.
- A plan showing the distribution of any threatened or ROTAP species and the vegetation communities on the site, and the extent of vegetation proposed to be cleared. This plan should be at the same scale as the plan of the area subject to development in order to assist in the assessment the impact of the proposal on the existing vegetation.
- A statement about the degree of conformance with the DECC guidelines, *"Threatened Biodiversity Survey and Assessment: Guidelines for Development and Activities – Working Draft 2004" and "Threatened Species Assessment Guidelines – The Assessment of Significance" (DECC August 2007)* for surveys completed. This should include the adequacy and limitations of the survey efforts, timing and techniques used in determining results, in order to establish an appropriate level of confidence in the conclusions drawn.
- Where the assessment concludes that threatened species, populations or ecological communities, or their habitats, exist on or in proximity to the subject land, the effect of the proposed development should be determined in accordance with the Assessment Of Significance described in Section 5A of the "*Environmental Planning and Assessment Act* 1979". An assessment of the impact of the development on the plant communities and/or ROTAP species should also be provided.
- A description of the measures proposed to mitigate and/or ameliorate the impact of the development on the plant communities, threatened and ROTAP species.

Fauna

An assessment of fauna on site must include:

- A fauna survey to identify the distribution and abundance of fauna species known or likely to utilise the site, including a description of available fauna habitats and an assessment of the conservation status of each of the faunal components at a local, regional and State level.
- A plan showing the results of the above survey. This plan should be at the same scale as the plan of the area subject to development to assist in the assessment of the impact of the proposal on fauna.
- A statement about the degree of conformance with the DECC guidelines, *"Threatened Biodiversity Survey and Assessment: Guidelines for Development and Activities – Working Draft 2004" and "Threatened Species Assessment Guidelines – The Assessment of Significance" (DECC August 2007)* for surveys completed. This should include the adequacy and limitations of the survey efforts, timing and techniques used in determining results, in order to establish an appropriate level of confidence in the conclusions drawn.
- An assessment of the impact of the development on the identified fauna.
- An assessment of the existence or likely occurrence of threatened species, populations or ecological communities, or their habitats on the subject land. Where the assessment concludes that threatened species, populations or ecological communities, or their habitats exist on or in proximity to the subject land, the effect of the proposed development should be determined in accordance with the Assessment Of Significance described in Section 5A of the *"Environmental Planning and Assessment Act 1979".*
- A description of the measures proposed to mitigate and/or ameliorate the impact of the development on fauna.

Surveys & Assessments

- Surveys and assessments should be undertaken by suitably qualified persons and the qualifications and experience of the persons undertaking the work detailed.
- Dates, site locations, design, methodology, analysis techniques, and weather conditions at the time of the assessments and surveys must be described. The limitations of surveys should be identified and the results interpreted accordingly.
- Conclusions drawn in surveys and assessments should be substantiated by evidence resulting from those surveys and assessments. The document being supported by the surveys and assessments should reflect these conclusions and clearly state where recommendations of the survey and assessments have been incorporated in the proposal.

8. Aboriginal Cultural Heritage

- The EIS should address and document the information requirements set out in the (former) Department of Environment and Conservation's (DEC's) draft *"Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation" (2005)* and the Department of Planning's and DEC's *"Part 3A EP&A Act Guidelines for Aboriginal Cultural Heritage Assessment and Community Consultation" (2007).*
- The EIS should include surveys by suitably qualified archaeological consultants and include evidence of consultation with traditional Aboriginal custodians.
- The EIS should identify the nature and extent of impacts on ACH values across the project area and the strategies employed to avoid/minimise these impacts.
- The EIS should assess the archaeological and Aboriginal significance of the sites ACH values.
- Describe the actions that will be taken to avoid or mitigate impacts of the project on ACH values. This should include an assessment of the effectiveness and reliability of the measures and any residual impacts after these measures are implemented.
- The EIS needs to clearly demonstrate that effective community consultation with Aboriginal communities has been undertaken in assessing impacts, developing options and making final recommendations. DECC supports broad based Aboriginal community consultation and has a guide DECC's *"Interim Community Consultation Requirements for Applicants"* (2005) provides a useful model to follow.

Note: If the EIS is relying on past surveys it is critical to confirm that the surveys are consistent with the requirements of the above guidelines. Furthermore, if any new sites or objects are located, they should be recorded on NPSW site cards and registered on the Aboriginal Heritage Information Management System (AHIMS). AHIMS contact details: Phone: (02) 95856470, address: Li6, 43 Bridge Street, Hurstville, NSW 2220, e-mail: ahims@environment.nsw.gov.au.

9. Estuary Management

Overview

DECC has responsibility for States Estuaries. In 1992 An Estuary Management Policy was formulated promoting cooperation between the State Government, Local Government, Catchment Authorities, landholders and estuary users in implementing Plans for each estuary. The primary goal of the Estuary Management Policy is to encourage the integrated, balanced, responsible and ecologically sustainable use of the States estuaries.

Nambucca Council has completed an Estuary Management Plan for the Nambucca. (http://www.nambucca.nsw.gov.au/content/uploacs/estuaryplan0408.pdf) This document highlights key objectives and management strategies for the next 5 to 10 years.

Estuary Health

Freshwater flows are integral component to the functioning of many ecological processes within the estuary. Potential water extraction just upstream of the tidal limit has the potential for impacts and interactions with the estuary that need to be identified and assessed.
Some factors to be considered include;

- Implications of altered freshwater flow regimes on extensive aquatic plant beds in the upper estuary and their role as critical habitat for various life cycle stages of key fish and other species
- Investigate implications of changed flow regimes on salinity patterns and levels within the upper estuary and its ecology.

(Martin Fitzhenry HO 02 98955968 may be able to add more here as Manly Hydraulics Lab have done some preliniary work in this area)

Climate Change

Intensification of droughts and sea level rise projections and resultant changes in the flushing characteristics and salinity regimes must be discussed given that the tidal limit has the capacity to move further upstream. This has implications on surface groundwater interactions and estuary ecology.

Riparian Land Management

Nambucca EMP has identified as high priority to improve overall riverbank condition including riparian habitats on all streams throughout the catchment.

This project to identify how riparian land is to be managed within the study area as well as the water supply catchment (North Arm, Missabotti) Note other Councils eg Coffs Harbour and Port Macquarie-Hastings have taken measures to improve the health of their rivers and riparian lands upstream of their town water supplies with a view of securing over the long term improved water quality and quantity benefits.

10. Department of Environment & Climate Change Estate

- Where the proposal may result in impacts on DECC estate or is on land adjacent to DECC estate, an assessment of the impact of the development on DECC estate.
- A description of the measures proposed to mitigate and/or ameliorate the impact of the development on the DECC estate.

11. Matters of National Significance

- Your attention is also drawn to the Commonwealth legislation, the *"Environment Protection and Biodiversity Conservation Act 2000"*. The Act specifically focuses on matters of national environmental significance (NES) which include listed threatened species and ecological communities, World Heritage properties, "Ramsar" wetlands of international importance, internationally protected migratory species and Commonwealth Marine Areas. If any NES matters under this legislation may be affected by the proposal, approval for the development may also be required from Environment Australia.

12. DECC Databases

- The DECC can provide records of flora and fauna held in the Wildlife Atlas and / or Rare or Threatened Australian Plants (ROTAP) databases. In addition searches of the DECC AHIMS database can be made. These services generally attract a fee. It should be noted that these databases are not comprehensive, should only be used as a guide and do not negate the need for specific site investigations. Enquires should be made to DECC Hurstville office, telephone (02) 9585 6444.

13. Cumulative impacts

- Identify the extent that the receiving environment is already stressed by existing development and background levels of emissions to which this proposal will contribute.
- Assess the impact of the proposal against the long term air, noise and water quality objectives for the area or region.
- Identify infrastructure requirements flowing from the proposal (eg water and sewerage services, transport infrastructure upgrades).
- Assess likely impacts from such additional infrastructure and measures reasonably available to the proponent to contain such requirements or mitigate their impacts (eg travel demand management strategies).

14. Greenhouse Emissions

DECC requires the following in relation to greenhouse emissions:

- A comprehensive assessment of and report on the project's predicted greenhouse gas emissions (tCO2e), including emissions on:
- a tonnes per unit of production basis;
- a total annual emissions basis; and
- a total project lifetime basis.

The emissions associated with the project should include direct emissions, indirect emissions (e.g. those associated with electricity use) and any significant upstream and/or downstream emissions associated with the project. The emissions should be estimated using an appropriate methodology (eg AGO's Factors and Methods Workbook 2006).

Annual emissions should be compared against:

- 'best practice' emissions for the activity; and
- total annual NSW emissions, so the impact of the proposal on NSW emission reduction targets can be evaluated.

The proponent should evaluate and report on the feasibility of measures to reduce emissions.

D. List of approvals and licences

- Identify all approvals and licences required under environment protection legislation including details of all scheduled activities, types of ancillary activities and types of discharges (to air, land, water).

E. Compilation of mitigation measures

- Outline how the proposal and its environmental protection measures would be implemented and managed in an integrated manner so as to demonstrate that the proposal is capable of complying with statutory obligations under DECC licences or approvals (eg outline of an environmental management plan).
- The mitigation strategy should include the environmental management and cleaner production principles which would be followed when planning, designing, establishing and operating the proposal. It should include two sections, one setting out the program for managing the

proposal and the other outlining the monitoring program with a feedback loop to the management program.

F. Justification for the Proposal

- Reasons should be included which justify undertaking the proposal in the manner proposed, having regard to the potential environmental impacts.

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Shaun Lawer
GHD Pty Ltd
2/115 West High Street
COFFS HARBOUR NSW 2450

JOB No. 2214133			
ENTERED TO DATABASE			
INITIAL		DATE	
DATE		REF. No.	
NAME	INIT	DATE	ACTION
PP		3/12	
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24 November 2008

Attention: Shaun

Dear Sir

Re: Bowraville off-river storage and associated works

Thank you for your letter of 22 October 2008 requesting NSW Fisheries outline requirements for the above mentioned proposal.

NSW Fisheries is responsible for managing fish (including aquatic invertebrates), fish habitat and aquatic biodiversity throughout NSW. Aquatic biodiversity occurs in permanent and intermittent waterways covering marine, estuarine, fresh, and flowing and still waters. Fish populations have and continue to suffer serious decline, consequently in addition to mitigation of deleterious impacts on fish and fish habitat some emphasis must be placed on restoration.

Cognisant of this charter, NSW Fisheries requires the environmental studies examine and demonstrate how impacts on aquatic biodiversity can be addressed to ensure compliance with habitat provisions in the *Fisheries Management Act* 1994 and NSW Fisheries policies that underpin them.

Issues identified by the Fisheries Ecosystems Unit include but are not limited to:

- Identification of threatened species likely to occur in the area or be effected by the proposal;
- How damage to marine vegetation and other fish habitats will be minimised;
- Whether dredging, reclamation or activities that obstruct fish passage are proposed and, if so, how impacts will be minimised;
- Construction of the Bowraville Off-River Storage Works (BORSW) may necessitate access roads in the vicinity of Bowra Creek, the degree to which the creek is impacted upon should be addressed by the EIS with reference to location and construction methods of any access roads. Details of rehabilitation should be included if roads are to be removed upon the completion of the works;
- Construction of the BORSW may involve clearing of a considerable area of land potentially releasing sediment and nutrients that can affect riparian vegetation and fish habitat, the EIS should address methods to be employed to contain sediment, nutrients and other materials associated with the works and prevent them affecting Bowra Creek;

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- The Nambucca River to which Bowra Creek is a tributary contains important habitat for many species including those with commercial and recreational value. Methods to be used to minimise disturbance and impacts to fish habitat within lower Bowra Creek and the Nambucca River should be addressed by the EIS;
- Diagrams supplied with the letter of 22 October 2008 propose routes for pipeline infrastructure which include several points of crossing on Bowra Creek, the EIS should address methods for minimising harm to riparian vegetation and aquatic habitat associated with any crossing. The EIS should also detail dredge and reclamation works within the water land of Bowra Creek as defined by the *Fisheries Management Act* 1994;
- The extent to which fish passage is impacted upon by the construction of pipeline crossings should be addressed including the extent and duration of any reduction of fish passage. The EIS should also address the design and methods for constructing crossings and include strategies for ensuring ongoing fish passage;
- The extent to which fish passage is impacted upon by the construction of the dam wall should be addressed including any opportunities for works providing connectivity between the storage and Bowra Creek;
- Water quality and timing of releases from the storage can have significant impacts on aquatic species and the habitats upon which they rely. The EIS should address strategies for managing water quality including temperature and the timing of releases to ensure suitable conditions are met and timing of flows matches natural conditions to ensure environmental cues are maintained;
- Management of flow in the river should be addressed by the EIS with particular attention given to species such as Australian bass (*Macquaria novemaculeata*) requiring passage over obstructions (natural and anthropogenic) at certain times including monthly and daily. The EIS should also address the needs of other species requiring stable flow conditions at certain times such as Freshwater catfish (*Tandanus tandanus*). Other issues arising from altered flow within the Nambucca River should also be addressed including maintenance of flows to prevent salt intrusions in times of low flow potentially damaging or reducing important freshwater habitat such as macrophyte beds;
- The EIS should also address adaptive flow management strategies that will respond to morphological changes within the river system and to reduced flow conditions. Management strategies should display the ability to adjust extraction and releases to mitigate against flow related impacts;
- Any opportunities for compensatory actions to replace habitat lost as a result of the proposed works should be explored by the EIS, these may included rehabilitation works to riparian zones lower in the catchment to compensate for habitat lost in the headwaters.

Finally, I have also included as an attachment NSW Fisheries' minimum information requirements for environmental assessment. Please ensure that

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the proponent address these requirements in the environmental studies. This will facilitate effective assessment of the proposal and reduce delays.

If you have any further enquiries please contact me on (02) 6686 1370

Yours sincerely

Marcus Riches
Senior Conservation Manager

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NSW FISHERIES' MINIMUM REQUIREMENTS FOR ENVIRONMENTAL STUDIES

GENERAL REQUIREMENTS

- Describe the purpose of the proposal;
- Describe the location and area of the proposal;
- Detail the location of all component parts of the proposal, including any auxiliary infrastructure;
- Provide a timetable for construction of the proposal with details of each phases of construction;
- Detail likely or possible future needs arising from the proposal;
- Provide a legible topographic map with scale, contours, north represented and the date the map/plan/air photo was prepared;
- Specify zoning, present land use and whether special conditions (eg SEPP 14 wetlands) apply to the land proposed for development or adjacent land;
- Describe the surrounding geomorphology;
- Identify all water bodies including wetlands and floodplains;
- Specify the direction of river flow and provide hydrological and stream morphological including depth contours and stream bed substrate information, water quality and if appropriate tidal characteristics;
- Describe / map aquatic habitats (generally within 100 metres of the boundary of the proposal and sometimes further if downstream) that could be impacted upon either directly or indirectly by the proposal during its construction, life and decommissioning including:
  - gravel beds,
  - deep pools,
  - rocky reefs,
  - aquatic vegetation (seagrass, mangroves, saltmarsh and emergent vegetation such as reeds),
  - riparian vegetation and snags,
  - wetlands and floodplains, and
  - under cut banks.
- Identify recreational and commercial fishing areas and aquaculture ventures that could be effected by the proposal or works during its construction;
- A statement about the presence or absence of threatened species. Threatened species and key threatening processes are listed in Schedule 4 of the Fisheries Management Act and regularly updated on the Fisheries Scientific Committee website: www.fsc.nsw.gov.au
- Detail the potential impacts of the various phases of the proposal;
- Outline ongoing management activities to ensure impacts on aquatic biodiversity are minimised;

REQUIREMENTS FOR ACTIVITIES THAT BLOCK FISH PASSAGE

- Purpose and type of works requiring fish passage to be blocked;
- Timing, duration and manner of proposed restriction / blockage to fish passage;
- Methods to be used to avoid stranding fish and any remediation works.

REQUIREMENTS FOR DREDGING AND RECLAMATION WORKS

- Purpose of works;
- Type(s) of marine vegetation in the vicinity of the proposed works;
- Distance of adjacent marine vegetation from the outer boundary of the proposed works;
- Method of dredging or reclamation to be used;
- Duration of dredging or reclamation works;
- Time of dredging or reclamation works;
- Dimension of area to be dredged or reclaimed;
- Depth of dredging height of reclamation activities;
- Nature of sediment to be dredged, including Acid Sulphate Soil and Potential Acid Sulphate Soils;
- Method of marking area subject to works;
- Environmental safeguards to be used during and after works;
- Measures for minimising harm to fish habitat under the proposal;
- Spoil type and source location for reclamation activities;
- Method of disposal of dredge material;
- Location and duration of spoil stockpiling, if planned;
- Volume of material to be extracted or placed as fill.

REQUIREMENTS FOR ACTIVITIES THAT DAMAGE MARINE VEGETATION

- Type of marine vegetation to be harmed;
- Amount of marine vegetation to be harmed, map distribution noting percentage densities of species of marine vegetation;
- Reasons for harming marine vegetation;
- Methods of harming marine vegetation;
- Construction details, including proposed drainage;

- Duration and timing of works/activities;
- Measures for minimising harm to marine vegetation under the proposal;
- Environmental measures to be employed;
- Method and location of transplanting activities or disposal of marine vegetation.

REQUIREMENTS FOR ACTIVITIES THAT COULD IMPACT ON THREATENED SPECIES OR CONTRIBUTE TO KEY THREATENING PROCESSES

- All assessments require a statement about the presence or absence of threatened species. Up to date listings are available on the Fisheries Scientific Committee website: www.fsc.nsw.gov.au
- In determining the presence of threatened species, consideration must be given to the habitat types present within the study area, recent records of threatened species in the locality and the known distributions of these species;
- The condition of the habitat within the area must be discussed noting habitat requirements of threatened species likely to occur and the effect of relevant historical events (including land clearing, agricultural activities, water abstraction/diversion, dredging, de-snagging, reclamation, siltation, commercial and recreational activities);
- Assess potential impacts on threatened species via the 'Eight-Part Test' and upon completion, consultation with NSW Fisheries prior to the EIS being finalised;
- The proponent should note that where significant impact on threatened species is likely, a detailed Species Impact Statement must be prepared to assist in forming a determination.
- The proponent should also note that the *Fisheries Management Act* 1994 contains provisions for strict penalties (up to $220,000 and 2 years imprisonment) to be imposed for individuals or companies that harm an endangered species, population or community or their habitat without proper authority carries.

ASSESSMENT OF LIKELY IMPACTS

- Investigate and report on an area extending downstream and/or upstream as far as is necessary to take all potential impacts into account;
- Discussion possible indirect effects of the proposal on species/habitats in the area surrounding the subject site: for example, through altered hydrological regimes including stormwater runoff and drainage, soil erosion or pollution;
- Outline the habitat requirements of threatened species and species important to commercial or recreational fishing likely to occur in the study area;
- Discuss fish habitats within the study area and the nature and extent of habitat removal or modification which may result from the proposed action;

- Discuss the potential impact of the modification or removal of habitat on fish species in the area;
- For all species likely to have their lifecycle patterns disrupted by the proposal to the extent that individuals will cease to occupy any location within the subject site, the EIS must describe and discuss other locally occurring populations of such species;
- The relative significance of this location for these species in the general locality must be discussed in terms of the extent, security and viability of remaining habitat in the locality;
- Describe the potential contribution of the proposal to cumulative impacts on fish and fish habitat in the vicinity of the proposal.

AMELIORATIVE MEASURES

- Discuss measures for minimising impacts on fish and fish habitat and other environmental safeguards to be employed such as how erosion and run off will be reduced and water quality maintained;
- Specify the nature of any rehabilitation or environmental compensatory works to be undertaken and ongoing maintenance of these works to ensure their benefits are maintained;
- Describe ongoing management actions within the proposal, both during construction and after completion, which relate to impact minimisation eg Environmental Management Plans;
- Detail monitoring programs, including methodologies that assess Before and After, Control and Impact sites to determine the success of techniques used to ameliorate impacts on aquatic biodiversity level of impact of the development;

The EIS must consider how the proposal has been or may be modified and managed to conserve fisheries habitat on the subject site and in the study area.

In discussing alternatives to the proposal, and the measures proposed to mitigate any effects of the proposal, consideration must be given to developing long term management strategies to protect areas within the study area which are of particular importance for fish species. This may include proposals to restore or improve habitat.

Any proposed pre-construction monitoring plans or on-going monitoring of the effectiveness of the mitigation measures must be outlined in detail, including the objectives of the monitoring program, method of monitoring, reporting framework, duration and frequency.

Please Note: Persons undertaking aquatic surveys may be required to hold or obtain appropriate permits or licences under relevant legislation. It is recommend that, prior to any field survey activities taking place, those persons proposing to undertake those activities give consideration to their obligation to

obtain appropriate permits or licences which may be required in the specific context of the proposed survey activities.
For example:

Fisheries Management Act 1994

- Permit to take fish or marine vegetation for research or other authorised purposes (Section 37)
- Licence to harm threatened (aquatic) species, and/or damage the habitat of a threatened species (Section 220ZW).

Animal Research Act 1985:

- Animal Research Authority to undertake fauna surveys.

USEFUL DEFINITIONS

The definitions given below are relevant to these requirements:

Fish means any part of marine, estuarine or freshwater fish or other aquatic animal life at any stage of their life history (whether alive or dead). Fish include oysters and other aquatic molluscs, crustaceans, echinoderms and beachworms and other aquatic polychaetes.

Marine vegetation means any species of plant that at any time in its life must inhabit water (other than fresh water).

Waters refers to all waters including tidal waters to the Astronomical High Tide Level (AHTL) as well as flowing streams, irregularly flowing streams, gullies, rivers, lakes, coastal lagoons, wetlands and other forms of natural or man made water bodies on both private and public land.

Further Information

The NSW Fisheries Policy and Guidelines series contains more detailed information on techniques and practices that satisfy NSW Fisheries requirements to minimise impacts of developments on fish and fish habitat. The Guidelines are available at www.fisheries.nsw.gov.au. Considering the information in these documents prior to developing and submitting your proposal is strongly recommended.

Another document "*Guidelines for the Assessment of Aquatic Ecology in EIA*" (Draft 1998) produced by the Department for Urban Affairs and Planning (now Planning NSW) may prove useful in outlining appropriate procedures and methodologies for conducting aquatic surveys required for the preparation of an EIS.

Your Reference:
Our Reference: 1371

FORESTS NSW
ABN 43 141 857 613

130 West High St (PO Box 535) Coffs Harbour NSW 2450
www.dpi.nsw.gov.au/forests T 02 6652 0111 F 02 6651 9891

ENTERED TO DATABASE	
INITIAL	DATE
DATE 16/12/08	REF. No.

NAME	INIT	DATE	ACTION
PP		16/12	—
SL		16/12	
TR			

7 December 2008

Shaun Lawer
Senior Planner
GHD Pty Ltd
PO Box 1340
Coffs Harbour NSW 2450

Dear Sir,

Re: Bowraville Off-River Storage and Associated Works

I refer to your letter dated 22 October 2008 advising that GHD has been engaged by Nambucca Shire Council to undertake corcept design and the Environmental Impact Statement for the Bowraville Off-River Storage and seeking Forests NSW response on the project and requirements for the EIS.

Forests NSW is a public trading enterprise within the Department of Primary Industries and is responsible for the management of State forests and the management of timber on other Crown-timber lands. Accordingly, Forests NSW interest in the scheme is limited to the impacts on State forest affected either directly or indirectly by the proposal. While there have been a number of direct approaches from GHD and Department of Commerce staff, the following information is provided in response to this request.

Tenure

The area was dedicated as Viewmont State Forest No 1035 on 12 September 984. Prior to dedication as State forest, the land was owned by a private forestry company and was purchased in 1984 along with most of the company's holdings in this region, for timber production purposes.

There is a Crown road traversing the southern part of area within Lots 183, 186, 190 and 309 Parish Missabotti that was excluded from State forest dedication.

Viewmont State Forest No 1035 is included within the area covered by the NSW Forest Agreement for Lower North East Region and the Regional Forest Agreement for North East New South Wales.

Forest Management Zoning

The site has been zoned under Forests NSW Forest Management Zoning classification. The forest management system is based on nationally agreed reserve criteria and differentiates between those areas that are specifically managed for conservation and those areas that are available for other activities including timber

harvesting. Forest Management Zoning data has been previously supplied to GHD. The area comprises the following Forest Management Zones:

FMZ 3A - Harvesting Exclusions and Special Prescription
These areas are managed for the conservation of identified values and forest ecosystems. These exclusions are designed to comply with JANIS "values protected by prescription" but to the fullest extent possible, they are currently managed to meet the requirements of JANIS Informal Reserves.

FMZ 4 - General Management
These areas are managed for native forests timber production utilising the full range of silvicultural options available under the Integrated Forestry Operations Approval and the conservation of broad area habitat and environmental values. The zone is designed for a range of uses with timber production having a high priority. The zone contributes to the JANIS criteria "values protected by prescription" through the application of protocols designed to detect and protect threatened flora and fauna species.

FMZ 5 - Hardwood Plantations
These areas are hardwood plantations with management aimed at maximising sustainable timber production on a continuing and cyclical basis. There is approximately 70 hectares within the catchment zoned for plantation purposes.

FMZ 8 - Areas for further assessment
This zoning is an interim zoning where field investigation is required to determine final FMZ classification. It may include areas of modelled GIS data where field investigation is necessary to accurately map the features.

In 2003, Forests NSW consulted with the former Department of Environment and Conservation (DEC) concerning the declaration of Special Management Zones under s21A of the *Forestry Act 1916*. Agreement was reached for the area of rainforest zoned as FMZ 3A not to be zoned as Special Management Zone with DEC advising that it expected that areas of conservation significance including rainforest and high conservation value old growth to be managed accordingly.

Flora and Fauna Values

Forests NSW has previously provided data on flora and fauna recorded in or near the area in separate correspondence. The following threatened species have been recorded within or near the site:

- Brown Treecreeper
- Little Bentwing-bat
- Eastern Bentwing-bat
- Eastern Long-eared Bat
- Giant Barred Frog
- Grey-headed Flying-fox
- Powerful Owl
- Sooty Owl
- Wompoo Fruit-dove
- Koala
- Rusty Plum
- Milky Silkpod

Details of the locations for Forests NSW records were provided in the letter dated 23 September 2008.

Forest Management History

The area comprises a number of forest types. An area of Blackbutt Forest Type 36 occurs in the north of the area with Flooded Gum Forest type 48 occuring in a number of patches on the lower slopes and southern aspects. The ridges are predominantly dry and semi moist hardwood that include Forest Types 60 and 62 while patches of Blue Gum Forest Type 46 and Tallowwood-Blue Gum Forest Type 47 are found in the moister gully sites. As previously discussed with GHD staff, forest type information can be provided if required for the environmental assessment.

Hardwood plantation was established on the valley floor and lower slopes on cleared sites or where wattle regeneration was occurring in the late 1980's. The plantation has not been thinned.

The native forest in the northern part of the catchment was harvested using a single tree selection silvicultural system in 2005 with the logging track along the northern ridge opened for log haulage purposes at the time. The southern part of the catchment was not harvested at the time.

Off-stream Storage Proposal

The area has been under consideration as a site for an off-stream storage area for some time and consultation and negotiations have occurred between Nambucca Shire Council and Forests NSW over at least the last 12 years. A brief overview is as follows:

- Council advised State Forests in 1996 that its preferred scheme for the provision of a drought secure water supply was the construction of an off-river storage near the existing headworks and borefields and that prior to preparing an EIS further investigations were to be undertaken at potentially suitable sites. In response to the likelihood that the site would include State forest, State Forests advised that it would require compensation for the entire catchment within State forest, with any perimeter roads and trails remaining within State forest.

- In 2000, Council advised that with the closure of a major processing industry, demand for water had dropped significantly and that it had decided to defer construction and it was expected that the facility would not be required until approximately 2020. Notwithstanding the deferral, Council advised that it wished to pursue acquisition of the land.

- In 2004, Nambucca Shire Council was advised that the Minister for Primary Industries has approved in principle the acquisition of about 207 ha of Viewmont State Forest No 1035 at an agreed compensation value with Council meeting all costs associated with the acquisition process. The acquisition area comprised the area of the catchment the part of State forest severed by the proposal immediately south of the catchment. The in-principle agreement was also subject to the areas of native forest areas being harvested prior to acquisition, and Council entering into agreement that provided for Forests NSW harvesting and marketing the timber on the dam site after acquisition. The approval was also subject to final determination of an Environmental Impact Statement.

Operational Planning Issues

There are a number of access roads and trails traversing the State forest that provide access to the catchment including the proposed inundation area. While Forests NSW has no objection to the use of the roads and trails where they are located on State forest, specific approval should be obtained prior to any use of earthmoving machinary to improve access to the area. Pending the acquisition of the site, any works will need to conform to Forests NSW standard operating requirements for roads and trails within State forest.

It is understood that a number of studies including surveys and geotechnical investigations will be required on State forest as part of the concept design and environmental assessment. Approvals either in the form of Special Purposes Permits or other authorities should be obtained prior to the conduct of any studies on State forest to ensure that any potential conflicts between forestry activities and the studies is minimised and that the necessary operational and environmental controls are implemented.

If further information is required, please contact Planning Manager John Murray (Phone 66520111).

Yours sincerely

For:
Craig Busby
Regional Manager
North East Region

NORTH COAST
AREA HEALTH SERVICE
NSW HEALTH

27th April 2009

Mr Shaun Lawer
Senior Planner
GHD
PO Box 1340
COFFS HARBOUR NSW 2450

Dear Mr Lawer

BOWRAVILLE OFF-RIVER STORAGE AND ASSOCIATED WORKS

I refer to your letter dated 21st November 2008 seeking comments in relation to the project and any requirements for the preparation of the EIS. I apologise for the delay in preparing the response and in getting this correspondence to you. Please find comments for consideration for the EIS relating to public health -

1. Australian Drinking Water Guidelines (ADWG) 2004 – NSW Health supports the use of a multi-disciplinary risk based framework approach to drinking water management as particularly outlined within the 12 steps of Chapter 3 of the ADWG. Please find link to this section of the guidelines –

http://www.nhmrc.gov.au/publications/synopses/_files/adwg_11_06_chapter_3.pdf

The development of a drinking water quality policy/plan is an important initial step in the framework. A water quality policy/ plan must address all elements of the Framework and should include:

- the undertaking of a comprehensive risk assessment of the water supply system
- the design of the system to apply multiple barriers against contamination of the water supplied to consumers
- a comprehensive water quality monitoring plan
- a protocol for responding to incidents that threatens (or could threaten) water quality, public health or safety
- a means to investigate and manage complaints of water quality
- a plan to provide reports of water quality to consumers
- a process for monitoring and auditing implementation of the Framework

2. Recreational and Agricultural considerations – Public access to the Off-River Storage for recreational use of water should be prohibited to ensure water in the storage is of the highest possible quality. Livestock should also be prohibited from the area in and around the storage to ensure there is no risk of contamination to water being stored.

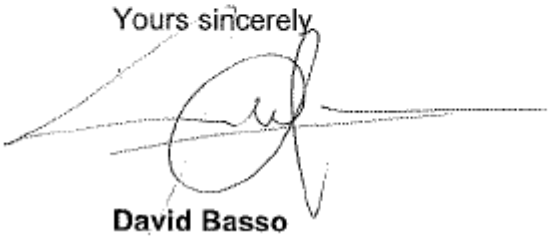
3. Public Health Act – involvement in the NSW Drinking Water Monitoring program and reporting of monitoring results to NSW Health via the internet based NSW Health Drinking Water Database. Details of the monitoring program can be found at -

http://www.health.nsw.gov.au/resources/publichealth/environment/water/pdf/dwmp_booklet05.pdf

Population Health, Planning and Performance
North Coast Area Health Service
PO Box 126 Port Macquarie NSW 2444
Tel (02) 6588 2750 Fax (02) 6588 2837
Website www.ncahs.nsw.gov.au
ABN 37 940 606 983

Trusting this information is of assistance and please call me if you have any further questions in relation to the matters raised.

Yours sincerely



David Basso
Environmental Health Officer

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Appendix B

Hydroilex Geomorphic Study

HYDROILEX PTY LTD
A.C.N. 003.372.834

HYDROILEX

Groundwater
Oil & Gas
Minerals

Geological Consultants
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Report on

Geomorphic Assessment of Bowraville Borefield

Prepared For

Nambucca Shire Council

And

NSW Department of Commerce

Distribution:
NSC (1)
DoC (1)
File (1)

Rohan Last
Hydrogeologist
Rep.No.HG.08.9.4.NC
October, 2008

COMMERCIAL IN CONFIDENCE

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PREPARED BY: Storm Consulting for Hydroilex Pty Ltd

VERSION: Revised October 2008

AUTHORISED BY: R.J.Lee

APPROVED FOR DISTRIBUTION: R.J.Lee

STORM_CONSULTING

Geomorphic Assessment of Bowraville Borefield

Report Prepared for:
Hydroilex Pty Ltd to Department of Commerce, on behalf of Nambucca Shire Council

October 2008
Project No. 843

Prepared by:
STORM CONSULTING PTY LTD

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Client Contact	Rohan Last, Hydroilex	

	Name	Signature	Issue	Date
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Rohan Last			15/09/08	pdf		
Rohan Last					30/10/08	.pdf

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TABLE OF CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

1.1. Preamble

The population of Nambucca valley is supplied with potable water from an off-river borefield located to the west of the Bowraville township in north eastern New South Wales. The existing bores are located in the alluvium and on the floodplain of the lower reaches of North and South Arm of the Nambucca River. There is currently a proposal to expand the borefield with the addition of new bores in the same general location.

This report presents the results of a geomorphic process study and risk assessment undertaken by STORM_CONSULTING (STORM) for the existing borefield and for the proposed expansion. STORM was engaged by the hydrogeological consultancy firm and project manager Hydroilex on behalf of the Department of Commerce (DOC). DOC represents Nambucca Shire Council.

The term geomorphic used in this report refers to riverine, or fluvial processes that rivers and streams display such as changes in flow paths, and erosional and depositional behaviour.

1.2. Background and Context

Due to their migratory nature and sensitivity to change depending on land use and climatic conditions, the Nambucca River and its tributaries have been the subject of several previous geomorphic studies. It is possible that the regional water supply may be at risk if geomorphic change continues. An example would be if the stream flow path were to change with the result that flow is directed toward the borefield.

The Nambucca River has been subject to significant change since European settlement. Land clearing and agricultural uses have lead to exposure of gravel river beds and banks that have subsequently become prone to river bed incision and channel widening. It is considered necessary to investigate the geomorphic condition of the River in and near the borefield and to assess likely risks to the town water supply integrity as a result of geomorphic processes.

1.3. Objectives & Scope

The purpose of this assessment is to undertake the fluvial geomorphic study to address the following concerns raised by Council with regards to the potential impact to the borefield:

- Potential for damage to borefield infrastructure in a flood event
- Possible change to hydrology due to change in river channel depth, width and path
- Changes to the borefield/river interaction if the existing pipe crossing is removed

Based on the findings of the assessment recommendations are made to manage or mitigate the likely risks to the current river/borefield interaction.

1.4. Study Methodology

This study has been compiled as a result of desktop investigations coupled with a field inspection. The field inspection was conducted after a large rain event in the catchment when flows were high and diminishing.

2.0 STUDY AREA DESCRIPTION

2.1. Site characteristics

The Nambucca valley is situated on the North Coast of NSW and experiences a reasonably warm and moist climate having a mean annual rainfall of approximately 1500mm per year and average temp range of 12-25.6 degrees. The area is unique in that the Great Dividing Range meets the coast in closer proximity than anywhere else along the east coast of NSW.

The Nambucca River catchment is bounded by a ridge line to the west having an elevation of up to approx 950m above sea level that does not retreat via gorges into an escarpment as do other systems on the eastern seaboard. The catchment is dominated by cleared land with steep (10-30 degrees) rugged hills (MRL 1999). The fertile soils and high rainfall in the area have lead to the development of extensive grazing pasture as the predominant land use in the catchment.

The study area is bounded in the lower extent by Lanes Bridge and in the upper extent approximately 1km upstream on both the North and South Arm of the Nambucca River.

Floodplain land in the study area is in private ownership and used for grazing.

Figure 2-1: Hills-Typical of Nambucca River catchment

2.2. River description

Nambucca River has an estuary from its mouth to the Bowraville junction of two streams, i.e. North and South Arm. Upstream of the junction, two other waterways connect to the North and South Arm, i.e. Missabotti River and Buckra Bendinni Creek respectively. The reach of the study area, identified by the 'Lower North Arm and Lower South Arm' (Figure 2-6), is characterised by a transition in the River from a steep powerful stream in the upper reaches to a flatter tidal stream in the estuarine reach. The fluvial channel of the River is moderately sinuous and winds through alluvial terraces in the valley floor that are typical of the floodplain throughout the catchment.

Commonly known as Nambucca Gold, quartz gravel is abundant in the River. The gravels were extracted both from the river bed and from a quarry upstream until recent knowledge of gravel mining impact on the River became understood (MRL, 1999).

The river character is defined by the formation of the valleys bounded by rugged hills. The hills in the upper catchment comprise steep confined valleys carrying headwaters of the River. Further downstream the hills become more undulating allowing greater fluvial variation in the valleys within either alluvium or bedrock. In the lower reaches of the River hills are more undulating again and valleys widen considerably. Much of the valley is filled with gravel and sand/silt soils deposited over time. This material represents the formation of an alluvial landform that is largely flat, although includes a variety of surface irregularities as a result of fluvial overbank processes discussed further in Section 3.4. The condition of the River is described as moderately eroded and is discussed in more detail in Section 3.1

Figure 2-2: Nambucca River North Arm

Figure 2-3: Nambucca Gold – Quartz Gravel Alluvium

2.3. Vegetation

Almost all native vegetation has been cleared in the study area. Any remaining native vegetation tends to be regrowth or small remnant clusters and no evidence of intact native vegetation communities was observed. The woody weed Camphor Laurel (*Cinnamomum camphor*) dominates the riparian zone, limiting the chance of native regeneration due to its quick spreading nature. This monoculture also hosts infestations of exotic birds, further limiting native habitat conservation (Plates 2-4 and 2-5). Another woody weed – willows (*Salix* spp) were observed on the river banks occasionally and more frequently in river tributaries. Some areas also exhibit infestations of shrubby weeds (e.g. *Lantana camara, Ligustrum* spp aka Privet) and weed goundcover (e.g. *Tradescantia* spp aka Wandering Dew).

Native species observed included some trees (*Casuarina* spp and *Eucalyptus* spp) and some shrubs (e.g Lomandra). No aquatic plants were observed in the river bed, which is probably a reflection of the dynamic nature of this river with active erosion and deposition.

Figure 2-4: Camphor Laurel

Figure 2-5: Camphor Laurel and associated bird habitat

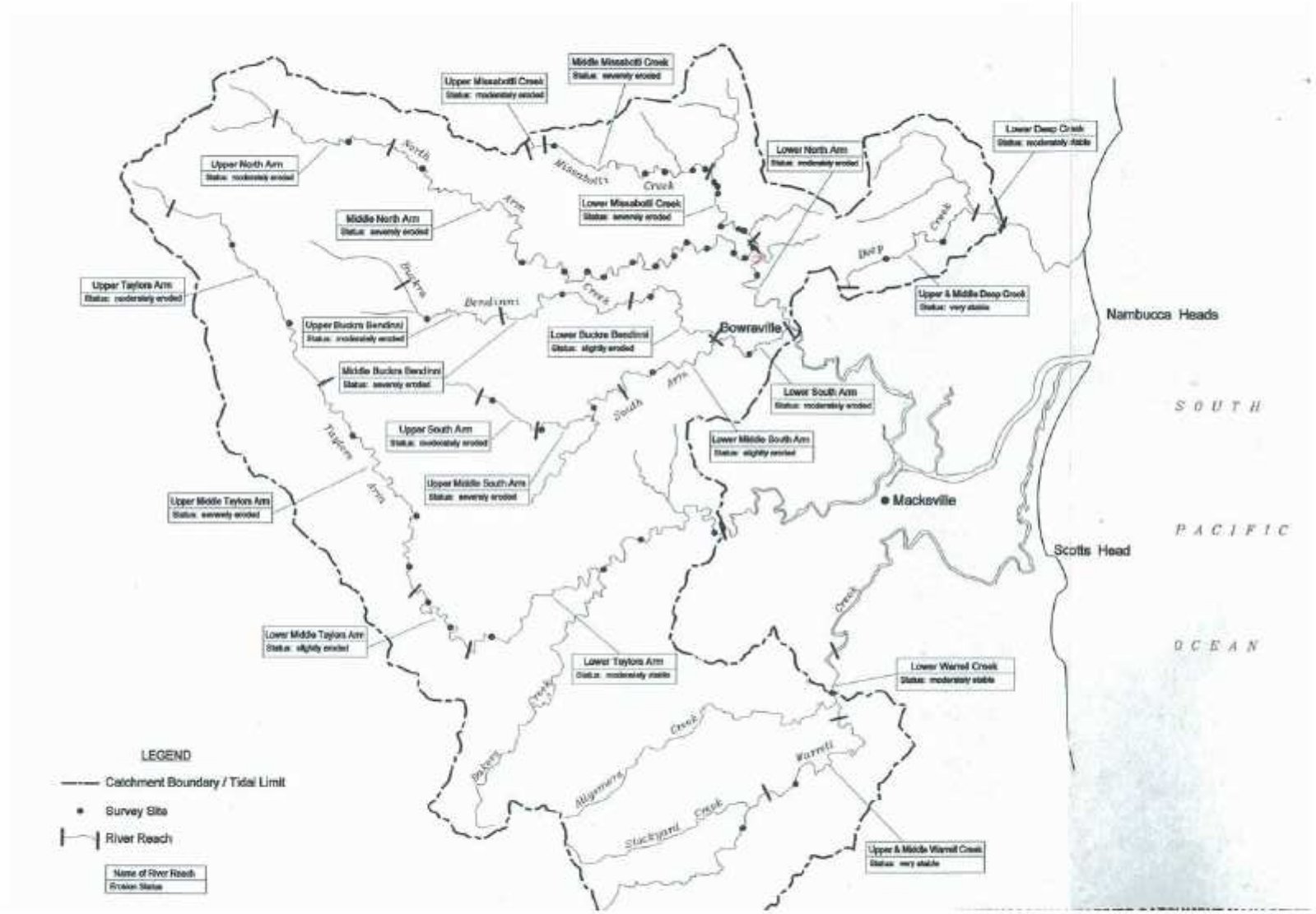


Figure 2-6: Catchment Plan

2.4. Pipeline crossing

A pipeline crosses the river and this pipeline is associated with the borefield water supply. The pipeline crossing is located on a straight section of the river. The pipeline is encased in concrete and this structure forms a barrier in the river in the form of a low weir approximately 1m in height. Above the weir, the backed up flow forms a weir pool. Water flowing over the weir proceeds down an artificial cascade comprising placed concrete blocks with steel armouring.

The river bed has been lowered both up and downstream of the existing structure and stabilisation has been undertaken with rock/gabions and concrete. Council reported that during dry periods the water level upstream of the crossing can drop up to 1m below the concrete crest and reappear further downstream of the structure.

In low flows, the structure is likely to be impassable to fish. In higher flows where the structure is drowned out, fish passage may be possible.

Figure 2-7: Pipeline crossing

3.0 GEOMORPHOLOGY

3.1. Approach

This geomorphic assessment has been based on the identification on physical changes within the catchment and in the river that have a follow-on effect on its geomorphology. In turn, the proximity of the borefield within the river landscape requires an assessment of the changes that are likely to affect the integrity and function of the borefield. This is depicted as inter-dependent relationships (Fig 3-1) which show that a physical change in the catchment causes the river to shift to a new geomorphic equilibrium.

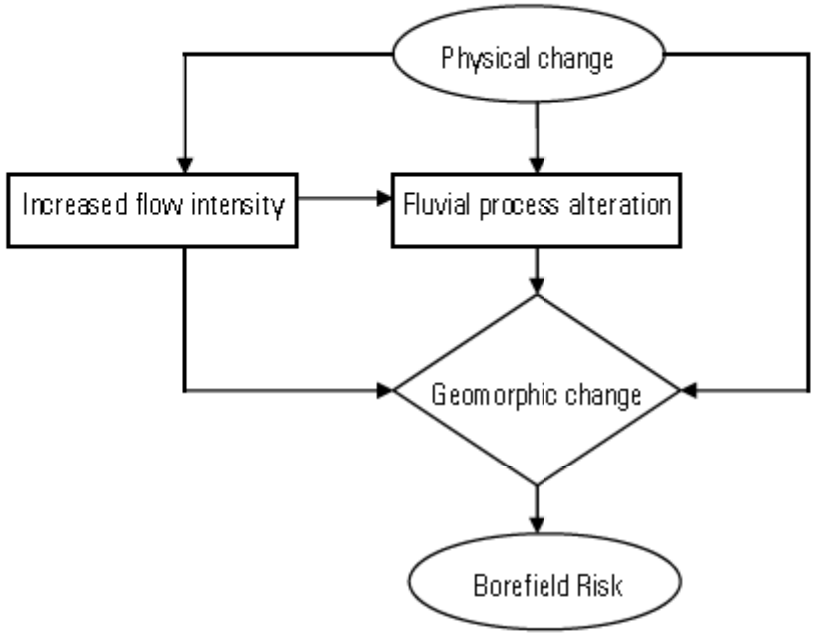


Figure 3-1: Geomorphic Assessment Flowchart

3.2. Current condition

The health of river systems is indicated by native habitat that is supported by important features such as riparian vegetation, woody debris, fish passage and high connectivity with adjoining reaches and tributaries. These features also represent fundamental components of a river with good geomorphic condition as they not only create habitat but have their place in fluvial processes. Currently the River is in poor condition, indicated not only by site observations but also by several preceding studies. Riparian vegetation consists only of exotic species (Section 2.3) which provides relatively poor habitat potential. The river has poor connectivity with adjoining streams and native habitat has very limited presence in upper locations of the study area.

In-stream conditions are dominated by deposits of quartz on point bars which are commonly found on the inside banks of meanders. The deposition can be attributed to transport of sediments from erosion in reaches upstream (L&M 1999). There is also evidence of bed incision given the exposed vertical nature of the stream banks along with a deep and over-widened channel. Further evidence to support incision of the river bed is that the previously subterranean pipeline that crosses the river in the borefield is now exposed and displays a 1 m drop in level from up to downstream.

River banks are also actively eroding through exposure to high energy flows, and having limited resistance in the form of deep rooted riparian vegetation and stable bank slopes. Camphor Laurel trees dominate the river banks and are renowned as being fast growing, invasive and shallow rooted. Over time this species has excluded native vegetation by spreading among remnant vegetation and eventually outcompeting other species. During high flows, the larger Camphor Laurel trees are uprooted by undercutting of the root system during bank erosion. Large trees often fall into the channel leaving a vertical face cut in the river bank and contributing large volumes of attached soil to the river.

3.3. River Style classification

The study area extent of both river arms are similar in that they exhibit near identical geomorphic features that can be described as:

- A defined channel with moderate sinuosity meandering within a rather wide valley floor confined by rugged hills on either side
- The Valley floor comprises a floodplain of alluvium as a result of vertical accretion over a long period of time. Build up of the alluvium has resulted in terracing where features such as benches and levees are present
- Floodplain material is transient due to its loose binding nature and surface irregularities are present as a result of large flows totally inundating the floodplain and causing mass erosion with observations of flood outs, back swamps and meander cut-offs
- Entrenchment of the channel was observed by low frequency of overbank connection with channel flows
- Gravel river bed throughout with point bars of quartz gravels deposited in-stream where velocity of flow is low, particularly on inside bank of meanders and tail out of woody debris

These features have attributed to the categorisation of the river as "confined valley with planform controlled discontinuous floodplain" as defined by the River Styles report (MRL 1999).

The connecting reach downstream is tidal with a near flat gradient with a planform that freely migrates across the coastal plain of sand dunes. This reach connects to a significant estuarine system supporting a large aquatic ecosystem of mangrove, saltmarsh and coastal rainforest including the estuaries of Taylor's Arm and Warrell Creek.

Connecting reaches upstream of both the North and South Arm defined as "confined valley with bedrock controlled discontinuous floodplain". The valley is more confined than in the study area with a defined channel often running in a straight line from edge to edge of the valley floor until meeting bedrock on outside bends. The loose nature of the floodplain alluvium and riparian vegetation clearing have allowed these reaches to erode significantly and have become a source of in-stream deposits downstream.

The reaches of the study area are a transition from the high stream powered reaches upstream to the more passive estuarine reach downstream. As such, variations of geomorphic features are present with the greater entrenchment of the channel and wider, flatter floodplain occurs from up to downstream.

A summary of the reach characteristics is provided in Table 3-1.

Table 3-1: Summary of river reach characteristics

Reach	Catchment (km^2)	Valley slope	Stream Slope	Sinuosity	Floodplain width (m)	Bedstone size (mm)	Bankfull flow (m^3/s)
North Arm	160-430	0.0025	0.0017	1.49	270-380	19-22	380 (1yr ARI)
South Arm	80-180	0.0025	0.0019	1.32	150-250	15-25	189 (2yr ARI)

Source: Nambucca River and Catchment Management Study, Fluvial Geomorphology (L&M 1999)

3.4. Fluvial Processes

It is important to assess the fluvial processes occurring and how the borefield will be sustained over time to maintain the town water supply. Much of the borefield is located in the floodplain/riverbanks drawing water from the aquifer of the river gravel substrate. In order to ensure longevity of the borefield and the health of the river, mitigation of potentially threatening fluvial processes must be addressed.

Accretion

Streams naturally transport sediments and the rate at which they do so varies over time according to changes both with the climate and with land formation. Layers of alluvial material have been vertically stratified in the valley floor by accretion. Layers of basal gravel, silt/sand and organic material have been found in the alluvium (L&M 1999). The shape of the vertically accreted matter is such that terraces have been created and more often than not, a clearly defined levee exists along the channel top of bank. Lower portions of the overbank exist behind the levee in the form of flood outs, back channels, back swamps, etc.

Figure 3-2: River overbank with alluvial material settlement as evidence of accretion

Floodplain interaction

Floodplains are commonly river flats adjacent to the river channel that allow high stream flows to be stored while the volume of the flow can be drained by the river channel. When bank overtopping occurs, sediment and organic material is transported overbank to the floodplain and is deposited in layers over time to give floodplains their character. Floodplain terraces concentrate overbank flows and accumulate flows from tributaries with poor connection to the channel in order to drain the stored flood volume. The concentrated flows then increase in volume and velocity having the potential to cause mass erosion and cause variation in the channel overbank to occur.

Figure 3-3: Back swamp of North Arm with the river defined by tree line in the background

Lateral movement

The Nambucca River floodplain of alluvial material is high in organic material deposited from the flood flows. These floodplain land formations are ideal for agricultural use and have been utilised for grazing and crops. This has resulted in clearing of large portions of riparian vegetation from the floodplain. In this river system with gravel soils, riparian vegetation is integral in supporting the stability of the river. Once the vegetation is cleared, the river and floodplain becomes susceptible to fluvial processes such that mass erosion may occur during large flow events.

The highly erosive nature of soils and lack of deep rooted riparian vegetation result in a tendency for lateral movement of river banks and a high amount of flood runner and back channel formation within the valley floor. In some cases, a meander cut-off may occur where the stream shortens its path by cutting off the inside bend of a meander and increasing stream slope. More often than not this will be observed as rather straight sections of the river channel cutting through the floodplain until meeting bedrock on either side of the valley. There is evidence of this occurring in North Arm.

Figure 3-4: Meander cut off damaging existing borefield

River bed incision

River bed materials other than solid bedrock are prone to incision due to variations in fluvial forces along a stream. The trigger for the incision is a nick point that is usually created by disturbance to the river geomorphology and/or change to hydrologic regime. This occurs through anthropogenic activity such as dredging, riparian vegetation removal, woody debris removal and catchment clearing. Following the formation of a nick point, the change in level in the river bed causes river flow to drop over the upstream edge scouring the bed below. Over time the scouring deepens and the flow energy over the nick point increases exposing the erosive river bed material to further disturbance. As a result the nick point will migrate upstream (headward migration) and the height and flow energy will increase. This will commonly continue until an in-stream structure such as natural (woody debris) or infrastructure (e.g. road crossing or pipeline) stabilises the incision by preventing headward migration.

Removal of the existing pipeline crossing the river has potential to create a nick point with subsequent headward migration resulting in river bed incision.

Figure 3-5: Downstream perspective of the pipeline crossing indicating evidence of bed incision

Channel Overwidening

Channel widening is a result of mass bank erosion extending the width of the channel. The most notable process that has lead to the overwidening of the Nambucca River is the migration of nick points on both the North and South Arm (L&M 1999). As the depth of the channel increases through upstream retreat of the nick point, the scouring processes erode the basal gravels to expose the basal material of the river banks. As is the case in Nambucca. The basal gravels are highly erosive and flows scour lower river banks lending to undercutting and upper bank failure. The expansion of the channel area also leads to entrenchment where the capacity of the channel is far greater and subsequently the frequency of overbank flow is reduced. Additionally with higher lateral capacity, the flow depth is proportionally reduced as it spreads from bank to bank.

3.5. Summary of geomorphic conditions and borefield threats

The reaches of the study area have changed significantly from their natural state and it is not deemed possible to restore the river due to the scale of overwidening and failure of previous stabilisation attempts (L&M 1999). It is evident from site investigations that the river channel has changed in planform and capacity over time and is likely to continue in future. Floodplain variations within the study area have been created as a result of the overbank flows and as discussed the loose nature of the alluvium is prone to erosion. The entrenchment of the river channel has created a situation where flows up to a recurrence interval of 5yr ARI can be contained in-stream. This has been estimated to have increased from a recurrence interval of 1 yr ARI before European settlement. As a result, less overbank flow is currently experienced that may have the opportunity to flow through the borefield.

Hence although the river has undergone significant modification, the entrenchment of the channel ensures that future geomorphic change in the floodplain is less likely to occur. This condition illustrates that the borefield is at risk due to the terracing of the floodplain if storm events greater than the 5yr ARI are experienced and alluvial material is stripped from the floodplain pockets. In the worst case, a meander cut-off will effectively isolate bores entirely from the floodplain or be swept away altogether where located on inside bends. As shown in Figure 3-4 flows from a storm event in 2001 breached the river bank and began to cut off a meander in the existing borefield. Although the flood runner did not completely cut-off the meander it swept away a power pole and increased the risk of total cut off in future storms. This site has been successfully stabilised and rehabilitated with the use of rock ramps, pin fences and revegetation. The works was completed in a joint effort by the Catchment Management Authority and Nambucca Valley Landcare, call Tim Ryan ph: 02 6564 7838.

Flows are more readily conveyed within the river channel and due to various fluvial processes such as lateral movement and nick point migration, the sinuosity of the river has decreased and the flow path has become steeper and shorter. Thus the stream power is increased as the length of the flow path is reduced and slope of the stream is increased. These factors, in combination with erosive bank material and shallow rooted vegetation, render the river banks prone to mass failure (Fig 3-6). Bank sections of up to 5m wide can be lost at any time if a large Camphor Laurel tree is uprooted and tears the upper bank in-stream along with the root mass. This condition is likely to pose significant risk to bores located within 20m of the river bank (Fig 3-7).

Figure 3-6: Mass bank failure adjacent to pasture land on floodplain approx 200m downstream of borefield

Figure 3-7: Existing borefield indicating several bores within 10m of the river bank (tree line to the right)

Furthermore recent studies conducted by Hydroilex indicate that river and corresponding bore water levels are correlated. The volume of borewater is dependant on the availability of water in the river. Thus slight variations in the water level of the river are critical to the yields from the borefield. Processes such as lateral migration and bed lowering both have the possibility of reducing the water level in the river. It is therefore reasonable to conclude that the health and stability of the river is integral to the security of town water supply and it is highly recommended that control measures are implemented to manage this condition.

3.6. Pipeline crossing options

Some form of pipeline crossing is required to enable ongoing transfer of the borefield waters across the River. The options are to retain the existing weir crossing, or to create a new crossing – concrete encased under the river or bridging structure over the river.

The existing weir provides a situation whereby a weir pool is created upstream of the structure. Advice from Hydroilex is that this situation causes a positive effect in the adjoining borefield as a result of hydraulic connectivity between the river level and groundwater level. In other words, the groundwater level is also raised. Therefore, retention of the pipeline/weir structure is desirable to maintain upstream pool levels. However, the existing structure prevents fish passage and this is undesirable.

The options for achieving an outcome where both a pipeline crossing and fish passage are provided are limited to the following:

retain existing structure	This prevents fish passage in low flows. A fishway structure could be installed from the weir crest (pipeline) downstream to flatten grade and reduce velocity that will enable fish passage.
create new under river crossing	This would involve installing a similar concrete encased pipe at a lower level so that the pipe would not form a weir structure. This would likely allow easy fish passage, however, the upstream weir pool would be drained. This could result in a decrease in groundwater levels adjacent the river and also could create further instability upstream due to loss of the bed control function of the weir. The instability may be controlled by installing a bed control structure upstream. The encased pipe may eventually be exposed in the long term if downstream bed lowering continues.
install a bridge-style pipeline crossing	Remove the existing structure and installation of bed control structure upstream to ensure no nick point is created, and to ensure that the appropriate grades for fish passage are achieved. Lowering of the weir pool may also affect groundwater levels adjacent the river.

The most pragmatic and least costly option would appear to be retaining the existing structure. The existing structure could be modified to allow fish passage.

4.0 RISK ASSESSMENT

For the purposes of this study a risk assessment has been undertaken to show how the threats to the borefield can be effectively managed. A qualitative approach has been adopted to assess the risks noting that the accuracy of the risk weightings assumed is highly dependant on unpredictable natural conditions and associated processes such as the weather.

The Risk Analysis leads to a series of control measures that together define a strategy for borefield risk mitigation.

4.1. Assessment methodology

A threat/occurrence matrix has been created to assess the risk of borefield damage or loss. A Total Threat Score is derived by multiplying the potential threat weighting by the likelihood of occurrence for each particular threat. This provides an indication of the priority of management for each particular issue to ensure risk of borefield degradation is mitigated.

The following key describes the parameters of the Risk Assessment Matrix.

- TW = Threat Weighting with a score of 1-3 assigned as follows: 1= bore damage; 2= single bore loss/bore function impaired; 3= numerous bore loss/numerous bore function impaired
- OP = Occurrence Probability with a score of 1-3 assigned as follows: 1= unlikely to occur within 20yr period; 2= slight to moderate chance of occurrence within 20yr period; 3= high possibility of occurrence within 20years
- TOTAL THREAT SCORE = TW*OP

4.2. Risk analysis

Table 4-1 presents the results of the borefield risk assessment.

Table 4-1: Risk analysis matrix

Issue	Process Description	Potential Threat	TW	OP	TOTAL
Bank Erosion	Degradation of river banks by high stream power scouring bank material exposed by deepening of the channel bed. Lack of native vegetation in the riparian area reduces the floodplain and river banks resistance to erosion.	Loss or damage to bores within 20m of the river bank	1	2	2
Bed incision	Physical changes to the river by anthropogenic activity causing nick points in the river bed. Follow on effects include bank erosion and over widening of the channel. Lack of native vegetation in the riparian area reduces the river banks resistance to erosion which can lead to increased bed incision. Undermining of pipeline crossing as bed downstream continues to lower	Exposure of basal bank structure leaving the bank prone to mass failure. Lowering of the river bed and associated river/aquifer storage levels Damage or breakage to pipeline	2	3	6
Lateral migration	High stream power and erosive soils of the river bank/ floodplain allow for the possibility of alluvium stripping. Lack of native vegetation in the riparian area reduces the floodplain resistance to erosion which promotes the threat of lateral migration.	Loss of numerous bores located on inside bank/floodplain of meanders	3	1	3

4.3. Risk mitigation strategies

Table 4-2 provides a strategic response to the risks comprising a series of control measures.

Table 4-2: Control strategy matrix

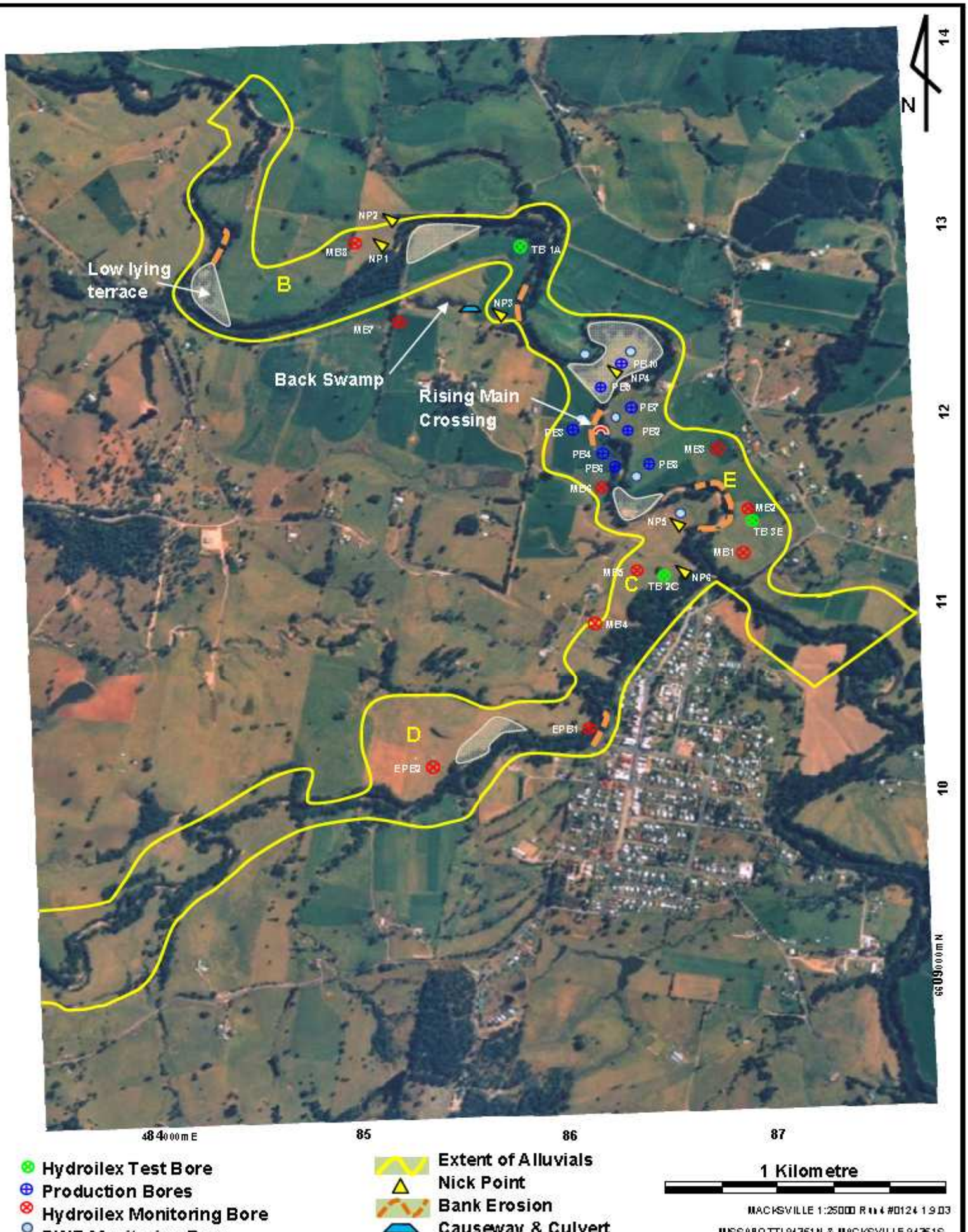
Issue	Control Measures	Likely outcome	Comments
Bank Erosion	Revetment of exposed river banks with rock boulders/woody debris placed at toe of bank in high risk areas. Riparian vegetation establishment program for entire river reach over the long term including stock exclusion and ongoing bush regeneration.	High probability of success for erosion prevention during small storm events that will protect native planting to promote biodiversity of in-stream and overbank plants.	Although the total score for this issue was low implementation of the structural controls (i.e. revetment) will significantly increase the success of any riparian regeneration
Bed incision	Stabilisation of existing pipeline crossing with fishway structure to ensure no lowering of bed level upstream and to promote fish passage. Provision of a further bed control structure downstream to prevent undermining of pipeline crossing Riparian vegetation establishment program for entire river reach over the long term including stock exclusion and ongoing bush regeneration.	Weir pool level and subsequent aquifer level maintained. The pipeline crossing will be sustained and native habitat will increase with restored fish passage.	The control strategy is considered integral to the stability and sustainability of the borefield and river ecosystem.
Lateral migration	Stabilisation of floodplain terraces having the potential to migrate in the vicinity of bores. These can be located at levee breaches and back swamp riffles to prevent mass erosion/meander cut-off. Riparian vegetation establishment program for entire river reach over the long term including stock exclusion and ongoing bush regeneration.	Risk of catastrophic loss of numerous bores mitigated during storm events greater than 5yr ARI.	Provided the control measures are located correctly, the mitigation of risk can be achieved. This may be considered a secondary measure to riparian regeneration.

5.0 RECOMMENDATIONS

As discussed the borefield is at risk through physical changes to the geomorphology of the channel and floodplain that inturn can lower water levels and reduce borefield yield. Each of these features pose risks discussed in Section 4.0 and must be managed to sustain town water supply. Various process features indicate triggers for these risks and have been recorded in this section in both a site specific and broad scale context.

5.1. Site Specific Concepts

Sites displaying visible triggers for potential risk to river and borefield stability must be managed with specific concepts. Locations of the features are indicated in Figure 5.1. and described in Table 5-1. Typical concepts figures are provided in Appendix A to inform the detailed design for construction.



	HG.08.X.X Hydrogeological Investigation	Scale: see scale bar
	Bowraville, NSW	Datum: MGA UTM
	Geomophological Risk Areas	**Figure 5.1**

Table 5-1: Recommended concepts for specific river features

Feature	Description	Proposed Concept
Bank Erosion	Generally outside bends of the channel where high powered flows have undercut the river bank. In these locations the erosion is active and has the potential to lead to channel migration. It is recommended that these locations are to be stabilised.	Rock or woody debris revetment of bank toe and batter back river bank behind to a max slope of 1:2. The earth bank is to be stabilised with pin retards and native vegetation. Use of rock is recommended in areas where stream velocity is high ie. on outside bank of meander.
Nick point	Several river tributaries and back channels are located within the floodplain and join the river at a level much higher than the channel invert. This naturally creates a nick point as the tributary/back channel flow enters the river. These locations must be stabilised to prevent migration of the nick point and potential mass erosion in the floodplain. In some cases the nick point has moved headward from the river channel.	Control nick point from headward migration with either: Rock drop structure where a vertical drop over 1m high is evident Rock chute where the nickpoint is less than 1m high. Note that in some cases the scour pool will be located within the river channel and should be suitably keyed into the channel banks.
Low lying Terrace	These locations were observed during site investigations and were confirmed by landowners as being overtopped by channel flows yearly on average.	Do not locate bores within this area. If existing bores are present revegetation of the entire terrace is recommended.
Causeway and Culvert	An existing farm road is acting as a causeway for a back swamp located on the river tributary. The gravel road is threatened by storm flows and must be stabilised to prevent mass erosion.	Existing causeway to be stabilised by resurfacing the road with rock/gravel and include rock lined box/piped culvert.
Pipeline crossing	The existing borefield is serviced by a concrete encased pipeline crossing the river. The river bed has been lowered both up and downstream of the existing structure and stabilisation has been undertaken with rock/gabions and concrete. Council reported that during dry periods, the water level upstream of the crossing can drop up to 1m below the concrete crest and reappear further downstream of the structure. Undermining of this structure is possible resulting in loss of weir pool level and threatening the structural integrity of the pipeline.	Bed control structure integrated with fish passage. The structure must ensure that outflanking will not occur. A bed control structure may be required further downstream to prevent future downstream bed lowering that further increases risk of undermining. The result is a stable structure that maintains weir pool level for the borefield and allows fish passage. The structure will require site-specific design, however there are standard concepts for bed control and fish passage in separate drawings titled "Rock chute design" and "Fishway passage requirements" in Appendix A.

5.2. General concepts

In general the river has been described as moderately eroded with poor river and riparian vegetation health. This is evident from physical changes to the river caused by:

- Clearing of vegetation from the floodplain during early European settlement
- Gravel extraction in the river and floodplain
- Climactic conditions (successive storms) posing hydrodynamic stress on the channel
- De-snagging and riparian vegetation clearing programs during the 1970's

It is known that the Nambucca River is prone to migrate and is sensitive to physical and hydrologic change. As described in Section 4.3 a broad scale control measure to reduce risk to the borefield and to improve river health is riparian revegetation. This control measure provides multiple benefits including rehabilitation of riverine habitat and reduced risk of bank erosion, lateral migration and bed incision. The success of such a program is dependent on cooperation with local landholders and long term commitment by community support groups such as Landcare and the Catchment Management Authority. Concepts to improve the survival rate of the revegetation are:

- Stock exclusion
- Bank toe revetment
- On-going monitoring and maintenance to prevent exotic plant invasion
- Irrigation during plant establishment period
- Planting on stable river bank slopes less than 1:1

Schematic diagrams of some of these concepts can be found in Appendix A.

6.0 CONCLUSION

Findings of this geomorphology assessment are summarised by the following:

- The condition of the lower reaches of the North and South Arm is poor in that they are moderately eroded, have poor habitat value, and are largely devoid of native riparian vegetation
- The borefield comprises existing and proposed bores located in the floodplain of the river supported by an alluvium of river gravels. This land is mostly owned privately and is used for grazing.
- The pipeline crossing North Arm has undergone changes over time and is under threat by fluvial processes and if changes to the bed level are permitted to migrate upstream, a lowering of water levels may result
- The structural integrity of the borefield is at risk due to the possibility of geomorphic change, commonly caused by high stream power, lack of native riparian vegetation and highly erosive soils.

The Nambucca River is prone to change in planform, bed level and channel size and these changes are likely to continue considering the current physical condition. Various fluvial processes occur that have the potential to pose risk to the borefield with subsequent effects to the town water supply. The most extreme risk is posed by a meander cut-off as a result of lateral migration of river planform.

A strategy to minimise borefield threats is recommended comprising the following measures:

- Bank revetment at the toe's of certain river bank sections
- Bed control structure to prevent headward migration at the pipeline crossing on North Arm
- Stabilisation of floodplain terraces/back channels and tributaries by nick point control
- Riparian revegetation in association with stock exclusion and ongoing bush regeneration

To implement these control measures, the following recommendations are made

- Undertake more detailed design of the recommended concepts, see Section 5.0 and Appendix A.
- Discuss the control measures proposed with stakeholders to gain an understanding of community support, landholder co-operation, constructability and economic viability.
- Develop a riparian revegetation program within the river channel and floodplain to ensure stability of the river and the concepts proposed. This shall be undertaken with support of landholders and community support groups such as Landcare and the Catchment Management Authority.
- Implement a monitoring and maintenance program for the proposed concepts to ensure they are sustainable.

7.0 REFERENCES

Geomorphology and River Management-Application of the River Styles framework, *G.J Brierley & K.A.Fryirs 2005*

L&M 1999 – Nambucca River and Catchment Management Study, Technical Report E - Fluvial Geomorphology, *Lyall & Macoun Consulting Engineers 1999*

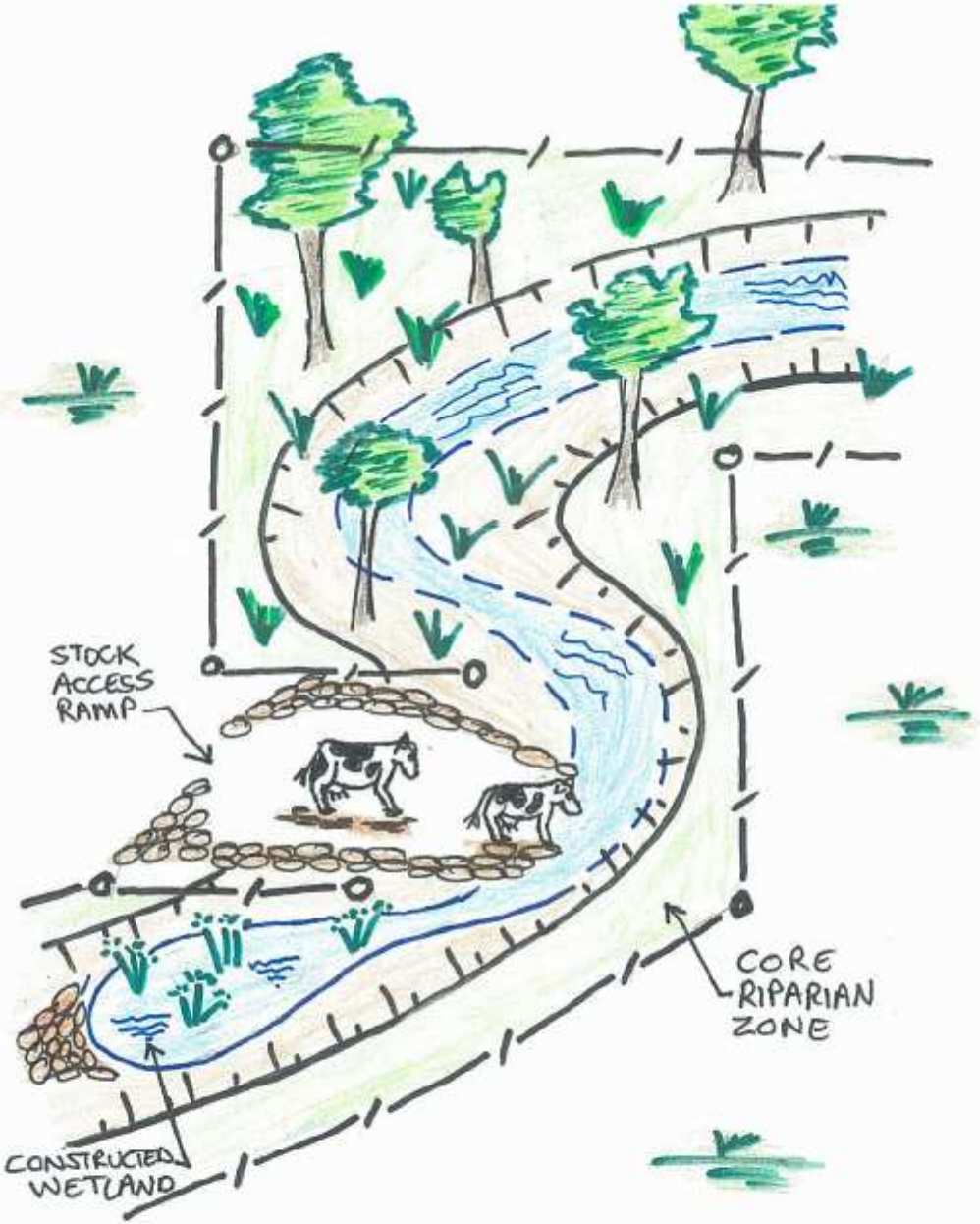
MRL 1999 –River Styles in the Nambucca catchment, North Coast, NSW, *Macquarie Research Ltd 1999*

APPENDIX A

Typical Concept Drawings

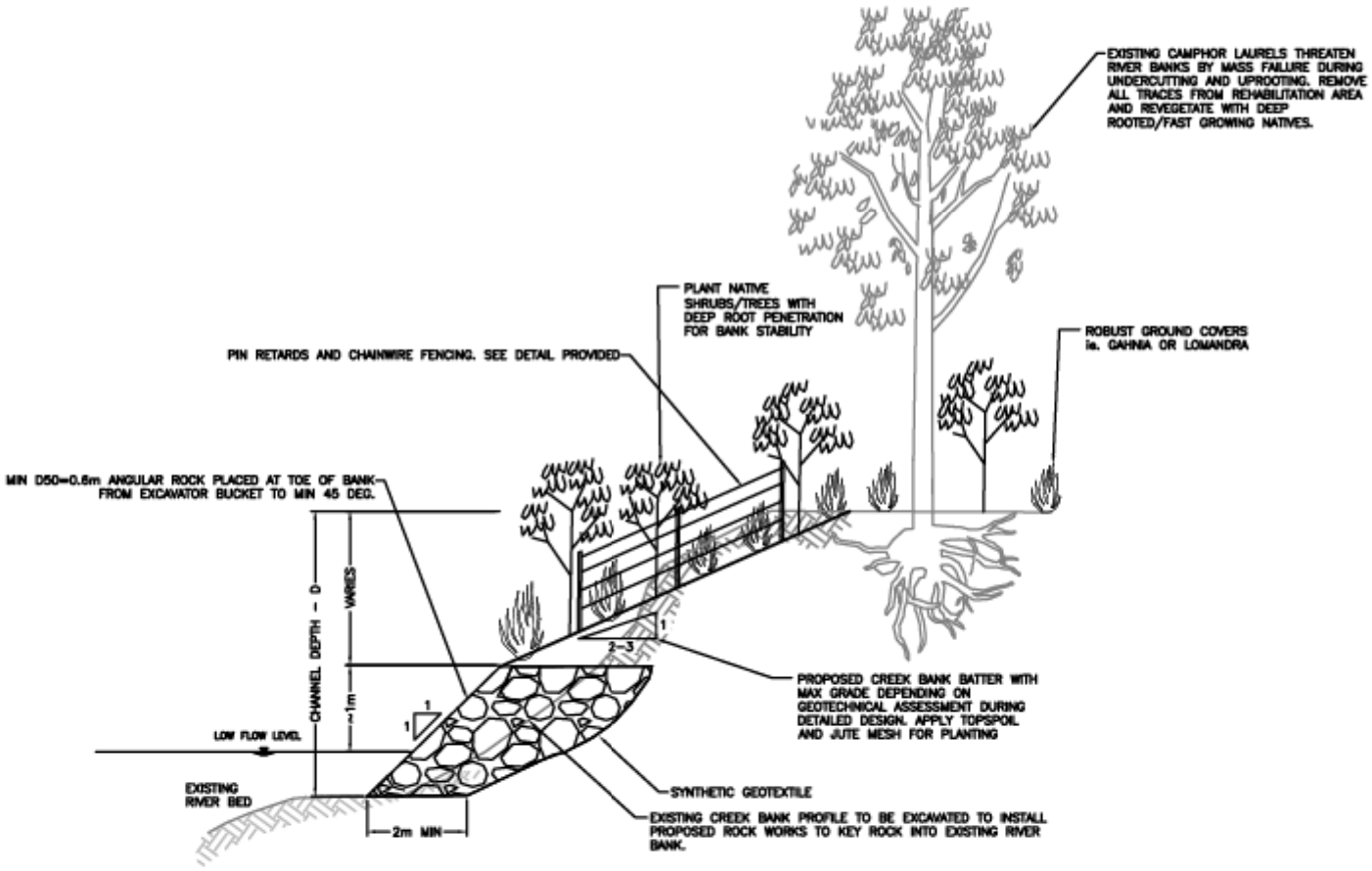
D3 - STOCK EXCLUSION

OPTION 1 - OFFLINE WATERING



OPTION 2 - RESTRICTED ACCESS WATERING

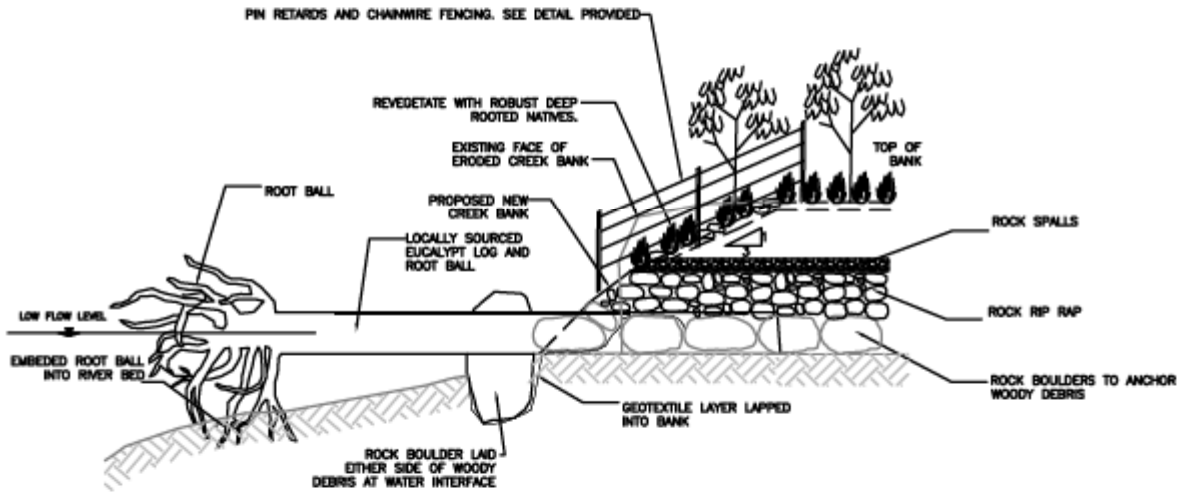
BANK REVETMENT CONCEPT 1



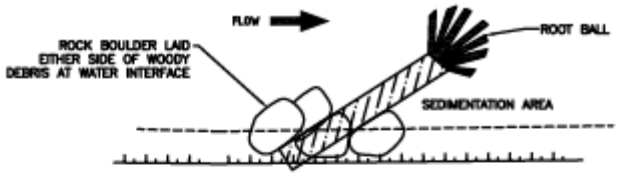
TYPICAL SECTION–ROCK TOE REVETMENT

NOT TO SCALE

BANK REVETMENT CONCEPT 2

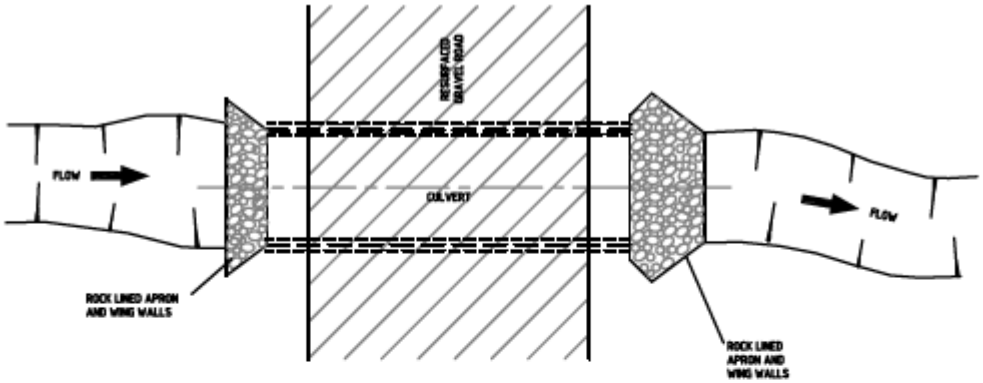


TYPICAL WOODY DEBRIS DETAIL

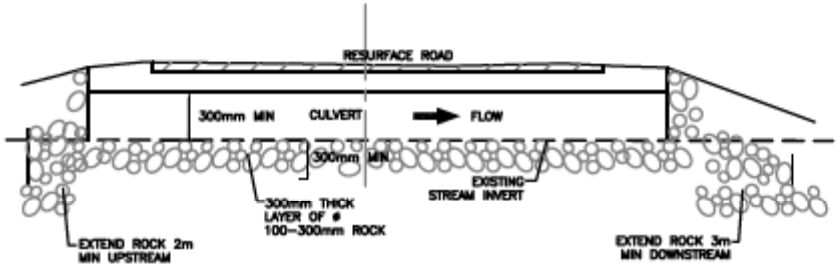


TYPICAL WOODY DEBRIS PLAN

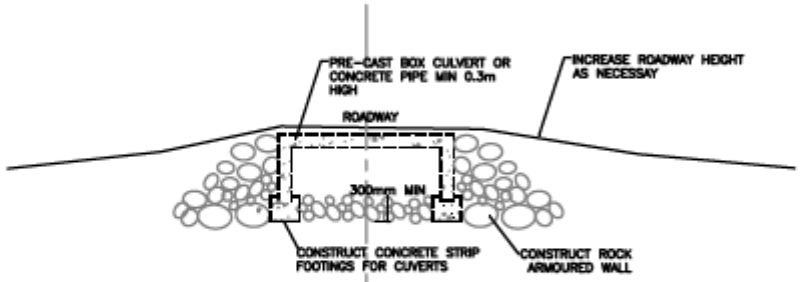
CAUSEWAY AND CULVERT CONCEPT



ACCESS ROAD CROSSING FOR CHANNEL FLOWS



ROAD CROSSING CULVERT LONG SECTION

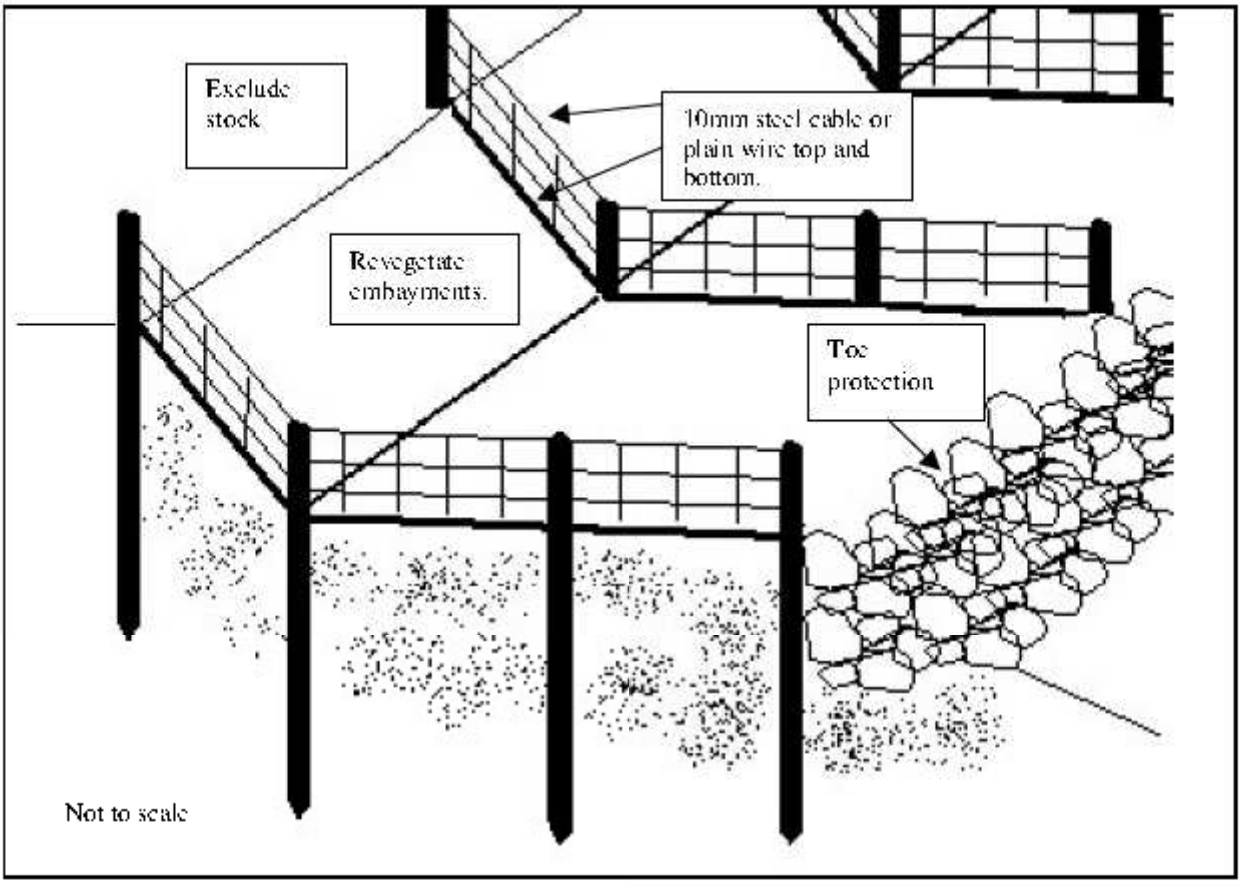


ROAD CROSSING CULVERT INLET SECTION

Northern Rivers CMA CATCHMENT MANAGEMENT AUTHORITY

River Erosion Control:

Retard Structures.

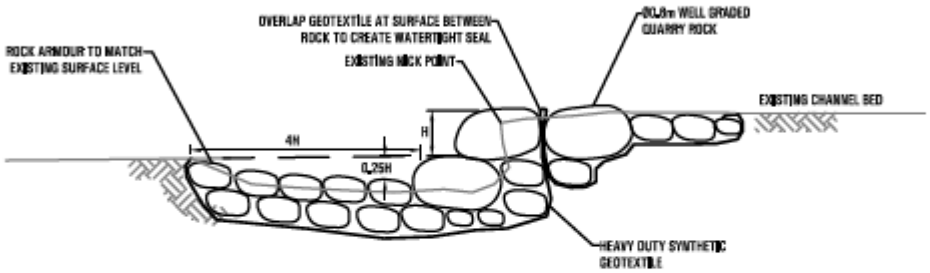


Specifications

1. Constructed on low gravel bench 0.3 - 0.5m above low flow water level.
2. Constructed on river bank face above toe protection.
3. Hardwood driven piles 0.2m diameter or star pickets at 2 - 3m intervals.
4. Reinforcement of structure using steel cable 7-10mm or plain wire 4mm.
5. Retard fencing either from vegetative brush, hinge joint wire or chain wire. Height above bench surface to 0.6m. Downstream spacing 5 - 10m.
6. Frontal section of bench protected by revetment, rock or logs, keyed into bed to maximum scour depth.
7. Fencing and revegetation with indigenous native riparian species.

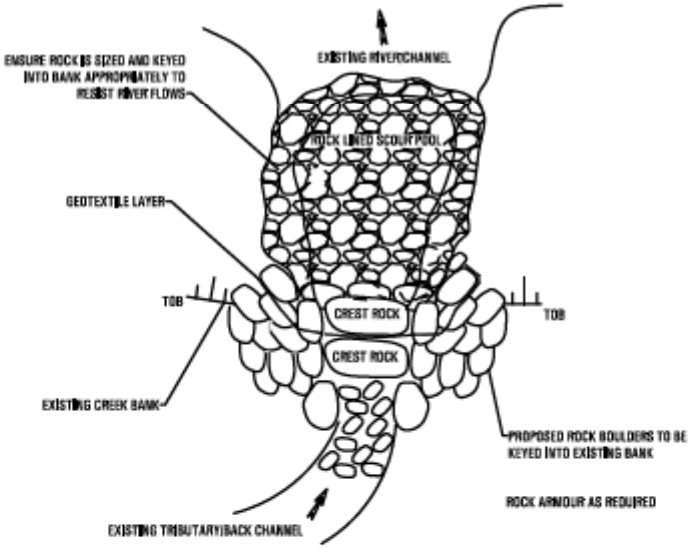
Regional Office - 49 Victoria St PO Box 618 Grafton 2460
Telephone (02) 6642 0622 Facsimile (02) 6642 0640 Website www.northern.cma.nsw.gov.au

ROCK DROP STRUCTURE CONCEPT



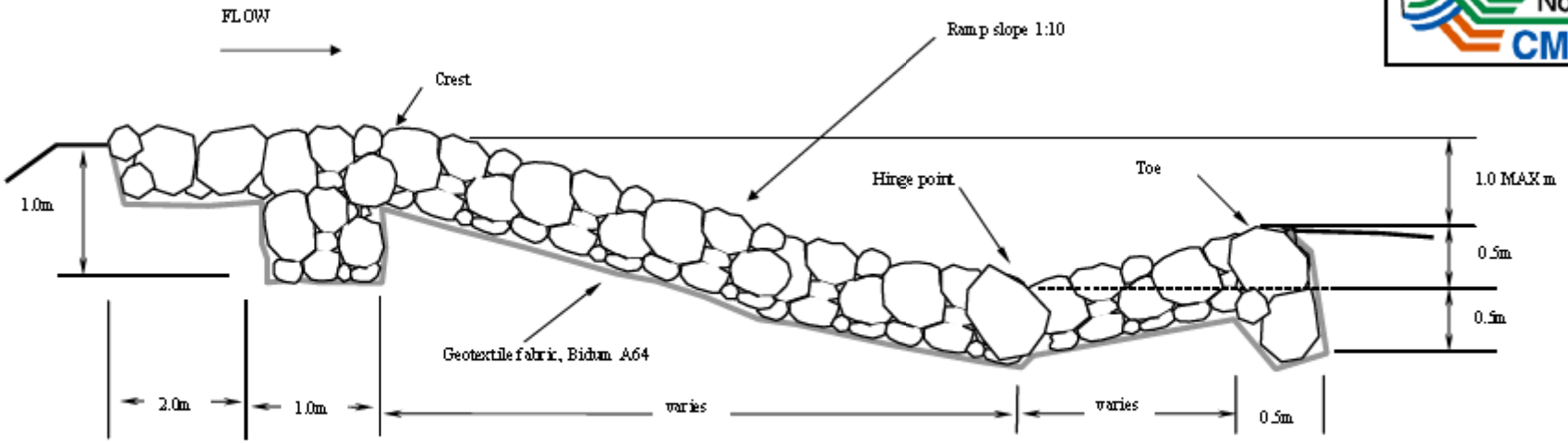
TYPICAL DROP STRUCTURE PROFILE

NOT TO SCALE

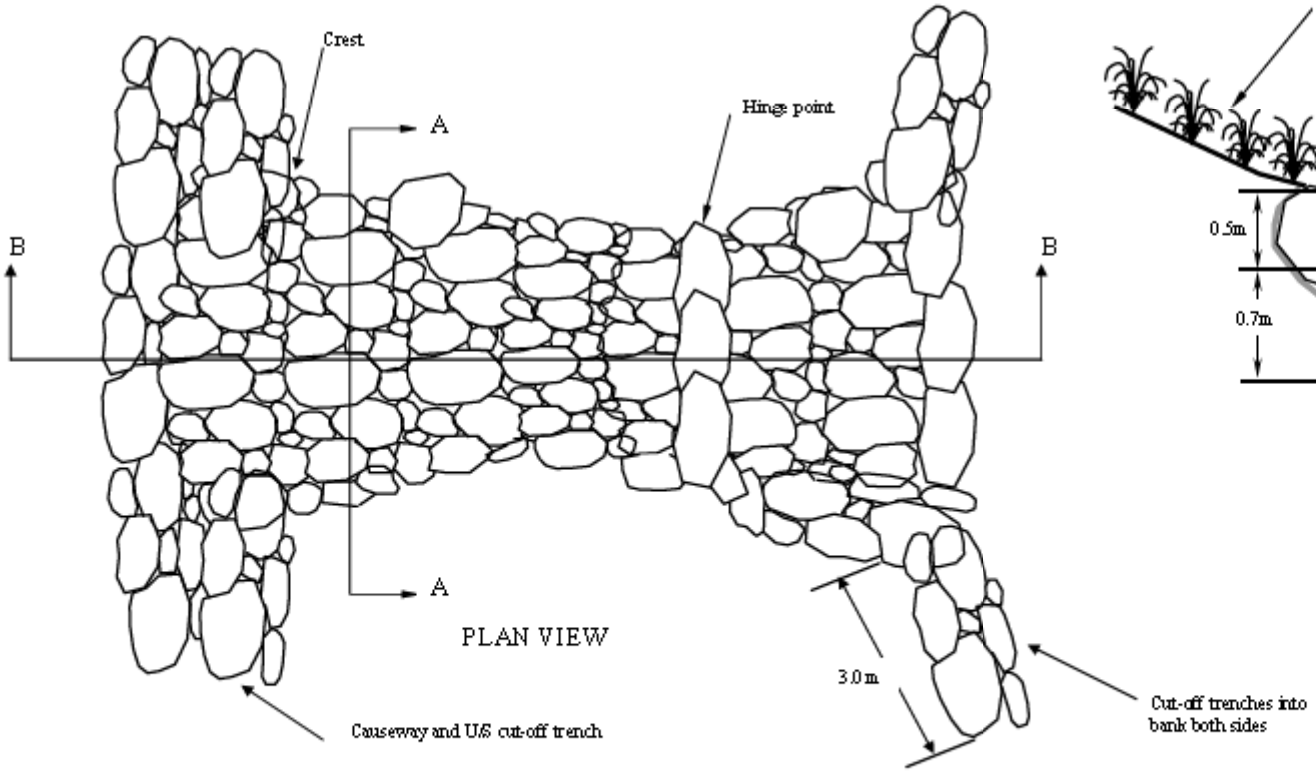


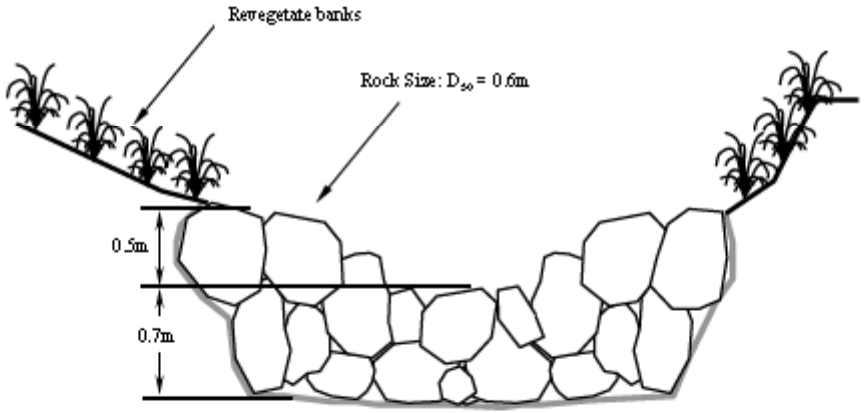
TYPICAL DROP STRUCTURE DETAIL

NOT TO SCALE



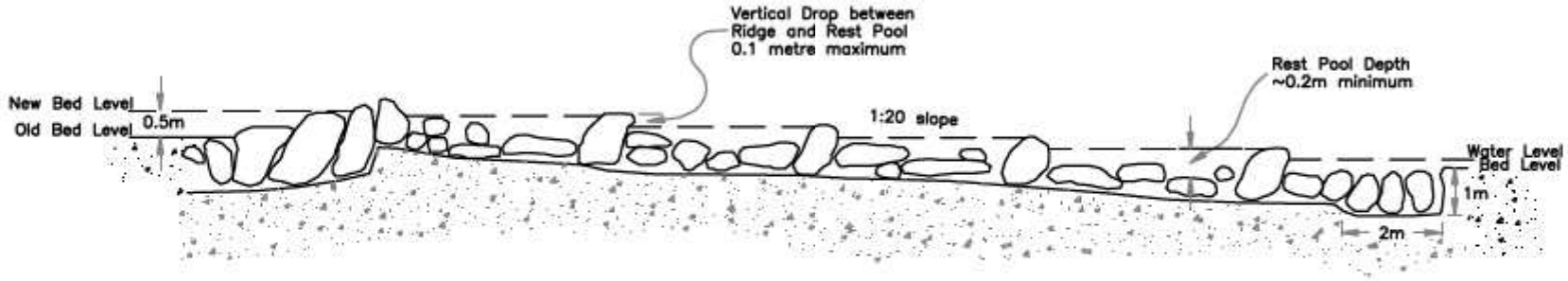
LONGITUDINAL SECTION B-B





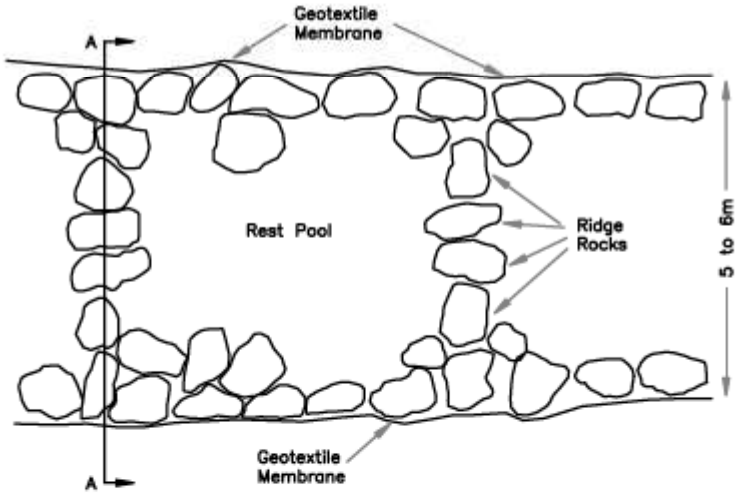
SECTION A-A

Northern Rivers Catchment Management Authority	BOWRAVILLE BOREFIELDS NAMBUCCA RIVER (Floodchannel)
	ROCK CHUTE DESIGN
	To control nickpoints upstream of channel bank
	DESIGNED BY PETER CORLIS
	Not to Scale | SEPTEMBER 2008

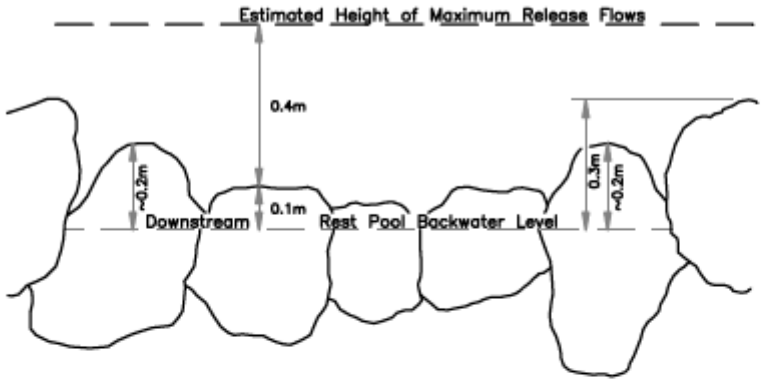


LONGITUDINAL SECTION

NB: An additional rest pool is required for every extra 0.1m rise in bed level.



PLAN



SECTION A–A

NB: Power station release flows will determine depth of flow over fish passage

DEPARTMENT OF LAND & WATER CONSERVATION	
	FISHWAY PASSAGE REQUIREMENTS
Date : Oct 2000	AS DEFINED BY NSW FISHERIES
Drawn : GPG	
Scale: Not to Scale	Plan No G00/608

Appendix C

Aquatic and Terrestrial Flora and Fauna Assessment

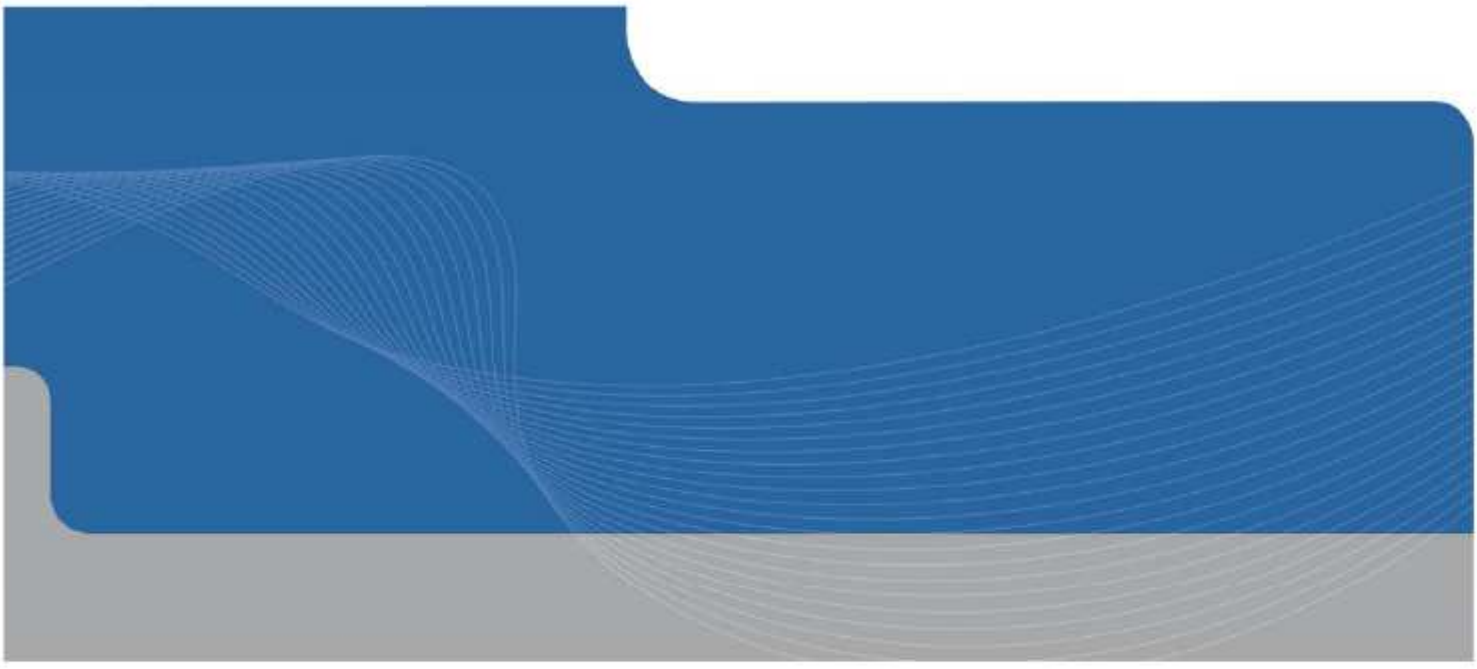
GHD CLIENTS | PEOPLE | PERFORMANCE

Nambucca Shire Council

Bowraville Off-River Storage and Associated Works

Aquatic and Terrestrial Flora and Fauna Assessment

September 2009



INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Contents

Table Index

Figure Index

Appendices

Acronyms and Definitions

The following terms would be utilised throughout this report. The definitions provided should be referred to when interpreting the results in this document:

dbh – Diameter at breast height.

DEC – Department of Environment and Conservation (NSW), now DECCW.

DECC - Department of Environment and Climate Change (NSW), now DECCW.

DECCW - Department of Environment, Climate Change and Water (NSW).

DEWHA – Department of Environment, Water, Heritage and the Arts (Commonwealth).

DG – Director-General of the NSW Department of Planning.

DPI – Department of Primary Industries (NSW), now DI&I.

DI&I – Department of Industry and Investment (NSW).

Direct impacts - Are those that directly affect habitat and individuals and include but are not limited to the mortality of animals and plants as a result of vegetation clearance and the removal of suitable habitat (DEC, 2004).

EEC – Endangered Ecological Community.

EP&A Act – NSW *Environmental Planning and Assessment Act 1979*.

EPBC Act – Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Epilimnion – The layer of water above the thermocline.

FM Act – NSW *Fisheries Management Act 1994*.

FSL – Full Supply Level.

GIS – Geographical Information System.

GPS – Global Positioning System.

Hypolimnion – The layer of water below the thermocline.

Indirect impacts - Occur when proposal-related activities affect resources in a manner other than a direct loss of the resource. Indirect impacts may include: killing a species through starvation, exposure, predation by domestic and/or feral animals, loss of breeding opportunities, loss of shade/shelter, deleterious changes in the water table, increased soil salinity, promotion of erosion, inhibition of nitrogen fixation, provision of suitable seed bed for introduced weed invasion, fertiliser drift, or increased human activity within or directly adjacent to sensitive habitat areas.

Lacustrine – of, or pertaining to, a lake.

LGA – Local Government Area.

Lifecycle - Is the series or stages of reproduction, growth, development, aging and death of an organism.

Likely - Taken to be a real chance or possibility of a species occurring within the study area.

Locality - The surrounding areas as defined by a 10 km radius of the study area.

Local population - The population that occurs within the study area, unless the existence of contiguous or proximal occupied habitat and the movement of individuals or exchange of genetic material across the boundary can be demonstrated.

ML – Megalitre (1,000,000 litres).

NES - National Environmental Significance.

NSC – Nambucca Shire Council.

NW Act – NSW *Noxious Weeds Act 1993*.

Proposal / Proposal - The action / works proposed to be undertaken.

Region - a biogeographical region that has been recognised and documented such as the Interim Biogeographical Regions of Australia (IBRA) (NSW NPWS, 2003). The study area falls within the North Coast Bioregion.

Riffle - Shallow reach with low flow characterised by small hydraulic jumps over rough bed material, causing small ripples, waves and eddies, without breaking surface tension.

SEPP 44 – NSW *State Environmental Planning Policy 44: Koala Habitat Protection*.

Study area - The areas, which are likely to be affected by the Proposal, either directly or indirectly. The study area is limited to the inundation area, the existing borefield and proposed borefields, other related infrastructure, including a pipeline connecting the off-river storage to the borefields and the immediate surrounds and the upgraded access roads.

Thermocline - A layer of water in an ocean or certain lakes, where the temperature gradient is greater than that of the warmer layer above and the colder layer below.

TSC Act – NSW *Threatened Species Conservation Act 1995*.

TSLA Act – NSW *Threatened Species Legislation Amendment Act 2004*.

Viable - The capacity to successfully complete each stage of the lifecycle under normal conditions.

Executive Summary

The following report details the outcome of an aquatic and terrestrial flora and fauna assessment, undertaken by GHD, for the proposed Bowraville Off-River Storage and Associated Works ('the Proposal').

The main objectives of the conducted assessments were to review previous studies; ground truth the previous studies; survey, identify and report on existing aquatic and terrestrial flora and fauna communities; provide a qualitative summary of the environmental values of the study area; undertake a risk assessment to identify the extent of potential impact to flora and fauna values; and provide management advice and tools to mitigate these impacts.

The Proposal would require the clearing of approximately 80ha of native vegetation including 27.45 ha of hardwood plantation, 20.02ha of Wet Flooded Gum and Tallowwood Forest, 7.85ha of Northern Wet Tallowwood – Blue Gum Forest, 6.79ha of Foothills Grey Gum – Broad-leaved Mahogany Forest, 0.64ha of Wet Bloodwood – Tallowwood Forest (Temperate Rainforest), 13.55 ha of pastureland and 3.79 ha of riparian vegetation. Whilst there is no obligation under the *Native Vegetation Act 2003* to provide compensatory habitat for the loss of the vegetation as part of the Proposal, opportunities exist to provide some protection areas via the acquisition of land in and around the storage.

Fourteen species of fauna listed under the TSC, FM and/ or EPBC Acts were confirmed as occurring within the study area. The fauna of conservation significance includes six mammal species (Koala, Spotted-tail Quoll, Grey-headed Flying-fox, Eastern Bentwing-bat, Golden-tipped Bat and Little Bentwing-bat), eight bird species (Masked Owl, Barking Owl, Sooty Owl, Powerful Owl, Glossy Black Cockatoo and Wompoo Fruit-dove), including two migratory birds (Rufous Fantail and Cattle Egret). The 7-part tests concluded that no significant impact is likely on these species as a result of the Proposal. Therefore a Species Impact Statement is not deemed necessary. No significant impacts are considered likely on the threatened species or migratory birds listed under the EPBC Act and therefore no referral to the Commonwealth Minister in relation to the EPBC Act is necessary.

Three threatened flora species listed under the TSC or EPBC Acts were considered likely to occur in the study area including Minute Orchid, Leafless Tongue Orchid, Rusty Plum and Tylophora.

No threatened aquatic fauna or EECs were recorded or assessed as likely to occur within the study area. Therefore no assessments of significance were undertaken for these entities.

The 7-part Tests concluded that no significant impact is likely on these species as a result of the proposed action. Therefore no Species Impact Statements are deemed necessary. No referral to the Commonwealth Minister in relation to the EPBC Act is necessary.

The key impacts associated with the Proposal include habitat loss, sedimentation and weed invasion. In order to minimise these key impacts it is proposed to provide a protection area of 122.58 ha around the storage and prepare an Environmental Management Plan for the Proposal. This plan would include the management of all proposed mitigation measures as outlined in this report.

1. Introduction

1.1 Purpose of this Report

GHD was commissioned by Nambucca Shire Council (NSC) to undertake an assessment of potential impacts on terrestrial and aquatic flora and fauna arising from the proposed Bowraville Off-River Storage and associated works ("the Proposal"), which includes the storage area, headworks, borefields and related pipeline corridors, upgraded access roads and other off-river storage infrastructure. This assessment has been prepared to satisfy the requirements of the *Environmental Planning and Assessment Act 1979 (EP&A Act)* and accompanies an Environmental Impact Statement (EIS) prepared in accordance with Part 5 of the EP&A Act.

Extensive studies to quantify existing environmental flows were beyond the scope of requirements for this study, but qualitative assessments based on habitat integrity and conditions were undertaken.

The objectives of the current assessment were to:

- Survey, identify and report on existing aquatic flora and fauna communities. In particular, species habitats and communities of conservation significance including riparian environments;
- Survey, identify and report on existing terrestrial flora and fauna communities. In particular, species habitats and communities of conservation significance;
- Assess the chemical and physical properties of the study area's waterways including the Nambucca River, Bowra Creek and South Creek;
- Assess the environmental values of the inundation area in comparison to adjacent ecosystems;
- Identify potential impacts to flora and fauna;
- Provide management advice and tools to mitigate potential impacts to flora and fauna values;
- Undertake assessment of significance for threatened flora and fauna; and
- Provide protection areas against potential impacts upon flora and fauna.

1.2 The Proposal

The water supply for the Nambucca Valley is currently sourced from a borefield located in the alluvium adjacent to the Nambucca River just upstream of Bowraville on the north coast of NSW. The existing system is very simple with source water conditioned, delivered to two balance tanks and then gravitated to the whole shire.

The 2002-2003 drought and subsequent studies have demonstrated that the secure yield of the aquifer is insufficient for the water supply requirements of the connected Nambucca Valley communities during an extended drought period. There is also a need to improve protection of the aquatic environment of the Nambucca River and to cater for population growth expected over the next 20 years. Following an extensive series of investigations, Council has resolved to complete the pre-construction work required for the construction of a 5,500 ML off-river storage and associated activities, including the expansion of the existing borefield.

Bowra Creek is a small tributary of Nambucca River and is located two kilometres north of Bowraville in the Nambucca Local Government Area (LGA). The Proposal entails construction of an off-river storage in the

Bowra Creek catchment, expansion of the borefield along the Nambucca River and South Creek, construction of a new collection tank and high lift pumping station, and installation of approximately 1,500 to 2,000 m of pipeline to connect the collection tanks and the proposed off-river storage along with other related roads and power infrastructure. The off-river storage would be transparently operated to assist in the maintenance of environmental flows along Bowra Creek.

The Proposal would require the clearing of approximately 75 ha of land for the off-river storage inundation area with approximately an additional 6 ha of clearing required for ancillary works (e.g. roads, river stabilisation works). A portion of the inundation area is presently owned by the NSW Department of Industry and Investment (DI&I)(formerly DPI) and is part of sustainable forestry operations. The transfer of the land and creation of easements required for the Proposal would be undertaken following the approval of the EIS.

1.3 Scope of Assessment and Approach

This Proposal aims to identify the existing aquatic and terrestrial flora and fauna values of the study area.

The fieldwork and associated data analysis and reporting provides a basis upon which to identify potential impacts on flora and fauna that could result from the construction and operation of the Proposal and its related infrastructure. To ensure these aims were achieved and delivered to NSC, GHD undertook an assessment of flora and fauna communities using standardised quantitative surveys of threatened and commonly occurring species and their distribution within the study area.

The surveys included:

- ***Flora:*** a standardised quantitative survey of terrestrial and riparian flora communities and an assessment of potential impacts caused by inundation and changed flow regimes;
- ***Fauna:*** a quantitative survey of listed and commonly occurring terrestrial and aquatic species and communities and their distribution in relation to vegetation types, topography and substrate occurring in the area or areas potentially affected by the proposed off-river storage;
- ***Riparian:*** assessment of riparian habitat and integrity using standardised AUSRIVAS methodologies; and
- ***Water Quality:*** assessment of existing and ongoing water quality conditions in the catchment.

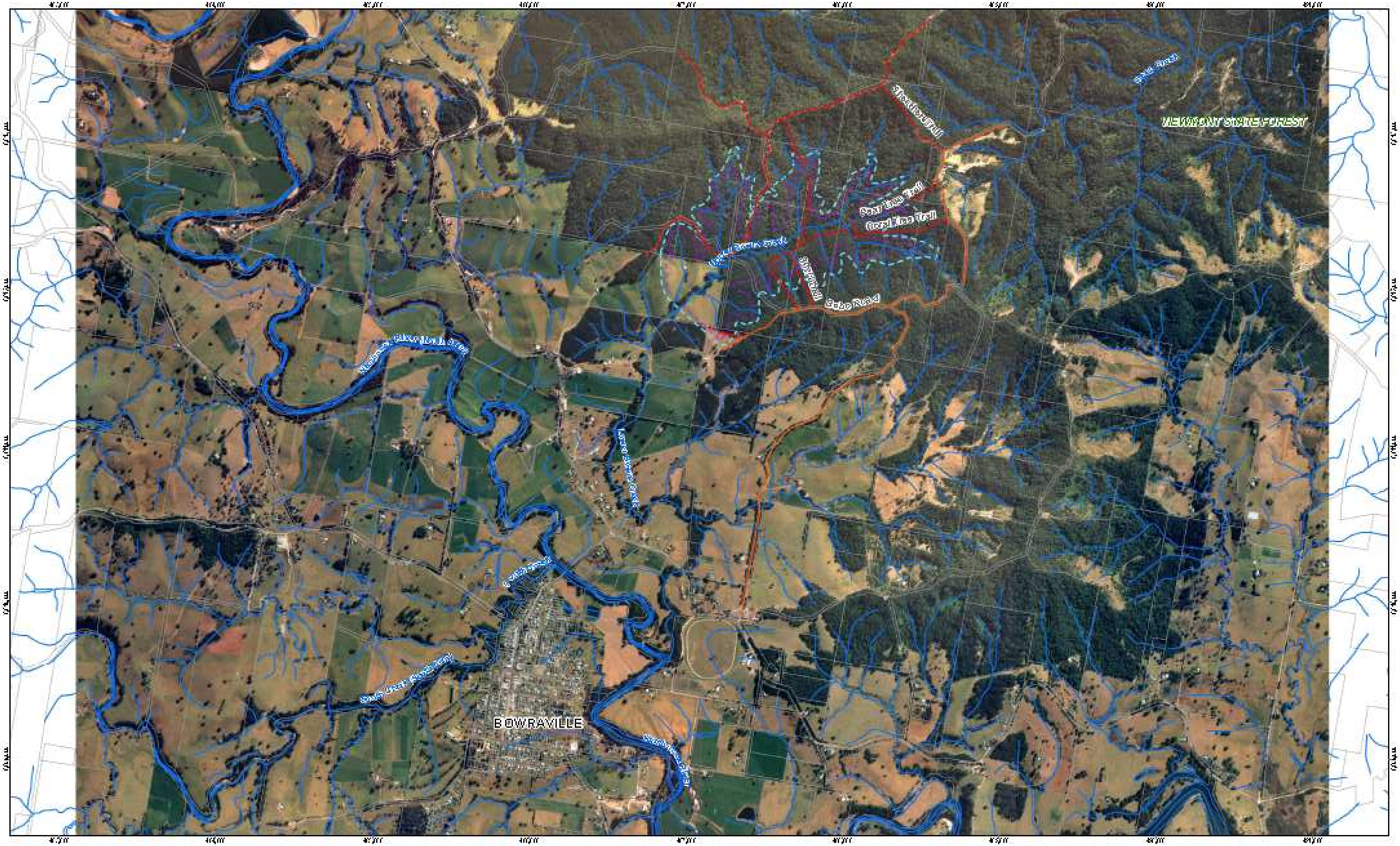
2. Existing Environment

2.1 Study Area

The study area is situated about 2 kilometres (km) north of Bowraville and 15 km west of Nambucca Heads in the Nambucca River Catchment. It is approximately 250 hectares in size and includes the upper Bowra Creek catchment area (146 ha) where the proposed off-river storage is to be located and the riparian environment of Bowra Creek downstream from the proposed off-river storage to the confluence of the Nambucca River as well as the alluvial floodplains of the Nambucca River and South Creek.

The majority of the proposed storage embankment would be located in already cleared grazing land, while the inundation area occurs within the upper Bowra Creek catchment that occupies part of the southern extent of Viewmont State Forest and features 5 forest types that are described in Section 6.1. This vegetation has been extensively logged by Forests NSW over many decades and has for most of this time been managed as a harvestable hardwood plantation.

Ecological issues considered in this report are limited to the storage area (comprising of the proposed storage embankment and inundation area), the alluvial floodplains of the Nambucca River and South Creek, the existing and proposed borefields, and the related infrastructure, including pipelines connecting the off-river storage to the borefields, and the immediate surrounds, known hereafter as the 'study area' as shown in Figure 1.



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0 105 210 420 630 840

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND

- Fire Trail
- Road
- Creeks
- Cadastre
- Stage 1 Inundation Area
- Ultimate Inundation Area

Nambucca Shire Council
Bowraville Off-River Storage
Environmental Impact Statement

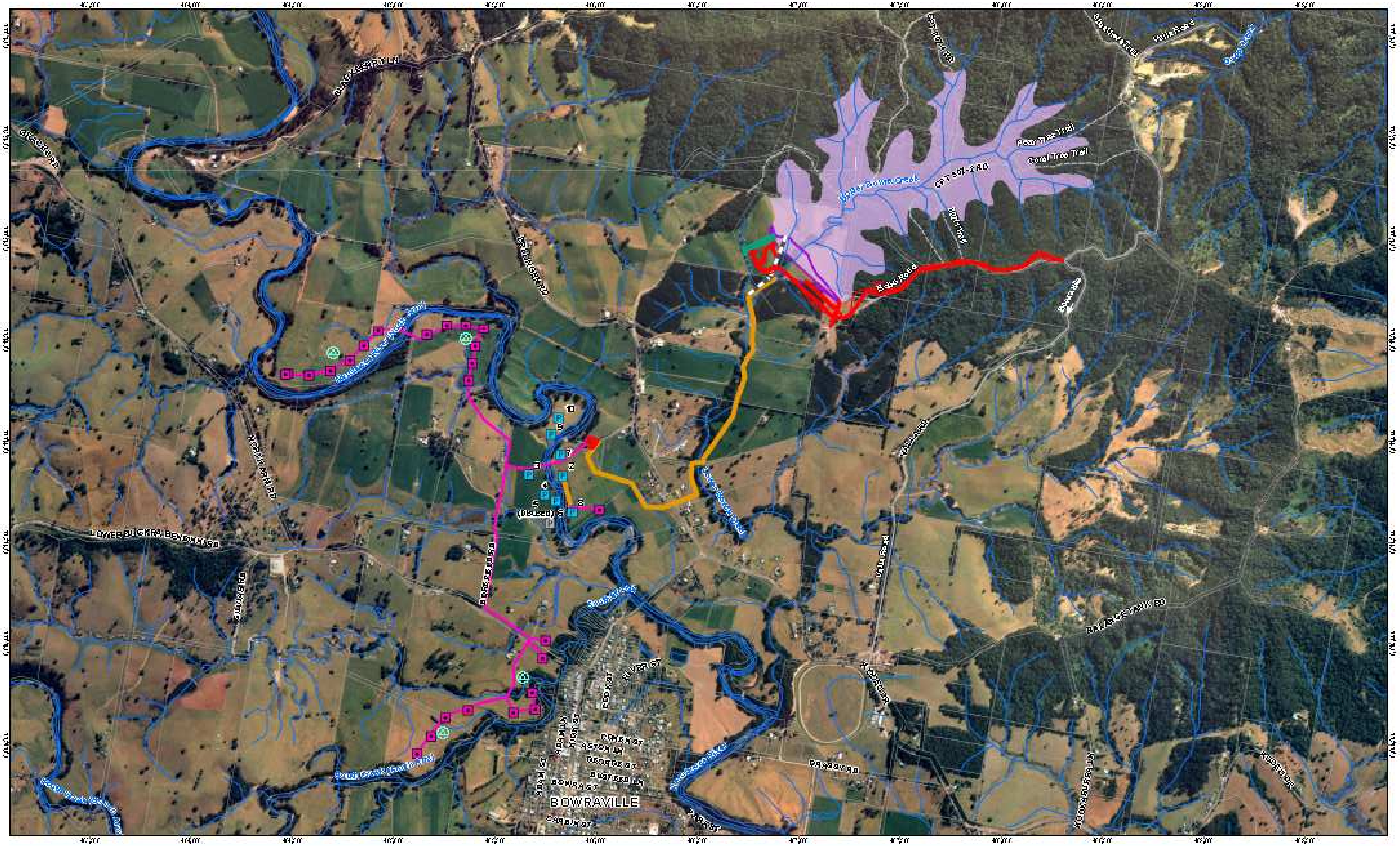
Job Number	22-14133
Revision	B
Date	02 SEP 2009

CLIENTS | PEOPLE | PERFORMANCE

Study Area

Figure 1

2/115 West High Street Coffs Harbour NSW 2450 T 61 2 6650 5600 F 61 2 6652 6021 E www.ghd.com.au



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0 87.5 175 350 525 700

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Fire Trail
- Road
- Creeks
- Outlet Pipe
- Spillway
- Cadastre
- Existing Headworks Area
- Proposed Inundation Area
- Proposed Storage Wall
- Proposed Pipeline Option 7 (GHD Preferred)
- Preliminary Road Design
- Proposed Borefield Locations
- Existing Bores
- Disused Bores
- Proposed Borefield Transformers
- Proposed Borefield Collection Pipeline

GHD

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Nambucca Shire Council
Bowraville Off-River Storage

Job Number	22-14133
Revision	A
Date	07 OCT 2009

Proposed Infrastructure

Figure 2

2/115 West High Street Coffs Harbour NSW 2450 T 61 2 6650 5600 F 61 2 6652 6021 E Www.ghd.com.au

2.2 Biogeographical Context

The study area is located within the North Coast Bioregion (NSW NPWS, 2003). The North Coast Bioregion runs up the east coast of NSW from just north of Newcastle to just inside the QLD border. The total area of the bioregion is 5,924,130 ha. The NSW portion of North Coast Bioregion occupies 7.11% of the state. The Sydney Basin Bioregion bounds the North Coast Bioregion in the south and the Nandewar and New England Tablelands bioregions are to the west (NSW NPWS, 2003).

The study area is located in the Nambucca Catchment and is administered by the Northern Rivers Catchment Management Authority (NRCMA). The Nambucca catchment is one of the smaller north coast catchments, with its headwaters located in the eastern side of the Great Dividing Range approximately 50 km from the coastline. The population of the catchment is approximately 19,000 and the towns of Macksville, Bowraville and Nambucca Heads are the principal centres (NRCMA, 2007).

The proposed inundation area is a sub-catchment in the southern portion of Viewmont State Forest. The catchment contains the headwaters of Bowra Creek.

2.3 Climate

The North Coast Bioregion has a sub-tropical climate on the coast with hot summers, through to a sub-humid climate on the lower slopes progressing to a temperate climate in the uplands along the western part of the bioregion, which is characterised by warm summers and no dry season (NSW NPWS, 2003).

The local climate is considered to be semi-tropical with summer dominant rainfall. The average daily maximum temperature is around 23.3°C, while the average daily minimum temperature is around 14°C (Bureau of Meteorology, 2007). Long-term average annual rainfall over the catchment is between 1,300 mm and 1,400 mm. Annual rainfall typically ranges from 1,300 mm to 1,600 mm in the northern and eastern section of the high ridge country and between 1,200 mm and 1,600 mm to the south and west along Taylors Arm. Annual pan evaporation is estimated to range from 1,650 mm at Bowraville to 1,200 mm in the upper Nambucca catchment (Lyall & Macoun Consulting Engineers, 1999).

2.3.1 Weather Conditions during Surveys

Weather conditions experienced during the survey varied from thunderstorms to clear skies. The maximum rainfall was 29.2 mm. The minimum temperature was 15.1°C and maximum 28.2°C.

The Bureau of Meteorology (BOM) weather station that was considered to be most representative of the location of the Proposal was Kempsey. As shown in Table 1, based on mean temperature records, the warmest month is January and the coolest month is July. February receives the greatest rainfall and September the least.

Table 1 provides some additional climate characteristics that have been provided by CSIRO (2007) for various locations on the North Coast of NSW. The current average of these characteristics also reflects the relatively mild climate experienced on the North Coast of NSW.

Table 1 Climate Statistics from Kempsey BOM Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Max Temp (°C)	29.2	28.8	27.8	25.5	22.6	20.0	19.7	21.3	24.0	25.6	27.1	28.6
Mean Min Temp (°C)	17.6	17.9	16.5	13.2	9.7	7.0	5.6	6.2	8.9	11.8	14.3	16.5
Mean Rainfall (mm)	134.0	155.7	152.2	115.0	92.3	95.4	67.1	62.5	56.6	78.4	93.5	109.0

2.4 Geology and Soils

The North Coast Bioregion is one of the most diverse in NSW. It has Devonian and Permian bedrocks that are part of the New England Fold Belt and have been closely faulted as they were thrust over the northern margin of the Sydney Basin. Small bodies of granite and granodiorite have intruded the sedimentary rocks and there are three centres of Tertiary basalt eruption (DECC, 2007).

Preliminary sub surface investigations have been undertaken at the storage site. There have been three main geotechnical units identified. The site area is covered by colluvial soil along the valley side slopes, which is in turn underlain by phyllite/schist bedrock.

Along Bowra Creek bed and adjacent narrow flood plain, colluvium is encountered at the surface, and is directly underlain by alluvial deposits.

Further soils and geology information is available in the geotechnical reports prepared for the Proposal.

2.5 Topography

The broader catchment area rises abruptly from 50 to 150 m AHD, with especially steep slopes along the northern boundary. The area between the proposed off-river storage and the Nambucca River is low lying with average elevations of 10 – 20 m AHD. The inundation area consists of lower elevations along Bowra Creek, which range from 20 to 60 metres (m) AHD and includes numerous moderately steep gullies.

2.6 Hydrology

The inundation area consists of a generally southerly flowing ephemeral creek (Bowra Creek) that meanders from the hill slopes in the Viewmont State Forest through lower agricultural land and feeds into the Nambucca River. The run-off from the catchment is required to pass through the inundation area. The existing and proposed borefields are adjacent to the banks of the Nambucca River and South Creek, located north of Bowraville.

2.6.1 River Style

Hydroilex (2008) describe the Nambucca River and South Creek as being similar in that they exhibit near identical geomorphic features that can be described as:

- *"A defined channel with moderate sinuosity meandering within a rather wide valley floor confined by rugged hills on either side;*

- *The Valley floor comprises a floodplain of alluvium as a result of vertical accretion over a long period of time. Build up of the alluvium has resulted in terracing where features such as benches and levees are present;*
- *Floodplain material is transient due to its loose binding nature and surface irregularities are present as a result of large flows totally inundating the floodplain and causing mass erosion with observations of flood outs, back swamps and meander cut-offs;*
- *Entrenchment of the channel was observed by low frequency of overbank connection with channel flows; and*
- *Gravel river bed throughout with point bars of quartz gravels deposited in-stream where velocity of flow is low, particularly on inside bank of meanders and tail out of woody debris"* (Hydroilex, 2008).

The categorisation of the Nambucca River and South Creek is *"confined valley with planform controlled discontinuous floodplain"* as defined in the Hydroilex report (2008). Bowra Creek is a small tributary of the Nambucca River and is considered to be the same categorisation although at a much smaller scale.

Connecting reaches upstream of both the Nambucca River and South Creek are defined as *"confined valley with bedrock controlled discontinuous floodplain"*. The valley upstream is more confined than in the study area with a defined channel often running in a straight line from edge to edge of the valley floor until meeting bedrock on outside bends (Hydroilex, 2008).

The loose nature of the floodplain alluvium and riparian vegetation clearing has allowed these reaches to erode significantly and have become a source of in-stream deposits downstream (Hydroilex, 2008).

The reaches of the study area are at a transition from the high powered reaches upstream to the more passive estuarine reaches downstream. As such, variations of geomorphic features are present with the greater entrenchment of the channel and wider, flatter floodplain occurs from up to downstream (Hydroilex, 2008).

The connecting reach downstream at Bowraville is tidal with a near flat gradient with a planform that freely migrates across the coastal plain of sand dunes. This reach connects to a significant estuarine system supporting a large aquatic ecosystem of mangrove, saltmarsh and coastal rainforest including the estuaries of Taylor's Arm and Warrell Creek (Hydroilex, 2008).

2.6.2 Groundwater Flows

Due to the ephemeral nature of the upper reaches of Bowra Creek in the inundation area it is unlikely that it is groundwater charged.

The rate of infiltration is variable across the Nambucca River and South Creek catchments, also between precipitation events as infiltration rates are controlled by the properties of the local soils such as permeability and antecedent moisture content. Infiltrating water may ultimately reach the water table and recharge the local aquifer, mixing with the local groundwater.

Precipitation falling in the catchments that feed Nambucca River and South Creek is subject to significant evapotranspiration as precipitation is heaviest during the summer season, and any water on the soil surface or retained in shallow soils is likely to evaporate quite readily. Evaporation leads to an increase in concentration of substances dissolved or suspended in the residual water. However, the replacement of deep-rooting native vegetation with shallower-rooting forage crops (such as annual crops) has decreased the total potential transpiration for the catchments, increasing the potential recharge to the underlying aquifer.

2.6.3 Groundwater dependant ecosystems

The NSW State Groundwater Dependent Ecosystem Policy (Department of Land and Water Conservation, 2002) identifies the major categories of groundwater dependent ecosystems as:

- Terrestrial vegetation;
- Base flows in streams;
- Aquifer and cave ecosystems; and
- Wetlands.

Other categories include:

- Terrestrial fauna;
- Estuarine and near-shore marine ecosystems; and
- Groundwater, including bedrock and alluvial aquifers, which contribute to stream base flows.

There are no caves or cave ecosystems affected by the Proposal, nor near-shore marine ecosystems. An assessment of potential impacts on groundwater dependent ecosystems is provided in Section 10.6.

2.7 Adjacent Land Use

The majority of the study area is located in Viewmont State Forest, which was logged in the mid-80's and the majority has been re-established as hardwood Flooded Gum (*Eucalyptus grandis*) plantations. The land adjacent to Bowra Creek, South Creek and Nambucca River typically includes privately owned agricultural land and NSC owned land.

3. Legislative Context

The proposed storage area and related infrastructure are subject to a number of State and Commonwealth Legislative Acts and planning policies addressing ecological issues, as outlined below.

3.1 Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act 1999) establishes a requirement for Commonwealth environmental assessment and approval for actions that are likely to have a significant impact on matters of national environmental significance, the environment on Commonwealth land, or actions taken on Commonwealth land. Matters of national significance include:

- World heritage properties;
- National heritage places;
- Wetlands of international importance;
- Listed threatened species and ecological communities;
- Listed migratory species;
- Commonwealth marine areas; and
- Nuclear actions.

When a proponent proposes to take an action that they believe may need approval under the EPBC Act, they must refer the Proposal to the Commonwealth Environment Minister. The purpose of the referral is to determine whether a proposed action is a 'controlled action' and thereby requires approval under the EPBC Act. If the Minister determines that a proposal is a controlled action, it would then proceed through the Commonwealth assessment and approval processes. Ecological assessments undertaken to date have not identified any nationally listed species or communities that would be significantly impacted by the Proposal.

In January 2007, the Commonwealth and NSW governments signed a Bilateral Agreement which allows DEWHA to accredit the assessment regimes under Part 3A, Part 4 and Part 5 of the EP&A Act for assessment purposes under the EPBC Act. The Bilateral Agreement applies only to proposals that the Commonwealth Environment Minister has determined are controlled actions under the EPBC Act, with the exception of nuclear actions (DoP 2007).

3.2 Environmental Planning and Assessment Act 1979

Section 5A of the *Environmental Planning & Assessment Act 1979*, (EP&A Act), aims to improve the standard of consideration and protection afforded to threatened species, populations and communities, and their habitats in the planning process. The outcome of any threatened species assessment should be that developments and activities are undertaken in an environmentally sensitive manner, and that appropriate measures are undertaken to minimise adverse effects on threatened species or their habitats.

Section 5A of the EP&A Act, as amended by the *Threatened Species Conservation Amendment Act 2002*, lists the factors to be addressed in the Assessment of Significance of impact on threatened species, populations and ecological communities. This has also affected the *TSC Act 1995* and the *Fisheries*

Management Act 1994. An essential outcome of the amendments is that as of late 2005, the previous "eight-part test" has been replaced with a set of revised factors now known as the "seven-part test".

The seven-part test assesses the likely significance of potential impacts on threatened species, populations, endangered ecological communities and their habitats that are listed under the TSC Act and FM Act.

Determining authorities have an obligation under the EP&A Act to consider whether a proposal is likely to significantly affect threatened species, populations or ecological communities, or their habitats. In this regard, the determining authority must take into account the seven-part test.

Discussions of species and ecological communities investigated under the provisions of Section 5A of the EP&A Act have been detailed below.

3.3 Threatened Species Conservation Act 1995

The TSC Act identifies and protects native plants and animals of 'threatened' conservation status. The Act also provides for species recovery and threat abatement programs.

The *Threatened Species Conservation Act*, (TSC Act) aims to conserve threatened species, populations and ecological communities of animals and plants. Specific objectives of the Act are to: -

a) Conserve biological diversity and promote ecologically sustainable development;

b) Prevent the extinction and promote the recovery of threatened species, populations and ecological communities that are endangered;

c) Protect critical habitat of those threatened species, populations and ecological communities;

d) Eliminate or manage certain processes that threaten the survival or evolutionary development of those threatened species, populations and ecological communities;

e) Ensure that the impact of threatening actions are properly assessed; and

f) Encourage the conservation of threatened species, populations and ecological communities by the adoption of measures involving co-operative management.

These are the broad principles underpinning the TSC Act, State and Federal biodiversity strategies and international agreements. The consideration of impacts at a local level is designed to make it easier for local government to assess, and easier for applicants and consultants to undertake the Assessment of Significance because there is no longer a need to research regional and state wide information.

There are fourteen fauna species and two flora species listed under the TSC Act that are considered relevant to this proposal and all species have thus undergone the seven-part test to determine whether significant impacts to these species are likely.

3.4 Fisheries Management Act 1994

Marine and freshwater threatened species, populations and ecological communities of fish and vegetation are addressed in the NSW *Fisheries Management Act 1994* (FM Act). The objectives of the FM Act are to:

- Conserve biological diversity of fish and marine vegetation and promote ecologically sustainable development and activities;
- Prevent the extinction and promote the recovery of threatened species, populations and ecological communities of fish and marine vegetation;

- Protect the critical habitat of those threatened species, populations and ecological communities that are endangered;
- Eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities of fish and marine vegetation;
- Ensure that the impact of any action affecting threatened species, populations and ecological communities of fish and marine vegetation is properly assessed; and
- Encourage the conservation of threatened species, populations and ecological communities of fish and marine vegetation by the adoption of measures involving co-operative management.

The FM Act would be applicable to the proposed works. Permits that would be required from Department of Primary Industries (NSW Fisheries) under this Act include:

- Minister to be notified under Section 218 in regards to the construction of the off-river storage and to enable consideration of the need for fish passage;
- Construction of the off-river storage (creating fish passage obstruction) under Section 219; and
- Dredging and reclamation in "waterland" under section 200.

Section 220ZZ of the FM Act, as amended by the *Threatened Species Legislation Amendment Act 2004*, lists the factors to be addressed in the Assessment of Significance of impact on threatened species, populations, ecological communities of fish and marine vegetation.

3.5 Key Threatening Processes

The KTPs that apply to this Proposal include:

- Land clearance (EPBC Act) and clearing of native vegetation (TSC Act);
- Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams;
- Degradation of native riparian vegetation along NSW water courses;
- Removal of large woody debris from New South Wales rivers and streams;
- Loss of hollow bearing trees; and
- Invasion of native communities by weeds.

3.6 Native Vegetation Act 2003

The *Native Vegetation Act 2003* (NV Act) sets a framework for:

- Encouragement of revegetation and rehabilitation of land with appropriate native vegetation;
- Providing incentives for landholders to undertake management of native vegetation on their properties; and
- An end to broad scale clearing, unless it improves or maintains the environment.

The NV Act provides three categories of native vegetation including regrowth, protected regrowth and remnant vegetation with clear definitions.

The NV Act provides greater flexibility and incentives for landholders to manage native vegetation sustainably. The Act gives effect to the Government's commitment to ending broad scale clearing unless it improves or maintains environmental outcomes.

Approval for clearing is exempt under the NV Act due to the assessment being undertaken under Part 5 of the EP&A Act.

3.7 Noxious Weeds Act 1993

The *Noxious Weeds Act 1993* (NW Act) is a NSW government instrument outlining the definition, declaration, and control of noxious weeds throughout the State. Local government bodies have the responsibility to ensure that the Act is complied with within their boundaries.

For a plant to be declared a Noxious Weed it must be considered to pose a serious threat to humans, agriculture and/or the environment. There must also be consideration given to the feasibility of control and enforcement of those methods. Plants are declared noxious by order of the Minister for Agriculture.

Landowners or occupiers have obligations under the NW Act to control any declared weed on their property. Council is required to conduct inspections of private properties to check compliance with the NW Act and Noxious Weed Officers have the authority to issue control notices for any breach. The weeds currently listed as noxious in the Nambucca control area are listed in the declaration.

3.8 State Environmental Planning Policies

3.8.1 SEPP 14 –Coastal Wetlands

State Environmental Planning Policy No 14 – Coastal Wetlands (SEPP 14) applies to many wetlands on the coast of NSW. The Policy is designed to protect wetlands from ad hoc clearing, draining, filling and levee construction. Where a development is proposed to involve clearing, draining, filling or the construction of a levee, preparation of an environmental impact statement is required to be approved by the local Council and the Department of Planning.

The aim of this policy is to ensure that the coastal wetlands are preserved and protected in the environmental and economic interests of the State.

The proposed works would not directly affect any SEPP 14 wetlands. However, the environmental assessment considers the affect of flows downstream of the borefields as several SEPP 14 wetlands occur downstream.

3.8.2 SEPP 44 – Koala Habitat Protection

State Environmental Planning Policy No. 44 – Koala Habitat Protection (SEPP 44) aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas in order to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline.

SEPP 44 applies to local government areas listed in Schedule 1. Nambucca LGA is included in Schedule 1; therefore consideration of the potential application of SEPP 44 is required. SEPP 44 technically only applies to development applications but the intent of the SEPP has been considered in preparing this report.

4. Methods

This ecological assessment incorporated the following project tasks:

- Literature review and database searches;
- Field investigations;
- Identification of ecological values across the study area in comparison to adjacent ecosystems; and
- Impact assessment of the Proposal under Section 5A of the EP&A Act.

4.1 Literature Review

Several environmental assessments have previously been undertaken for the Proposal. These reports contain documentation of the ecological attributes of the area, including terrestrial and aquatic flora and fauna.

A review of previous biodiversity and ecological assessment surveys and reports within the study area and in adjoining areas for records of threatened species and ecological communities was completed. This review included previous flora and fauna surveys (terrestrial and aquatic) completed for the study area and in the region, water quality data, Council documents and conversations with Forests NSW personnel.

Previous Flora and Fauna investigations within the study area include:

- Connell Wagner (1996) *Nambucca District Water Supply - Storage Dam Site Options 1 and 2 - Preliminary Flora and Fauna Investigation*, NSW Department of Public Works and Services;
- Connell Wagner (1997) *Flora and Fauna studies Nambucca District Water Supply Storage Dam Site Options 2A and 2B – Flora and Fauna Investigation*, Department of Public Works and Services;
- Forests NSW (2002) *Pre-logging and Pre-roading Survey Report*, NE Region, Urunga Management Area Viewmont State Forest;
- Biosis (2004) *Draft Nambucca Flora and Fauna Assessment for the Nambucca District Water Supply*, NSW Department of Commerce;
- Biosis (2005) *Updated Flora and Fauna Assessment for the Nambucca District Water Supply Scheme Augmentation*, Nambucca Shire Council and NSW Department of Commerce;
- Biosis (2005) *Nambucca Water Supply Scheme: Targeted Survey for Acacia chrysotricha*, Nambucca Shire Council and Department of Commerce;
- Bishop, K., (2005) *Nambucca District Water Supply Augmentation. Field Appraisal of suggested flow rules and issues arising from the 1996-1997 Aquatic Ecology Study,* Department of Commerce, Nambucca Shire Council; and
- Nambucca Shire Council (August 2006) *Preliminary Environmental Planning Overview Water Supply Scheme*.

The reports listed above assessed equivalent project designs and outcomes as this report; therefore the respective impact assessments, assessments of significance and recommended mitigation measures were considered as part of this report.

Other Flora and Fauna investigations within the region include:

- Darkheart Eco-Consultancy (2000) *Threatened Species and SEPP 44-Koala Habitat Assessment of Proposed Sand and Gravel Extraction Industry on Lot 42, DP 788702 Graces Road via Bowraville*, Town Planning Consultants and Drafting Services, Nambucca Heads;
- Jelliffe Environmental (1997) *Review of Environmental Factors Proposed Bowraville Effluent Reuse Scheme Irrigation Sites*, Department of Public Works and Services, Coffs Harbour; and
- NCMC (2000) *Nambucca CMC Community Water Quality Monitoring Proposal*, Nambucca Catchment Management Committee; and
- Relevant species recovery plans and/or supporting information.

Other relevant reports relating to the region:

- Pertinent environmental planning documentation and applicable legislation and its relevance to the Proposal area;
- Local government data, including State of the Environment reports; and
- Previous catchment consultancy reports.

The results of this research have been used as background information to select appropriate sampling sites and techniques during the development of the field program.

No prior flora and fauna investigations have considered the pump station, filtration plant, proposed borefields, proposed access roads to be upgraded and associated pipeline development footprints. The location and ecological value of the land to be potentially impacted by this infrastructure has been assessed in this document.

4.2 Database Searches

Searches of the following databases were undertaken on the 27th July and 15th August 2008:

- Department of Environment, Water, Heritage and the Arts (DEWHA) Protected Matters Search Tool for Matters of National Environmental Significance (NES) listed under the EPBC Act, which may occur within a 10 km radius of the study area ;
- Department of Environment and Climate Change (DECC) Atlas of NSW Wildlife Database Records for threatened species and endangered ecological communities listed under the TSC Act and FM Act which have been recorded within a 10 km radius of the study area.;
- NSW Government's BioNet database of records from the collections of Australian Museum, Forests NSW, DECC and NSW Department of Primary Industries (including NSW Fisheries); and
- Community non-government groups including Birds Australia.

4.3 Terrestrial Flora and Riparian Vegetation Survey Methods

Field surveys were undertaken within the study area by GHD ecologists between 17th and 21st November 2008. The field surveys aimed to verify the vegetation communities previously identified within the study area, as shown in Figure 3 (Connell Wagner, 1997), and assess the potential for the study area, including the inundation area and pipeline routes, to provide habitat for threatened flora.

The flora field studies involved:

- Ground truthing of previous vegetation mapping and aerial photography;

- Preparation of a plant species list for the vegetation communities that would be directly impacted by the proposed action;
- Identification of species of conservation significance; and
- Identification of potential habitat for significant flora species.

The survey design to determine the potential for threatened species listed on the TSC Act and EPBC Act that are likely to occur within the study area was based on an assessment of habitat suitability, previous studies, local government records and species distribution range. The survey methods included walked transects, Rapid Appraisal of Riparian Condition (RARC) assessments and random meanders targeting threatened flora species. Quadrats were deemed unnecessary, as previous quadrat survey effort had been undertaken throughout the study area. All observations were recorded on appropriate proforma field data sheets.

Rainfall leading up to the survey was good with 122 mm occurring during September and 45.4 mm during October (BOM, 2008). The vegetation was responding well to this rainfall with new shoots appearing. Timing was appropriate as several spring flowering species were observed in flower.

Flora survey locations are shown on Figure 4. Survey effort and techniques are outlined in Table 2.

The following methods were used to ground truth the existing vegetation mapping that was undertaken by Connell Wagner (1997) and assess the ecological condition of the riparian vegetation at specified locations along the Nambucca River, Bowra Creek and South Creek.

4.4 Flora Survey Effort

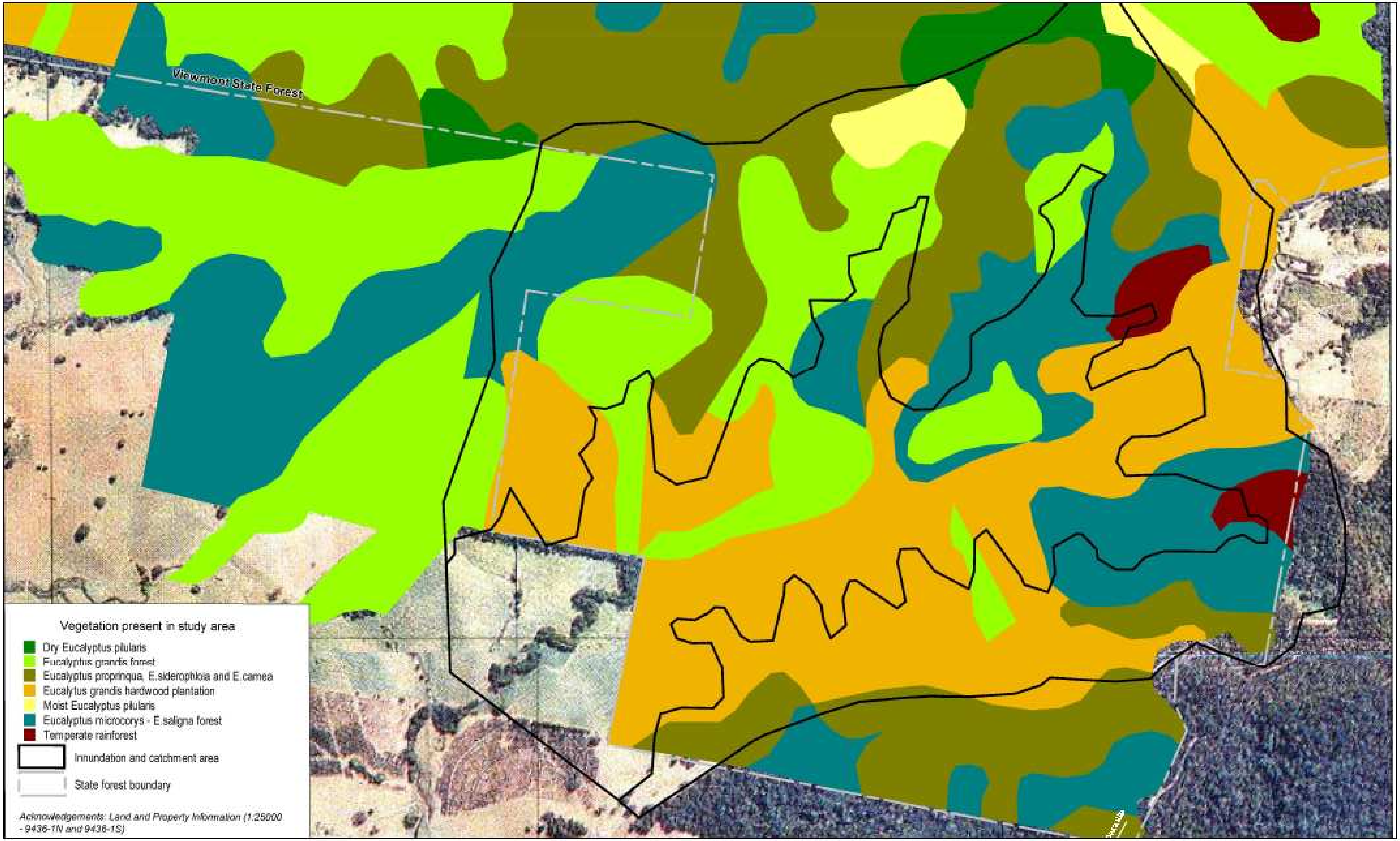
The terrestrial survey of the inundation area, riparian appraisal and aquatic flora assessment were undertaken over five days between 17th and 21st November 2008. Survey methods, effort and timing was consistent with the DECC guidelines (DEC, 2004). Table 2 details the effort implemented during the survey period.

Table 2 Flora Survey Effort

Survey Tasks	Technique	Survey Effort
Terrestrial Vegetation	100 m x 50 m Transects 1 m x 1 m subplots	10 transects scattered throughout the inundation area covering different vegetation communities. 5 subplots were undertaken in the 5 forest types present in the inundation area in combination with relevant transects.
Random Meanders	Random meanders of varying lengths	Random meanders aimed at covering each vegetation community present within the study as well as targeting threatened flora species.
Riparian vegetation Rapid Appraisal of Riparian Condition (RARC)	200 m x 40 m Transects alongside creek or river banks	5 locations along Nambucca River, 4 along Bowra Creek, 2 along South Creek and 1 control location at an unnamed creek off Helliwells Road.

Aquatic Weed Surveys	Identifying and targeting aquatic weeds at each RARC location, and including any other waterbodies encountered whilst accessing survey locations (farm creeks and dams).	12 locations in association with RARC.

The locations of the flora transect surveys are shown in Figure 4.



Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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NEW SOUTH WALES 2008

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Nambucca Shire Council
Bowraville Off-River Storage
Environmental Impact Statement

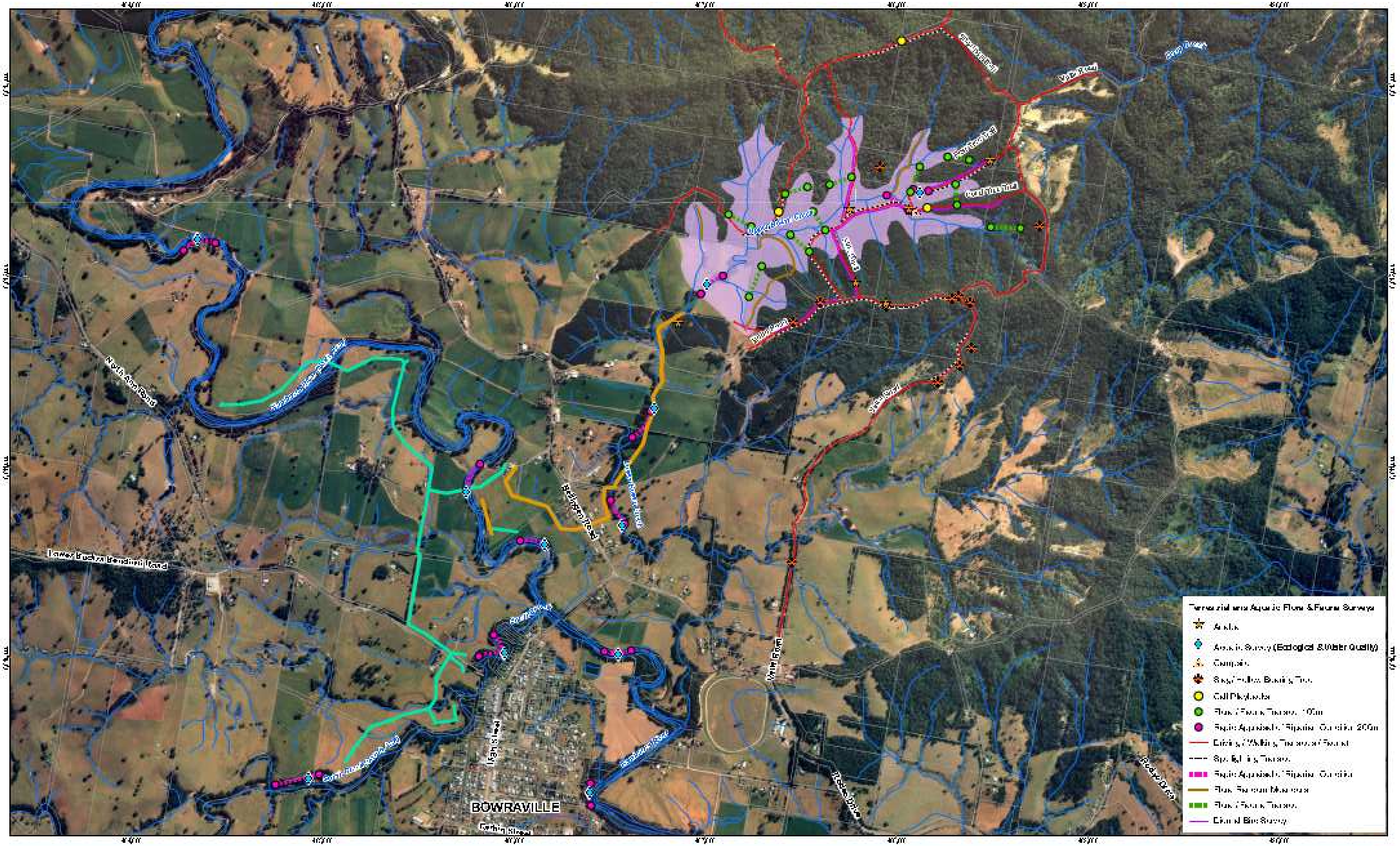
Job Number	22-14133
Revision	A
Date	22 APR 2009

Vegetation Communities as mapped by Connell Wagner (1997). Source: Biosis 2005

Figure 3

27115 West High Street Coffs Harbour NSW 2450 T 61 2 66505600 F 61 2 66526021 E Www.ghd.com.au

Data Source: Connell Wagner/Biosis: Vegetation Communities - 2005. Created by: Gamoeding, Rsuckey



LEGEND

Metres

Terrestrial and Aquatic
Flora & Fauna Survey Locations Figure 4

4.4.1 Terrestrial Flora Survey

As mentioned above the survey effort focused on ground truthing previous survey efforts. Therefore no additional quadrats were deemed necessary, as previous extensive quadrat survey efforts had been undertaken throughout the inundation area.

The areas not covered by previous surveys that are of relevance to this proposal were located along the riparian corridors of Nambucca River, South Creek and the lower reaches of Bowra Creek. Subsequently these areas were surveyed in light of proposed pipeline routes.

Vegetation communities occurring within the study area were surveyed using walking transects and random meanders to ground truth previous investigation's determination of vegetation boundaries, floristic diversity and potential habitat for threatened flora.

Prior to undertaking the detailed field surveys, a general walk/drive over of the study area was undertaken to:

- Obtain an understanding of the plant communities in the survey area and identify ecological community boundaries in combination with aerial photographic interpretation;
- Identify locations for traverse sampling within the various communities;
- Identify the potential distribution of threatened plants and record inconspicuous species; and
- Record opportunistic flora sightings.

The ten 100 m x 50 m walking transects were completed across the study area to obtain an understanding of the previously surveyed vegetation communities and to identify community boundaries and record species. At least one transect was located within each vegetation community, whilst the remainder were placed across the boundaries of vegetation communities.

Information recorded whilst surveying transects included all plant species observed within a 50 m wide strip (25 m either side of the centreline of the transect), together with other relevant information relating to the distribution of plant species such as aspect, topographic position, elevation and vegetation community boundaries. A hand-held GPS was used to map proximate boundaries of vegetation communities across the study area.

Plants were identified as far as possible to species or subspecies level. For plants, which could not be identified in the field, a voucher specimen was collected and identified in the lab using taxonomic keys such as Flora of New South Wales (Harden 1992, 1993, 2000, 2002) and other reference material.

The information collected from the field surveys was used to:

- Verify (ground truth) the previous field investigations;
- Make a determination as to whether or not any EECs listed under the TSC Act or threatened ecological communities under the EPBC Act occur within the study area;
- Assess the impacts on native vegetation associated with the off-river storage and related infrastructure; and
- Consider offset opportunities where vegetation is required to be removed.

Targeted searches for the threatened plants Rusty Plum (*Amorphospermum whitei*) and Tylophora were undertaken in areas supporting potential habitat for these threatened species. Random meander transects within these areas were carried out and any threatened flora species recorded. In addition, the boundaries of

any endangered ecological communities (EEC) occurring within the study area were to be recorded using GPS and subsequently mapped in GIS, however this did not eventuate as no EECs were identified.

4.4.2 Assessment of Vegetation Condition

Each terrestrial vegetation community identified within the study area was assessed with respect to the degree to which the vegetation resembled that of undisturbed remnant vegetation. The following criteria were used to assess vegetation condition:

- Species composition and degree of weed infestation; and
- Vegetation structure as a representation of each original layer of vegetation.

Three categories 'Good, Moderate and Poor' were then used to evaluate the condition of each vegetation community surveyed, as shown below:

Good

- High number of indigenous species;
- No weeds present or restricted to forest edges and dirt roads;
- Contains original layers of vegetation (groundcovers, understorey and canopy); and
- Layers are intact.

Moderate

- Contains a moderate number of indigenous species;
- Moderate level of weed invasion, either in isolated patches or scattered throughout;
- One or more of the vegetation layers have been disturbed; and
- Layers are mostly intact.

Poor

- Contains a low number of indigenous species;
- High level of weed invasion or heavily scattered throughout;
- One or more of the vegetation layers has been heavily disturbed; and
- Layers are missing as a result of disturbance.

4.4.3 Riparian Vegetation Survey

The method of data collection used to assess the riparian vegetation was the Rapid Appraisal of Riparian Condition (RARC). The RARC method is used to assess and monitor riverbank condition as developed by the Commonwealth Department of Land and Water Australia and is compatible with AUSRIVAS methodologies.

The method is used to score a number of vegetation attributes in the riparian zone, and thus provides an overall score that is intended to rank the ecological status of the site. Scores are calibrated to be between 0 and 50, and the greater the score the better the condition of the riparian zone. The basic scoring system is composed of five components:

- Habitat continuity and extent (HABITAT);
- Vegetation cover and structural complexity (COVER);

- Dominance of natives versus exotics (NATIVES);
- Standing dead trees, fallen logs and leaf litter (DEBRIS); and
- Indicative features of a diverse intact riparian (FEATURES).

Each RARC location was surveyed using a 200 m x 40 m transect along the riparian zone of one side of the creek or river being evaluated.

Twelve survey sites were located throughout the study area as shown in Figure 4. They were located along the Nambucca River, South Creek and Bowra Creek.

4.5 Terrestrial Fauna Survey Methods

One of the primary aims of this assessment was to build on the existing information regarding threatened species and habitats, as established in previous investigations. The survey effort and results of the previous investigations were used to determine the survey methods, locations and effort for this investigation with particular reference to areas of the study area that were not covered in previous investigations (i.e. Nambucca River, South Creek, Bowra Creek, proposed pipeline routes and proposed access roads).

Dedicated trapping surveys (such as Elliots, cage traps and pitfall traps) for terrestrial animals were not completed during this assessment. Trapping of terrestrial fauna was not undertaken due to efforts undertaken by Connell Wagner (1997); therefore reference has been made to the results of their trapping survey effort as shown in Table 3. Considerations of the species that may be listed in recent database searches that may not have been listed in previous searches were used to assist in this survey effort.

The survey effort for all fauna groups, including targeted surveys for some threatened species are described in Table 4 and the location of surveys are shown in Figure 4.

The potential for threatened species listed on the TSC Act, EPBC Act and/or FM Act to occur within the study area was based on an assessment of habitat suitability, previous studies, local government records and species distribution range.

The fauna field studies aimed to:

- To build on substantial existing information from previous assessments in regards to threatened species;
- Identify and describe the commonly occurring and listed terrestrial species and communities known or likely to be present in the study area, and assess which species or communities may be affected by the Proposal;
- Identify the presence or potential presence of threatened and migratory fauna species and populations listed under the TSC Act and EPBC Act;
- Describe habitats that may be directly or indirectly affected by the Proposal and assess the value of the habitats available to threatened fauna species within the inundation area and surrounding study area; and
- Describe the type, location, size and condition of habitat of affected species and communities and provide details of the distribution and condition of similar habitats in the region.

Field surveys were undertaken within the study area by GHD ecologists between 17th and 21st November 2008.

The survey design to determine the potential for threatened species listed on the TSC Act, EPBC Act and/or FM Act that are likely to occur within the study area was based on an assessment of habitat suitability, previous studies, local government records and species distribution range.

GIS analysis was used to determine the area in hectares of each vegetation community to be removed "impacted" by the Proposal. These figures were then used in the assessments of significance to determine likely impacts to threatened species.

Fauna survey locations are shown on Figure 4. The current survey techniques and effort are outlined in Table 4.

4.5.1 Previous Surveys

Previous surveys have been conducted within the inundation area and along the proposed pipeline routes by Connell Wagner between 18th November and 7th December 1996, and Biosis on the 13th and 14th December 2004. Weather conditions during the survey periods have been typically been fine and warm with intermittent showers (BOM, 2008). The surveys constituted of a variety of techniques as detailed in Table 3.

Table 3 Previous Fauna Survey Effort

Survey Effort	Who	Survey Effort
Bats	Connell Wagner	Harp trapping at 13 Locations Anabat at 6 locations Handheld bat detector used along walking transects over 3 nights 2 hours/night
Active fauna searches	Biosis	Actively searching, listening and incidental observations
Forest Owls	Connell Wagner	Spotlighting along bat detection transects over 3 nights Call playback 3 sessions over two nights
Koalas	Connell Wagner	Searches for scats and scratch marks over a 3 km long transect comprised of forest trails
Terrestrial and Arboreal Mammals	Connell Wagner	Fifty Elliot traps both tree mounted and on the ground, and five cage traps were set along four transect locations covering five vegetation types. Spotlighting and stag watching 12 person-hours over two nights. Active searches over a four day period including litter searches and track, scat and sign identification.
Birds	Connell Wagner	Diurnal bird surveys at dawn and dusk over 4 days
Frogs and Reptiles	Connell Wagner	Habitat searches over 4 days along creek lines Call playback and call identification techniques

4.5.2 Current Survey

The current tasks, methods and survey efforts are summarised in Table 4.

Table 4 Current Fauna Survey Effort

Target Guild	Sampling Technique	Total	Units
Tree hollows	50 m transects	10	Transects
Mammals/Reptiles/Avifauna	Spotlighting walked	10	Three person-hours
Mammals	Anabat	6	Three survey-nights
Amphibians/Mammals/Birds	Call Playback	3	Survey Locations
Koalas	Spot Searches/ Call Playback	10/ 3	Feed trees at flora survey locations
Arbioreal Mammals	Stag Watches	3	One person-hours
Amphibians	Diurnal/ Nocturnal Searches	5	Person Hours
Reptiles	Diurnal Search	5	Person Hours
Avifauna	Diurnal Search	10	Person Hours

4.5.3 Fauna Habitat Assessment

The fauna habitat assessment involved collecting data on the nature and condition of habitats, detailing specific resources and features of relevance for native fauna, such as tree-hollows, logs, rocky outcrops, fallen timber, leaf litter, grassy groundcover, shrub strata, foraging substrates, summer-flowering eucalypts, casuarinas and mistletoe. In addition, indirect evidence of fauna (i.e., scats, feathers, fur, tracks, dens, nests, scratches, chew marks and owl wash) was recorded.

General fauna habitat assessments were focused on areas where vegetation is proposed to be removed due to the construction of the storage area and related infrastructure. Specific resources such as shelter, basking, roosting, nesting and foraging sites for amphibians, bats, birds, arboreal mammals, ground-dwelling mammals and reptiles were noted.

Results of the diurnal habitat assessments were used to appropriately locate nocturnal owl, bat, arboreal mammal, frog and aquatic fauna surveys.

4.5.4 Incidental Scats, Tracks and Traces

Incidental records of fauna tracks and scats were collected during the execution of other field survey tasks such as reptile searches and habitat assessments. Scats of feral animals often provide important information on native species present in the area and were also collected. Furthermore, incidental records of scratches and feed scars on trees were recorded during surveys to help identify arboreal species' presence within the study area.

4.5.5 Tree Hollow Transects

Hollow-bearing trees provide a valuable and potentially limiting resource for some native fauna for nesting and roosting. Fifty metre transects were completed in each vegetation community to identify hollow-bearing trees. Hollow bearing trees were recorded where observed along access roads and fire trails.

Data recorded for hollow-bearing trees included:

- GPS coordinates;
- Height of tree;
- Evidence of fauna use (eg. scratches, scats, owl wash); and
- Other notable features (eg. proximity to stands of *Allocasuarina* spp, watering points, etc).

4.5.6 Stagwatching

Arboreal mammals and microchiropteran bats are known to emerge from hollows at dusk. Therefore, stagwatching was conducted at dusk prior to spotlighting to identify den or roost trees. Hollow-bearing trees were watched for approximately 30 minutes from dusk until dark for the emergence of arboreal mammals and, potentially, bat species (Figure 4).

4.5.7 Spotlighting

Spotlight searches for nocturnally active mammals, as well as birds and herpetofauna including dedicated listening periods for fauna vocalisations, were carried out over two nights throughout the site. Species were identified by observation under spotlight or by call identification.

Each survey involved a series of transects conducted on foot at approximately 1 km/h. Walked transects were undertaken along walking and vehicle tracks (Figure 4) and in adjacent bushland areas.

Surveys commenced at dusk and targeted areas with trees with hollows to detect arboreal mammals, forest owls and bats emerging from diurnal roosts to forage. Open water bodies were also targeted at this time to detect species coming to these locations to drink or forage above in the case of microbats.

Mammals and nocturnal birds were identified by observation under spotlight or by vocalisations heard whilst spotlighting. Identifications were in accordance with Strahan (1995) and Pizzey and Knight (2006).

4.5.8 Surveys for Threatened Terrestrial Fauna

Systematic searches for Commonwealth and State listed threatened species were undertaken using a combination of the techniques presented in this section.

Birds

Target Species:

- Australian Painted Snipe (*Rostratula australis*);
- Black-necked Stork (*Ephippiorhynchus asiaticus*);
- Brown Treecreeper (*Climacteris picumnus victoriae*);
- Glossy Black-cockatoo (*Calyptorhynchus lathami*);
- Osprey (*Pandion haliaetus*);
- Regent Honeyeater (*Xanthomyza phrygia*);
- Powerful Owl (Ninox strenua);

- Sooty Owl (*Tyto tenebricosa*); and
- Swift Parrot (*Lathamus discolor*).

Diurnal bird surveys were conducted using 20 minute, one-hectare searches. Surveys were conducted in the early morning and late afternoon when birds are typically most active. All bird species heard or sighted during the surveys were recorded. Incidental sightings of birds during other field surveys were also noted.

Diurnal bird surveys also included searches for habitat features of relevance for particular threatened species, including searching for evidence of feeding, such as cracked Allocasuarina seed cones from Glossy Black-cockatoos and signs of bird presence, such as pellets, whitewash (owls), nests (Osprey) etc.

Call playback surveys were conducted for the Powerful Owl, Barking Owl, Masked Owl, and Sooty Owl for three consecutive nights. Surveys involved call playing for five minutes followed by a listening period of five minutes (undertaken separately for each species), and a final listening period of approximately 10 minutes. Calls were played through a portable CD player connected to a (ER-409) 15-watt megaphone. Potential roost sites in the immediate area were then scanned for 10 minutes using spotlights.

Active searches around waterways for Black-necked Stork and Australian Panted Snipe were undertaken at the RARC and aquatic survey locations.

Mammals (Excluding Bats)

Ground-dwelling Mammals

Target Species:

- Hastings River Mouse (*Pseudomys oralis*);
- Spotted-tail Quoll (*Dasyurus maculatus*); and
- Long-nosed Potoroo (*Potorous tridactylus*).

The likely presence of ground-dwelling mammals was determined through detailed habitat assessments. Habitat features such as fallen debris and extensive ground cover that offer potential suitable shelter and runways through native grasses and diggings were used as indicators of use. Scat and latrine searches(Spotted-tail Quoll) were also completed in appropriate areas to indicate usage.

Arboreal Mammals

Target Species:

- Koala (*Phascolarctos cinereus*); and
- Yellow-bellied Glider (*Petaurus australis*).

Spot surveys targeting the presence of Koalas were completed in appropriate vegetation communities. This technique involves identifying mature feed trees and completing searches under nearby relevant trees for koala scats, scratches and presence, as well as spotlighting and call playback.

The Yellow-bellied Glider has been previously recorded to the northwest of the study area in Viewmont State Forest, as indicated in DECC Atlas of Wildlife and Bionet database searches. Accordingly spotlighting and call playback was also completed for Yellow-bellied Gliders.

Microchiropteran and Megachiropteran Bats

Target Species:

- Eastern Bentwing Bat (*Miniopterus schreibersii oceanensis*);
- Eastern Long-eared Bat, (*Nyctophilis bifax*);
- Large eared Pied Bat, (*Chalinolobus dwyeri*);
- Little Bentwing Bat, (*Miniopterus australis*); and
- Grey-headed Flying Fox, (*Pteropus poliocephalus*).

Ultrasonic call recording devices were placed in suitable flyways within a variety of vegetation communities to detect microchiropteran bats. Focus was placed on riparian areas and natural flyways, which typically provide an abundance of insects for feeding. Anabat SD1 detection units were set before dusk and retrieved each morning.

Incidental records of potential roost habitat (hollow bearing trees) for threatened species were recorded and diurnal habitat searches were undertaken to identify potential roost habitat for the Grey-headed Flying Fox. These surveys were based on the presence of appropriate food and roosting trees or indirect evidence, such as bat guano.

Spotlighting for megachiropteran bats (e.g. flying foxes, tube nosed bats, larger insectorivous bats) while listening for vocalisations was undertaken in conjunction with spotlighting for other mammals.

Amphibians

Target Species:

- Green and Golden Bell Frog (*Litoria aurea*);
- Booroolong Frog, (*Litoria booroolongensis);*
- Southern Barred Frog, (*Mixophyes balbus); and*
- Giant Barred Frog, (*Mixophyes iteratus*).

Diurnal and dusk searches of suitable habitat for listed frog species were undertaken at each aquatic survey site (see Figure 4). Surveys included tadpole searches using dip nets along transects of streams and backwaters, along with a visual search for basking individuals within the vegetation around the water body or watercourse and in-stream vegetation (if present).

GHD has recorded breeding and territorial calls of all NSW frog species of conservation significance, and most of the common species. A frog megaphone was used to play callback mpegs for the above mentioned frogs at appropriate drainage lines and wetland sites just after dusk. Surveys started with an initial listening period of 10 minutes and then calls were broadcast intermittently for five minutes. This was followed by a 10 minute spotlighting and listening period.

Spotlighting for frogs was undertaken along in-stream vegetation and vegetation adjacent to the site.

Incidental records of other frog species heard or sighted during the inspections were noted. General habitat features and water quality parameters were recorded in conjunction with the surveys.

Reptiles

One threatened terrestrial reptile species, Stephens' Banded Snake (*Hoplocephalus stephensii*), was identified during the database searches. .

Reptile surveys involved active searches of the study area and surrounds to identify potential breeding and foraging habitat for reptile species, including in particular the threatened species Stephens' Banded Snake, which could potentially occur in the study area as well as all fossorial species, including skinks, blind snakes, and other snakes.

Survey techniques employed included:

- Diurnal searches for sheltering or basking frogs and reptiles;
- Rock, log and debris rolling; and
- Spotlight surveys for nocturnally active species (e.g. Stephens Banded Snake, geckos).

4.6 Aquatic Survey Methods

GHD ecologists undertook an aquatic assessment over five days, between 17th and 21st November 2008. The aquatic assessment included the following components:

- Aquatic habitat assessment;
- Fish sampling;
- Macroinvertebrate sampling; and
- Water Quality.

4.6.1 Survey Site Selection

GHD undertook aquatic surveys at a total of 11 sites on three waterways:

- Bowra Creek;
- South Creek; and
- Nambucca River.

The aquatic survey sites were selected after conducting a background survey using NSW government database searches, a literature review and available spatial data. The survey sites were located within the greater catchment to provide a wide-ranging assessment of the aquatic conditions. To increase the power of the statistical analysis, multiple sites were selected along the length of the Nambucca River and two of its tributaries. Sites selected can be incorporated into future monitoring programs to detect changes in aquatic habitat.

The sampling program included:

- Bowra Creek - four sites:
  - Two within the inundation area (BC1 and BC2);
  - One upstream and downstream of the proposed pipeline crossing (BC3 and BC4).
- South Creek -two sites:
  - One upstream and downstream of the proposed bore field (SC1 and SC2).
- Nambucca River -five sites:

- One reference site at Missabotti Creek (NR1);
- One upstream and one downstream of the existing bore field (NR2 and NR3);
- One downstream of the proposed bore field, south of the South Creek/Nambucca River confluence (NR4); and
- One downstream of the confluence of the Nambucca River and Bowra Creek (NR5).

Bowra Creek originates within the inundation area and therefore no samples were taken upstream of the inundation area.

Aquatic survey methods and effort are described in the following sections. The location of the aquatic sampling sites is presented in Figure 4.

4.7 Aquatic Survey Effort

Table 5 details the aquatic survey effort implemented during the survey period.

Table 5 Aquatic Survey Effort

Survey Tasks	Technique	Survey Effort
Macroinvertebrate sampling	AUSRIVAS standards, D-framed 250 µm dipnet	All 11 sites (Bowra Creek, South Creek and Nambucca River); 10 m sweeps of edge and riffle (where possible) habitats
Fish survey	Fyke nets: set overnight	2 nets / 2 nights / 4 locations
Fish survey	Seine nets: sweep of pools or shallow areas	5 sweeps at different locations
Reptile survey	Turtle traps: set overnight	4 nights at 4 locations
Water Quality	Sampling containers	All 11 sites (Bowra Creek, South Creek and Nambucca River)

4.7.1 Aquatic Habitat Assessments

The GHD field team undertook aquatic habitat assessments using the AUSRIVAS methodology (Turak and Waddel, 2002) which assesses aquatic habitat values, including riparian and bank structure and habitat variability. The habitat assessments consider the integrity of the habitat present and its level of significance on a local, regional and national scale. Additionally, the habitat assessments were completed on a species-specific basis, which considers the various requirements of the species at a commonly occurring community level. The habitat assessments incorporated the expected inundation levels and were undertaken with the specific aim of providing baseline data for identifying habitat changes and resulting environmental flow requirements.

4.7.2 Fish Sampling

No threatened fish listed under the FM Act were identified during the database searches or have been collected in previous surveys.

The following methods were employed to develop a baseline of community assemblages within the study area. Native fish species were identified in the field and returned to the water.

Fyke Nets

Fyke nets used for the Proposal consisted of a 1300 mm long cone of 500 µm mesh, with a 500 mm diameter opening. Nets were set at the upstream and downstream ends of the site, facing perpendicular to the current, with their upper margin submerged 50 – 100 mm below the water surface. The fyke nets were generally set by tying one end to riparian branches or snags and attaching the opposite end to a wooden stake and hammering it into the substrate. The nets were set during the afternoon and retrieved the following morning.

Seine Net

A seine net of 5 m x 1.5 m and 2 mm mesh was used at various sites in areas with unobstructed, deep pools. The seine net was dragged in an arc through the pool and all fish collected were placed in a bucket, identified and released back into the original pool.

Turtle Traps

Emydura macquarii signata (Brisbane River Turtle) was identified by EPBC searches as 'species or habitat may exist' within the study area. Standard crab traps were used to capture turtles for identification by an aquatic ecologist.

4.7.3 Macroinvertebrate Sampling

GHD undertook macroinvertebrate surveys at each of the aquatic survey sites using AUSRIVAS protocols (Figure 4). The use of macroinvertebrates to monitor creek health and changes over time is well documented and provides high quality data relating to creek health. In this case, the use of macroinvertebrates as indicators of waterway health would allow NSC to undertake ongoing monitoring of the potential impacts of the off-river storage on the surrounding creeks and rivers.

Field Survey

The sampling methodologies were undertaken in accordance with the NSW AUSRIVAS Sampling and Processing Manual for the collection and processing of macroinvertebrate samples. Each sampling site was defined as a 100 m reach and bed, riffle and edge habitats were sampled when present. Within each reach a distance of 10 metres of each habitat type was sampled using a 250-micrometre sweep/dip net with an opening of 250 mm x 250 mm x 250 mm. The resulting specimens were placed into labelled sample bags containing 70% ethanol and transported to the GHD laboratory for identification and enumeration.

Identification and Analysis

The samples were sorted to family level of identification where possible using the latest identification keys. The families were placed in separate vials and would be stored in 70% ethanol for the life of the Proposal for future monitoring purposes.

Information from the fieldwork was incorporated into a number of different formats for analysis and interpretation. GIS analysis of the data provided information on both spatial and temporal distributions and provided the data in a readily interpretable visual display that is often easier to understand than pure statistical outcomes. However, environmental factors were also presented in tabular form and have been incorporated into statistical analysis (SIGNAL2 and Primerv5). Data was not analysed using the AUSRIVAS predictive model.

Details of the statistical analyses and the outputs are provided in Appendix B.

4.7.4 Water Quality Sampling Methods

A water quality assessment was undertaken at all aquatic habitat sampling sites (Figure 4). The resulting data were compared against locally derived reference values for the region from the *Australian Water Quality Guidelines for Fresh and Marine Waters* Australian and New Zealand Environment and Conservation Council Guidelines (ANZECC/ARMCANZ, 2000).

The water quality studies were undertaken to:

- Assess the existing water quality conditions in the catchment in consideration of the catchment geology and existing groundwater extraction activities to provide benchmarks for ongoing water quality monitoring;
- Determine the potential water quality values of the inundation area and downstream; and
- Gather baseline data to assist in the determination of environmental flow requirements of the study area in the future.

Insitu Water Quality Monitoring

General physio-chemical water quality parameters were recorded at each aquatic sampling site (Figure 4). Water quality parameters were measured using a TPS 90FL multiparameter water quality meter. The variables measured were temperature (^{o}C), pH, turbidity (NTU), salinity (ppt), dissolved oxygen (% saturation) and conductivity (µS/cm).

Water Quality Samples

Water quality samples were taken at each of the aquatic survey sites (Figure 4) to measure the following:

- Total Nitrogen (TN);
- Total Phosphorus (TP);
- Ammonia;
- Heavy metals; and
- Biochemical Oxygen Demand (BOD_5).

Field sampling protocols followed the Australian Standards for water quality sampling (AS5667.1:1998). Water samples were taken by using a gloved hand to dip clean, laboratory supplied containers into the representative stream reach.

Samples were taken in the centre of the water body, or as far from the bank as possible. The water was stored in a chilled cooler during the day, before being couriered to a nominated NATA accredited laboratory.

In all cases, samples were taken from areas within the water body where sediments had not been disturbed. This process ensures sample results are not influenced by suspended particles.

4.8 Ecological Values of Study Area

The ecological values of the study area were compared to the ecological values of adjacent lands. This was based on observations of the study area and the surrounding lands in consideration of the following factors:

- The level of weed infestation;
- The degree of past disturbances (i.e. logging intensity);

- The presence of hollow bearing trees; and
- The overall condition of native vegetation (floristic structure and biodiversity).

4.9 Impact Assessment

In accordance with Section 5A of the EP&A Act, an impact assessment of the Proposal upon any relevant threatened species, populations or ecological communities was undertaken to determine the significance of these impacts. In doing so informed decisions could be made to minimise any likely direct or indirect impacts upon threatened species, populations or ecological communities.

4.10 Limitations of Methods

The terrestrial and aquatic flora and fauna surveys undertaken for this investigation were not designed to detect all species, either resident or transitory to the study area. Instead they aimed to provide an overall understanding of the ecological values of the study area with particular emphasis on threatened species, ecological communities and their habitats to allow an assessment of the impacts of the Proposal. Whilst targeted surveys for particular species and fauna groups were undertaken, a heavy focus was placed on habitat assessment and resource identification to assess the likely occurrence on site of threatened species known to occur in the wider locality and region. The above approach was consistent with DECC survey method guidelines (DEC, 2004) in light of previous investigations having occurred across the study area in reference to the same project.

Flora and fauna field surveys conducted during one season and/ or for a short period are expected to detect only a sample of the total species present or which may occur within the area surveyed. This survey ground truthed the different habitat types identified as present within the study area and used recognised survey techniques to target fauna groups and threatened species and were timed to coincide as far as possible with known high activity periods of specific fauna groups (e.g. early morning bird surveys and dusk/ nocturnal surveys for nocturnal species).

Despite this, the surveys conducted would not be expected to have detected all species likely to occur in the study area over an extended time period, as some species may occur in the locality or region on a seasonal basis (e.g. Swift Parrot), use habitats or areas periodically (as part of a wider home range) or become active at different times of the year. Some plant species are also very cryptic and not easily identified when not in flower.

The survey effort for fauna groups focused on the identification of suitable foraging and roosting habitat for species within the study area. Based on the findings of the habitat assessment it is considered likely that a variety of species known from the locality occur at least on occasion.

For these reasons, the impact assessment and conclusions of this study rely on information obtained from a variety of sources in addition to the field data collected during this investigation. In instances where it is considered that the likelihood of observing a particular threatened species was reduced because of survey extent or seasonal or climatic factors, this has been indicated. An assessment of the likelihood of occurrence of threatened species has been provided, on the basis of known distributional ranges, previous records in the locality, and habitat and resource availability in the study area. Impact assessments have been prepared for those threatened species recorded in the study area during the field surveys as well as those species not detected but considered likely to occur or to be impacted by the Proposal.

Given the ground truthing survey and assessment approach undertaken, it is considered that the flora and fauna species of relevance to the study area have been identified and that the ecological value, conservation significance and likely impacts on threatened species and their habitats have been appropriately assessed.

5. Desktop Assessment Results

5.1 Literature Review

5.1.1 Review of Connell Wagner Reports

Connell Wagner conducted flora and fauna surveys in the study area in 1996 and 1997 were undertaken in relation to the same proposal, but only in regards to the proposed inundation area and dam embankment footprint. The potential impacts of the proposed access roads, pipeline routes were not part of Connell Wagner's scope, as well as aquatic surveys and water quality testing.

They recorded 179 flora species and 129 fauna species, comprising 78 species of birds, 14 reptile species, 6 amphibians and 31 mammals.

Vegetation transects (200 m) and 1 m x 1 m grid surveys were completed to determine the vegetation communities present. Fauna survey techniques included harp traps (bats), call playback (owls), koala surveys, ground and arboreal Elliott trapping, spotlighting, scat and track searches, dawn and dusk bird surveys and frog and reptile surveys where appropriate. Threatened species with the potential to occur in the study area were assessed under the TSC Act. Assessment under the EPBC Act was not required at the time of this report.

One TSC Act listed threatened flora species were recorded within the study area, Dunns White Gum (*Eucalyptus dunnii*), whilst two other threatened flora species Nambucca Ironbark (*E. fusiformus*) and Arrow-head Vine (*Tinospora tinosporoides*) where recorded beyond the study area. Of these, Dunns White Gum and Nambucca Ironbark are no longer listed under the TSC Act and therefore do not require further assessment. Arrow-head Vine is currently listed as vulnerable on the TSC Act and the EPBC Act. An 8-part test (Assessment of Significance) by Connell Wagner concluded that the proposed works were unlikely to have a significant impact on this species. Because the Arrow-head Vine was recorded outside of the study area and the 8-part test undertaken by Connell Wagner determined that no impacts upon this species were considered likely, no additional assessment of significance (7-part test) is considered necessary.

A combined 8-part test to assess the potential for impacts on threatened fauna, including the Large Bent-wing Bat, Little Bent-wing Bat, Large-eared Bat, Golden-tipped Bat, Sooty Owl and the Koala, concluded that there would be no significant impact on any of the identified threatened fauna species.

The report states that the loss of forest habitat would be somewhat compensated by the establishment of aquatic vegetation and the conservation of the rest of the vegetation in the upper part of the catchment that is an extension of the same vegetation that may be potentially removed. They also stated that there would be an increase in the amount of edge vegetation and possible weed proliferation due to the Proposal.

No Endangered Populations or Endangered Ecological Communities listed on the TSC Act were recorded within the study area during the survey period.

5.1.2 Review of Forests NSW Flora Fauna Report

Forests NSW completed a pre-logging and pre-roading flora and fauna survey of the inundation area according to the provisions of their Threatened Species License in 2002. This survey consisted of a database assessment and some limited ground truthing of the site. The threatened species database review identified

one frog, three mammals including one bat and three birds have the potential to utilize the proposed inundation area due to on site habitats.

Threatened species observed during the survey comprised one bird species Wompoo Fruit Dove (*Ptilinopus magnificus*) and one species frog Southern Barred Frog (*Mixophyes iteratus*). Neither species was recorded within the inundation area. However potential habitat does occur within the inundation for both of these mobile fauna species inferring that they are likely to occur within the inundation area.

Koala scats were also found but no individuals were observed within the proposed inundation area, however potential habitat does occur within the inundation area and one male Koala was heard calling at night time during the current survey. One common mammal, the Greater Glider (*Petauroides volans*), was also observed during spotlighting. In addition, two threatened plants Rusty Plum (*Amorphospermum whitei*) and Milky Silkpod (*Parsonsia dorrigoensis*) were observed at several locations within Viewmont State Forest. None of the locations of these recorded species are within the inundation area and it is unlikely that they occur within the inundation area due to significant past disturbances associated with logging practices.

No aquatic survey was completed as part of this assessment.

5.1.3 Review of Biosis Reports

Biosis conducted flora and fauna surveys in the study area in 2004 and 2005 were undertaken in relation to the same proposal, but only in regards to the proposed inundation area, dam embankment footprint, pipeline routes and along Bowra Creek downstream of the proposed dam embankment where aquatic surveys were undertaken. A total of 109 flora species and 71 fauna species were observed during the survey including 55 bird species, 4 reptiles, 2 amphibians 2 mammals and 8 fish.

Vegetation within the study area was verified using the random meander method in each vegetation community identified by Connell Wagner. Targeted surveys of threatened species known to occur in the locality were also completed. The study area contained potential habitat for nine threatened flora species, including: Newry Golden Wattle (*Acacia chrysotricha*), Rusty Plum (*Amorphospermum whitei*), Hairy Jointgrass (*Arthraxon hispidus*), White-flowering Wax Plant (*Cynanchum elegans*), Monkey Nut (*Hicksbeachia pinnatifolia*), Clear Milkvine (*Marsdenia longiloba*), Quassia sp., Arrow-head Vine (*Tinospora tinosporoides*) and Tylophora woollsii. Assessments of Significance concluded that the proposed works were unlikely to significantly affect any of the above threatened flora species. One species Newry Golden Wattle was considered to be potentially impacted by the Proposal due to its restricted distribution and further surveys were recommended. A supplementary five-day targeted survey for this species was completed. No individuals of this species were found in the survey period. The 8-part test was updated and it was concluded that this species would not be affected due to the proposed works.

Fauna occurrence within the study area was assessed according to the presence and quality of suitable habitat and by completing active searches and listening, as well as recording incidental observations. No trapping was completed as part of this study. Biosis concluded that the study area contained potential habitat for 18 threatened fauna species, including the Sooty Owl, Spotted-tail Quoll, Long-nosed Potoroo, Koala, Southern Barred Frog, Giant Barred Frog, Grey-headed Flying Fox, five microbat species and six migratory species. The inundation area was not considered to be core koala habitat within the meaning of SEPP 44, because the study area is located in NSW State Forest and therefore SEPP 44 does not apply and the one listed feed tree species does not occur in densities greater than 15 % and was therefore only considered potential habitat, however other areas potentially impacted by the proposal are not NSW State Forest land and may have greater densities of listed feed trees and if so SEPP 44 would apply accordingly. Assessments

of Significance undertaken for all 18 species concluded that the proposed works associated with the inundation area were unlikely to significantly affect any threatened fauna species.

Aquatic habitats were briefly surveyed by visual assessment as well as recording incidental observations. No live trapping of aquatic fauna was completed. There are 20 known species of freshwater fish in the Nambucca Catchment, including two exotic species. Thirteen of these species have been recorded at the NSW Fisheries Survey Site at Bowraville Gauging Station on the Nambucca River. Eight fish species were recorded during the survey, including seven native species Long-finned Eel (*Anguilla reinhardtii*), Striped Gudgeon (*Gobiomorphus australis*), Empire Gudgeon (*Hypseleotris compressa*), Flathead Gudgeon (*Philypnodon grandiceps*), Southern Blue-eye (*Pseudomugil signifer*), Mullet sp., and Crimson-spotted Rainbowfish (*Melanotaenia fluviatilis*) and one exotic species, Gambusia (*Gambusia holbrooki*).

There were no threatened aquatic animals recorded during the survey. There are no known threatened aquatic species or populations listed on the EPBC or FM Acts for the Nambucca Catchment therefore no 8-part tests or Assessment of Significance were completed for aquatic species. The study did recommend measures be put in place to minimise the potential for Gambusia to populate the storage area. It was determined that the proposed works would not have a significant impact on the aquatic habitat in the area.

5.1.4 Review of Keith Bishop Report

Dr. Keith Bishop reviewed the flow rules and ecological issues associated with the Proposal and determined that there was potential for saltwater intrusion to occur in the upper estuary in drought periods due to current extraction. Provided the environmental flow rules are applied together with an adaptive management framework, the potential for saltwater intrusion and resulting changes to riparian vegetation would be minimised. It was also concluded that the removal or augmentation of the concrete encased pipe near the borefield, which is effectively acting as a weir, would be beneficial to fish passage between the estuary and the river.

5.1.5 Review of Regional Surveys

Darkheart Eco-consultancy (2000) completed a survey of a site to the west of the study area, which consisted of pasture, degraded riparian vegetation and eucalypt regrowth that was assessed to determine whether potential Koala habitat was present. Relatively low fauna diversity was recorded and no threatened fauna species were identified during the survey.

Jelliffe Environmental (1997) completed a survey as a component of an REF for a proposed effluent scheme in Bowraville. The study site was located on previously cleared agricultural land dominated by Kikuyu (*Pennisetum clandestinum*). No significant species of flora or fauna were identified during the survey.

The Nambucca CMC (2000) completed a baseline water quality monitoring project in the Nambucca catchment and concluded that the catchment had "reasonably good" water quality. In-situ and chemical analysis of water quality was recorded at several sites in the Nambucca River and South Creek. It was concluded that the freshwater water quality was good while the estuarine water quality was poor. The reason for the poor results was high nutrient levels and turbidity. The difference in results of the freshwater and estuarine areas was attributed to the effects of tidal flushing and less intensive land use in the estuarine sections of the catchment. The ANZECC guidelines are also much more stringent in estuarine environments.

5.2 Threatened Species Database Search Results

The results of the DECC database search revealed a number of threatened flora and fauna previously recorded within a 10 km radius of the study area is shown in Figure 5. No EECs listed under the TSC Act occur in the study area. A full list of threatened species obtained from the DECC database search is available in Appendix A.

5.2.1 Threatened Species Conservation Act

The results of the DECC wildlife and BioNet database searches indicated 20 species, comprising seven birds, seven mammals (including four bats), two amphibians and four plants listed as threatened under the TSC Act previously recorded within the locality of the study area.

Threatened species that may potentially occur within a 10 km radius of the study area, including their conservation status, habitat requirements and likelihood of occurrence is presented as Appendix A. A review of the specific habitat requirements of these species, and the habitat present within the study area and its surrounds allowed a number of these species to be eliminated as having nil, or low likelihood of occurrence at the site.

5.2.2 Environmental Protection and Biodiversity Conservation Act

A search using the DEWHA protected matters search tool provided the following results:

- World heritage properties
  - The study area is not listed as a world heritage area;
- National heritage properties
  - The study area is not listed as a national heritage site.
- Ramsar wetlands of international importance
  - No Ramsar wetlands occur on the study area, nor does the Proposal affect a Ramsar wetland;
- Listed threatened species and communities

Three birds, four frogs, one insect, five mammals, including two bats, one reptile and 10 plants that are listed as threatened species under the EPBC Act have the potential to occur within the locality of the study area. No EECs listed under the EPBC Act are predicted to occur within the study area.

- Migratory species protected under international agreements
  - Fifteen migratory bird species were identified as potentially using the study area at some time of the year.
- Commonwealth marine environment (CME)
  - The site is not within the CME nor would it be affected;

Species that are known or predicted to occur within the locality of the study area are listed in Appendix A and the results of the database search are shown in Appendix D. A review of the specific habitat requirements of these species, and the habitat present within the study area and its surrounds allowed a number of these species to be eliminated as having nil, or low likelihood of occurrence at the site.

5.3 Conclusions of Database Assessment

The key findings of the literature review relate to the recording of threatened species and the potential alteration of estuarine habitats due to water extraction and saltwater intrusion. The database searches revealed the potential presence of several threatened species that are likely to occur within the potentially impacted areas. A summary of the threatened species recorded or assessed as likely to occur onsite by previous studies and this study are displayed in Table 6.

Table 6 Previous and Current Study Threatened Species Recorded and Likelihood of Occurring

Investigative Body	Species Definitely Recorded	Species Likely to Occur
Connell Wagner	◗ Arrow-head Vine; ◗ *Dunns White Gum; and ◗ *Nambucca Ironbark.	◗ Large Bent-wing Bat; ◗ Little Bent-wing Bat; ◗ Large-eared Bat; ◗ Golden-tipped Bat; ◗ Sooty Owl; and ◗ Koala.
NSW State Forests	Koala.	◗ Wompoo Fruit Dove; and ◗ Southern Barred Frog.
Biosis	None	◗ **Newry Golden Wattle; ◗ Rusty Plum; ◗ Hairy Jointgrass; ◗ White-flowering Wax Plant; ◗ Monkey Nut; ◗ Clear Milkvine; ◗ Quassia sp.; ◗ Arrow-head Vine; ◗ Tylophora woollsii; ◗ Sooty Owl; ◗ Spotted-tail Quoll; ◗ Long-nosed Potoroo; ◗ Koala; ◗ Southern Barred Frog; ◗ Giant Barred Frog; ◗ Grey-headed Flying Fox; ◗ Five microbat species; and

Investigative Body	Species Definitely Recorded	Species Likely to Occur
		◗ Six migratory species.
GHD	◗ Barking Owl; ◗ Masked Owl; ◗ Sooty Owl; ◗ Powerful Owl; ◗ Glossy Black Cockatoo; ◗ Wompoo Fruit-dove; ◗ Koala; ◗ Golden-tipped bat; ◗ Little Bentwing-bat; and ◗ Eastern Bentwing-bat.	◗ Spotted-tail Quoll; ◗ Grey-headed Flying-fox; ◗ Southern Barred Frog; ◗ Giant Barred Frog; ◗ Rusty Plum; ◗ Tylophora; ◗ Leafless Tongue Orchid *(Cryptostylis hunteriana)*; ◗ Minute Orchid *(Taeniophyllum muelleri)*; ◗ Rufous Fantail *(Rhipidura rufifrons)*; and ◗ Cattle Egret *(Ardea ibis)*.

*No Longer Listed

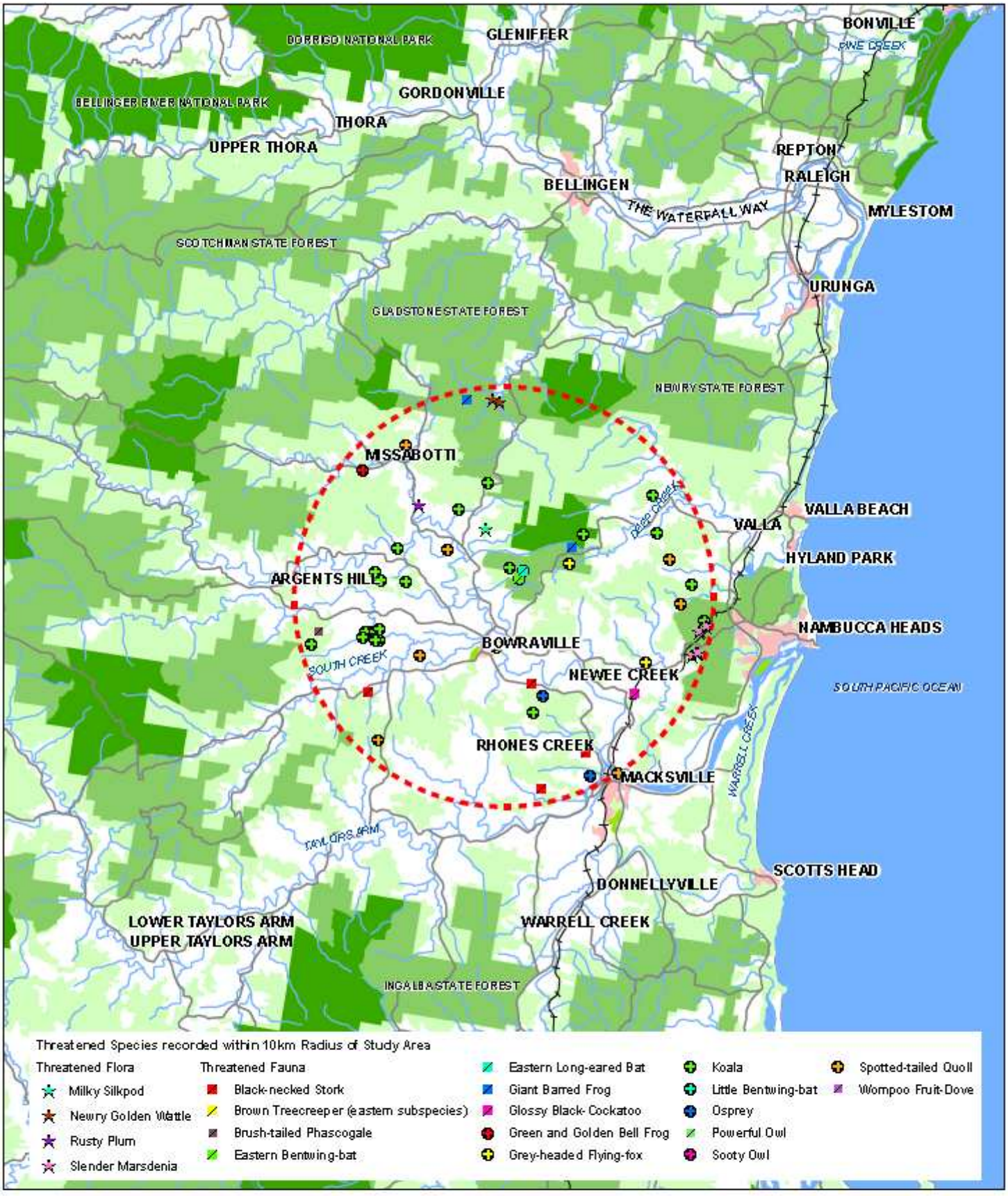
**Five Day targeted search

All previous assessments concluded that no significant impacts were considered likely in regards to threatened species recorded or determined likely to occur within the inundation area, dam embankment footprint or in the case of the Biosis assessment the proposed inundation area, dam embankment footprint, pipeline routes and along Bowra Creek downstream of the proposed dam embankment. The extent of the inundation area and location of proposed infrastructure is the same as what has been surveyed in the current (GHD) study.

Forests NSW has recorded several species of listed flora and fauna in Viewmont State forest, but all were in the northeastern section of the forest that would not be impacted by the proposed works. Suitable habitat for Koalas is present, however other threatened flora and fauna are unlikely to occur in the inundation area (site of proposed works) because the area has been extensively logged and replanted over many decades, resulting in a habitat that is disturbed, heavily infested with weeds, has an inherent low level of biodiversity and at present is in the early stages of ecological successional development.

All of the flora and fauna assessments completed to date have concluded that no threatened species, populations or communities, or their preferred habitat would be significantly impacted due to the proposed works. The results of the DECC database, DECC Atlas of Wildlife and Bionet searches indicated that four plants, five birds, seven mammals including four bats, two amphibians and one reptile listed as threatened under the TSC Act have been recorded within the vicinity (10 km radius) of the study area (see Appendix A).

The results of the DEWHA database search indicated that three birds, four frogs, one insect, five mammals including two bats, one reptile and 10 plants that are listed under the EPBC Act have the potential to occur within the area. Fifteen migratory species were identified as potentially using the study area at some time of the year. No other matters of NES were identified (see Section 10.9).



LEGEND

Road
Railways
Watercourse
Built Up Areas
Recreation Areas
Forest Or Shrub
Watercourse Area
Forestry Reserve
Nature Conservation Reserve
10km Radius

1:250,000 (at A4)
0 9501,900 3,800 5,700 7,600
Metres
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

GHD
CLIENTS|PEOPLE|PERFORMANCE

Nambucca Shire Council
Bowraville Off-River Storage
Environmental Impact Statement

Job Number | 22-14133
Revision | A
Date | 21 APR 2009

Threatened Flora & Fauna previously recorded in the locality (DECC 2009)

Figure 5

2/115 West High Street Coffs Harbour NSW 2450 T 61 2 6650 9500 F 61 2 6652 6021 E www.ghd.com.au

G:\22\14133\GIS\Maps\EIS\22-14133_EIS_Fig5_Th_Flora_Fauna_20090421_A.mxd

Data Source: DECC: Threat Species - 2009; Geoscience Australia: Topology - 2005. Created by: tmackay

6. Terrestrial and Riparian Flora Survey Results

6.1 Terrestrial Flora Survey Results

For the purpose of this assessment, the study area consisted of the inundation area, the riparian zones of three potentially impacted waterways (Nambucca River and, South and Bowra Creeks), the pipeline route, the existing and proposed borefields and Bobo Road. Where applicable, vegetation communities have been classified with reference to *North East New South Wales: Field Key to Forest Ecosystems* (DECCW, 2004). Communities that don't fit these classifications have been classified based on dominant canopy species and floristic structure (i.e. riparian vegetation dominated by Camphor Laurel and Small-leaf Privet). The survey locations in the inundation area were based upon covering the different vegetation communities, as depicted in Biosis's Figure 3 *Vegetation communities present in the study area* (Biosis, 2005). The survey locations of the current study are shown in Figure 4.

The vegetation communities recorded are summarised in Table 7, whilst the survey locations are shown in Figure 4 above and details pertaining to each community are described below. Additionally Table 7 summarises the dominant canopy species, approximate areas to be impacted and condition assessment scoring for each vegetation community identified in the study area.

Table 7 Summary of Terrestrial Flora Survey Results

Vegetation Community Type	Dominant Species	Approximate Area (ha) that would be Impacted	Condition Assessment Scoring
Hardwood Plantation	Flooded Gum, Blackbutt and Broad-leaved Mahogany	27.45	Poor
Wet Flooded Gum – Tallowwood Forest	Flooded Gum with Tallowwood, Dunn's White Gum, Pink Bloodwood and Turpentine.	20.02	Moderate
Northern Wet Tallowwood – Blue Gum Forest	Tallowwood and Sydney Blue Gum with Brush Box, Blackbutt and Turpentine	7.85	Moderate
Foothills Grey Gum – Broad-leaved Mahogany Forest	Small-Fruited Grey Gum, Broad-leaved Mahogany, Grey Ironbark and Turpentine	7.16	Moderate
Wet Bloodwood – Tallowwood Forest (Temperate Rainforest)	Pink Bloodwood, Tallowwood, Small-Fruited Grey Gum and Blackbutt	0.64	Moderate
Pastureland	Common Paspalum and Kikuyu	13.55	Poor
Riparian Vegetation	Camphor Laurel, Small-leaf Privet and Lantana	3.79	Poor

6.1.1 Inundation Area / Storage Embankment

The inundation area consists of remnant native forest on the upper slopes with managed plantation forest on the lower slopes and flatter ground associated with Bowra Creek. Descriptions of each forest community identified in the inundation area, as well as the plantation forest, are provided below.

Wet Flooded Gum – Tallowwood Forest

This community is classified as Ecosystem 154 Wet Flooded Gum - Tallowwood (DECCW, 2004) and is consistent with Forest Type 48 as described in Forestry Commission (1989). Wet Flooded Gum - Tallowwood Forest occurs along the upper southern facing slopes of the Bowra Creek catchment. This tall open forest had a canopy up to approximately 35 m in height. Approximately 20.02 ha of this vegetation community would be removed from the inundation area, as shown in Figure 10.

The dominant canopy species was Flooded Gum (*Eucalyptus grandis*), with Tallowwood (*E. microcorys*), Dunn's White Gum (*E. dunnii*), Pink Bloodwood (*Corymbia intermedia*), and Turpentine (*Syncarpia glomulifera*) making up the remainder of the canopy. The understorey included trees such as Blackwood (*Acacia melanoxylon*), Green Wattle (*Acacia irrorata*), Coachwood (*Ceratopetalum apetalum*) and Large Mock-Olive (*Notelaea longifolia*), shrubs such as Native Peach (*Trema tomentosa* var. *viridis*), Breynia (*Breynia oblongifolia*), Veiny Wilkiea (*Wilkiea huegeliana*) and Narrow-Leaved Palm Lily (*Cordyline stricta*), and climbers such as Twining Guinea Flower (*Hibbertia dentata*) and Five-Leaf Water Vine (*Cissus hypoglauca*).

Weed species included Lantana (*Lantana camara*), Camphor Laurel (*Cinnamomum camphora*) and Small-leaf Privet (*Ligustrum sinense*), which were present throughout the understorey. This vegetation was considered to be in **moderate** condition, because the understorey and groundcover was infested with weeds.

Northern Wet Tallowwood – Blue Gum Forest

This community is classified as Ecosystem 104 Northern Wet Tallowwood – Blue Gum (DECCW, 2004) and is consistent with Forest Type 47 (Forestry Commission, 1989). Northern Wet Tallowwood – Blue Gum forest occurs on west and north-facing slopes of the Bowra Creek catchment. This tall open forest had a canopy up to approximately 35 m in height. Approximately 7.85 ha of this vegetation community would be removed from the inundation area, as shown in Figure 10.

The dominant canopy species were Tallowwood and Sydney Blue Gum (*Eucalyptus saligna*), with Brush Box (*Lophostemon confertus*), Blackbutt and Turpentine making up the remainder of the canopy. The understorey included trees such as Forest Oak (*Allocasuarina torulosa*), Scrub Turpentine (*Rhodamnia rubescens*), Bangalow Palm (*Archontophoenix cunninghamii*), Jackwood (*Cryptocarya glaucescens*), Guioa (*Guioa semiglauca*) and Rough Treefern (*Cyathea australis*) and climbers such as Five-Leaf Water Vine (*Cissus hypoglauca*), Anchor Vine (*Palmeria scandens*) and Water Vine. Groundcovers included Gristle Fern (*Blechnum cartilagineum*), Narrow-Leaved Palm Lily and Spiny-Headed Mat-Rush (*Lomandra longifolia*).

Weed species included Lantana, Camphor Laurel and Small-leaf Privet, which were present throughout the understorey. This vegetation community is considered to be in relatively **moderate** condition, however the understorey and groundcover was infested with weeds.

Foothills Grey Gum – Broad-leaved Mahogany Forest

This community most closely fits the DECCW classification of Ecosystem 55 Foothills Grey Gum – Spotted Gum (DECCW, 2004), however no Spotted Gums were observed only co-dominants such as Broad-Leaved Mahogany and Grey Ironbark. Therefore the naming of this community has been modified to Foothills Grey Gum – Broad-Leaved Mahogany to make it applicable to the site. This community is consistent with Forest Type 62 (Forestry Commission 1989). Foothills Grey Gum – Broad-Leaved Mahogany primarily occurs on the outer perimeter upper slopes of the Bowra Creek catchment. This tall open forest had a canopy up to approximately 35 m in height. Approximately 4.14 ha of this vegetation community would be removed from the inundation area, as shown in Figure 10.

The dominant canopy species included Small-Fruited Grey Gum (*Eucalyptus proprinqua*), Broad-Leaved Mahogany (*E. carnea*), Grey Ironbark (*E. siderophloia*) and Turpentine. Understorey trees included Forest Oak, White Dogwood (*Ozothamnus diosmifolius*), Maiden's Wattle (*Acacia maidenii*), Blackwood, Blueberry Ash (*Elaeocarpus reticulatus*), and Elderberry Panax (*Polyscias sambuccifolia*) associated with climbers such as Twining Guinea Flower and Green-Leaved Bramble (*Rubus nebulosus*). Groundcovers included grasses such as Blady Grass (*Imperata cylindrical*) and Kangaroo Grass (*Themeda australis*).

Weed species including Lantana were present throughout the understorey. This vegetation community is considered to be in **moderate** condition.

Wet Bloodwood – Tallowwood Forest (Temperate Dry Rainforest)

This community most closely fits the DECCW classification of Ecosystem 152 Wet Bloodwood – Tallowwood (DECCW, 2004) and is consistent with Forest Type 23 (Forestry Commission 1989). Wet Bloodwood – Tallowwood (Temperate Dry Rainforest) is found on the upper west-facing slopes appearing as narrow strips in close proximity to drainage lines. This tall open forest had a canopy up to approximately 35 m in height. Approximately 0.64 ha of this vegetation community would be removed from the inundation area, as shown in Figure 10.

The dominant canopy species included Pink Bloodwood, Tallowwood, Small-Fruited Grey Gum and Blackbutt. The midstorey (approximately 20 m in height) was relatively dense and included Brush Box (*Lophostemon confertus*), Forest Oak, Black Wattle (*Callicoma serratifolia*), Blueberry Ash, Creek Sandpaper Fig (*Ficus coronata*), and (*Rhodamnia rubescens*) with Epiphytes such as Elkhorn (*Platycerium bifurcatum*). The understorey included Citriobatus pauciflora, Narrow-Leaved Palm Lily and Burrawang (*Lepidozamia peroffskiana*) with numerous vines such as Sarsaparilla (*Smilax australis*), Water Vine and Five-Leaf Water Vine.

The vegetation at one of the survey locations for this community was in good condition with a healthy tall canopy with a diverse understorey and groundcover, whilst the vegetation at the other survey location was in poorer condition due to past disturbances and encroaching weeds (Lantana) around the perimeter. Weed species identified included Camphor Laurel, Small-leaf Privet, Lantana and Broad-Leaf Privet (*Ligustrum lucidium*) that were scattered throughout this vegetation community in low numbers. This vegetation community is considered to be in **moderate** condition.

Hardwood Plantation Forest

The most dominant vegetation class in the inundation area (25.94 ha) is hardwood plantation forest primarily dominated by Flooded Gum in association with Blackbutt and Broad-Leaved Mahogany. The plantation forest was dominated by either Blackbutt or Broad-Leaved Mahogany with Flooded Gum as a minor component. The trees are on average 180 - 250 mm diameter at breast height (DBH) and 20-25 m high. Approximately 25.94 ha of this vegetation community would be removed from the inundation area, as shown in Figure 10.

The plantation forest has been logged several times since being managed as harvestable forest resulting in a disturbed understorey and groundcover, with very few emergent trees greater than 25 m tall. The understorey and groundcover consisted mainly of Camphor Laurel, Lantana and Small-leaf Privet especially on the lower slopes and along drainage lines. Native understorey species included White Dogwood, Maiden's Wattle, Blackwood and Breynia.

Remnant and cleared vegetation across the inundation area maintains good connectivity with vegetated areas to the north, including areas of Viewmont State Forest (890 ha) and Bollonolla Nature Reserve (666 ha) which connect with Newry State Forest towards the coast and Gladstone State Forest towards the interior of the State. The degree of Lantana infestation creates a high level of competition for native flora that may be introduced into the plantation area by means of native fauna, wind or surface water runoff. The plantation forest resembles a monoculture and as a result would have reduced ecological function and conservation significance due to a lack of species diversity and simplified floristic structure typically associated with forestry managed land. This vegetation was considered to be in **poor** condition due to heavy weed infestation and past disturbances.

This vegetation community also occurs in the form of a small plantation forest located at the off-river storage dam embankment footprint and would be partially cleared to make way for the off-river storage dam embankment and access road.

Pastureland

The floodplain of the Nambucca River, to the west and south of Viewmont State Forest, consisted largely of agricultural land that has been cleared of native vegetation. Approximately 10.54 ha of this vegetation community would be removed from the inundation area, as shown in Figure 10.

This vegetation community was dominated by introduced grass species such as Common Paspalum (*Paspalum dilatatum*) and Kikuyu (*Pennisetum clandestinum*), and was infested with agricultural weed species such as Tall Fleabane (*Conyza albida*), Dandelion (*Taraxacum officinale*) and Purpletop (*Verbena bonariensis*). A few scattered native species were present, including Star Cudweed (*Euchiton involucratus*) and Blown Grass (*Lachnagrostis filiformis*). This vegetation community was in **poor** condition.

Riparian Vegetation

The riparian areas along Nambucca River, Bowra Creek and South Creek potentially impacted by the Proposal were surveyed for terrestrial and aquatic flora and fauna. Water quality testing was carried out at these same locations. Riparian zones along the Nambucca River, Bowraville Creek and South Creek would have originally been comprised of undisturbed native vegetation typical of coastal floodplains Eucalypt forest that may have once resembled something similar to the listed *River-flat Eucalypt Forest on Coastal Floodplain* EEC but has been cleared extensively. At present the riparian zones are typically 0 to 25 m wide with some locations > 40 m. All of the riparian vegetation surveyed was highly disturbed due to logging and land clearing for agricultural purposes and is now dominated by exotic plant species. Approximately 2.35 ha of riparian vegetation along Bowra Creek would be removed as part of proposed inundation.

The Nambucca River and South Creek are permanent streams whilst Bowra Creek is partly ephemeral, particularly immediately downstream of the storage embankment. The dominant species along all of the surveyed streams were exotic species, generally comprising Camphor Laurel, Small-leaf Privet and Lantana. Although, there were a number of large scattered native trees, including Forest Red Gum (*Eucalyptus tereticornis*), Weeping Lilly Pilly (*Waterhousea floribunda*), Strangling Fig (*Ficus watkinsiana*) and Swamp Oak

(*Casuarina glauca*) that may provide resources for a number of native bird species. There were also moderate amounts of leaf litter and large woody debris (LWD) in the riparian areas.

The riparian vegetation along Bowra Creek upstream of the proposed off-river storage dam embankment generally consisted of dense stands of plantation Flooded Gum in association with the exotic Camphor Laurel. The understorey was dominated by Lantana and Small-leaf Privet with native vines such as Morinda (*Morinda jasminoides*) and Snake Vine (*Stephania japonica*) and scattered emergent rainforest seedlings. This vegetation was considered to be in **moderate to poor** condition.

The riparian vegetation along Bowra Creek where it emerges into pastureland from the plantation forest and downstream of the proposed off-river storage embankment to the confluence with the Nambucca River at Rapid Appraisal of Riparian Condition (RARC) survey locations generally consisted of dense stands of the exotic Camphor Laurel with scattered Flooded Gum and Forest Red Gum and the naturalised Weeping Willow (*Salix babylonica*). The understorey was generally sparse and dominated by Lantana and Small-leaf Privet with scattered native species such as Grey Myrtle (*Backhousia myrtifolia*), Rainbow Fern (*Calochlaena dubia*), Large-Leaf Hop-Bush (*Dodonaea triquetra*) and Large Mock-Olive. Native vines such as Morinda and Snake Vine were also present in the understorey. Exotic understorey species such as Paddy's Lucerne (*Sida rhombifolia*) and Wandering Jew (*Tradescantia albiflora*) were frequently recorded. This vegetation was considered to be in **poor** condition.

6.1.2 Bank Stabilisation Works

Approximately 1.49 ha of riparian vegetation along the Nambucca River and South Creek would be removed or disturbed as part of proposed riverbank stabilisation works. These works are designed to ensure that the unstable riverbanks identified in the study area are modified to ensure their long-term stabilisation. The impacted area along the riparian zones, where riverbank stabilisation is proposed to take place, comprises of the area between the waters edge and the immediate river bank approximately 5 m wide at designated locations along approximately 2,970 m of riverbank.

The riparian vegetation at the proposed release and pump points along the Nambucca River and South Creek, where some of the proposed riverbank stabilisation works are to take place, consisted of highly degraded native vegetation with scattered remnant trees, including the native Swamp Oak (*Casuarina glauca*) and Forest Red Gum (*Eucalyptus tereticornis*) and the exotic Camphor Laurel (*Cinnamomum camphora*). Native understorey species included shrubs, grasses and ferns such as Rough Maidenhair (*Adiantum hispidulum*), Water Gum (*Tristaniopsis laurina*), Spiny-Headed Mat-Rush (*Lomandra longifolia*) and *Opismenus imbecillus*. Exotic understorey species included Tall Fleabane (*Conyza albida*), Lantana (*Lantana camara*) and Small-leaf Privet (*Ligustrum sinense*) and Wild Tobacco (*Solanum mauritianum*). There were numerous vine species present, including the native Water Vine (*Cissus antarctica*) and the exotic Moth Vine (*Araujia sericifera*) and Japanese Honeysuckle (*Lonicera japonica*). This vegetation was considered to be in **poor** condition.

Borefield/ Transfer Pipeline Route

The majority of the vegetation associated with the borefield and transfer pipeline options is open pastureland as described in Section 6.1.1 and are considered to be of low ecological value due to previous land clearing and present grazing activities.

The final borefield and transfer pipeline routes was primarily selected on the basis of engineering constraints and associated costs of establishment. Therefore the proposed options are the most cost effective and logical choice in regards to engineering simplicity and effectiveness. In regards to environmental impact, the

establishment of the proposed pipeline routes are considered to have minimal environmental impacts, because the only vegetation to be impacted is pastureland.

No riparian vegetation is to be impacted 'removed' by the construction of the proposed pipeline routes. Underboring of the Nambucca River for the installation of the borefield pipeline would not impact upon riparian vegetation and is to occur within pastureland. The transfer pipeline would also not impact upon any riparian vegetation as the exitsting culvert across Bowra Creek would be used to attach the transfer pipeline.

The two proposed minor trenched creek crossings for the borefield pipeline are to occur on creeks that run through farmland and no riparian vegetation is to be directly or indirectly impacted at these sites.

The riparian vegetation that is located adjacent to or in close proximity to the pipeline route is dominated by the noxious weed species Camphor Laurel, Lantana and Small-leaf Privet with scattered small clusters of native trees such as Flooded Gums and Forest Red Gums. Minimal amounts of native understorey and groundcovers were present due to livestock grazing and maintained residential gardens.

Overall the riparian vegetation is in **poor** condition and any potential impacts associated with the riverbank stabilisation works are considered minimal.

Borefield Sites and Headworks

The existing borefields and pumping station are located adjacent to the Nambucca River upstream from South Creek. There is a small weir next to the existing borefield, which has been created by an accumulation of debris behind the existing pipeline crossing.

The proposed borefields are located north of the existing borefield along the Nambucca River. The borefield sites typically consist of grazing land and a thin riparian zone. The riparian vegetation in these locations is disturbed and in poor condition comprising Camphor Laurel and River Oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*) with an understorey dominated by Lantana and introduced pasture grasses. The vegetation associated with the existing and proposed borefields and pumping station is highly disturbed and considered to be in **poor** condition.

The thin strip of riparian vegetation would not be impacted 'removed' at these locations as the infrastructure associated with the borefield sites are located within pastureland beyond the riparian vegetation. The existing headworks are to be upgraded to accommodate the increased volume of water to be delivered to the off-river storage and are also located within pastureland beyond the riparian vegetation and as such no riparian vegetation is to be impacted by the proposed upgrading activities.

6.1.3 Bobo Road Upgrade

Bobo Road runs through the Viewmont State Forest. This section of road was vegetated on both sides with varying compositions of dominant canopy trees such as Flooded Gum, Tallowwood, Small-Fruited Grey Gum, Pink Bloodwood, Dunn's White Gum, Grey Ironbark, Broad-Leaved Mahogany, Blackbutt, Turpentine, Forest Red Gum, Sydney Blue Gum, Brush Box, Forest Oak, Blackwood, Black Wattle and Turpentine. The composition of the canopy changed as the road traversed ridges and gullies, different soil types and increased in elevation.

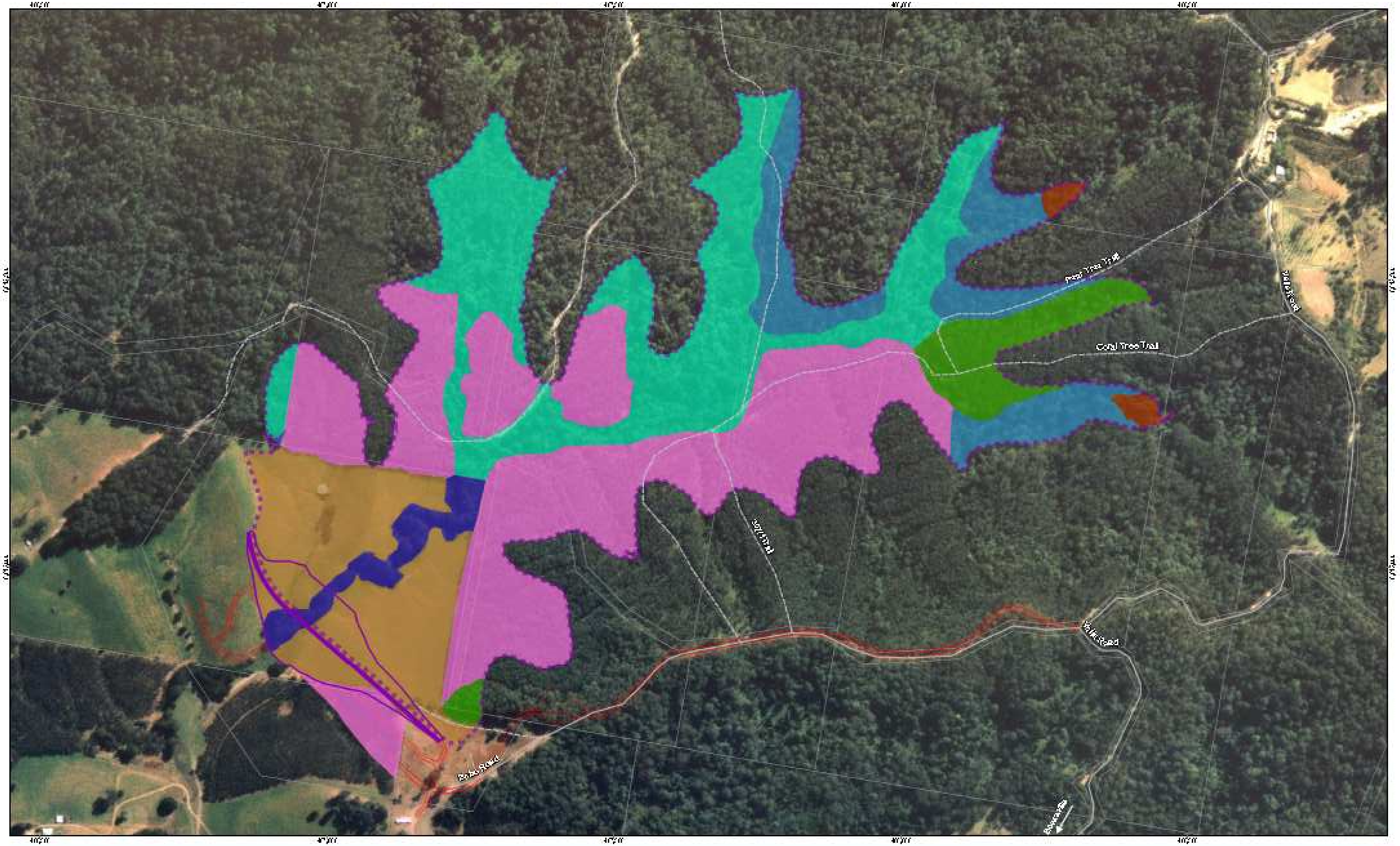
The understorey was primarily infested with weeds from approximately a 2 to 10 m depth from the roadside along the majority of the section of road surveyed, extending >100 m in one gully. The density of Lantana decreased with distance from the road edge into the forest. The overall condition of the canopy along either side of Bobo Road was considered to be good, whilst the understorey was considered to be poor because of

heavy weed 'Lantana' infestation. In consideration of the different ratings for canopy and understorey, a resulting rating of moderate has been used to describe the overall condition of this vegetation.

It is proposed that Bobo Road provide access to the storage area and would be upgraded to accommodate construction traffic and to ensure public safety. The upgrade would involve approximately 2 km of road being widened by approximately 3 metres. The survey effort examined 5 m either side of Bobo Road identifying canopy tree species and the presence of weeds.

Approximately 4.04 ha of vegetation may be removed as part of road upgrade activities. Of which 1.39 ha is Hardwood Plantation Forest, 2.65 ha is Foothills Grey Gum – Broad-leaved White Mahogany Forest dominated by the exotic plant species Camphor Laurel.

The vegetation communities within the inundation area are shown in Figure 6.



1:6,000 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND

- Fire Trail
- Road
- Cadastre
- Proposed Storage Wall
- Proposed Inundation Area

Vegetation Communities

- Foothills Grey Gum - Broad-Leaved Mahogany
- Hardwood Plantation
- Northern Wet Tallowwood - Blue Gum Forest
- Pastureland
- Riparian Vegetation
- Wet Bloodwood - Tallowwood Forest (Temperate Forest)
- Wet Flooded Gum - Tallowwood Forest
- Preliminary Road Design

Nambucca Shire Council
Bowraville Off-River Storage

Vegetation

Job Number	22-14133
Revision	A
Date	08 OCT 2009

Figure 6

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6.2 Terrestrial Flora of Conservation Significance

The Commonwealth Protected Matters Online Search Tool and the DECC Wildlife database were used to identify a preliminary suite of flora species of conservation significance that occur, or have the potential to occur (based on habitat assessment) within the study area. Appendix A presents a list of these species, and identifies their conservation status, if they were detected during the surveys or if not, their likelihood of occurrence in the study area. A summary of Appendix A is provided in Table 8.

Twelve Commonwealth and/or State listed flora species were identified on the databases, of which none were recorded during the current surveys:

- Newry Golden Wattle (*Acacia chrysotricha*);
- Rusty Plum (*Amorphospermum whitei*);
- Hairy-joint Grass (*Arthraxon hispidus*);
- Leafless Tongue-orchid (*Cryptostylis hunteriana*);
- White-flowered Wax Plant (*Cynanchum elegans*);
- Monkey Nut (*Hicksbeachia pinnatifolia*);
- Clear Milk Vine (*Marsdenia longiloba*);
- *Quassia sp. Moonee Creek (J. King s.n. 1949)*;
- Milky Silkpod (*Parsonsia dorrigoensis*);
- Minute Orchid (*Taeniophyllum muelleri*);
- Austral Toadflax (Thesium australe); and
- *Tylophora woollsii.*

Four of these species are considered likely to occur (the Rusty Plum, Tylophora woollsii, Leafless Tongue-orchid and Minute Orchid), therefore an assessment of significance has been undertaken for these species. The Newry Golden Wattle is the only other species that has the potential to occur in the study area. Biosis undertook a five-day targeted search for the Newry Golden Wattle in 2005 and recorded no individuals in the study area or surrounding lands (Biosis, 2005). This species was also not recorded during this survey effort.

Table 8 Summary of the Likelihood of Occurrence of Threatened Flora Species

Scientific Name	Common Name	Likelihood of Occurrence
Acacia chrysotricha	Newry Golden Wattle	Unlikely. Unsuitable habitat found on site due to logging and weed infestation.
Amorphospermum whitei	Rusty Plum	Possible. Suitable habitat found on site.
Arthraxon hispidus	Hairy-joint Grass	Unlikely. Little to no suitable habitat found on site. Competitive grass species occur where suitable habitat exists.
Cryptostylis hunteriana	Leafless Tongue-orchid	Possible. Suitable habitat found within the inundation area
Cynanchum elegans	White-flowered Wax Plant	No. Unsuitable habitat found on site.
Hicksbeachia pinnatifolia	Monkey Nut	Unlikely. Unsuitable habitat found on site due to

		logging and weed infestations including Lantana.
Marsdenia longiloba	Clear Milk Vine	Unlikely. Due to logging and weed infestations.
Parsonsia dorrigoensis	Milky Silkpod	Unlikely. Due to logging and weed infestations including Lantana, as well as unsuitable soil type found on site.
Quassia sp.	Moonee Quassia	No. The study area does not contain appropriate habitat. Not known from the immediate locality.
Taeniophyllum muelleri	Minute Orchid	Possible. Suitable habitat found within the inundation area.
Thesium australe	Austral Toadflax	No. This species habitat was not recorded within the study area.
Tylophora woollsii	Tylophora	Possible. Suitable habitat found on site.

6.3 Endangered Ecological Communities

The riparian vegetation in the study area has been substantially altered (both structurally and floristically) and degraded as a result of previous land management activities (logging, clearing and grazing) and is dominated by Camphor Laurel, Privet and Lantana with scattered native canopy trees. Areas of this vegetation along the Nambucca River, South Creek and lower reaches of Bowra Creek contain some elements possibly representative of the *River-flat Eucalypt Forest on Coastal Floodplains* EEC listed under the TSC Act. However, the riparian vegetation in these areas is not considered to constitute this EEC given:

- The vegetation, including canopy, understorey and groundcover strata, is dominated by exotic species;
- Native species, potentially indicative of the EEC, including Forest Red Gum and Flooded Gum, are only present as scattered and isolated individuals. The majority of the understorey was clear of vegetation due to livestock grazing and the remainder was comprised of exotic species, whilst no native understorey species typically associated with this EEC were present; and
- The study area is located well beyond the identified northern-most occurrence of the community in the Port Stephens LGA (Scientific Committee Determination, (DEC, 2005)).

Whilst the riparian vegetation of the Nambucca River and South Creek is not considered to comprise the River-flat Eucalypt Forest on Coastal Floodplains EEC as determined by the Scientific Committee, a precautionary approach has been taken and an assessment of significance has been prepared with respect to this community (refer to Appendix C). Given the relatively small area along the Nambucca River and South Creek of highly modified and disturbed riparian vegetation to be impacted (approximately 1.49 ha), a significant impact on the community is considered highly unlikely even if it does occur in some areas.

A similar riparian community was also recorded at various locations on the upper slopes of Bowra Creek catchment. These areas of vegetation are not considered to constitute 'floodplain' ecosystems and hence are not considered to constitute this EEC.

No other EECs listed under the TSC or EPBC Acts were recorded in the study area.

6.4 Terrestrial Flora Summary

The vegetation communities surveyed had differing levels of ecological function, biodiversity and weed infestation due to varying degrees of past disturbances associated with logging activities. The entire

catchment has been logged at sometime in the past, resulting in the absence of any old growth vegetation within the study area. The assessment of the survey results has determined that the condition of the Wet Flooded Gum – Tallowwood forest, Northern Wet Tallowwood – Blue Gum forest, Foothills Grey Gum – Broad Leaved Mahogany forest and Wet Bloodwood – Tallowwood forest (Temperate Rainforest) vegetation communities is **moderate**. The hardwood plantation forest, pastureland, riparian vegetation, pipeline route options, borefields and pumping station is rated as **poor**.

The adjacent lands associated with Viewmont State Forest, Bollonolla Nature Reserve, Bowraville Nature Reserve and Gladstone State Forest provide vegetation communities that have undergone less disturbance in the past with less weed infestation and greater floristic biodiversity. These vegetation communities are considered to have greater habitat value for threatened species than those identified within the study area.

6.5 Riparian and Aquatic Flora Survey Results

6.5.1 Rapid Appraisal of Riparian Condition (RARC)

The floristic and species composition of the riparian vegetation demonstrated significant variability. This variability was related to four major elements:

- Weed infestation;
- Erosion;
- Degree of flood exposure; and
- Cattle access.

All four of the above variables contributed extensively to the degree of canopy coverage, the nature and type of ground cover present, and degree of exotic species (weed) or native dominance, and intensity and type of erosion evident on the bank and riverbed.

The condition of the riparian vegetation for each of the surveyed locations is summarised in Table 9 and photographs of each survey location is available in Appendix F. A maximum score of 50 out of 50 is indicative of intact riparian vegetation where:

- All layers of native vegetation are present and provide good coverage;
- The vegetation is free of introduced weed species;
- There is a good layer of mulch present; and
- Fauna habitat is present in the form of fallen logs, branches and hollow bearing trees.

A low score below 20 out of 50 is indicative of degraded vegetation where:

- Layers of native vegetation are missing, in low numbers, fragmented and provide poor coverage;
- There is high content of introduced weed species;
- There is very little mulch present to stabilise surface soils;
- Fauna habitat in the form of fallen logs, branches and hollow bearing trees is absent or minimal.

Table 9 Summary of RARC Survey Results

Site	Stream Name & Location	Dominant Species	RARC Scoring (score out of)					
			Habitat	Cover	Natives	Debris	Features	Total
			11	*12*	*9*	*10*	*8*	*50*
R1	Bowra Creek upper catchment	*Eucalyptus grandis and Cinnamomum camphora with Ligustrum sinense, Lantana camara and native species understorey*	11	10.5	6.25	6	3.25	**37**
R2	Bowra Creek centre of proposed off-river storage dam embankment	*Cinnamomum camphora with Ligustrum sinense understorey*	7.75	8.5	1.5	3.5	1.25	**22.5**
R3	Bowra Creek downstream of proposed off-river storage dam embankment	*Exotic grasses with Cinnamomum camphora, Eucalyptus grandis and Ligustrum sinense understorey*	5.5	7.25	3	5.75	0.75	**22.25**
R4	Bowra Creek lower catchment	*Exotic grasses with Cinnamomum camphora, Eucalyptus grandis with Ligustrum sinense understorey*	1.75	7.25	2.25	3.25	0.75	**15.25**
R5	South Creek	*Casuarina cunninghamiana* subsp. *cunninghamiana, Eucalyptus grandis and Cinnamomum camphora, with Ligustrum sinense understorey*	6	8.75	1.25	4.5	0.13	**20.63**
R6	Nambucca River adjacent to the borefields	*Exotic grasses with Cinnamomum camphora, Casuarina cunninghamiana* subsp. *cunninghamiana*	2	9	4	2.75	1	**18.75**
R7	South Creek upstream from confluence with Nambucca River	*Cinnamomum camphora, Casuarina cunninghamiana* subsp. *cunninghamiana with Ligustrum sinense and Lantana camara understorey*	6.75	9.5	0.75	4.5	0.5	**22**
R8	Downstream of Nambucca River and South Creek confluence	*Cinnamomum camphora and Waterhousea floribunda*	5.75	5.25	2.25	5.25	0.38	**18.88**
R9	Nambucca River just above confluence with South Creek	*Exotic grasses with Cinnamomum camphora, Casuarina cunninghamiana* subsp. *cunninghamiana and Waterhousea floribunda*	4.25	9	0.75	3.75	0.75	**18.5**

Site	Stream Name & Location	Dominant Species	RARC Scoring (score out of)					
R10	Downstream of Nambucca River and Bowra Creek confluence	*Cinnamomum camphora and Waterhousea floribunda with Ligustrum sinense understorey*	2.75	9	2	5	0.75	***19.5***
R11	Nambucca River up North Arm Road	*Exotic grasses with Salix babylonica and Casuarina cunninghamiana* subsp. *cunninghamiana*	1.5	7	1.25	2	0	***11.75***
R12	(Missabotti Control) Unnamed Creek along Helliwells Road	*Exotic grasses with Cinnamomum camphora, Eucalyptus grandis and Tristaniopsis laurina*	3	6.75	2	3.75	1.75	***17.25***
Average Score								***20.36***

As indicated in Table 9 the average condition score for the riparian vegetation assessed was 20.36 which is indicative of past disturbances associated with grazing in the pastural land and logging within the inundation area. However the highest condition score of 37 was located at R1 in the upper reaches of Bowra Creek within the inundation area where less disturbance overtime has occurred, which is in contrast to R2 located further downstream scoring 22.5 where the hardwood plantation is located.

The lowest condition score was 11.75 at R11 located along the Nambucca River where very little riparian vegetation is present due to agricultural grazing activities. The remainder of condition scores are reflective of this same scenario where agricultural landuse has reduced the amount of riparian vegetation and encouraged the invasion of weeds.

6.6 Noxious and Environmental Weeds

The noxious weed policy of the Nambucca Shire Council is to meet the requirements as outlined in the NW Act. Acting as the Local Control Authority (LCA), Council has a responsibility to ensure that all plants declared as Noxious within the Shire are controlled according to their classification. Noxious Weeds are currently classified from Class 1 to Class 5, with differing control requirements according to their Class. Currently there are approximately 100 plants that are declared as Noxious Weeds within the Shire. There are many other plants within the Shire that are considered Environmental Weeds (NSC, 2009).

Weeds that pose a threat to lands within the Shire include Groundsel Bush (*Baccharis halimifolia*), Lantana (*Lantana* spp.) and various invasive aquatic weeds such as Salvinia (*Salvinia molesta*) and Water Hyacinth (*Eichhornia crassipes*) (NSC, 2009). There are no legal requirements to remove environmental weeds from your land unless they are declared noxious weeds (NCWAC, 2003).

Photo 1: Lantana infestation within the inundation area.

Photo 2: Camphor Laurel infestation along the lower reaches of Bowra Creek.

Under the NW Act, the growth and spread of Class 4 and 5 noxious weeds must be controlled according to the measures specified in a Noxious Weed Policy developed by the LCA. Class 5 noxious weeds are plants that are likely, by their sale or the sale of their seeds or movement within the State or an area of the State, to spread in the State or outside the State. Therefore the LCA has a responsibility to ensure that all plants declared as Class 4 or 5 noxious weeds within the LGA are controlled as shown in Table 10. Control methods may include herbicides, hand or mechanical removal or stock-grazing to consistently defoliate the plants and to control emerging seedlings.

Table 10 Noxious and Environmental Weeds Recorded in the Study Area

Common Name	Scientific Name	Listed Weed of National Significance	Noxious or Environmental Weed	*Noxious Weed Act 1993 Class*	*Noxious Weed Act 1993 Weed Control Order*
Camphor Laurel	*Cinnamomum camphora*		Noxious	Class 4	Locally Controlled Weeds
Crofton Weed	*Ageratina adenophora*		Noxious	Class 4	Locally Controlled Weeds
Giant Parramatta Grass	*Sporobolus fertilis*		Noxious	Class 4	Locally Controlled Weeds
Lantana	*Lantana camara*	Yes	Noxious	Class 4	Locally Controlled Weeds
Mistflower	*Ageratina riparia*		Noxious	Class 4	Locally Controlled Weeds
Broad-Leaf Privet	*Ligustrum lucidium*		Noxious	Class 4	Locally Controlled Weeds
Small-leaf Privet	*Ligustrum sinense*		Noxious	Class 4	Locally Controlled Weeds
Weeping Willow	*Salix babylonica*	Yes	Noxious	Class 5	Restricted Plants
Japanese Honeysuckle	*Lonicera japonica*		Environmental	N/A	N/A
Moth Vine	*Araujia sericifera*		Environmental	N/A	N/A
White Passionflower	*Passiflora subpeltata*		Environmental	N/A	N/A

The presence of eight declared weed species within the inundation area, including two Weeds of National Significance, Lantana and Weeping Willow. Camphor Laurel, Lantana, Broad-Leaf Privet and Small-leaf Privet were found in large populations throughout the inundation area and lower reach of Bowra Creek. Crofton Weed and Mistflower were primarily found where the plantation forest meets pastureland in the proximity of the proposed off-river storage dam embankment. Giant Parramatta Grass was found in the pastureland in the proximity of the proposed off-river storage dam embankment and in pastureland adjacent to the lower reaches of Bowra Creek. Weeping Willow was found in isolated locations in the lower reaches of Bowra Creek.

6.6.1 Terrestrial and Riparian Weeds

Eight noxious weeds listed under the NW Act for the Nambucca LCA occur within the inundation area and six noxious weeds were recorded in the riparian vegetation assessed whilst undertaking RARC surveys, as shown in Table 11.

Table 11 Weeds Recorded in Terrestrial and Riparian Vegetation

Noxious Weeds Recorded	Terrestrial	Riparian
Camphor Laurel	X	X
Crofton Weed	X	X
Giant Parramatta Grass	X	X
Broad-Leaf Privet	X	X
Mistflower	X	X
Lantana	X	X
Weeping Willow	X	X
Small-leaf Privet		X
Environmental Weeds Recorded		
Japanese Honeysuckle	X	
White Passionflower	X	
Moth Vine	X	

6.6.2 Aquatic Weeds

One aquatic environmental weed, Parrot's Feather (*Myriophyllum aquaticum*), listed by the Nambucca LCA was recorded in a waterbody adjacent to riparian vegetation whilst undertaking RARC surveys. The listed weeds recorded are depicted in Table 12

Table 12 Riparian and Aquatic Noxious and Environmental Weeds Recorded whilst undertaking RARC surveys.

Common Name	Scientific Name	Listed Weed of National Significance	Noxious or Environmental Weed	*Noxious Weed Act 1993 Class*	*Noxious Weed Act 1993 Weed Control Order*
Camphor Laurel	*Cinnamomum camphora*		Noxious	Class 4	Locally Controlled Weeds
Giant Parramatta Grass	*Sporobolus fertilis*		Noxious	Class 4	Locally Controlled Weeds

Lantana	*Lantana camara*	Yes	Noxious	Class 4	Locally Controlled Weeds
Small-leaf Privet	*Ligustrum sinense*		Noxious	Class 4	Locally Controlled Weeds
Weeping Willow	*Salix babylonica*	Yes	Noxious	Class 5	Restricted Plants
Parrots Feather	*Myriophyllum aquaticum*		Environmental	N/A	N/A

6.7 Riparian and Aquatic Flora of Conservation Significance

The Commonwealth Protected Matters Online Search Tool and the DECCW Wildlife database were used to identify a preliminary suite of flora species of conservation significance that occur, or have the potential to occur (based on habitat assessment) within the study area. Appendix D presents a list of these species, their conservation status, and their detection during the surveys and likelihood of onsite occurrence in relation to the habitat present in the study area. No additional threatened aquatic flora species appeared in the database searches, therefore all relevant threatened flora species have been discussed in Section 6.2.

6.8 Riparian and Aquatic Flora Summary

Almost the entire riparian vegetation surveyed scored poorly 20.36 out of 50 under the RARC scoring system. The only exception was R1 located in the upper catchment of Bowra Creek scoring 37, however R2 scored 22.5, which is more indicative of the riparian vegetation observed throughout the upper catchment. The poor level of scoring is primarily due to past disturbances associated with land clearing and livestock grazing. This was to be expected due the prominence of agriculture in the area creating fragmented thin strips of riparian vegetation adjacent to the waterways surveyed. The high level of weed infestation also contributed significantly to the low scores.

Only one aquatic weed species was recorded at the survey sites, Parrots Feather (*Myriophyllum aquaticum*). This weed is an environmental weed under the NW Act for the Nambucca LCA and conversations with NSC's weed officer has identified this weed as a potentially invasive weed. It was recorded at R4 survey site in a small dam along Bowra Creek. Precautionary measures should be taken to ensure that this weed does not spread any further as a result of pipeline construction works.

Photographs of each survey location are available in Appendix F.

7. Terrestrial Fauna Survey Results

7.1 Fauna Habitat

The fauna habitats recorded during the current assessment are described below. For the purpose of this assessment, the study area consisted of the inundation area, a section of three potentially impacted waterways (Nambucca River and, South and Bowra Creeks), the pipeline route, the existing and proposed borefields and Bobo Road. The above mentioned areas are shown on Figure 4 and described below.

7.1.1 Inundation Area

The inundation area consists of 58.59 ha of both managed plantation forest and remnant native forest, as described below and shown in Figure 7.

Native Forest Habitat (32.65 ha)

The non-plantation forest habitat comprises of four different vegetation communities of varying extent and were typically found on the upper slopes of the inundation area. In general these areas were characterised by larger trees (up to 35 m high) and provided some small hollows and stags potentially used by a variety of bird, mammal and reptile species. However the hollows observed were small and unsuitable for larger forest fauna. The majority of hollows were recorded in the higher elevations of the study area above the inundation area and were of a small to medium size whilst some larger more developed hollow-bearing trees and stags were recorded along Bobo Road.

Dominant canopy species included Flooded Gum, Tallowwood, Blackbutt and Sydney Blue Gum. The understorey consisted of sapling trees and groundcover typically comprising ferns and grasses. Smaller sections of rainforest habitat with dense vegetation were also present in gullies.

There was an abundant groundcover of fallen debris and leaf litter (approximately 10 %), which would provide suitable foraging and shelter habitat for bird, mammal, frog and reptile species. The larger debris mainly comprised of fallen branches and small trees.

Good connectivity remains with surrounding habitats of greater habitat value whilst the native forest within the inundation area is considered to be of low to moderate habitat value to native fauna, due to a shortage of large hollow bearing trees, a high level of noxious weed infestation and a low level of floristic diversity in the understorey.

Hardwood Plantation Forest Habitat (25.94 ha)

A large proportion of the inundation area is Flooded Gum and Blackbutt hardwood plantation forest. The trees are on average 200 –350 mm diameter at breast height (DBH) and 20-25 m high. Due to this area being historically logged, there were no hollows in this area identified that would provide shelter and breeding habitat for hollow dependant forest fauna such as microbats and owls, however some small hollows and fissures in trees may provide roosting habitat for microbats. The understorey and groundcover consisted mainly of Camphor laurel and Lantana especially on the lower slopes and along drainage lines. These species are both considered noxious weeds but are providing shelter and foraging resources for a number of species.

There was also typically an abundant groundcover of fallen debris and leaf litter (approximately 20 %), which would provide suitable foraging and shelter habitat for bird, mammal, frog and reptile species, however no

large logs with hollows were identified as present as most debris was form thin small trees and fallen branches.

Remnant and cleared vegetation across the inundation area maintains good connectivity with vegetated areas to the north including areas of Viewmont State Forest (890 ha), Bowraville Nature Reserve (80 ha) and Bollonolla Nature Reserve (666 ha) which connect with Newry State Forest towards the coast and Gladstone State Forest (7,200 ha) towards the Great Dividing Range. The plantation forest was considered to have low fauna habitat value. The conservation significance of this vegetation community is considered low due to decreased species diversity and structural modification due to human management.

Riparian Habitat

The riparian habitat was a mixture of hardwood plantation forest and native forest. This habitat was primarily dominated by Flooded Gum and Blackbutt that averaged 180 –250 mm diameter at breast height (DBH) and were in the range of 20-25 m high. This native canopy was associated with the weed Camphor Laurel and had an understorey primarily infested with the weeds Lantana and Small-leaf Privet. Due to this area being historically logged, there were little to no hollows in this area that would provide shelter and breeding habitat for hollow dependant forest fauna such as microbats and owls, however some small hollows and fissures in trees may provide roosting habitat for microbats. The weed species occurring in the riparian habitat may provide shelter and foraging resources for a number of species.

There was also typically an abundant groundcover of fallen debris and leaf litter, which would provide suitable foraging and shelter habitat for bird, mammal, frog and reptile species, however this debris and leaf litter would become disturbed and unavailable in the advent of flood events. Good connectivity remains with surrounding habitats and this area was thought to be representative of moderate to low fauna habitat due to a lack of hollow bearing trees, a high level of noxious weed infestation and structural modification resulting in a low level of floristic diversity in the understorey.

Pastureland

The pastureland associated with the location of proposed access roads, pipeline route and off-river storage embankment infrastructure has been used to graze livestock and grow fodder crops. The habitat values in these areas for native fauna are considered low because most flora species are introduced and frequently grazed by livestock.

Connectivity of Inundation Area with Wildlife Corridors

The study area is 81.08 ha and is situated in the southern-most portion of the Viewmont State Forest (VSF), which covers an area of approximately 890 ha. Directly north of VSF is the Bollonolla Nature Reserve (650 ha), which connects to the northern portion of VSF. Further to the northwest VSF is adjacent to Bowraville Nature Reserve (80 ha) and is contiguous with the large Gladstone State Forest (approximately 7,200 ha). Agricultural land occurs to the south and west of the inundation area. Additionally it is proposed that NSC acquire approximately 220 ha of land with approximately 123 ha of vegetation surrounding the inundation area being identified as a protection area for the Proposal which would be conserved and protected from logging over the long-term.

7.1.2 Riparian Corridor Habitat

Riparian areas along the Nambucca River, South Creek and below the inundation area forest along Bowra Creek were typically thin and structurally modified or cleared due to agriculture and other anthropogenic activities.

The Nambucca River is a permanent flowing river while Bowra Creek is ephemeral. The dominant species along all waterways surveyed were exotic species, Camphor Laurel, Small-leaf Privet and Lantana. Although, there were a number of large scattered isolated native trees including Flooded Gum, Forest Red Gum and River Oak that would provide resources for a number of native bird species. There were also sections of the waterways with moderate amounts of leaf litter and large woody debris (LWD) in the thin riparian areas. The riparian corridors were considered to be of low habitat value due to their minimal width and the prevalence of exotic species in the canopy and understorey.

The relative local and regional value of these riparian corridors is considered low because of land clearing and agricultural land use that has resulted in riparian corridors that are structurally modified, weed infested, fragmented and of reduced habitat value. This is the case with a vast amount of the riparian corridors in the Nambucca catchment. The availability of better riparian habitats is minimal and restricted to the upper reaches of the catchment that are steeper, unsuitable for agriculture and are primarily owned and managed by DI&I.

7.1.3 Pipeline Route

The borefield pipeline route transects agricultural and urban lands adjacent to Bowra Creek and existing roads. The pipeline route runs south along Bowra Creek and veers west toward the existing borefields. These areas adjacent to the riparian zone were considered to be of reduced habitat value due to previous and present clearing and grazing activities resulting in structurally modified vegetation communities.

There would be two under bores created for the pipeline at identified locations along the Nambucca River whilst the transfer pipeline to the storage would be either connected to the side of the existing crossing of Bowra Creek or underbored, as shown in Figure 4. The underboring/ connection to the culvert process would not impede movement in either the river or the creek and is considered to minimally impact the surrounding environment once construction is completed.

7.1.4 Borefields and Headworks

The existing borefields and headworks are located adjacent to the Nambucca River upstream from South Creek. There is a small weir next to the existing borefield, which has been formed due to accumulation of debris behind the existing pipeline crossing.

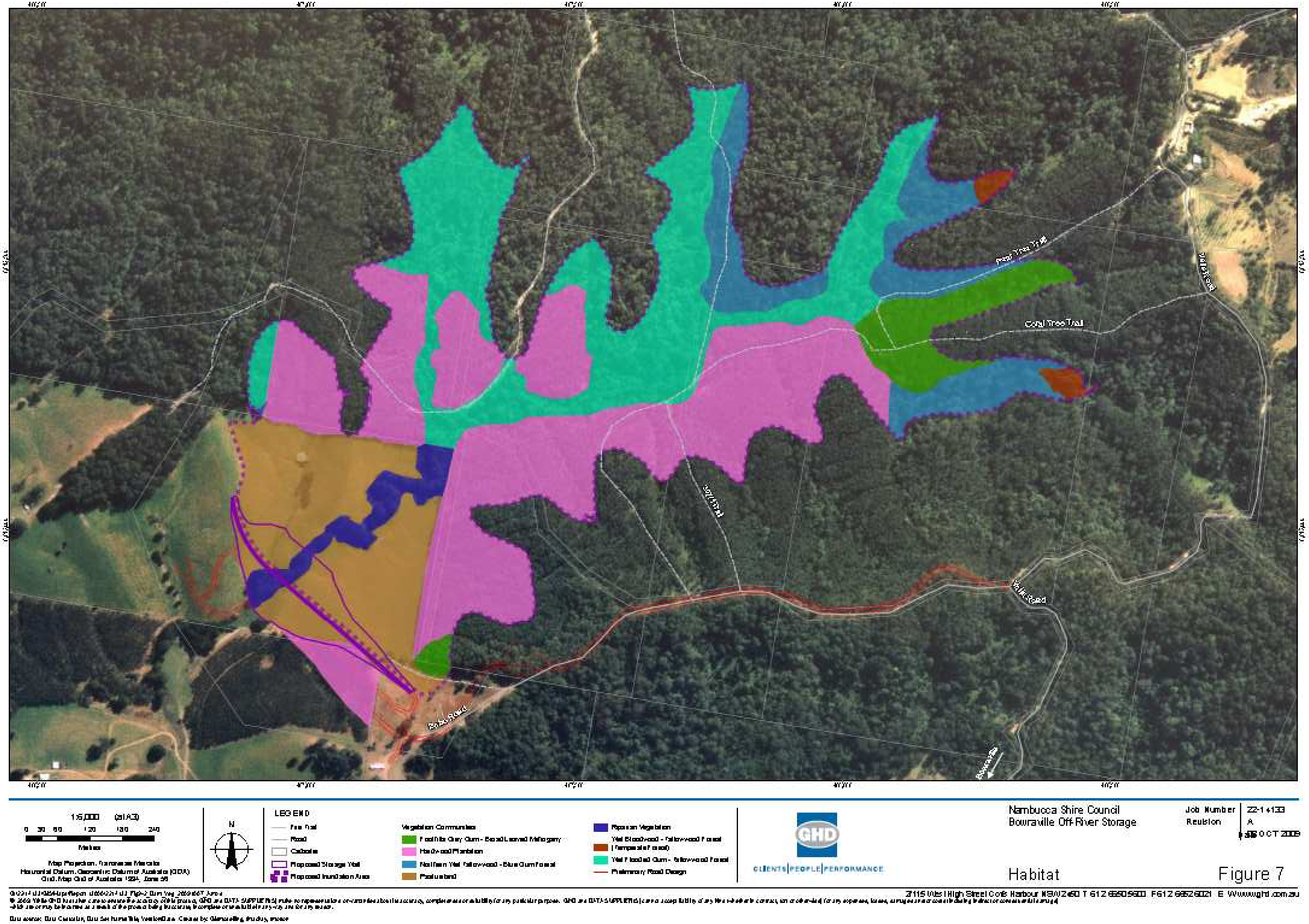
The proposed borefields are located north of the existing borefield along the Nambucca River and adjacent to the west bank of South Creek. The borefield sites typically consist of grazing land and a thin disturbed riparian zone. These areas adjacent to the riparian vegetation were considered to be of low fauna habitat value due to previous clearing and existing grazing activities.

7.1.5 Bobo Road

Bobo Road, which runs to the west of Valla Road to the inundation area, would need to be upgraded due to improve construction access. The upgrade would involve approximately 2.0 km of road being widened to a 6 m formation with 3 m bitumen seal.

Bobo Road was considered moderate quality fauna habitat due to several large stags/ hollow-bearing trees and abundant ground debris and leaf litter, however there is a high level of noxious weed infestation and a low level of floristic diversity in the structurally modified understorey.

The habitat resources described above are shown in Figure 7.


Pipe Tree Trail
Coral Tree Trail
Valla Road
Bowraville
1:6,000 (at A3)
0 30 60 120 180 240
Metres
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56
LEGEND
Fire Trail
Road
Cadastre
Proposed Storage Wall
Proposed Inundation Area
Vegetation Communities
Foothills Grey Gum - Broad-Leaved Mahogany
Hardwood Plantation
Northern Wet Tallowwood - Blue Gum Forest
Pastureland
Riparian Vegetation
Wet Bloodwood - Tallowwood Forest (Temperate Forest)
Wet Flooded Gum - Tallowwood Forest
Preliminary Road Design
CLIENTS | PEOPLE | PERFORMANCE
Nambucca Shire Council
Bowraville Off-River Storage
Habitat
Job Number 22-14133
Revision A
Date OCT 2009
Figure 7
2/115 West High Street Coffs Harbour NSW 2450 T 61 2 6650 5600 F 61 2 6652 6021 E www.ghd.com.au

7.1.6 Fauna Habitat Discussion

The inundation area, dam embankment footprint, pipeline routes and access roads are all considered to possess low to moderate habitat values in comparison to the surrounding lands associated with the greater Viewmont State Forest because:

- The open forest vegetation within the study area has limited native food resources due to structural modification resulting from past logging activities and subsequent weed invasion;
- The understorey and groundcover of the study area is heavily infested with invasive noxious weeds, making the vegetation somewhat unsuitable for most predatory birds such as owls and may restrict the movement of larger native mammals;
- The study area contains forested land, although structurally modified, that makes up a small portion of an extensive tract of native vegetation that is comprised of a large expanse of State Forests and Nature Reserves (Viewmont State Forest 890 ha, Bollonolla Nature Reserve 650 ha and Bowraville Nature Reserve 80 ha). The study area is located at the southern extent of this wildlife corridor;
- The presence of noxious weeds in the study area has modified the floristic structure and reduced diversity in the understorey. This is even more so along the ephemeral creek lines and riparian corridors;
- There were no hollow bearing trees recorded in the inundation area that would typically provide habitat for threatened species such as forest owls and colonies of microchiropteran bats. These trees are more prevalent in the steeper/ elevated areas (ridgelines) above the inundation area associated with the greater Viewmont State Forest, where logging activities appear to have been less frequent; and
- The inundation area contains a variety of preferred Koala feed trees (e.g. Grey Gum, Flooded Gum, Blackbutt and Tallowwood), however this habitat is not considered core Koala habitat, because the study area is located in DI&I land and therefore SEPP 44 does not apply and the one listed feed tree species (Tallowwood) does not occur in densities within the study area greater than 15 %, therefore the study area is only considered potential Koala habitat. However the presence of these trees would provide foraging resources for a population of Koalas. In light of this finding in combination with the recording of one male Koala during a call playback session indicates that the study area may be part of a larger home range and therefore the Assessment of Significance has been undertaken for this species (see Appendix C).

7.1.7 Surrounding Habitat & Habitat Links/Wildlife Corridors

The study area is situated on the southern edge of an extensive wildlife corridor at this locality that links with east-west regional corridors, as shown in Figure 1. The habitats in the inundation area are considered to be of moderate to low value given its spatial context within the surrounding landscape. This wildlife corridor is comprised of Viewmont State Forest (890 ha), Bollonolla Nature Reserve (650 ha), Bowraville Nature Reserve (80 ha) and the large Gladstone State Forest (approximately 7,200 ha). The wildlife corridor connected to the study area is vast and provides ideal connectivity to the study area to allow the ease of passage of native fauna.

Visual inspections of the vegetation along driving transects in the surrounding lands associated with the greater Viewmont State Forest indicated a greater abundance of native food resources than that of the study area with an understorey that is less structurally modified.

The abundance foraging resources provides viable foraging habitat for forest and woodland avifauna such as the Wompoo Fruit Dove (*Ptilinopus magnificus*), Glossy Black Cockatoo (*Calyptorhynchus lathami*) and Brown

Treecreeper (*Climacteris picumnus*) and bat species such as the Grey-headed Flying-fox (*Pteropus poliocephalus*), Golden-tipped Bat (*Kerivoula papuensis*), Little Bentwing Bat (*Miniopterus australis*) and Eastern Long-eared Bat (*Nyctophilus bifax*), frogs such as Green and Golden Bell Frog (*Litoria aurea*), Giant Barred Frog (*Mixophyes iteratus*) and Southern Barred Frog (*Mixophyes balbus*) and invertebrate species.

Potential nest sites for passerine birds are present throughout the forest communities of the study area, including dead branches, small tree-hollows, open cavities, and patches of dense undergrowth that was primarily comprised of Lantana and was structurally modified as a result. A number of large tree-hollows in the more elevated areas of the study area and surrounding lands provide potential nesting sites for forest owls such as the Barking Owl (*Ninox Connivens*), Masked Owl (*Tyto novaehollandiae*) and Sooty Owl (*Tyto tenebricosa*) and parrots such as the Glossy Black-Cockatoo and high branch perches and stable branch or trunk nest platforms are present which are used by other non-passerine bird species.

The majority of hollows recorded in the higher elevations of the study area above the inundation area and associated with the proposed access roads were of a small to medium size ideal for most hollow dependant fauna apart from large forest owls and large arboreal mammals (Yellow-bellied Glider). Some larger more developed hollow-bearing trees and stags were recorded along Bobo Road that may potentially provide hollows large enough for large forest owls and large arboreal mammals.

The open forest within the study area and on surrounding land provides some resources for arboreal herbivorous and sap feeding mammals such as the Koala (*Phascolarctos cinereus*) and Sugar Glider (*Petaurus breviceps*), browsing carnivores such as the Spotted-tail Quoll (*Dasyurus maculatus*) and nectarivorous birds such as the Regent Honeyeater (*Xanthomyzon phrygia*). However the vegetation in adjacent lands is considered of greater habitat value due having undergone a decreased frequency of logging.

Most of the microchiropteran bats recorded apart from the Golden-tipped Bat are likely to forage widely throughout the areas of open forest in the inundation area preying upon insects above and within the canopy and along the ecotones between creek lines, forest stands and open areas. The Golden-tipped Bat prefers to forage in the more elevated areas on upper-slopes, however its roosting sites would be located in the riparian areas of the inundation area in abandoned Yellow-throated Scrub-wren and Brown Gerygone hanging bird nests.

The structurally modified understorey (primarily comprised of noxious weeds) and groundcover would provide some shelter and foraging habitat for certain species, including arboreal and terrestrial mammals, reptiles and passerine and non-passerine bird species. The moderate leaf litter layer provides suitable foraging habitat for some small ground-dwelling mammals as well as small reptiles and foraging birds. Moreover, the fallen timber and hollow logs in some areas may provide suitable denning, sheltering and foraging habitat for a range of fauna such as the Long-nosed Potoroo (*Potorous tridactylus*), Hastings River Mouse (*Pseudomys oralis*), Spotted–tail Quoll, Southern Barred Frog and Giant Barred Frog, non of which were recorded. However the vegetation in adjacent lands is considered of greater habitat value due having undergone a decreased frequency of logging.

Larger terrestrial mammals (Long-nosed Potoroo and Koala) may seek diurnal refuge in the dense gully vegetation and may be more likely to forage on vegetation in surrounding lands that potentially provide a greater range of resources because this vegetation is not as structurally modified. It is possible that the Spotted-tail Quoll, which requires large areas of forest and woodland habitat to meet its home range requirements, also occurs in the study area and adjacent lands on a transient basis. This species was not recorded during the recent survey.

The Wet Bloodwood - Tallowwood Forest (Temperate Rainforest) located in the upper reaches of the inundation area is likely to provide habitat for the Southern Barred frog, Giant Barred Frog and Wompoo Fruit-dove. This rainforest vegetation could be considered degraded because of past structural modification associated with logging practices and weed infestation. This vegetation is in the early stages of successional development with a canopy dominated by Tallowwood with very few large rainforest trees favourable to the Koala and Wompoo Fruit-dove. Additionally these areas may easily become dry due the canopy being fragmented and not entirely closed potentially making it seasonally unsuitable for the Southern Barred Frog and Giant Barred Frog.

The Bowra Creek riparian habitat in the inundation area is structurally modified reducing habitat values for the Southern Barred Frog and Giant Barred Frog, however these species were still considered likely to occur. Additionally Bowra Creek is ephemeral in nature and can remain dry for varying periods of time such as during the recent drought period.

7.1.8 Hollow Bearing Trees and Logs

As mentioned earlier there is a shortage of hollow bearing trees present within the inundation area of the study area, of which only small hollows are present. This could be expected due to past logging practices having removed trees large enough to become hollow bearing.

None of the hollow bearing trees identified had hollows large enough to accommodate threatened large forest owls, arboreal mammals or microbat colonies. There were some small hollow fallen logs identified that may provide denning sites for common small ground dwelling mammals, however none were identified as being large enough for the threatened Spotted-tail Quoll or Long-nosed Potoroo.

7.2 Fauna Survey Results

Fauna species recorded during the current assessment are described below. A full list of fauna species recorded in the study area has been included in Appendix C.

7.2.1 Birds

During this survey, 38 native bird species were recorded in the study area. Three are listed as threatened species in NSW, the Barking Owl, Masked Owl and Sooty Owl, all of which were recorded during call playback surveys, whilst two are migratory species, Cattle Egret and Rufous Fantail, listed under the EPBC Act. These species are discussed further in Section 7.3. Additional species typical of woodland and open forest were recorded, including: Australian Magpie (*Gymnorhina tibicen)*, Magpie-lark *(Grallina cyanoleuca),* Eastern Whipbird (*Psophodes olivaceous)* and Sulphur-crested Cockatoo (*Cacatua galerita).*

Six common wetland avifauna were also recorded in several large farm dams within the study area and surrounds including Hardhead Duck (*Aytha australis*), Pacific Black Duck (*Anas superciliosa*), and Cattle Egrets (*Ardea ibis*). White Ibis *(Threskiornis molucca)*, Nankeen Night Heron (*Nycticorax caledonicus*) and White-faced Heron (*Egretta novaehollandiae)* were also opportunistically recorded in or nearby open water bodies throughout the locality.

The dominant nectarivorous species recorded included common honeyeaters. Common insectivorous species included Willie Wagtail (*Rhipidura leucophrys*) Grey Fantail (*Rhipidura fuliginosa*), and Superb Fairy-wren (*Malurus cyaneus*). Seed-eating species such as the Red-browed Finch (Neochmia temporalis), Sulphur-crested Cockatoo (*Cacatua galerita*), Eastern Rosella (*Platycercus eximius*) and Crimson Rosella

(*Platycercus elegans)* were also commonly recorded in woodland stands and foraging in open areas. A number of frugivorous bird species (e.g. Pied Currawong (*Strepera graculina*) and Green Catbird (*Ailuroedus crassirostris*)) were also recorded in woodland and forest habitats.

Two diurnal raptor species Pacific Baza (*Aviceda subcristata*) and Black-shouldered Kite (*Elanus axillaris*) were recorded in the study area during the current survey. However, it is expected that other raptors may occur in the locality. The contiguous nature of the vegetation across the study area and wider locality is of particular relevance for species that require large areas for foraging and can migrate large distances.

Other predatory bird species, such as Laughing Kookaburra (*Dacelo novaeguineae*), were recorded searching for prey from high vantage points, including in tree canopies at the ecotones between native vegetation and cleared areas and along tracks and roadsides.

Five introduced bird species have also been recorded in the study area or locality (Appendix C). These species including the Common Myna (*Acridotheres tristis*) and Rock Dove (*Columba livia*) are ubiquitous in semi-rural and modified urban environments.

7.2.2 Ground and Arboreal Mammals

Four (4) ground dwelling and two (2) arboreal mammal species were recorded in the study area during this survey. Two of the ground dwelling species, cattle (domestic) and horse (domestic) were observed in the agricultural areas south of the inundation area. The other two species, Feral Cat (*Felis catus*) and Eastern Grey Kangaroo (*Macropus giganteus*), were observed crossing Bobo Road and within the inundation area.

The two arboreal species, the TSC Act listed Koala and non-threatened Brushtail Possum (*Trichosurus vulpecular*), were recorded near the back of the inundation area close to the headwaters of Bowra Creek. The Brushtail Possum was seen while spotlighting and the Koala was heard calling during nocturnal survey activities.

No other threatened mammal species listed in Appendix A, have the potential to occur, due to reduced habitat values because of structural modification associated with past logging activities and subsequent weed invasion.

Although, a number of additional mammal species, including small terrestrial mammals and medium-sized terrestrial mammals are likely to occur in the locality from time to time given the diversity of habitats and specific resources (e.g. mature hollow-bearing trees in elevated areas, dense ground cover) and the connectivity of existing areas of habitat with more extensive areas in all directions. Ground dwelling mammals are likely to include the Brown Antechinus (*Antechinus stuartii*) and Long-nosed Bandicoot (*Perameles nasuta*), as well as a number of murids, such as the Bush Rat (*Rattus fuscipes*) and the introduced Black Rat (*Rattus rattus*) and House Mouse (*Mus musculus*) (all of which have been observed in previous surveys). The presence of the latter two species is more likely in the disturbed environments.

All of the ground and arboreal mammal species observed to date are common or introduced except the Koala, which is discussed further in Section 7.3.

7.2.3 Bats

Surveys were completed for megachiropteran and microchiropteran bats. Anabat survey data was recorded at a number of locations within Viewmont State Forest (inundation area) between 17th and 21st November 2008. Diurnal surveys and spotlighting were also completed to determine the potential for flying fox campsites within the study area.

Anabat data results

The Anabat data was analysed by Greg Ford. Results are presented in Table 13.

Overall data quality was poor to fair, with significant background interference in many files making call identification difficult for most recording sessions. In particular, of the 2,000 sequence files included for "Anabat s1" on 17th November, more than 1,800 contained only low-frequency noise, interspersed with occasional poor-quality bat calls. Despite the poor recording quality, however, most calls belonged to just a few species and enough clear calls were available to enable reliable identification.

Table 13 Data Quantity and Proportion with Recognisable Bat Calls

Folder Name	Survey Date	Number of sequence files	Number of files with bat calls
Anabat n1	17/11/2008	142	96
	18/11/2008	137	111
	21/11/2008	111	26
Anabat s1	17/11/2008	36	33
	18/11/2008	2002	180
	21/11/2008	1	0

Call identification standard

Call identification for this data set was based on bat call keys published for southern Queensland (Reinhold *et al.* 2001) and New South Wales (Pennay *et al.* 2004), and an extensive library of reference calls recorded in southern Queensland and northeastern New South Wales.

Analysis results

At least eight and possibly ten species were recorded during this survey; however, only six species could be positively identified.

Table 14 lists the species recorded and shows the reliability of identification attributed to the best calls available for each species. Species presence is coded according to highest level of confidence achieved in call identification. Identification confidence is coded as follows:

A **Definite** one or more calls where absolutely no doubt about identification of bat

B **Probable** most likely the species named; low probability of confusion with species that use similar calls

C **Possible** call is comparable with the listed species, but moderate to high probability of confusion with species with similar calls

The reliability of identification and probability of occurrence for each species is discussed in the "Species Notes" section following the table.

Table 14 Bats Recorded at Bowraville, November 2008

SPECIES	COMMON NAME	STATUS	Anabat n1			Anabat s1		
			17th	18th	21st	17th	18th	21st
Tadarida australis	White-Striped Free-Tailed Bat	Not listed		A		A		No bats recorded
Chalinolobus gouldii	Gould's Wattled Bat	Not listed	C					
Kerivoula papuensis	Golden-Tipped Bat	Vulnerable[1]				A		
Miniopterus australis	Little Bent-Winged Bat	Vulnerable[1]	A	B	B	C	A	
Miniopterus schreibersii oceanensis	Eastern Bent-Winged Bat	Vulnerable[1]	A				A	
Nyctophilus species	Unknown Long-Eared Bat	Not listed		A	A		A	
Scotorepens orion	Eastern Broad-Nosed Bat	Not listed					B	
Vespadelus pumilus	Eastern Forest Bat	Not listed	A	A	A	B	A	

1 = listed as Vulnerable under the TSC Act.

Species Notes

Tadarida australis (White-striped Freetail-bat)

This species produces distinctive calls at a lower frequency than any other bat likely to occur in the survey area. Several brief call sequences recorded during two sessions.

Chalinolobus gouldii (Gould's Wattled Bat)

This species is one of the easiest to identify in Anabat call data, due to its characteristic alternating pulse frequency. Minor frequency overlap with *S. orion* and *S. rueppellii* (see below), so possible to confuse brief or poor calls, but latter species has consistent pulse frequency in better quality calls.

A single brief and noisy call was allocated as possibly from *C. gouldii* for "Anabat n1" on 17th November; however, the poor call quality prevented confirmation of the species' presence.

Kerivoula papuensis (Golden-tipped Bat)

Produces very low intensity calls that are not well-recorded by the Anabat system unless the bat is flying close to the detector; however, call shape and frequency are highly distinctive and fairly easy to differentiate from other species likely to occur in the survey area. This species is listed as vulnerable under the TSC Act.

A single call was positively attributable to this species on 17th November for "Anabat s1".

Miniopterus australis (Little Bentwing-bat)

Usually produces distinctive calls >55 kHz, but some frequency overlap with *V. pumilus* (see below) and poor quality calls can be difficult to differentiate. *M. australis* may have been present at all recording locations, but was positively identified for only two sessions. Most calls in the overlap frequency range were considered more likely *V. pumilus*. This species is listed as vulnerable under the TSC Act.

Miniopterus schreibersii oceanensis (Eastern Bentwing-bat)

Calls are usually distinctive, with long-duration pulses and, often, erratic changes in frequency; however, some frequency overlap with *Vespadelus darlingtonii* and *V. regulus*, and poor quality sequences are not reliably differentiated. A few brief calls were positively identified as this species for two sessions; pulse characteristics were typical of *M. s. oceanensis* and showed no similarities to the *Vespadelus* spp. This species is listed as vulnerable under the TSC Act.

Nyctophilus species

Distinctive calls readily differentiated from most other species. Can be confused with Large-footed Myotis (*Myotis macropus*), but differences in pulse slope and repetition rate can be used to separate these species in better quality recordings. Several good quality calls were readily attributable to *Nyctophilus* sp. for three sites.

Nyctophilus species cannot be differentiated using call data. Published distributional information (e.g. Churchill 1998) suggests that three species may occur in the survey area: Eastern Long-eared Bat (*Nyctophilus bifax*), Lesser Long-eared Bat (*N. geoffroyi*), and Gould's Long-eared Bat (*N. gouldi*).

Scotorepens orion (Eastern Broad-nosed Bat)

Calls overlap slightly with those of *C. gouldii* (see above), but *S. orion* call pulses are repeated at consistent frequency (*cf.* alternating frequency in *C. gouldii*). More likely to be confused with *Scoteanax rueppellii* (Greater Broad-nosed Bat), which may also be present in the survey area (Churchill1998).

A single call recorded on 18th November for "Anabat s1" was considered most likely from *S. orion*, but data quality was insufficient to obtain positive identification. It is possible that this call was from *S. rueppellii*.

Vespadelus pumilus (Eastern Forest Bat)

Calls are generally distinctive; however, frequency overlaps with *M. australis* (see above), as well as Little Forest Bat (*V. vulturnus*) and Eastern Cave Bat (*V. troughtoni*). Differentiation between the three *Vespadelus* species is difficult where frequencies overlap; however most calls for this survey were at a higher frequency than expected for either *V. troughtoni* or *V. vulturnus* and were therefore considered most likely from *V. pumilus*.

Megachiropteran Bats

The Grey-headed Flying Fox was recorded by Connell Wagner (1997) in the inundation area and is known from the locality (there is an existing GHFF camp on the lower reaches of the Nambucca River just south of the Bowra Creek Nambucca River confluence, adjacent to aquatic survey site NR-5) and is likely to forage within the study area occasionally. The Grey-headed Flying Fox is listed as a vulnerable species under both the TSC Act and the Commonwealth EPBC Act. This species feeds on a variety of fruiting and flowering plants, including the fruits of native figs and palms and the blossoms of eucalypts, angophoras, tea-trees and banksias. Grey-headed Flying Foxes roost in large camps, which are commonly located in vegetation with a dense canopy in gullies in close proximity to water. The impacted area does not contain a known campsite for this species and the gully forest habitats are not considered suitable roost sites for this species.

7.2.4 Reptiles

Seven terrestrial reptile species were recorded in the study area including snakes, skinks and monitors (Appendix C).

The Grass Skink (*Lampropholis delicata*) was recorded amongst leaf litter and ground debris in stands of remnant or regenerating vegetation and is likely to be abundant and widespread in such habitats throughout the study area. Similarly, Eastern Water Dragon (*Tympanocryptis diemensis*) were recorded in woodland and forest where suitable logs and rocks and other natural debris provided cover.

There were scratches on a number of Grey gums from varanid species. Lace Monitor (*Varanus varius*) was sighted several times in numerous locations climbing trees during the survey period.

Two snake species were recorded, Red-Bellied Black Snake (*Pseudechis porphyriacus*) and Diamond Python (*Morelia spilota spilota*). Both were observed on the trail near the origin of Bowra Creek. Several Blue tongues were also observed on the roadside, alive and dead.

The diversity of reptiles recorded was low due to the low presence of potential habitats in the study area, it is anticipated that other reptile species may be present but were not detected during the current investigations. No threatened reptile species such as Stephens' Banded Snake were recorded.

7.2.5 Amphibians

Four species were identified as threatened under the EPBC Act that may occur in the study area as shown in Table 15. None of these species were recorded during the survey.

The Eastern Common Froglet (*Crinia signifera*) is known to inhabit the study area and was audible at sites BC1 and BC2 during the survey. Numerous individuals were also heard and sighted above the proposed inundation area on the night of November 20th during terrestrial fauna call playback surveys.

Table 15: Threatened and Recorded Amphibians of the Study Area

Common name	Scientific name	Family name	Native/ exotic	EPBC status	TSC status	Location
Green and Golden Bell Frog	*Litoria aurea*	Hylidae	Native	Vulnerable	Endangered	-
Booroolong Frog	*Litoria booroolongensis*	Hylidae	Native	Endangered	Endangered	-
Southern Barred Frog,	*Mixophyes iteratus*	Myobatrachidae	Native	Endangered	Endangered	-
Eastern Common Froglet	*Crinia signifera*	Myobatrachidae	Native	Least concern	Not listed	BC1
Striped Marsh Frog	*Limnodynastes peronii*	Hylidae	Native	Least concern	Not listed	BC1, BC2

7.3 Terrestrial Fauna of Conservation Significance

7.3.1 Threatened Fauna Species

The Commonwealth Protected Matters Online Search Tool and the DECCW Threatened Species database were used to identify a preliminary suite of fauna species of conservation significance that occur, or have the potential to occur (based on habitat assessment) within the study area. Forty-two Commonwealth and/or State listed fauna species were identified on the databases.

Seven threatened species were recorded in the present study and another seven threatened species were considered likely to occur based on this assessment. Assessment of Significance (AoS) of impacts on these species are provided in detailed in Appendix C and summarised in Section 10.8.

These species and their EPBC Act and TSC Act status are detailed in Table 16.

Table 16 Conservation Status of Threatened Species Recorded or Considered Likely to Occur

Species Recorded	EPBC Act Status	TSC Act Status
Barking Owl	Not Listed	Vulnerable
Masked Owl	Not Listed	Vulnerable
Sooty Owl	Not Listed	Vulnerable
Koala	Not Listed	Vulnerable
Golden-tipped bat	Not Listed	Vulnerable
Little Bentwing-bat	Not Listed	Vulnerable
Eastern Bentwing-bat	Not Listed	Vulnerable
Species Considered Likely to Occur		
Spotted-tail Quoll	Endangered	Vulnerable
Grey-headed Flying-fox	Vulnerable	Vulnerable
Powerful Owl	Not Listed	Vulnerable
Wompoo Fruit-dove	Not Listed	Vulnerable
Glossy Black Cockatoo	Not Listed	Vulnerable
Southern Barred Frog	Vulnerable	Endangered
Giant Barred Frog	Endangered	Endangered

The likely abundance and the extent and quality of available habitat for each of these species, is described below.

Barking Owl

One Barking Owl was heard just after a call playback session during the present study. It was recorded along an elevated ridge beyond the northern extent of the inundation area within the Viewmont State Forest.

However due to its large range that would include the inundation area it has been included in this assessment. It was not recorded in any of the previous studies. The Barking Owl did not appear in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008). This may be due to no previous recordings or targeted searches for the species having occurred in the vicinity of the study area.

It is generally considered uncommon in southern Australia. It is rarely recorded in coastal and escarpment forests (DECC, 2009). Very little foraging habitat is available for it in the inundation area due to a lack of suitable habitat for its prey. There is also a lack of large stags and hollow bearing trees within the inundation area, which is primarily plantation forest that would provide suitable roosting habitat. This is even more so in the lower reaches of Bowra Creek where the proposed off-river storage embankment and other infrastructure are to be located.

It is likely that this species uses the study area as part of its overall habitat area. However, it is unlikely that the study area is an important component of the overall habitat for this species because of the lack large hollow hollows and preferred foraging habitat.

Masked Owl

Two Masked Owls were observed in a tree whilst undertaking a call playback session during the present study. They were recorded along an elevated ridge beyond the northern extent of the inundation area within the Viewmont State Forest. However due to its large range that would include the inundation area it has been included in this assessment. It was not recorded in any of the previous studies. The Masked Owl did not appear in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008). This may be due to no previous recordings or targeted searches for the species having occurred in the vicinity of the study area.

It is most abundant along the coast (DECC, 2009). The foraging habitat available in the inundation area is poor in comparison to the surrounding lands associated with Viewmont State Forest; however it may hunt along the forest edges and trails located within the inundation area. There is also a lack of large stags and hollow bearing trees within the inundation area, which is primarily plantation forest that would provide suitable roosting habitat. This is even more so in the lower reaches of Bowra Creek where the proposed off-river storage dam embankment and other infrastructure are to be located.

It is likely that this species uses the study area as part of its overall habitat area. However, it is unlikely that the study area is an important component of the overall habitat for this species because of the lack large hollows and preferred foraging habitat.

Sooty Owl

One Sooty Owl was heard opportunistically whilst spotlighting during the present study. It was recorded within the inundation area. It was also recorded in two of the previous studies. The Sooty Owl appeared in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008).

It is known to occur on the coast, coastal escarpment and eastern tablelands (DECC, 2009). The foraging habitat available in the inundation area is poor in comparison to the surrounding lands associated with Viewmont State Forest. There is also a lack of large stags and hollow bearing trees within the inundation area, which is primarily plantation forest that would provide suitable roosting habitat. This is even more so in the lower reaches of Bowra Creek where the proposed off-river storage dam embankment and other infrastructure are to be located. Therefore it is more likely to roost in the hollow bearing trees located at higher elevations in the study area above the inundation area.

This species uses the study area as part of its overall habitat area. However, it is unlikely that the study area is an important component of the overall habitat for this species because of a lack of dense vegetation suitable for roosting.

Koala

One male Koala was heard calling onsite during the present study approximately in the centre of the inundation area. Previous studies undertaken by Connell Wagner and Biosis also identified the Koala as existing in the inundation area. Koala populations are known to occur in the Coffs Coast and Escarpment region of NSW in wet and dry sclerophyll forests (DECC, 2009). Flooded Gum, Tallowwood, Grey Gum and Blackbutt are all Koala habitat trees and are found throughout the inundation area, but are fragmented in the riparian areas of lower Bowra Creek, South Creek and Nambucca River. In these fragmented areas the Koala is less likely to occur.

Eastern Bentwing-bat

The Eastern Bentwing-bat was recorded onsite during the present study via definite Anabat recordings at two locations within the inundation area. It was not recorded in any of the previous studies. The Eastern Bentwing-bat appeared in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008).

The Eastern Bentwing-bat occurs along the east coast of Australia (DECC, 2009). The foraging habitat available in the inundation area is poor in comparison to the surrounding lands associated with Viewmont State Forest because of the degree of weed infestation. It is known to occur in the Coffs Coast and Escarpment region of NSW in wet and dry sclerophyll forests (DECC, 2009). However no large caves or mine sites are available within the immediate locality of the study area that would be suitable for maternity colonies.

There is also a lack of large stags and hollow bearing trees within the inundation area, which is primarily plantation forest that would provide suitable diurnal roosting habitat. It is more likely to roost in the hollow bearing trees located at higher elevations in the study area above the inundation area.

Golden-tipped Bat

The Golden-tipped Bat was recorded onsite during the present study via definite Anabat recordings at one location within the inundation area. It was recorded in two of the previous studies. The Golden-tipped Bat did not appear in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008).

The Golden-tipped Bat occurs along the east coast of Australia (DECC, 2009). It is known to occur in the Coffs Coast and Escarpment region of NSW in rainforest, wet and dry sclerophyll forests and would roost in abandoned hanging Yellow-throated Scrubwren located in rainforest gullies on small first and second-order streams (DECC, 2009). It is therefore assumed that there may be abandoned hanging Yellow-throated Scrubwren nests within the inundation area as this bird species has been recorded in previous and present studies.

The majority of the inundation area is not the preferred foraging habitat for the Golden-tipped Bat whereas the rainforest and sclerophyll forest on the upper slopes is, although the inundation area may provide suitable roosting sites for the species (DECC, 2009).

Little Bentwing–bat

The Little Bentwing-bat was recorded onsite during the present study via definite Anabat recordings at two locations. These locations are within the study area associated with the inundation area. It was recorded in two of the previous studies. The Little Bentwing-bat did not appear in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008).

The Little Bentwing-bat occurs in northeastern NSW (DECC, 2009). The foraging habitat available in the inundation area is poor in comparison to the surrounding lands associated with Viewmont State Forest. It is known to occur in the Coffs Coast and Escarpment region of NSW in rainforest and wet sclerophyll forest (DECC, 2009). There is also a lack of large stags and hollow bearing trees within the inundation area, which is primarily plantation forest that would provide suitable diurnal roosting habitat. It is more likely to roost in the hollow bearing trees located at higher elevations in the study area above the inundation area but is likely to utilise the study area as a foraging resource.

It is likely that this species uses the study area as part of its overall habitat area for foraging purposes. However, it is unlikely that the study area is an important component of the overall habitat for this species because of the lack of hollow bearing trees.

Spotted-tail Quoll

The Spotted-tail Quoll was not recorded onsite during the present study and it was not recorded in during previous studies. The Spotted-tail Quoll appeared in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008).

The Spotted-tail Quoll occurs across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline (DECC, 2009). It is known to occur in the Coffs Coast and Escarpment region of NSW in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and riparian forests (DECC, 2009). It utilises hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites (DECC, 2009). Due to the disturbed condition of the site no large hollow bearing trees and hollow fallen logs were available as den sites and greater potential foraging and denning sites would exist in adjacent lands.

It is likely that this species uses the study area as part of its overall habitat area. However, it is unlikely that the study area is an important component of the overall habitat for this species because of the shortage of denning resources (e.g. large hollow logs and rocky outcrops) and preferred foraging habitat.

Grey-headed Flying-fox

The Grey-headed Flying-fox was not recorded onsite during the present study but it has been recorded in the inundation area during previous studies. The Grey-headed Flying-fox appeared in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008).

The Grey-headed Flying-fox occurs within 200 km of the eastern coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria (DECC, 2009). The foraging habitat available in the inundation area is poor in comparison to the surrounding lands associated with Viewmont State Forest. It is known to occur in the Coffs Coast and Escarpment region of NSW in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops (DECC, 2009). Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy (DECC, 2009). There is a Grey-headed Flying-fox roosting camp in the vicinity of the study area on the banks of the Nambucca River .The inundation area does not provide habitat suitable for a Grey-headed Flying-fox roost camp.

Powerful Owl

The Powerful Owl appeared in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008).

In NSW, this species is widely distributed throughout the eastern forests from the coast inland to the tablelands (DECC, 2009). Very little foraging habitat is available for it in the inundation area due to a lack of suitable habitat for its prey. There is also a lack of large stags and hollow bearing trees within the inundation area, which is primarily plantation forest that would provide suitable roosting habitat. This is even more so in the lower reaches of Bowra Creek where the proposed off-river storage embankment and other infrastructure are to be located.

It is likely that this species uses the study area as part of its overall habitat area. However, it is unlikely that the study area is an important component of the overall habitat for this species because of the lack large hollow hollows and preferred foraging habitat.

Wompoo Fruit-dove

The Wompoo Fruit-dove appeared in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008).

This species is rarely recorded south of Coffs Harbour (DECC, 2009). Preferred foraging and breeding habitat for the species is available in the inundation area in the form of some rainforest pockets, although this habitat is relatively small in comparison to surrounding lands. This species, if it is present would be at the very limit of its southern distribution, as it is rarely recorded south of Coffs Harbour.

It is likely that this species uses the study area as part of its overall habitat area. However, it is unlikely that the study area is an important component of the overall habitat for this species because of the lack large hollow hollows and preferred foraging habitat.

Glossy Black Cockatoo

The Glossy Black Cockatoo appeared in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008).

In NSW, this species is widely distributed throughout the eastern forests from the coast inland to the tablelands (DECC, 2009). Foraging habitat the species is available in the inundation area in the form of *Allocasuarina littoralis and A. Torulosa* tree species, although this habitat is relatively small in comparison to surrounding lands. There is also a lack of large stags and hollow bearing trees within the inundation area, which is primarily plantation forest that would provide suitable roosting habitat. This is even more so in the lower reaches of Bowra Creek where the proposed off-river storage embankment and other infrastructure are to be located.

It is likely that this species uses the study area as part of its overall habitat area. However, it is unlikely that the study area is an important component of the overall habitat for this species because of the lack large hollow hollows and preferred foraging habitat.

Southern Barred Frog

The Southern Barred Frog was recorded in one of the previous studies. It breeds in streams during summer after heavy rainfall, which may be the reason why the present study did not record it. The Southern Barred Frog did not appear in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008).

The Southern Barred Frog occurs along the east coast of Australia from southern Queensland to northeastern Victoria (DECC, 2009). Outside the breeding season adults live in deep leaf litter and thick understorey vegetation on the forest floor (DECC, 2009). These habitats exist in the upper reaches of the inundation area. However the lower reaches of the inundation area where the proposed off-river storage dam embankment and other infrastructure is to be located is not considered to provide suitable habitat for the species. Past logging practices may have decreased its population in the inundation area and driven it to adjacent more favourable habitat associated with Viewmont State Forest.

Giant Barred Frog

The Giant Barred Frog was not recorded during the present study, however its habitat was recorded during the current assessment and it has been recorded within the study area during the previous studies. Giant Barred Frog appeared in the results of the threatened species search as occurring within a 10 km radius of the study area (DECC, 2008).

The Giant Barred Frog occurs in northeastern NSW, particularly the Coffs Harbour-Dorrigo area, which is now a stronghold for the species (DECC, 2009). It forages and lives amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest (DECC, 2009). These habitats exist across the inundation area. However potential habitat was not recorded in lower reaches of Bowra Creek where the proposed off-river storage dam embankment and other infrastructure are to be located. Past logging practices may have decreased its population in the inundation area and driven it to adjacent more favourable habitat associated with Viewmont State Forest.

It is likely that this species uses the study area as part of its overall habitat area for foraging purposes. However, it is unlikely that the study area is an important component of the overall habitat for this species due to the levels of past disturbances and the degree of weed infestation and because the upper reaches of Bowra Creek are ephemeral where this species more favourable habitat exists.

It is likely that this species uses the study area as part of its overall habitat area for foraging purposes. However, it is unlikely that the study area is an important component of the overall habitat for this species due to the levels of past disturbances and the degree of weed infestation and because the upper reaches of Bowra Creek are ephemeral where this species more favourable habitat exists.

7.3.2 Migratory Bird Species

The Commonwealth Protected Matters Online Search Tool revealed 13 migratory species that have the potential to occur in the study area. Two migratory species, Rufous Fantail and Cattle Egret were recorded in the study area and may regularly utilise the site as vagrants and as such would be assessed together. No migratory species were considered likely to occur in the study area as outlined in the EPBC Act AoS.

Rufous Fantail

One Rufous Fantail was recorded within the inundation area amongst the hardwood plantation forest. The Rufous Fantail is found in northern and eastern coastal Australia. It is typically found in rainforest, dense wet eucalypt and monsoon forest, paperbark and mangrove swamp, riverside vegetation, and in open country whilst on migration. It prefers deep shade, and is often seen close to the ground and within the mid level vegetation (Morcombe, 2003).

The wet eucalypt / hardwood plantation forest habitat may be considered less desirable due to the increased densities of Lantana in the understorey and limited mid storey vegetation. However the small pockets of rainforest vegetation within the inundation area may provide more favourable habitat for this species as less Lantana is present in the understorey with a greater level of midstorey vegetation. Therefore the Rufous Fantail is more likely to favour the denser rainforest vegetation that is located in the upper extent of the Bowra Creek catchment which is predominantly above the proposed inundation water level.

Cattle Egret

A number of cattle Egrets were recorded in agricultural grazing lands in the study area. This species is most widespread in south-eastern Australia from Bundaberg, Queensland to Port Augusta, South Australia. The Cattle Egret is found in grasslands, woodlands and wetlands, and is not common in arid areas. It also uses pastures and croplands, especially where drainage is poor. Will also forage at garbage dumps, and is often seen with cattle and other stock (Morcombe, 2003).

A small portion of grassland habitat considered favourable to this species would be impacted by the proposed location of the off-river storage dam embankment, as well as the location of the proposed access roads and pipeline route that traverse grasslands. However these impacts are considered minimal in contrast to similar habitat throughout the study area.

8. Aquatic Fauna Survey Results

8.1 Site Descriptions

The aquatic surveys undertaken at all sites included fish, macroinvertebrates, reptiles, amphibians, mammals, macrophytes and riparian vegetation survey and water quality and habitat assessments. The site locations, catchment position, description and detail of general habitat recorded are outlined in Table 17 and Photographs of each aquatic survey location is available in Appendix F.

Table 17: Site Details and Characteristics

Site code	GPS Location		Site Type	Catchment Position	General Habitat Present
	Northing	Easting			
BC1	56 J 488138	6812269	Impact	Within inundation area	Middle of inundation area. Riparian corridor of temperate rainforest trees and vines with understorey of the introduced *Cinnamomum camphora* (Camphor Laurel) and *Lantana camara* (Lantana). Continuous forest both sides of the creek. Large dead hollowtrees (stags) present. Abundant leaf litter and moderate to large wood debris present in the riparian zone. Creek depth 0.5 m and width 1-2 m.
BC2	56 J 486977	6811945	Impact	Within inundation area	Thin (2-3 m) riparian zone of closed *Camphor laurel* canopy with understorey of *Privet*. Grazing land adjacent on both sides. Highly eroded banks with abundant leaf litter and woody debris present within the creek and riparian zone. Creek depth 0.5 m and width 3.0 m.
BC3	56 J 486724	6811307	Control	Upstream of pipeline crossing	Thin (2-3 m) riparian zone of closed *Camphor laurel* canopy. Groundcover of grass and some ferns. Grazing land adjacent on both sides. Highly eroded banks (suspected to be impacted by access from cattle) with moderate leaf litter and woody debris present within the creek and riparian zone. Creek depth 1.0 m and width 5.0 m.
BC4	56 J 486559	6810689	Impact	Downstream of pipeline crossing	Thin (3-4 m) riparian zone with closed canopy. *Camphor laurel* with sapling and banks discontinuously lined with *Lamandra* making up the understorey. Floating duckweed was observed in the creek. Patchy groundcover of grass and some ferns. Grazing and residential land adjacent. Highly eroded banks with moderate leaf litter and woody debris present within the creek and riparian zone. An old wooden bridge crosses the creek. Creek depth 1.0 m and width 10.0 m.
SC1	56 J 484928	6809374	Control	Upstream of proposed bore fields	Riparian corridor, approximately 20 m wide, consisting of *Casuarina cunninghamiana* (River Oak) and *Eucalyptus grandis* (Flooded Gum) canopy with an understorey of *Camphor laurel* and *Privet*. Groundcover of *Tradescantia albiflora* (Wandering Jew). Steep, eroded banks with moderate large woody debris and minimal leaf litter present within the creek and riparian zone. Large dead hollowtrees (stags) present. Creek depth 1.0 m and width 10-15 m.

Site code	GPS Location		Site Type	Catchment Position	General Habitat Present
	Northing	Easting			
SC2	56 J 486023	6610202	Impact	Downstream of proposed bore fields	Moderate (4-6 m) riparian zone of *Camphor laurel* canopy with understorey of *Privet* and *Lomandra* discontinuously lining the banks. Grazing land adjacent on both sides. Highly eroded banks with abundant leaf litter and woody debris present within the creek and riparian zone. Creek depth 1.0 m and width 15.0 m.
NR2	56 J 484343	6612197	Control	Upstream of existing borefields	Moderate (4-6 m) riparian corridor of *Camphor laurel* and *Salix babylonica* (Weeping Willow) with some *Casuarina cunninghamiana* (River Oak). Midstorey of *Lantana* with grassy groundcover on banks. Abundant large woody debris present within the creek. zone. Creek depth 2.0 m and width 10-15 m.
NR3	56 J 486159	6610595	Impact	Downstream of existing borefields	Moderate (4-6 m) riparian corridor of sporadic *Camphor laurel* canopy with large breaks. Understorey of *Privet* and grassy groundcover. Highly eroded steep banks with some sedge present. Moderate large woody debris present in the riparian zone. Creek depth 0.5 m and width 10.0 m.
NR4	56 J 486546	6610019	Impact	Downstream of the confluence of Nambucca river and South Creek	Thin (3-4 m) riparian zone of *Camphor laurel* canopy with understorey of *Privet*. Mature *Waterhousia floribunda* (Weeping Lillypilly) present along upper region of the northern bank. *Casuarina cunninghamiana* (River Oak), *Camphor laurel* and *Privet* comprising the southern bank riparian zone. Isolated beds (approximately 1-2 m2) of eelgrass *sp.* in shallowareas (0.5-1.0 m deep). Grazing land adjacent on both sides. Highly eroded banks. Several large snags (5-7 m long) in waterway. Creek depth 1.0 m and width 15.0 m.
NR5	56 J 486392	6609296	Impact	Downstream of the confluence of Nambucca river and South Creek	Riparian corridor of *Camphor laurel* and *Privet*. *Lamandra* and grassy groundcover. Larger trees utilised by Grey-headed Flying Fox adjacent to river. Creek depth > 3 m and width 20 m.
NR1	56 J 484555	6615617	Reference	Outside of catchment in Missabotti (Bowra creek reference)	Sporadic canopy of *Camphor laurel* with a sapling understorey and groundcover of grass and ferns. Discontinuous *Lomandra* lining banks. Grazing land adjacent both sides. Moderate leaf litter and abundant large woody debris present in the riparian zone. Creek depth 0.5 m and width 5.0 m.

8.1.1 Nambucca River

The Nambucca River is a moderate sized lowland river (observed width ranging from 5-20 m within study area) surrounded by floodplain that is used for grazing livestock. The river is characterised by low to moderate flows (generally between 1-2.5 m/sec) and water is generally clear indicated by low turbidity (NTU #). It is typically 10-15 m wide and 1-2 m deep and exhibits riffle run and pool habitats along its length. The substrate consists of sand and gravel and has regularly exposed sandbars.

Large woody debris and overhanging vegetation is abundant and provides habitat for aquatic fauna. The banks are typically steep and vegetated with Camphor Laurel and some *Salix babylonica* (Weeping Willow). Native species including *Eucalyptus tereticornis* (Forest Red Gum) and *Casuarina glauca* (Swamp Oak) are interspersed throughout the canopy. Riparian vegetation within the study area ranges from 3-7m in width due to clearing for agricultural purposes. The river provides potential habitat for at least 18 native species.

8.1.2 Bowra Creek

Bowra Creek displays characteristics of both an ephemeral creek, in the upper to mid reaches, and a permanent/semi-permanent creek in the mid to lower reaches. It flows southwest through the middle of the plantation habitat and discharges into the Nambucca River. The habitat along the length of the creek transitions from its headwaters to the confluence with Nambucca River. The headwaters (BC1) consist of a tall open forest system with a continuous mixture of native and exotic riparian vegetation comprised of Flooded Gum, Blackbutt and Camphor Laurel with an understorey of Lantana camara and Small-leaf Privet.

The lower reaches of Bowra Creek, within the cleared agricultural sites (BC2, BC3 and BC4), are an open system of semi-permanent pools with scattered exotic tree and understorey species. Banks are gradual and undisturbed in the upper reaches and become steep and highly disturbed in the agricultural areas. The substrate mostly consists of sand, silt and clay sized particles which released odorous gasses when disturbed, suggesting anoxic conditions. The upper reaches and small feeder drainage lines that supply Bowra Creek are ephemeral and only flow intermittently during rain events.

There was minimal in-stream vegetation at sites within the upper reaches of the creek. These sites did have an abundance of woody debris and leaf litter, which provide potential habitat for crayfish, frogs/tadpoles and aquatic invertebrates. The striped marsh frog (*Limnodynastes peronii*) was noted calling and numerous tadpoles were observed at BC-1. Numerous mosquito fish (*Gambusia holbrooki*), an exotic pest, were observed at BC2.

Riparian vegetation on the lower reaches within the agricultural region typically consisted of a narrow strip of Camphor laurel (<5 m) with and understorey of saplings and Privet. Approximately 20% of the creek was devoid of any canopy or understorey vegetation due to clearing for pastoral land. Emergent vegetation was abundant in the lower reaches, which appeared to provide habitat for common frog species such as *Crinia signifera* that was noted calling during the survey.

The creek was not fenced and livestock has had a major impact along most of the lower reaches. Several farm dams located adjacent to the creek could potentially provide habitat for frogs and turtles. These dams are typically unconnected to the creek system, making them unlikely refuge for common creek dwelling animals. These dams did not have riparian vegetation and contained approximately 30% surface cover of both emergent and floating vegetation.

8.1.3 South Creek

South Creek is a moderate sized creek (observed width ranging from 7-15m within the study area) that flows northeast into the Nambucca River. The creek has a moderate (4-20 m wide) riparian corridor dominated by Camphor laurel with 5-10% interspersed native species and an understorey of Privet and Camphor laurel saplings. The entire length of the creek is surrounded by agricultural and residential land. The substrate consists of sand and gravel and has regularly exposed sandbars. There was abundant large woody debris in areas and the banks are typically steep and undercut. The confluence of South Creek and Nambucca River is in Bowraville and has been historically used for recreational purposes including swimming and is also a Department of Industry and Investment survey site.

8.1.4 Reference Site

The reference site was located on Missabotti Creek. This creek is located on the northern adjacent catchment to Nambucca River. This is an ephemeral creek that flows following rainfall periods and ceases to flow over periods of low rainfall. It is a narrow and shallow creek system with clear and slow flowing water.

8.2 Fauna Assemblages

8.2.1 Fish

There are 20 known species of freshwater fish in the Nambucca catchment including two exotic species. Thirteen of these species have been recorded at the NSW Fisheries Survey Site at the Bowraville Gauging Station on the Nambucca River.

A total 216 individual fish, representing two species were netted during the survey. Of the two species, the Empire Gudgeon (*Hypseleotris compressa*) dominated samples (164 individuals) at sites SC1, SC2 and NR4. All fish caught at SC1 and SC2 were assumed to be near mature and ranged from 50 to 70 mm in length. Individuals caught at NR4 were assumed to be juvenile and all were approximately 35 mm in length.

Pacific Blue-eye (*Pseudomugil signifer*) was the second most abundant species sampled (52 individuals) at sites SC1 and SC2. All individuals were approximately 35 mm in length, which is close to their maximum size of 40 mm, and thus they were assumed to be mature based on size.

Seven species of fish were recorded during the survey, as identified in Table 18.

Table 18 Threatened and Recorded Fish of the Study Area

Common Name	Scientific Name	Family Name	Native/ Exotic	EPBC status	TSC status	Location netted during this survey	Location observed during this survey
Long-finned eel	*Anguilla reinhardtii*	Anguilladae	Native	Least concern	Not listed	Not recorded	Not recorded
Empire gudgeon	*Hypseleotris compressa*	Eleotridae	Native	Least concern	Not listed	SC1, SC2 and NR4	NR3, NR5
Striped gudgeon	*Gobiomorphus australis*	Eleotridae	Native	Least concern	Not listed	Not recorded	Not recorded
Cox's gudgeon	*Gobiomorphus coxii*	Eleotridae	Native	Least concern	Not listed	Not recorded	Not recorded
Firetail gudgeon	*Hypseleotris galii*	Eleotridae	Native	Least concern	Not listed	Not recorded	Not recorded
Gudgeon	*Hypseleotris sp.*	Eleotridae	Native	Least concern	Not listed	Not recorded	Not recorded
Flathead gudgeon	*Philypnodon grandiceps*	Eleotridae	Native	Least concern	Not listed	Not recorded	Not recorded
Oxeye herring	*Megalops cyprinoides*	Megalopidae	Native	Least concern	Not listed	Not recorded	NR3, NR4
Crimson-spotted Rainbowfish	*Melanotaenia duboulayi*	Melanotaeniidae	Native	Least concern	Not listed	Not recorded	Not recorded
Freshwater mullet	*Myxus petardi*	Mugilidae	Native	Least concern	Not listed	Not recorded	NR2, NR4
Sea mullet	*Mugil cephalus*	Mugilidae	Native	Least concern	Not listed	Not recorded	NR2, NR4
Freshwater catfish	*Tandanus tandanus*	Plotosidae	Native	Least concern	Not listed	Not recorded	NR2, NR3

Common Name	Scientific Name	Family Name	Native/ Exotic	EPBC status	TSC status	Location netted during this survey	Location observed during this survey
Gambusia	*Gambusia holbrooki*	Poeciliidae	Exotic	Least concern	Not listed	Not recorded	BC2
Pacific blue-eye	*Pseudomugil signifer*	Pseudomugilidae	Native	Least concern	Not listed	SC1, SC2	Not recorded
Bullrout	*Notesthes robusta*	Scorpaenidae	Native	Least concern	Not listed	Not recorded	Not recorded
Yellowfin bream	*Acanthopagrus australis*	Scaridea	Native	Least concern	Not listed	Not recorded	NR4

The descriptions of those species that were captured are summarised below from Allen *et al.* (2002).

8.2.2 Brief Biology of Recorded and Observed Fish Species

Empire gudgeon (*Hypseleotris compressa*)

Empire Gudgeon inhabit lower reaches of rivers (also found further upstream) in flowing or still water. They are usually found in flowing streams among aquatic vegetation or branches of submerged trees. Juveniles often occur in swiftly flowing water or brackish estuaries. Empire Gudgeon are tolerant of salinity levels equal to seawater and temperatures up to 35°C and pH 5.0-9.1. Feeds on micro-crustaceans, mosquito larvae and algae. Spawning occurs during the warmer months when males establish breeding territories and display their colours to attract a mate. The eggs adhere to rocks, sand or weeds and are guarded and fanned by the male until hatching, which occurs in 10-14 days. Juveniles live for up to a year in the estuaries before moving upstream to freshwater during spring.

Pacific blue-eye (*Pseudomugil signifer*)

The Pacific blue-eye is a native Australian species that occurs in extremely variable habitat from sea water to pure freshwater. It is common and widely distributed along the east coast of QLD and NSW from Cooktown (QLD) to Ulladulla (NSW). This species lives in clear, fast flowing freshwater streams and tributaries in mountain regions through to tidal mangrove estuaries. Being a small fish, the pacific blue-eye is able to approach the margins of the water and feed on mosquito larvae and other insects.

In their natural environment spawning usually occurs from October to January. This species is an egg-scatterer, generally spawning amongst aquatic plants and grasses. Eggs would take around 12 to 17 days to hatch at a temperature range of 22 to 28° Celsius. Males exhibit territorial behaviour guarding the spawning site from intruders. They inhabit waters with a temperature range of 15-28° Celsius, and pH 5.5 to 8.3.

They inhabit waters with a temperature range of 15-28° Celsius, and pH 5.5 to 8.3.

Oxeye herring (*Megalops cyprinoides*)

Ox-eye herring or tarpon are a common species that inhabit the tropical waters of Australia from northern NSW around the top end of Australia to northern WA. They are a school fish found in bays, inlets, estuaries, rivers and creeks often into the fresh water regions. The juvenile fish are more commonly found in shallow waters whereas the adults prefer deeper water.

This species feeds on a variety of crustacean, insect and fish and must breathe air from the surface to supplement its oxygen supply. They are known to inhabit clear to turbid water and tolerate a wide pH range (pH 5.2-9.1)

Freshwater mullet (*Myxus petardi*)

The freshwater mullet is endemic to Australia. It occurs in freshwater coastal streams, as well as estuarine and coastal waters from southern QLD to southern NSW. It is primarily an estuarine species and is typically very common in coastal brackish waters. This species inhabits a wide variety of habitats including coastal seas, estuaries, lakes and rivers. It is often found in freshwater far above tidal influence. This is a shoaling fish, which often congregates in large numbers in shallow water over sand, gravel and mud banks. Shoals usually enter rivers on a rising tide and may move well above tidal influence, returning to estuaries and the sea on a falling tide. The freshwater mullet is omnivorous, feeding on algae, crustaceans, detritus and occasionally planktonic creatures.

Sea mullet (*Myxus cephalus*)

The sea mullet is considered a marine species with a world-wide range throughout tropical, sub-tropical and temperate seas. It is known around the coast of Australia as primarily an estuarine fish, but would frequent the lower freshwater reaches of large rivers.

This species is a bottom feeding herbivore, with the gut including a large muscular gizzard for grinding food. Diet typically varies with age. Juveniles feed on small plankton and crustaceans, while adult fish eat microscopic plants.

Mature males and females congregate in large schools in estuaries for some time before moving out to sea to spawn. This migration may commence as early as February or as late as July, after which adult fish return to river systems for the greater part of the year to feed and grow. A single mature female may produce between 300,000 and 7,200,000 eggs, and it has been suggested that females do not spawn every year.

This species can withstand temperatures from 12 to 25°C and very high salinities to twice that of seawater. It is also an important commercial food fish species.

Freshwater catfish (*Tandanus tandanus*)

Freshwater catfish are a freshwater, bottom-dwelling fish found in freshwater lakes and slow moving rivers and streams. They are widely distributed throughout the Murray-Darling River system and eastern coastal drainages from the Hawkesbury River (NSW) to the Daintree River north of Cairns (QLD). This species was formerly common in the Murray-Darling, but numbers are now declining possibly due to the introductions of carp (which have similar feeding habits) and/or the degradation of suitable breeding habitat.

They feed and live on the bottom, preferring deeper water or cover of undercut banks, weedbeds and snags by day, and move into shoreline shallows at night. Eel-tail catfish feed on shrimps, crayfish, aquatic insects and small mussels.

Eel-tailed catfish spawn in spring and early summer when water temperatures rise to between 20°C and 24°C. They are more abundant in lentic environments and are one of the few angling species that would breed in dams. They build a circular gravel and pebble nest in which the eggs are laid. Catfish nests are often in shallow water and eggs are guarded until they hatch.

Yellowfin bream (*Acanthopagrus australis*)

The yellowfin bream is widely distributed along the eastern coast of Australia from Townsville (QLD) to Lakes Entracne (VIC). It is known to inhibit estuaries, coastal rivers, creeks, lakes and bays. It can tollerat both freshwater, brackish and marine waters, prefering the later of the three. They consume a wide range of plants and animals, although benthic invertebrates includign molluscs, crabs and urchins formt he bulk of the diet.

Mosquito Fish (*Gambusia holbrooki*)

The mosquito fish is a major pest species in the freshwaters of eastern New South Wales. It prefers warm water that is still or gently flowing. In many streams it greatly outnumbers native species. It can tolerate a wide range of temperatures (from under ice to 44^{0}C) and water conditions encompassing salinities from freshwater to marine. As a result of its high reproductive rate (an average of 5000 young per brood, with up to nine broods per year), fast maturation (may reach maturity in under two months), and aggressive fin-nipping behaviour, it often out-competes small native fishes.

The introduced mosquito fish (*Gambusia holbrooki*) was observed at site BC2 only. BC2 was located in the mid section of Bowra Creek. This section of creek was characteristically similar to preferred habitat of this species.

8.2.3 Reptiles

One species of threatened reptile (Bellinger River Emydura (*Emydura signata*)) was listed by the EPBC as 'species or species habitat may occur within area', however no individuals of this species were observed or captured during the survey. A total of 17 individuals of the eastern long neck turtle (*Chelodina longicollis*) were captured during the field survey, as shown inTable 19.

Table 19: Threatened and Recorded Aquatic Reptiles from the Study Area

Common Name	Scientific Name	Family Name	Native/exotic	EPBC status	TSC status	Location
Bellinger River Emydura	*Emydura macquarii signata*	Chelidae	Native	Vulnerable	Vulnerable	Not recorded
Eastern long-neck turtle	*Chelodina longicollis*	Chelidae	Native	Least concern	Not listed	SC1, Upstream of BC4

Eastern long neck turtle (*Chelodina longicollis*)

Chelodina longicollis is a small snake-necked turtle from southeastern Australia and reaches about 20 cm carapace length in captivity. It is widely distributed and is the most common turtle found from the Adelaide area in South Australia, throughout Victoria, coastal and inland New South Wales to the Roma area in Queensland and as far North along the East Coast as Cap York. This species is very hardy and is also able to tolerate lower temperatures than most other turtles of the genus.

Bellinger River Emydura (*Emydura macquarii signata*)

The turtles occupy long, deep pools along moderately broad reaches of river. The species utilises partially submerged logs for basking. This habitat was present at some locations within the survey boundaries, however no members of this species were netted or observed.

Mammals

The Nambucca River is suitable habitat for one aquatic mammal, the Platypus (*Ornithorhynchus anatinus*). Historically, based on local resident's reports, Platypuses have been observed in the Nambucca River. Sightings occurred along the Nambucca River during GHD's survey. No platypi were observed at these sites, or any other, during the survey as shown in Table 20.

The platypus is widespread in eastern Australia, ranging from tropical lowlands to sub-alpine areas. Although the platypus is a strong swimmer they prefer slow flowing streams. Platypi live in burrows that they dig on the banks of fresh water rivers, lakes or streams. Burrows are usually 4.5 to 9 m in length, oval shaped and are constructed just above the water line, often obscured by vegetation. This habitat was readily available along the Nambucca River at the time of the survey.

This species is listed on the International Union for the Conservation of Nature (IUCN) Red List as 'near threatened' but is not currently listed as threatened under NSW or Commonwealth legislation.

No threatened aquatic mammals were recorded in the study area.

Table 20 Recorded Mammals of the Study Area

Common name	Scientific name	Family name	Native/exotic	EPBC status	IUCN status	Location
Platypus	*Ornithorhynchus anatinus*	Ornithorhynchidae	Native	Least concern	Near threatened	Not recorded

8.3 Aquatic Species of Conservation Significance

8.3.1 Threatened Fish Species

The FM Act lists threatened aquatic species, populations and endangered ecological communities for marine and freshwater habitats. None of the FM Act listed fish species are known to occur in the study area and no listed species or preferred habitat was recorded during the survey.

8.3.2 Threatened Reptiles

One threatened species listed under the EPBC Act may potentially occur in the study area, the Bellinger River Emydura. No members of this species were recorded during the survey. This species distribution is restricted to the upper Bellinger River above Thora and therefore is unlikely to occur in the Nambucca catchment.

8.3.3 Threatened Mammals

No threatened aquatic mammals were recorded in the study area.

8.4 Macroinvertebrates

8.4.1 Community Composition

An estimated 24,168 individuals from 47 families of macroinvertebrates were collected from the eleven survey sites. The community composition for the family taxa of macroinvertebrates recorded at each siteis shown in Figure 8. The five more dominant families across all the sites combined were:

- Diptera, chironomidae (Non-biting Midge);
  - Chironomidae can be simple detritivores, omnivores or carnivores that feed on a mixture of algae and bacteria in soft sediments. They are found in a variety of water sources and most genera are relatively tolerant to pollution. This family is the third most species family of diptera.
- Isopoda, sphaeromatidae (Water Slater);
  - Sphaeromatidae are generally limited to saline waters within estuaries, they are mostly detritivores and shredders of leaves and other organic material. Some genera of the family are known to be parasitic on freshwater fish.
- Ephemeroptera, caenidae (Mayfly);
  - Caenidae inhibit slow-flowing streams and are often found on bark, logs and rocks in streams, wetlands and pools. They are detritivores and herbivores. Most mayflies are pollution intolerant and are frequently used as an indicator group for environmental monitoring programs (Dean and Suter 1996).
- Coleoptera, elmidae (Riffle Beetle); and
  - Elmidae adults and larvae are aquatic. They are herbivorous feeding on decaying vegetation and algae. They are found on log and stone surfaces of well oxygenated streams and rivers.
- Diptera, tanypodinae (Non-biting Midge).
  - Tanypodinae are predators but feed on some algae, bacteria and diatoms in their early larval stages.

Nambucca River

Sites NR2R (riffle), NR2E (edge), NR3 (edge) and NR4 (edge) displayed similar patterns of order dominance between sites. The most dominant orders were diptera (flies), coleoptera (beetles) and ephemeroptera (mayflies). The dominant families in the groups are those associated with slow flowing low-land rivers and the associated riffles and pools along the length of the rivers. *Coleoptera elmidae* are usually found in the riffles of fast following sections of the creeks. The high number of individuals captured indicates that water in this section of the Nambucca River is well oxygenated as indicated by the dissolved oxygen (DO) results for sample locations NR1 to NR5 that ranged between 77 and 92.1 % saturation, as shown in Table 24.

NR5 (edge) was exceptionally depauprate in terms of overall numbers of animals in comparison to the other sites from the Nambucca River. This site was dominated by two families – isopoda sphaeromatidae (water slater) and amphipoda paramelitidae (side swimmers). The isopod is usually associated with high electrical conductivity or salinity and is generally found in the estuaries, as indicated by the electrical conductivity results for sample location NR5 of 117.4 uS/cm, as shown in Table 24. Many genera of amphipods are associated with saline waters. This family is known to occur throughout south-eastern Australia and are grazed upon by other aquatic invertebrates.

South Creek

The South Creek sites had a high level of variation between the two sites (i.e. SC1 and SC2) but similarity between the two sampling habitats at each site (i.e. edge and riffle). SC1M (riffle) was dominated by ephemeroptera (mayflies) with sub-dominance by diptera (flies) and coleoptera (beetles). SC2 (riffle) was dominated by orders of diptera (flies), isopoda (water slaters) and coleoptera (beetles). The major difference between the two riffle sites is the greater abundance of isopods at SC2.

The edge sites SC1E and SC2E were dominated by isopoda (water slaters). Both sites recorded low numbers of five other orders.

South Creek and NR5 (Nambucca River) were the only sites to be dominated by the isopoda (water slaters). The EC (us/cm) was higher at South Creek sites than at any other site sampled and can explain the presence of the isopods, a family generally associated with the marine environment, although it is uncertain how they moved so far upstream from a marine environment. The NR5 site had a much lower EC and it is unusual for this family of isopods to be captured in a freshwater environment.

Bowra Creek

The Bowra Creek sites are widely distributed from the creek headwaters in the Viewmont State Forrest, south west to its confluence with the Nambucca River, within the agricultural district of Bowraville. The most upstream site (BC1 (edge)) was dominated by emphemeroptera (mayflies). BC2, approximately 0.75 km downstream was dominated by coleoptera (beetles), diptera (flies) and hemiptera (true bugs). The two most downstream sites (BC3 (edge) and BC4E and M (edge and riffle)) were dominated by diptera (flies).

The Bowra Creek sites recorded the highest turbidity, the lowest percentage of dissolved oxygen and the lowest pH of all the sites sampled. The most upstream site (BC1) recorded slightly less harsh physiochemical conditions than the 3 downstream locations. The presence and dominance of mayflies at BC1 and absence from all other sites is an indicator that water quality is poor and the habitat likely to have been degraded downstream from BC1. The physiochemical conditions are likely to have contributed to the low diversity of pollution tolerant animals recorded at the lower sites. Less tolerant species are unlikely to survive in these harsh environmental conditions.

Reference Site

The Bowra Creek sites are widely distributed from the creek headwaters in the Viewmont State Forrest, south west to its confluence with the Nambucca River, within the agricultural district of Bowraville. The most upstream site (BC1 (edge)) was dominated by emphemeroptera (mayflies). BC2, approximately 0.75 km downstream was dominated by coleoptera (beetles), diptera (flies) and hemiptera (true bugs). The two most downstream sites (BC3 (edge) and BC4E and M (edge and riffle)) were dominated by diptera (flies).

The Bowra Creek sites recorded the highest turbidity, the lowest percentage of dissolved oxygen and the lowest pH of all the sites sampled. The most upstream site (BC1) recorded slightly less harsh physiochemical conditions than the 3 downstream locations. The presence and dominance of mayflies at BC1 and absence from all other sites is an indicator that water quality is poor and the habitat likely to have been degraded downstream from BC1. The physiochemical conditions are likely to have contributed to the low diversity of pollution tolerant animals recorded at the lower sites. Less tolerant species are unlikely to survive in these harsh environmental conditions. (See Water Quality Results for more details).

Table 21 Community Composition

Sample Code	Number of individuals (estimated[1])	Number of families	Number of order
BC1	4200	15	6
BC2	2010	15	7
BC3	2310	6	5
BC4M	418	3	2
BC4E	1307	7	5
SC1M	510	11	7
SC1E	512	17	8
SC2R	1970	12	5
SC2E	2140	16	8
NR2R	3340	13	8
NR2E	2090	16	9
NR3	1010	12	5
NR4	1326	19	6
NR5	90	9	8
NR1E	935	24	8

[1] Numbers were estimated as N = n/z, where N is the estimated number of animals, n = the number of animals counted, and z = the proportion of the collected matter (debris plus animals) sorted to provide the counted animals. Proportions of collected matter are estimated visually.

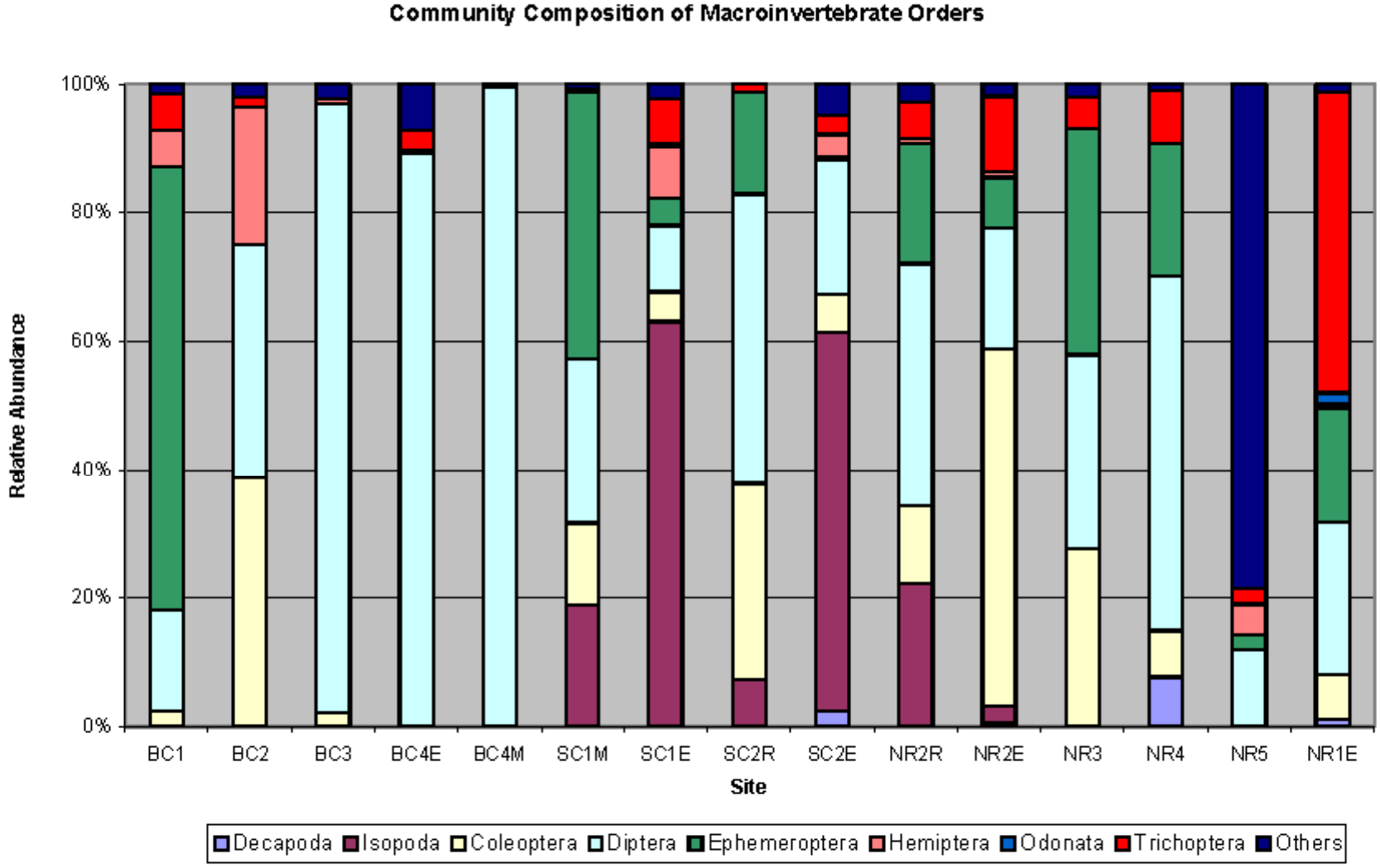


Figure 8 The Community Composition for the Family Taxa of Macroinvertebrates Recorded at Each Site

8.4.2 SIGNAL2

The SIGNAL 2 (Stream Invertebrate Grade Number – Average Level) index is a simple scoring system for macroinvertebrates in Australian rivers (Chessman, 2003). The score provides an indication of water quality in the river sampled. Together with species richness, SIGNAL2 can indicate the types of pollution and other physical and chemical factors that are affecting a macroinvertebrate community. It was first developed in 1993 for east coast systems and revised in 2003 to be more adaptable to northern, western and inland river systems (Chessman, 2003).

Each macroinvertebrate family is assigned a 'grade number' between 1 and 10, with 1 indicating those organisms with a high tolerance of a range of environmental conditions and 10 indicating those organisms that are very sensitive to environmental conditions. Each family is assigned a weight factor (1 to 5) that represents the total number of individuals counted from a particular sample. The signal grade number for each macroinvertebrate family is multiplied by the weight factor to give a 'grade × weight factor'. The 'grade × weight factor' is added together for each site to give the 'total grade × weight factor'. This number is divided by the total weight factor for the site to give the SIGNAL2 score (Table 22).

The SIGNAL2 scores can be mapped on a biplot as a quadrant diagram. The biplot is divided into four quadrants. The appropriate boundaries of the axis (in red, Figure 9) are different between geographic regions of Australia due to the natural variation of macroinvertebrate assemblages. For this study area the boundaries are selected as suggested by Chessman (2001) for regions east of the Great Dividing Range in northern NSW and southern QLD. The values have been averaged between the edge and riffle sites and provided on the one biplot (Figure 9).

Nambucca River

The Nambucca River sites are distributed across three quadrants. NR5 is located in quadrant four because of the low number of taxa recorded and the low SIGNAL2 score generated from those taxa. Quadrant four is generally representative of urban, industrial or agricultural pollution, or is sometimes associated with the downstream effects of off-river storage dams. There are no dams on the upper Nambucca River.

Sites NR2 (both edge and riffle) and NR3 are located in quadrant three because. These sites had low taxa diversity but slightly higher SIGNAL2 scores. Quadrant three generally represents sites with toxic pollution or harsh physical conditions. Agricultural activities along the Nambucca River have resulted in clearing of a large portion of the riparian zone. Each of these three sites recorded concentrations of copper slightly greater than the ANZECC/ARMCANZ (2000) guideline value of 0.0014 mg/L (see Water Quality Results section for more details). The physiochemical properties recorded at these sites are considered abnormal or above the recommended national guidelines (ANZECC/ARMCANZ).

Site NR4 is located in quadrant one because of high taxa diversity and high SIGNAL2 scores. This is the only non-reference site to fall into this quadrant. This section of the river is likely to support favourable conditions for macroinvertebrate habitat and the water is likely to be chemically diluted. This site was the only Nambucca River site not to record copper concentrations above the detection limit.

Bowra Creek

The Bowra Creek sites were divided between quadrants three and four. The separation between the two quadrants is caused by variation in SIGNAL2 scores. The SIGNAL2 scores are representative of very few but very pollution tolerant animals present. Sites BC2, BC3 and BC4M (riffle) exhibited SIGNAL2 scores indicating low diversity with an abundance of pollution tolerant animals. Harsh physical conditions caused by

agricultural, industrial and urban clearing, development and associated run off all contribute to the low presence of sensitive taxa along the Bowra Creek sites.

Sites BC1 and BC4E (edge) are marginally located within quadrant three. Development and clearing are likely to be major contributing factors to the low scores at these sites, as they are of the sites located in quadrant four

Extensive agriculture occurs along most of the length of Bowra Creek. Within the flooding zone of the creek agricultural activities have resulted in highly modified bed and bank conditions. It was noted that the riparian vegetation was extremely disturbed in some areas. Bowra Creek is ephemeral and variations in flow regime through the annual cycle may contribute to the low SIGNAL2 scores. The anthropogenic modification of the riparian zone and the creek impact the turbidity, pH and water temperature in the creek and the Nambucca River.

South Creek

The South creek sites were divided between quadrants three and four. Similar to the Bowra Creek sites, the only factor separating the sites between quadrants is the number of taxa and a slight difference in the SIGNAL2 scores. All four sites are located marginally above and below the axis. The harsh physical conditions and the affects of agricultural development and runoff are likely to be contributing to the impact at these sites.

Both edge sites are located in quadrant four while both riffle sites are located in quadrant three. The differences between the sites are less than 1 unit of the SIGNAL2 scores. The physiochemical properties recorded for these sites indicate that conductivity is higher at these two sites than any other site sampled. The high conductivity is not outside of the guidelines of 'normal' conditions, cited in the ANZECC/ARMCANZ (2000) guidelines for southeast Australia.

Extensive agriculture continues to occur along the length of South Creek. Site SC1 is located in the agricultural district and is approximately 2 km upstream from site SC2, which is located in the urban district of Bowraville. Urban, industrial and agricultural pollution would contribute to the poor SIGNAL2 scores and low taxa diversity at these sites. The ephemeral nature of South Creek and annual variation in flow may also contribute to the low SIGNAL2 scores.

Reference Site

The reference site is located in quadrant 1. This quadrant is representative of favourable conditions for macroinvertebrates and chemically dilute waters. It is expected that the reference site would fall into this quadrant.

The reference site is located on Missabotti Creek in a catchment adjacent in the Nambucca River. This creek does not necessarily reflect the Nambucca River catchment in terms of continual annual flow. This site is subject to annual flooding and ephemeral flows, as are the Nambucca catchment sites.

Table 22 SIGNAL 2 Scores

Site	Number of Taxa	SIGNAL 2 Score
BC1	15	4.68
BC2	15	3.56
BC3	6	3.54
BC4M	3	3.73
BC4E	7	4.84
SC1M	11	4.52
SC1E	17	4.37
SC2R	12	4.62
SC2E	16	4.28
NR2R	13	4.629
NR2E	16	4.811
NR3	12	4.886
NR4	19	5.023
NR5	9	3.8
NR1E	24	4.898

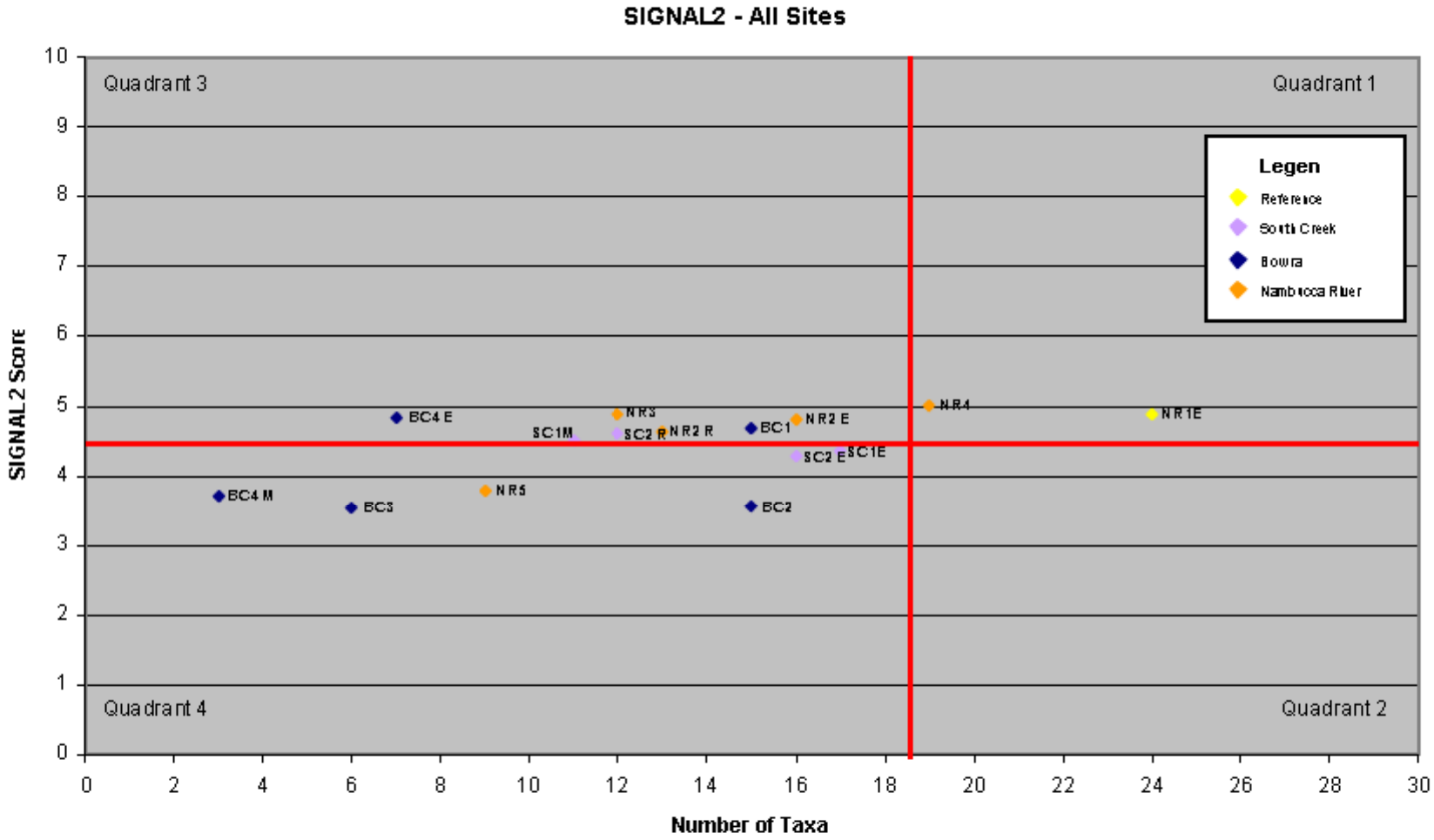


Figure 9 The SIGNAL2 Quadrant Diagram (biplot) for the Family Taxa of Macroinvertebrates Recorded at Each Site.

8.4.3 Ephemeroptera, Plecoptera, and Trichoptera (EPT) Ratio Results

The EPT index is widely used to measure taxa richness based on the Ephemeroptera (Mayflies), Plecoptera (Stoneflies) and Trichoptera (Caddisflies) families (Bode *et al*, 1997). These three orders are intolerant of pollution and widely used as indicators of disturbance. The EPT index is simply the percentage of the total number of individuals that are in EPT taxa from each sample (Table 23).

Higher ratios of EPT indicate a greater abundance of taxa that are less tolerant of disturbance (reflecting higher aquatic habitat values), whereas lower EPT ratios indicate a lower abundance of taxa intolerant of disturbance, and hence lower aquatic habitat values.

Nambucca River

The EPT ratios for the Nambucca River, with the exception of NR5, are more consistent between sites than the Bowra or South Creek samples. Sites NR2 (edge and riffle), NR3 and NR4 recorded EPT ratios of between 20.1 and 40.1%. This is considered a low to moderate ratio and indicative of the low to moderate abundance of pollution tolerant taxa present in the samples.

NR5 recorded the lowest EPT ratio of 2.22%. This is not surprising given the exceptionally low taxa abundance and diversity at this site. The low EPT ratio is consistent with the low SIGNAL2 score and the position of the site in quadrant four of the biplot. This site is likely to be the most disturbed site of those sampled along the Nambucca River.

Bowra Creek

The EPT ratios for Bowra Creek were all less than 4% with the exception of BC1 that recorded 74.76%. The high ratio at BC1 may provide evidence that harsh physical conditions or pollution noted at all of these sites using the SIGNAL2 and biplot analysis are not as devastating at this one site. The dominant family recorded at this site was ephemeroptera Leptophlebidae. This animal is known to be sensitive to pollution and is used as an indicator species for environmental monitoring. The absence of this family from the other sample sites indicates that the headwater where BC1 is located is not subject to the same harsh physical or pollution conditions present at downstream sites.

South Creek

Both South Creek sites recorded very different EPT ratios between the edge and riffle samples. The higher value noted at the riffle sites (SC1 – 48.53% and SC2 – 14.21%) may indicate that pollutants are less likely to persist in the faster flowing waters of the riffle habitat at this site. The lack of pollution intolerant animals in the edge sample has resulted in low EPT values for these samples (SC1 – 11.71% and SC2 – 3.27%). It is likely that the low EPT values result from habitat degradation and pollutants from the adjacent agricultural operations.

Reference Site

The reference site NR1E sample was collected from edge habitat. The EPT ratio was 58.82%. In comparison to all other edge samples, the only site that is comparable was BC1 (74.76%). The reference site is located on Missabotti Creek on a catchment adjacent to the Nambucca River. It is likely that this site has not suffered the impacts of urban, industrial or agricultural pollution.

Table 23 EPT percentage

Site	EPT Percentage
BC1	74.76
BC2	1.493
BC3	0
BC4M	0
BC4E	3.061
SC1M	48.53
SC1E	11.71
SC2R	14.21
SC2E	3.271
NR2R	31.14
NR2E	20.1
NR3	40.1
NR4	20.1
NR5	2.222
NR1E (Reference Site)	58.82

9. Water Quality Results

9.1 Meteorological Data

Rainfall* during the months (September, October and November) prior to sampling was above average in September and November and below average in October. Over the four-week period prior to sampling, approximately 157 mm of rain was recorded.

Observed rain events were sporadic prior to sampling (one week), however, no rainfall was observed during the time of sampling.

*All rainfall data referred to was recorded at Coffs Harbour and obtained from the *Bureau of Meteorology* website (/www.bom.gov.au) due to no data being available, specific to the Bowraville area.

9.1.1 River Height Data

River height, over a four week period prior to sampling, steadily decreased from 23/10/08 to 11/11/08. River height from 1211/08 showed a marked increase in height over a seven-day period (12/11/08 – 19/11/08).

River height data prior to sampling was obtained from the *NSW Water Information* website (www.waterinfo.nsw.gov.au).

9.2 Physiochemical Data

The water quality variables measured provide an assessment of the health of the waterways. Insitu physiochemical data were collected at all sites during the survey. The insitu physiochemical water quality data at each site recorded values for pH (pH), temperature (ºC), dissolved oxygen (% saturation), conductivity (µS/cm) and turbidity (NTU). The insitu results were compared against locally derived reference values for the region from the *Australian Water Quality Guidelines for Fresh and Marine Waters* (Australian and New Zealand Environment and Conservation Council (ANZECC/ARMCANZ, 2000) Guidelines. Two replicates of each parameter were recorded and averaged for increased accuracy.

The sites for the water quality sampling are the same as those for the aquatic sampling sites and are shown in Figure 4.

Sampling sites for water quality are the same as those for sampling aquatic communities. All results are presented in Table 24. Any exceedances of trigger values have been shaded.

Table 24 Insitu Water Quality

Site	Number of replicates recorded	pH	Temp	DO	Conductivity	Turbidity
			°C	% sat	uS/cm	NTU
ANZECC/ARMCANZ guidelines for aquatic ecosystems (95% protection level)		**6.5-8.0[1]**	**n/a**	**85-110[1]**	**200-300[2]**	**50[3]**

BC1	2	5.75	17.8	16.5	157.2	5.4
BC2	2	5.78	19.5	11.2	136	17.9
BC3	2	5.92	20.4	11.9	116.7	12
BC4	2	6.15	20.8	15.9	148.8	11.8
SC1	2	6.77	23.2	75.3	294	8.2
SC2	2	6.95	21.9	73.3	258	4.7
NR1	2	6.77	19.5	77	64.2	0.6
NR2	2	7.14	20.8	92.1	74.8	0.3
NR3	2	6.98	23	90.9	81.5	1.2
NR4	2	6.91	22.3	78.4	166	3.4
NR5	2	7.22	21.1	87.5	117.4	1.0

[1] DO values were derived from daytime measurements. DO concentrations may vary diurnally and with depth; [2] EC values are typically in the range of 200-300 µS/cm in NSW coastal rivers; and [3] NTU values in the higher range of the typical 6-50 NTU for lowland rivers expected in rivers draining from slightly disturbed catchments and rivers at high flows.

The water quality results displayed in Table 24 are insitu measurements and indicative of water quality at the time of sampling only. It is assumed that variation within parameters may occur seasonally and meteorologically.

9.2.1 pH

pH can be strongly affected by rainfall events, the condition of surrounding riparian vegetation, runoff and the regional geology.

Nambucca River

All sites sampled along the Nambucca River recorded pH within the ANZECC/ARMCANZ (2000) guideline range for lowland rivers in southeast Australia (6.5-8.0 pH).

Bowra Creek

All Bowra Creek sites were below the ANZECC/ARMCANZ (2000) guideline range for lowland rivers in southeast Australia (6.5-8.0 pH). All sites were very slightly acidic.

South Creek

All sites sampled along South Creek recorded pH within the ANZECC/ARMCANZ (2000) guideline range for lowland rivers in southeast Australia (6.5-8.0 pH).

Reference Site

The reference site recorded pH within the ANZECC/ARMCANZ (2000) guideline range for lowland rivers in south east Australia of 6.5-8.0 pH.

9.2.2 Dissolved Oxygen (DO)

Rainfall, temperature and the natural lotic environment can affect levels of dissolved oxygen. Rainfall increases the percentage of dissolved oxygen available in the water. Temperature can alter the DO and diurnal data acquisition is generally avoided. Riffles, run and pools within the lotic environment are likely to record differing DO readings.

Nambucca River

All sites except NR3 and NR4 recorded DO within the ANZECC/ARMCANZ (2000) guideline range for lowland rivers in southeast Australia (85-110 % saturation). Site NR3 and NR4 recorded DO slightly below the guideline range.

Bowra Creek

All Bowra Creek sites were well below the ANZECC/ARMCANZ (2000) guideline range for lowland rivers in southeast Australia (85-110 % saturation). The slow moving ephemeral nature of this creek with the absence of numerous riffle areas may have contributed to the low readings.

South Creek

Both sites sampled along South Creek were slightly below the ANZECC/ARMCANZ (2000) guideline range for lowland rivers in southeast Australia (85-110 % saturation).

Reference Site

The reference site recorded DO below the ANZECC/ARMCANZ (2000) guideline range for lowland rivers in southeast Australia (85-110 % saturation). The DO was 77% saturation, marginally below the guideline range.

9.2.3 Electrical Conductivity (EC)

The concentration of dissolved ions in water becomes more diluted, as more water is available in the system i.e. following rainfall or in a larger or faster moving system.

Nambucca River

All sites were considerably below the ANZECC/ARMCANZ (2000) typical range for lowland rivers in southeast Australia (200 – 300 µS/cm). The Nambucca River is a large river that there is more water available to dilute ions in comparison to the higher concentrations of ion in the smaller creeks of the study sites.

Bowra Creek

All sites were marginally below the ANZECC/ARMCANZ (2000) typical range for lowland rivers in southeast Australia (200 – 300 µS/cm). The concentration of ions is higher than in the lower volume of water availably in the smaller creek.

South Creek

Both sites were within the ANZECC/ARMCANZ (2000) typical range for lowland rivers in southeast Australia (200 – 300 µS/cm).

Reference Site

The reference site was below the ANZECC/ARMCANZ (2000) typical range for lowland rivers in southeast Australia (200 – 300 µS/cm).

9.2.4 Turbidity

Nambucca River

All sites were below the ANZECC/ARMCANZ (2000) value for lowland rivers draining through slightly disturbed catchments in southeast Australia (50 NTU).

Bowra Creek

All sites were below the ANZECC/ARMCANZ (2000) value for lowland rivers draining through slightly disturbed catchments in southeast Australia (50 NTU). The Bowra Creek sites recorded slightly higher turbidity than the Nambucca River and the reference site. It is likely that the agricultural influence along this creek is contributing to the higher turbidity.

South Creek

All sites were below the ANZECC/ARMCANZ (2000) value for lowland rivers draining through slightly disturbed catchments in southeast Australia (50 NTU). Turbidity at the South Creek sites was similar to that of Bowra Creek and higher than the Nambucca River and the reference site. It is likely that agriculture along this creek is contributing to the higher turbidity.

Reference Site

The reference site was below the ANZECC/ARMCANZ (2000) value for lowland rivers draining through slightly disturbed catchments in south east Australia (50 NTU).

9.3 Chemical Data

Chemical analysis was undertaken at all sites for nutrients, BOD and metals (Table 25). One set of water samples were taken at each site during the study. The water quality results displayed in Table 26 are indicative of nutrients, BOD and metals at the time of sampling only. It is assumed that variation within parameters would occur seasonally and meteorologically.

The sites for sampling water quality are the same as those for sampling the aquatic communities.

9.3.1 Nutrients

Nutrient concentrations can be strongly related to riparian habitat or the absence of such habitat, availability of shade and oxygen to the water body, runoff from surrounding land uses and natural conditions of particular regions. Nambucca River, Bowra Creek and South Creek are all adjacent to some form of agriculture, industry or urban encroachment/development.

Nambucca River

Nutrient levels at the Nambucca River site were within the ANZECC/ARMCANZ (2000) guidelines. Ammonia marginally exceeded the recreational use guideline value (0.01 µg/L) at NR2 (0.02 µg/L), NR4 (0.02 µg/L) and NR5 (0.03 µg/L). The values did not exceed the 95% species protection value (0.9 µg/L).

Bowra Creek

Nutrient levels at the Bowra Creek sites were within the ANZECC/ARMCANZ (2000) guidelines with the exception of ammonia (as N). Ammonia exceeded both the recreational use value (0.01 µg/L) at BC1 (0.38 µg/L), BC2 (0.07 µg/L), BC3 (0.15 µg/L) and BC4 (0.11 µg/L).

South Creek

Nutrient levels at the South Creek sites were within the ANZECC/ARMCANZ (2000) guidelines with the exception of ammonia (as N). Ammonia exceeded the recreational use value (0.1 µg/L) at SC1 (0.03 µg/L), SC2 (0.07 µg/L). Both values were below the 95% species protection value (0.09 µg/L).

Reference Site

Nutrient levels at the reference site were within the ANZECC/ARMCANZ (2000) guidelines with the exception of ammonia (as N). Ammonia exceeded the recreational use value (0.1 µg/L) at this site (0.02 µg/L) and was below the 95% species protection value (0.09 µg/L).

9.3.2 BOD

Biochemical oxygen demand (BOD) is a measure of how much dissolved oxygen is being consumed as microbes break down organic matter. A high demand can indicate that levels of dissolved oxygen are falling, with potentially dangerous implications for the biodiversity of the aquatic system.

High levels of organic pollution can cause high biochemical oxygen demand. This is often from poorly treated wastewater or high nitrate levels that trigger high plant growth rates.

BOD was not recorded above the detection limits at any site for this survey.

9.3.3 Metals

Metals were reported below the ANZECC/ARMCANZ (2000) guidelines for all sites and all analytes with the exception of zinc. Zinc was reported in elevated concentrations at all sites. The reported zinc concentrations are not considered to be representative of "gross" impact. They may represent naturally occurring 'background' levels in the local area (although this cannot be confirmed based on the current (limited) data set).

Table 25 Water chemistry results

Analyte Description	Units	PQL	ANZECC/ ARMCANZ (2000)	ANZECC/ ARMCANZ (2000)	ANZECC/ ARMCANZ (2000)	BC1	BC2	BC3	BC4	SC1	SC2	NR2	NR3	NR4	NR5	NR1 Reference
Date Sampled			95% species protection	Lowland river south-east Australia	Recreational Use	21/11/08	21/11/08	21/11/08	21/11/08	21/11/08	21/11/08	21/11/08	21/11/08	21/11/08	21/11/08	21/11/08
Ammonia as N	mg/L	<0.01	0.9		0.01	0.38	0.07	0.15	0.11	0.03	0.07	0.02	0.01	0.02	0.03	0.02
Total Phosphorus	mg/L	<0.05		50		0.1	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Kjeldahl Nitrogen	mg/L	<0.2				0.8	<0.2	0.6	0.3	0.3	0.3	<0.2	<0.2	<0.2	<0.2	<0.2
Total Nitrogen	mg/L	<0.2		500		0.8	<0.2	0.64	0.3	0.53	0.49	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrite as N	mg/L	<0.05				<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrate as N	mg/L	<0.05	0.7			<0.05	<0.05	<0.05	<0.05	0.26	0.23	<0.05	0.06	0.14	<0.05	<0.05
Biochemical Oxygen Demand - BOD_5	mg/L	<2				<5	<5	<5	<5	<5	<5	<2	<2	<5	<2	<2
Arsenic	µg/L	<1	24*		50	2	1	2	1	1	1	<1	<1	<1	<1	<1
Cadmium	µg/L	<0.1	0.2		5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<1	<0.1	<1	<1
Chromium	µg/L	<1	1.0**		50	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Copper	µg/L	<1	1.4		1000	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Lead	µg/L	<1	3.4		50	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Nickel	µg/L	<1	11		100	<1	2	2	<1	<1	<1	<1	<1	<1	<1	<1
Zinc	µg/L	<1	8		5000	78	74	75	74	79	48	64	68	77	53	130
Mercury (Dissolved)	mg/L	<0.0005	0.6		1	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005

Highlighting indicates level of protection, categories of applicable trigger values and exceedances of each trigger value per category.

9.4 Laboratory Analysis

The surface water samples obtained from the river and creeks are all within the trigger values for the ANZECC/ARMCANZ (2000) Guidelines for Aquatic Ecosystems (95 % level of protection) and recreational water quality.

The results of the water quality analysis are presented in Table 26. Exceedances of guidelines are marked by shaded sections.

Table 26: Laboratory Water Quality Results

Analyte grouping / Analyte	Units	Lower limit of reporting	ANZECC guidelines for 95% aquatic ecosystem protection	ANZECC guidelines for recreational water quality	BC1	BC2	BC3	BC4	SC1	SC2	NR1	NR2	NR3	NR4	NR5
Arsenic	mg/L	0.001	24	*	0.006	0.008	0.009	0.008	0.007	0.006	0.003	0.005	0.016	0.016	0.019
Arsenic	mg/L	0.001	0.024	0.05	<0.005					0.008	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.0001	0.2	5	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0004	0.0003	<0.0001	<0.0001	<0.0001
Cadmium	mg/L	0.0001	0.0002	0.005	<0.0002					<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Chromium	mg/L	0.001	1	*	<0.001	<0.001	<0.001	0.001	0.001	0.002	0.001	<0.001	<0.001	<0.001	<0.001
Chromium	mg/L	0.001	0.001	0.05	<0.002					<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Copper	mg/L	0.001	1.4	1000	0.002	0.001	<0.001	<0.001	<0.001	0.001	0.003	0.01	0.005	0.004	0.004
Copper	mg/L	0.001	0.0014	1	<0.001					<0.001	0.002	0.002	0.008	<0.001	0.002
Lead	mg/L	0.001	0.0034	0.05	<0.001					<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.001	0.011	0.1	<0.002					<0.002	<0.002	<0.002	0.002	<0.002	<0.002
Zinc	mg/L	0.005	0.008	5	0.005					<0.005	0.006	<0.005	<0.005	<0.005	<0.005
Mercury	mg/L	0.0001	0.0006	0.001	<0.0002					<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002

Analyte grouping / Analyte	Units	Lower limit of reporting	ANZECC guidelines for 95% aquatic ecosystem protection	ANZECC guidelines for recreational water quality	BC1	BC2	BC3	BC4	SC1	SC2	NR1	NR2	NR3	NR4	NR5
Ammonia Nitrogen NH3 as N	mg/L	0.05		0.01	<0.05					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Kjeldahl Nitrogen as N	mg/L	0.05	*	*	0.55					0.16	0.13	0.16	1.13	0.1	0.14
Total Nitrogen as N	mg/L	0.05	*	*	0.55					0.16	0.13	0.16	1.13	0.1	0.14
BOD	mg/L	0.5													
Total Kjeldahl Phosphorus as P	mg/L	0.02	*	*	0.03					<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

10. Potential Impacts

10.1 Overview of Potential Ecological Impacts

The assessment of potential ecological impacts arising from the Proposal was based on:

- Field surveys targeting terrestrial vegetation communities and habitats;
- GIS mapping to determine the areas of terrestrial vegetation and habitats to be inundated and/or removed;
- Compilation of broad aquatic habitat descriptions drawn from Bishop (2005);
- Review of Bishop (2005) to ascertain potential impacts on fish communities;
- Review of profiles on threatened species and endangered ecological communities recorded, or considered likely to occur, within the study area;
- Knowledge of species' life cycle requirements, distribution and current threats; and
- Review of various other ecological studies previously conducted on the Bowraville site, including Biosis (2005) and Connell Wagner (1997).

The study area provides resources and habitat features for threatened and common native terrestrial and aquatic flora and fauna. Consequently, some of these species are likely to be adversely affected by the Proposal. The potential short and long term impacts of the Proposal to the terrestrial and aquatic flora and fauna values of the study area (see sections 5 – 9) are discussed below.

It is unlikely that the threatened species known from the study area would be significantly impacted by the proposed activities. The significance of these impacts is discussed in Section 10.8.

For the purpose of addressing the potential ecological impacts, the proposed works area includes the construction of the storage embankment, inundation area, access roads, pipeline routes and other water supply infrastructure.

10.2 Potential Short Term Impacts

Short-term impacts are primarily related to the immediate construction and post construction period of the off-river storage. There exists a likelihood of fauna mortality over the short-term in relation to vegetation clearing activities. The time that it may take to clear the off-river storage area is dependent on construction sequencing, and this in turn would determine the immediacy of the impacts, and potentially the degree of impact. Impacts are likely to be less severe if the clearing takes longer, as terrestrial fauna populations may be able to more readily disperse as clearing progresses up the catchment.

10.3 Long Term Impacts

Longer-term impacts are associated with the ongoing maintenance and operation of the off-river storage. These primarily involve impacts on population dynamics and river morphological processes. The potential long-term effects are described below.

Caveats and Assumptions

The assessment of the potential impacts of the Proposal is based on a number of caveats and assumptions. These include:

- Assessment of the potential impacts was undertaken with regard to the inundation area being at its maximum extent. This area of maximum extent was based on information provided by NSC;
- Transparent releases of water from the off-river storage would be made as part of the flow release strategy and should minimise environmental impacts along Bowra Creek below the embankment (see Chapter 4 in EIS);
- There are currently no environmental flow rules in place for the existing groundwater extraction with the exception of a 3,100ML annual limit. The environmental flow rules for the operational limits of the scheme as specified by the water license are designed to reduce ecological impacts of the scheme. These operational restrictions include limiting groundwater extraction to provide environmental flows and to prevent the drying out of reed vegetation downstream of the Proposal;
- The clearing limits of the inundation area would be clearly marked just above the full storage level (FSL) and "no go" areas created to protect retained vegetation from unnecessary damage;
- The inundation of the inundation area would be cumulative, and may not reach maximum capacity for a number of years. This is based on a review of the seasonal climatic conditions in reference to the Nambucca area, and based on information obtained from various sources (including NSC and the Department of Commerce) as to the likely rate of filling off-river storages of similar capacities, in similar environmental climates. This review suggests that an off-river storage with the capacity of the Bowraville off-river storage, in normal seasonal conditions, may fill within 24 months. As the severity of some of the potential impacts is dependent on this time frame, there is some latitude in the assessment on these specific impacts;
- The proposed slow filling of the off-river storage should provide a long enough timeframe for any threatened and non-threatened species populations to relocate into surrounding lands, especially those species that have a smaller home range and as long as the filling does not occur quickly; and
- The capacity to mitigate the full extent of inundation impacts is limited. Inundation would become a permanent feature of the ecological landscape, and in some instances there are no viable mitigation strategies for the anticipated residual impacts. It is anticipated the the proposed protection area would assist in offsetting these residual impacts.

10.4 Terrestrial Flora and Fauna

10.4.1 Removal and modification of terrestrial vegetation and habitat

The construction of the off-river storage embankment, construction and maintenance of access roads, and water supply infrastructure would require the immediate clearing of vegetation for

this and other associated infrastructure. The extent of vegetation clearing and habitat types is depicted in Table 27 below and shown in Figure 10.

Vegetation and associated habitat within the inundation area would be cleared prior to inundation over a period of 3 months. As previously identified, this may be undertaken in two stages. However, it would seem more logical that the clearing be a continuous operation considering the cost associated wth locating heavy machinery to site and access issues getting to selective trees only. The approximate extent of vegetation clearing for the Proposal and the habitat types are depicted in Table 27.

The riparian vegetation to be removed is along the Nambucca River and South Creek where riverbank stabilisation works are proposed. The total area of riparian vegetation to be removed from the study area is 3.98 ha.

This riparian vegetation has undergone past disturbances due to land clearance for agriculture and is mainly comprised of exotic plant species, such as Camphor Laurel. Where the pipeline traverses pastureland, pasture would be re-established and measures would be taken in accordance with a weed management plan to minimise the invasion of the noxious weed Giant Parramatta Grass.

Table 27 Extent of Removal of Terrestrial vegetation and associated fauna habitat within Study Area

Vegetation Community / Habitat Type	Vegetation to be removed				
	Storage Embankment Footprint (Ha)	Native Vegetation within Inundation Area (Ha)	Bobo Road Access (Ha)	River Stabilisation Works (ha)	Total Removed from Study Area (Ha)
Hardwood Plantation Forest	0.12	25.94	1.39	0	**27.45**
Wet Flooded Gum – Tallowwood Forest	0	20.02	0	0	**20.02**
Northern Wet Tallowwood – Blue Gum Forest	0	7.85	0	0	**7.85**
Foothills Grey Gum – Broad-leaved Mahogany Forest	0	4.14	2.65	0	**6.79**
Wet Bloodwood – Tallowwood Forest (Temperate Rainforest)	0	0.64	0	0	**0.64**
Pastureland	3.01	10.54	0	0	**13.55**
Riparian Vegetation	0.8	1.5	0	1.49	**3.79**
Totals	***3.93***	***70.63***	***4.04***	***1.49***	***80.09***
Total Footprint and Inundation Area (Ha)	***74.56***				

10.4.2 Fauna displacement

The degree of impact would vary depending on the rate at which the clearing of vegetation and associated habitat would occur. Threatened fauna and common native flora and fauna would be displaced and/or removed as a result of the Proposal from the study area as a proportion of vegetation and habitat would be permanently removed and modified. Removal of vegetation and habitat has the potential to disrupt the lifecycle of species that currently utilise the study area.

In the short term, fauna may be subject to mortality and would be displaced by immediate noise, construction and other human activity and through the initial clearing of the inundation area over a 3 month construction period. Displaced terrestrial fauna are likely to move into the surrounding vegetation of greater habitat value with the potential to increase pressures on adjacent populations through territorial disputes, and competition for the resources.

Displacement of fauna is likely to be progressive across the life of the Proposal depending on the species. The Proposal is likely to result in reducing the local populations of some species (e.g. plants, resident fauna species and less mobile fauna species including reptiles and amphibians) in the proposed works area that may be subject to mortality.