TECHNICAL PAPER 8

NATIONAL CARP CONTROL PLAN

NCCP Murray and Murrumbidgee case study

This suite of documents contains those listed below.

NCCP TECHNICAL PAPERS

1. Carp biocontrol background
2. Epidemiology and release strategies
3. Carp biocontrol and water quality
4. Carp virus species specificity
5. Potential socio-economic impacts of carp biocontrol
6. NCCP implementation
7. NCCP engagement report
8. NCCP Murray and Murrumbidgee case study
9. NCCP Lachlan case study

NCCP RESEARCH (peer reviewed)

Will carp virus biocontrol be effective?

1. 2016-153: Preparing for Cyprinid herpesvirus 3: A carp biomass estimate for eastern Australia
2. 2018-120: Population dynamics and carp biomass estimates for Australia
3. 2017-148: Exploring genetic biocontrol options that could work synergistically with the carp virus
4. 2016-170: Development of hydrological, ecological and epidemiological modelling
5. 2017-135: Essential studies on Cyprinid herpesvirus 3 (CyHV-3) prior to release of the virus in Australian waters
6. 2020-104: Evaluating the role of direct fish-to-fish contact on horizontal transmission of koi herpesvirus
7. 2019-163 Understanding the genetics and genomics of carp strains and susceptibility to CyHV-3
8. 2017-094: Review of carp control via commercial exploitation

What are the carp virus biocontrol risks and how can they be managed?

9. 2017-055 and 2017-056: Water-quality risk assessment of carp biocontrol for Australian waterways
10. 2016-183: Cyprinid herpesvirus 3 and its relevance to humans
11. 2017-127: Defining best practice for viral susceptibility testing of non-target species to Cyprinid herpesvirus 3
12. 2019-176: Determination of the susceptibility of Silver Perch, Murray Cod and Rainbow Trout to infection with CyHV-3
13. 2016-152 and 2018-189: The socio-economic impact assessment and stakeholder engagement
    Appendix 1: Getting the National Carp Control Plan right: Ensuring the plan addresses community and stakeholder needs, interests and concerns
    Appendix 2: Findings of community attitude surveys
    Appendix 3: Socio-economic impact assessment — commercial carp fishers
    Appendix 4: Socio-economic impact assessment — tourism sector
    Appendix 5: Stakeholder interviews
    Appendix 6: Socio-economic impact assessment — native fish breeders and growers
    Appendix 7: Socio-economic impact assessment — recreational fishing sector
    Appendix 8: Socio-economic impact assessment — koi hobbyists and businesses
    Appendix 9: Engaging with the NCCP: Summary of a stakeholder workshop
14. 2017-237: Risks, costs and water industry response
15. 2017-054: Social, economic and ecological risk assessment for use of Cyprinid herpesvirus 3 (CyHV-3) for carp biocontrol in Australia
    Volume 1: Review of the literature, outbreak scenarios, exposure pathways and case studies
    Volume 2: Assessment of risks to Matters of National Environmental Significance
    Volume 3: Assessment of social risks
16. 2016-158: Development of strategies to optimise release and clean-up strategies
17. 2016-180: Assessment of options for utilisation of virus-infected carp
18. 2017-104: The likely medium- to long-term ecological outcomes of major carp population reductions
19. 2016-132: Expected benefits and costs associated with carp control in the Murray-Darling Basin

NCCP PLANNING INVESTIGATIONS

1. 2018-112: Carp questionnaire survey and community mapping tool
2. 2018-190: Biosecurity strategy for the koi (*Cyprinus carpio*) industry
3. 2017-222: Engineering options for the NCCP
4. NCCP Lachlan case study (in house) (refer to Technical Paper 9)
5. 2018-209: Various NCCP operations case studies for the Murray and Murrumbidgee river systems (refer to Technical Paper 8)

FRDC
FISHERIES RESEARCH & DEVELOPMENT CORPORATION

National Carp Control Plan Murray and Murrumbidgee River Systems Case Study

Outcomes Report

The Wedge Group Pty Ltd

Karl Mathers

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Ertech Pty Ltd

Greg Stevens

December 2019

FRDC Project No 2018-209

ISBN [Insert ISBN/ISSN – researcher to obtain]

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In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

Contents

Tables

Figures

Abbreviations

ARI - Arthur Rylah Institute

FRDC – Fisheries Research and Development Corporation

NCCP – National Carp Control Plan

CyHV-3 - Cyprinid herpesvirus 3

TWG – The Wedge Group

MDB – Murray-Darling Basin

1 Introduction

The Fisheries Research and Development Corporation (FRDC) is leading the development of a National Carp Control Plan (NCCP), exploring merits of the use of the virus known as Cyprinid herpesvirus 3 (CyHV-3, hereafter 'the carp virus') as a biocontrol agent to control invasive common carp, *Cyprinus carpio*, in Australian freshwater environments.

The NCCP will inform governments on the technical feasibility of releasing the carp virus, associated costs, benefits and risks and views of communities and stakeholders. It will also identify whether further work is required to inform deployment of the virus, should this be shown to be feasible.

The Wedge Group, and delivery partner Ertech, were engaged by the FRDC under the auspices of the National Carp Control Plan (NCCP) to develop and report on a conceptual case study and cost estimate for the carp virus deployment and management across the Southern Murray-Darling Basin catchment.

The case study was undertaken in three parts, being:

I. An initial investigation designed to develop a conceptual deployment and carcass management strategy and to test approaches to developing resource plans and costs estimates. This initial investigation was focussed on the Mid-Murray region of Southern NSW and Northern Victoria, specifically the Edward River offtake through to the Kow Swamp and Gunbower Creek areas.
II. A further regional investigation applying the conceptual deployment and management strategies to a higher carp biomass region with a range of differentiating factors to the Mid-Murray area, for example static weir pools and extensive connected wetlands. For this investigation a section of the Lower Murray River and associated wetlands was selected, specifically the Lock 1 to Lock 3 region in South Australia.
III. The third component of the case study involved scaling up the adopted methodologies to the entire Murray and Murrumbidgee Rivers systems. The area covered included the respective river systems downstream, and inclusive of, Hume and Burrinjuck reservoirs through to the Murray Mouth, including the Lower Lakes in South Australia.

It is the third component that is the primary focus of this report, and along with a parallel case study undertaken by the NCCP covering the Lachlan River catchment in NSW, illustrate how the carp virus would be implemented to suppress carp populations and manage risks. In addition, the conceptual resource plans, scheduling and cost estimates have informed the NCCP cost-benefit analysis.

1.1 Case Study Objective and Key Tasks

The overall objective of the case study project is to support the ongoing refinement of the NCCP implementation strategy and associated cost-benefit analysis through the development of conceptual carp virus deployment and management strategies for a given geographic region.

In meeting the overall project objective several case study specific tasks were identified prior to undertaking the case studies, these included:

i. mapping of carp populations at a scale that would enable the identification of risks to key environmental assets and water users (consumptive, recreational and cultural),
ii. identifying and assessing carp virus deployment and carcass management technologies and methods suitable for high volume biomass management (including carp virus deployment, surveillance, collection, removal/transport, disposal) to accommodate scenarios across the range of inland water body types,
iii. determining the human resources and management arrangements required for the range of technologies and methods,
iv. developing an operational response based on the case study findings; and
v. estimating indicative costs of the operational response.

1.2 Case Study Approach

The approach adopted to for the initial Mid-Murray and Lower Murray case studies (summarised in Appendix 3 and 4), and further applied to the Murray and Murrumbidgee Rivers system case study, was based around a process of data review and presentation, expert elicitation and stakeholder engagement, output capture, strategy refinement and cost estimation.

The case studies were developed and refined through several regionally based workshops with key NCCP representatives, technical experts, water managers, state agency representatives, natural resource managers and private sector contracting and waste management representatives. The case study stages, key processes and outcomes are summarised in Table 1 below, and further explained in the following sections.

Table 1-1 Case Study Stages

Stage	Inputs/Process	Outcomes
Data review and presentation	Collation & mapping presentation of biomass estimates from the respective NCCP biomass modelling projects. Review of draft Epidemiology study outputs and various draft NCCP technical papers	Mapping outputs based on the average year biomass modelling scenarios (web map publication of NCCP modelling data) Development of a draft virus deployment and carcass management strategy for workshop testing and to enable the identification of key risks and opportunities
Stakeholder engagement/expert elicitation	Facilitated workshops with key technical and stakeholder representatives, involving site inspections of key water management assets and structured sessions to identify and refine risks and opportunities along with carp virus deployment and carcass management strategies	Map based outputs identifying key risks and opportunities. Identified risk mitigation actions Indicative virus deployment and carcass management strategies
Strategy refinement	The project team in consultation with NCCP representatives undertook to review and refine the	An amended deployment strategy addressing key issues of infection targets (3%* of any one target sub-population) and program

Stage	Inputs/Process	Outcomes
	overall carp virus deployment and management strategies.	duration (extending from one to two years of active deployment and management)
Resource plan and cost estimation	Development of reach by reach resource plans and targets (including the identification of logical Control Centres and Forward Command Centres) based on the management risks Workshop development and refinement of a cost estimation model (in *Expert Estimation Genesis* software) Cost estimation refinement	Resource plan and numbers on a reach by reach basis Draft and final cost estimates based on adopted carp virus deployment and carcass management strategies.

* The 3% infection target is indicative and based on research to date and would be subject to a range of biomass and environmental factors and time of deployment. It should be further reviewed through the implementation planning and early operational phases.

1.3 Case Study Areas

The Mid-Murray case study covered an area from the Edward River offtake (Picnic Point, east of Mathoura, NSW) through to the Torrumbarry Weir on the Murray River and extending through the National Channel (Goulburn Murray Water's Torrumbarry Irrigation Area offtake), the Gunbower Creek lagoons and incorporating Kow Swamp, west of Gunbower (VIC). The Mid-Murray case study area is show in Figure 1-1 below.

The Lower Murray case study region, shown in Figure 1-2, covers an area from Lock 1 at Blanchetown back upstream to Lock 3 at Overland Corner in South Australia. This case study area included the main river channel and adjoining wetlands and lakes.

The larger up-scaled case study, shown in Figure 1-3, covers the Murray and Murrumbidgee Rivers systems inclusive of both Hume and Burrinjuck reservoirs through to the Murray Mouth, including the Edward-Wakool system, the Darling River (Wentworth weir pool extent) and the Lower Lakes in South Australia.

The larger case study represents a 'southern zone' for carp virus deployment and management. It incorporates the entire Mid-Murray case study area with the major difference being the distribution of carp virus deployment and carcass management resources and the delineation of Catchment Control Areas (CCA's). The CCA's being the operational resource units incorporating Control Centres and Forward Command Centres, discussed further in Section 5.

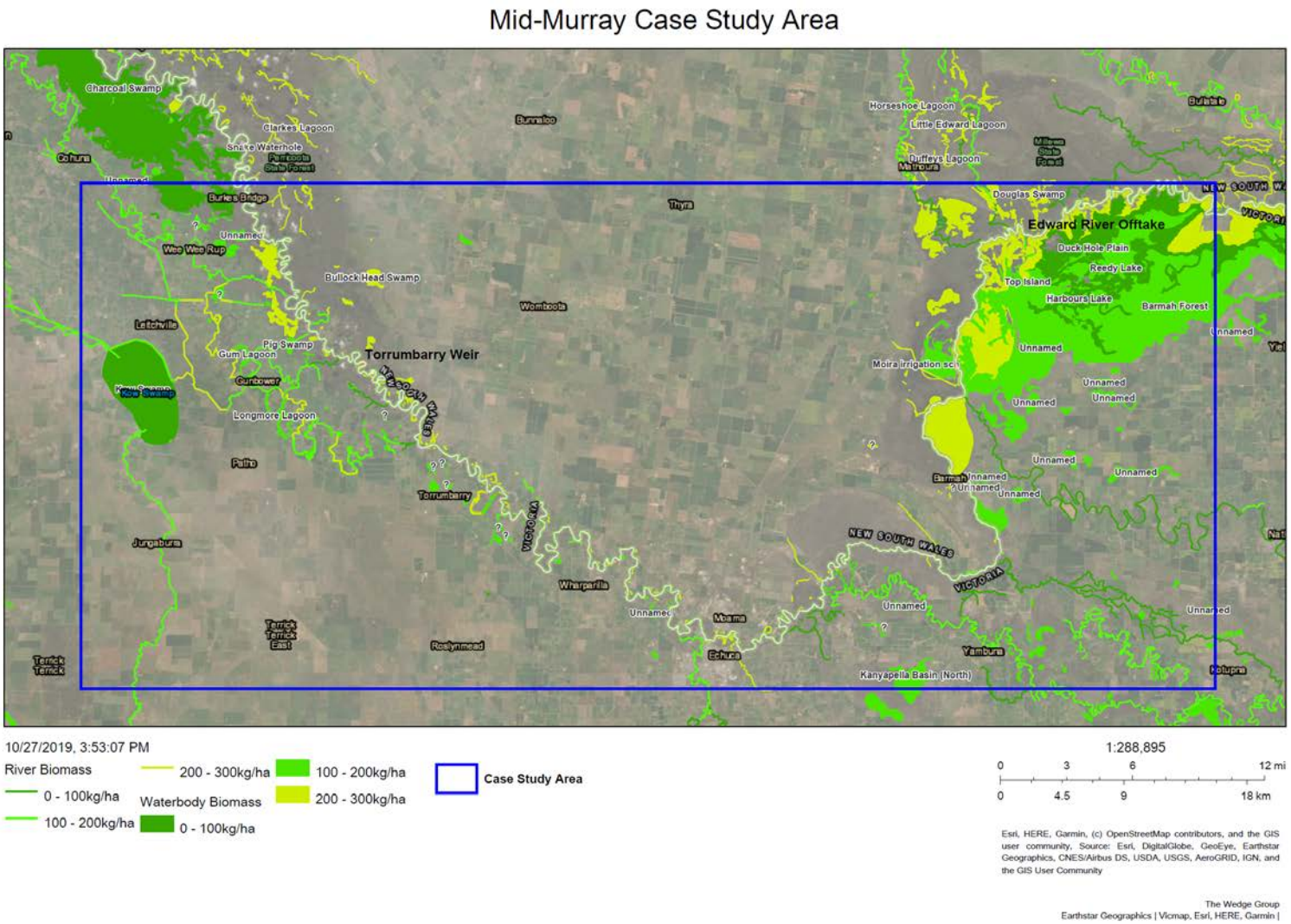


Figure 1-1 Mid-Murray Case Study Area

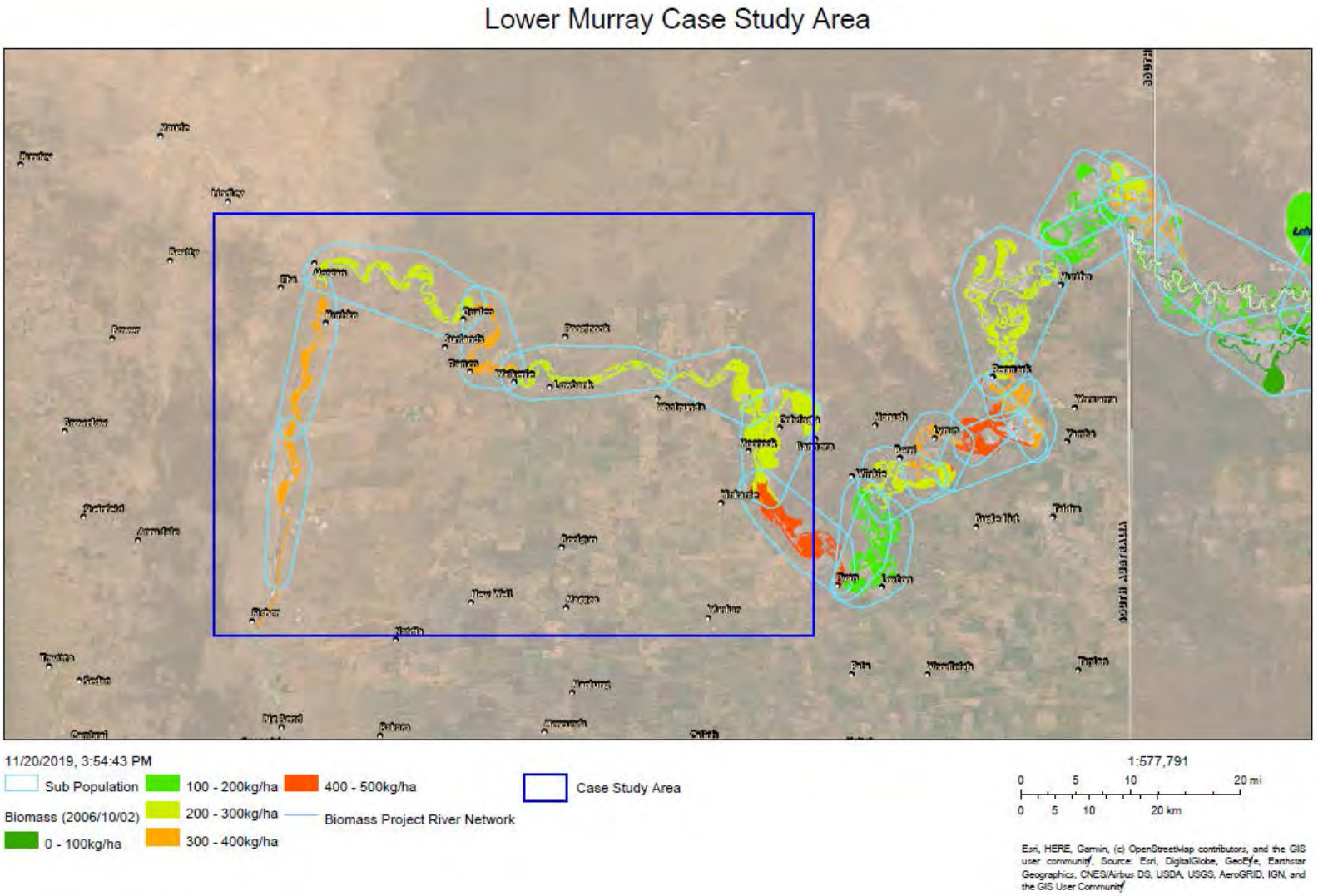
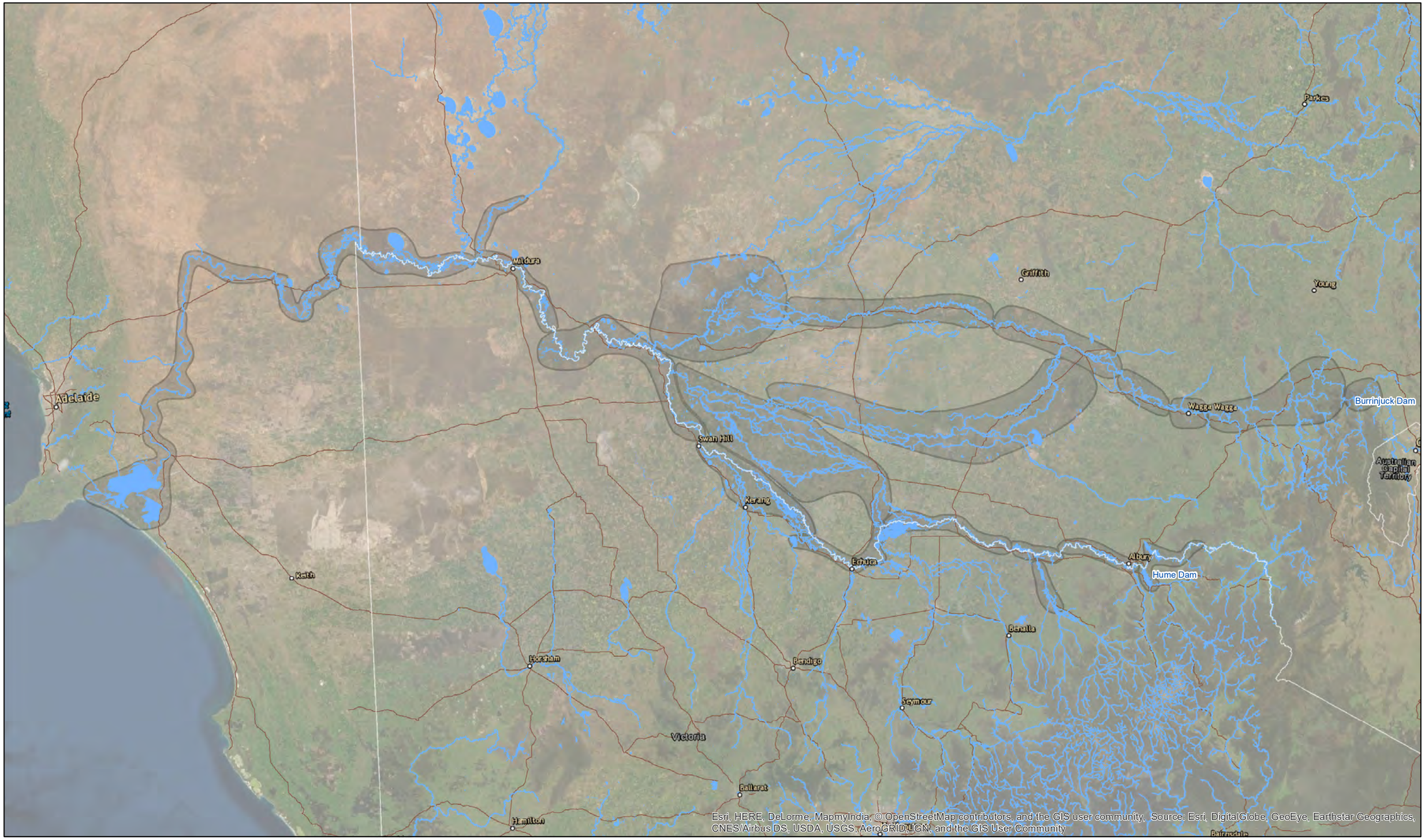
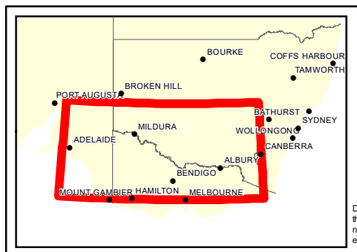


Figure 1-2 Lower Murray Case Study Area





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Kilometres

Scale 1:2,500,000 @ A3

GDA94 Lambert Conformal Conic

Legend

Main Highway | River | Waterbody

THE WEDGE GROUP

Figure 1-3

Murray & Murrumbidgee Case Study Area

2 Biomass Mapping

An initial stage of the case study investigations was the collation and mapping of carp biomass data derived from the two discrete NCCP Biomass modelling projects lead by the Arthur Rylah Institute (ARI) and the CSIRO. Spatially represented biomass data (in kg/ha) from both the CSIRO and ARI led projects was provided and published as a series of Arc GIS web maps. This format enabled both fine and broader scale interrogation of the biomass data in real time during the case study workshops as well as the publication of a range of map outputs for reporting purposes.

NCCP biomass estimation research indicates that carp population density across the case study areas varies considerably, with distributions from less that 50-100kg/ha to more than 500kg/ha. NCCP modelling indicates that targeting carp populations towards the upper end of this biomass range for carp virus deployment would see those populations reduced below the identified risk threshold of 150kg/ha.

The mapping of carp biomass distribution across the case study reaches provided a key platform from which risk and management strategies could be identified and carp virus deployment and management resources determined.

The higher carp densities are in the connected and typically regulated systems of the Murray-Darling Basin. This is due to regulated systems creating suitable conditions for carp population growth with more permanent water and annual higher water levels during deployment periods that promote spawning and migration. These areas are the focus of NCCP virus deployment.

The following two screenshots provide an example of the biomass mapping outputs interrogated at both a broad and fine scale.

Figure 2-1 ArcGIS Web map Screenshot - Catchment Wide Biomass (Average Year)

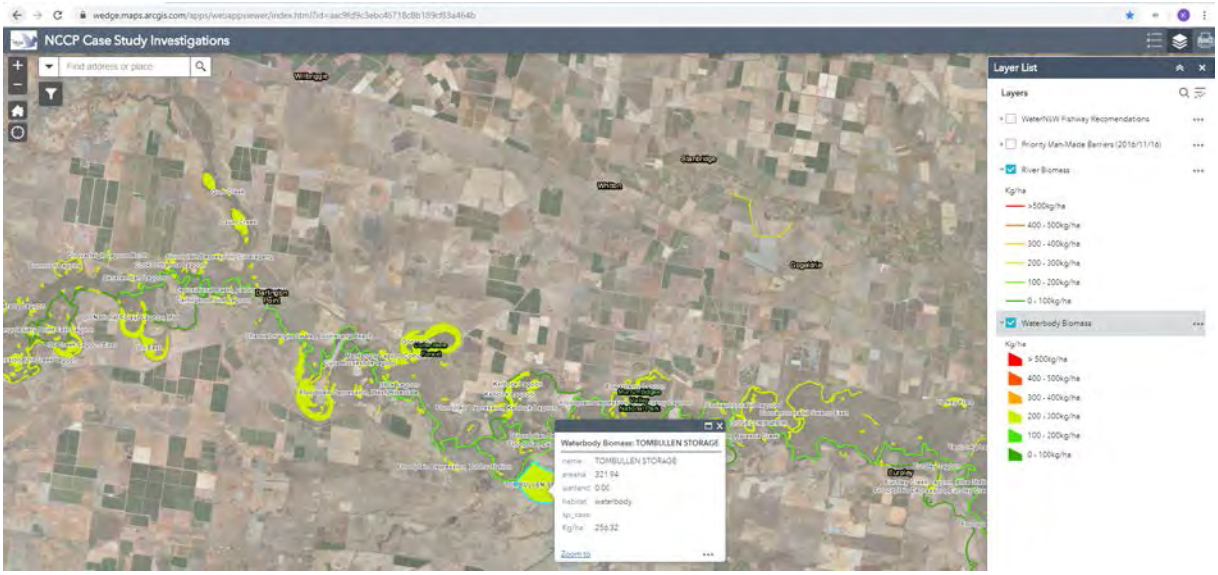


Figure 2-2 ArcGIS Web map Screenshot Wetland Scale Biomass Interrogation

The individual case study biomass map outputs for the four case study regions are accessible via the following links.

Lachlan Case Study Biomass Mapping

https://wedge.maps.arcgis.com/apps/webappviewer/index.html?id=f39c489f66db41bf832abf602b7ea56b

Lower Murray Biomass Mapping

https://wedge.maps.arcgis.com/apps/webappviewer/index.html?id=1467ae43410e4f2da9d6d13d9b64c2d2

Mid-Murray Biomass Mapping

https://wedge.maps.arcgis.com/apps/webappviewer/index.html?id=72f7c95fe37041be83054eb284cb4dea

Murray and Murrumbidgee Biomass Mapping

https://wedge.maps.arcgis.com/apps/webappviewer/index.html?id=aac9fd9c3ebc46718c8b189cf83a464b

2.1 Murray-Murrumbidgee Case Study Biomass

The ARI led biomass modelling project outputs, for the 'average year' model scenario, was adopted for the Murray-Murrumbidgee case study. This data, shown mapped in Figure 2-3 below, was then investigated at a sub-catchment scale by the case study project team to identify the range of risks and mitigation strategies.

This investigation resulted in the case study area being segmented in to some 23 operational reaches (Figure 2-4) based on river regulation units (reaches between regulators and weirs) and an initial assessment of possible risks and opportunities associated with the potential deployment of the virus.

Reach by reach biomass estimates derived by the project team, for both rivers and water bodies, along with the combined totals based on the ARI average year scenario are presented in Table 2-1. The results presented in Table 2-1 demonstrate the significant variability in per hectare and total biomass estimates across the case study area. The majority of the 23 reaches contain sub-populations of carp exceeding the risk threshold of 150kg/ha, whilst many reaches in the lower sections of the Murray and Murrumbidgee Rivers systems have per hectare biomass totals exceeding 200-300kg/ha and upwards of 500kg/ha in the main Murray River channel in the Lower Murray and Lower Lakes.

The changes in biomass across the study area are also shown in Figure 2-3.

The NCCP estimates that the overall case study area contains up to 85,000 tonnes of carp under the modelled 'average year' scenario.

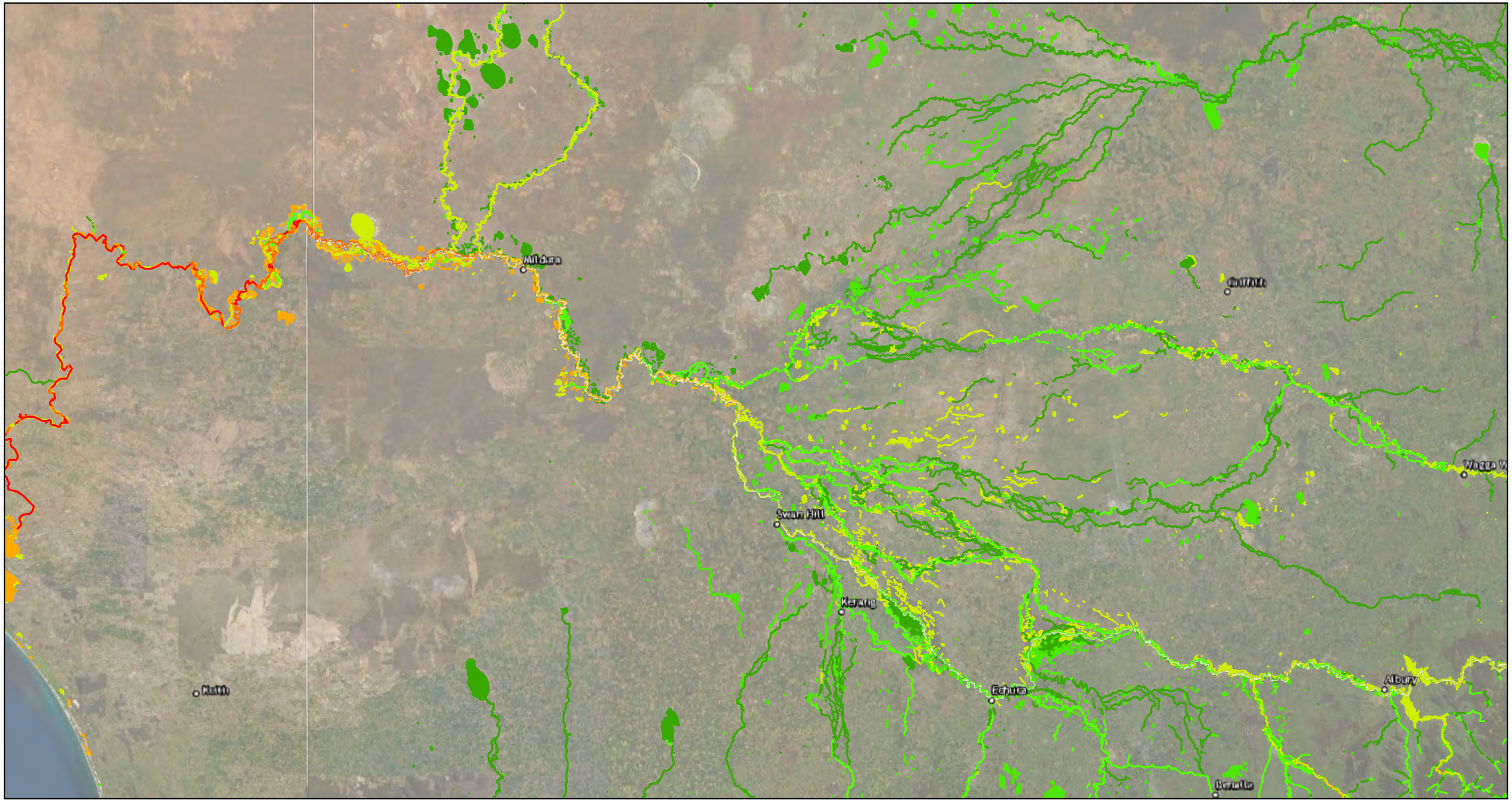
Table 2-1 Murray-Murrumbidgee Reach by Reach Biomass

Reach by Reach Average Biomass Estimates
Derived from "A national carp biomass estimate for Australia. Unpublished Client Report for the Fisheries Research and Development Corporation". (Citation below)

Reach	Waterbody Kgs	River Kgs	Total Kgs	Total Tonnes
M0	4,855,571	23,515	4,879,086	4,879
M1	217,018	219,514	436,533	437
M2	1,242,003	162,036	1,404,040	1,404
M3	3,107,825	394,808	3,502,634	3,503
M4	3,638,884	346,762	3,985,646	3,986
M5	1,961,633	516,416	2,478,049	2,478
M6	1,065,543	1,504,616	2,570,158	2,570
M7	909,426	988,198	1,897,624	1,898
M8	6,558,356	2,458,752	9,017,107	9,017
M9	2,502,421	986,828	3,489,250	3,489
M10	967,513	1,333,318	2,300,831	2,301
M11	29,801,524	1,961,906	31,763,430	31,763
O1	35,768	119,977	155,744	156
D1	33,495	203,983	237,478	237
EW1	1,781,181	1,049,566	2,830,747	2,831
MB0	3,987,892	3,206	3,991,098	3,991
MB1	34,693	377,003	411,697	412
MB2	48,115	82,703	130,818	131
MB3	38,993	151,754	190,747	191
MB4	847,765	207,771	1,055,536	1,056
MB5	390,228	337,163	727,391	727
MB6	4,102,117	471,181	4,573,299	4,573
YB1	2,694,509	556,856	3,251,365	3,251
		Total	**85,280,308**	**85,280**

Ivor Stuart, Ben Fanson, Jarod Lyon, Jerom Stocks, Shane Brooks, Andrew Norris, Leigh Thwaites, Matt Beitzel, Michael Hutchison, Qifeng Ye, John Koehn and Andrew Bennett (2019). **A national carp biomass estimate for Australia. Unpublished Client Report for the Fisheries Research and Development Corporation.** Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Murray- Murrumbidgee Case Study Biomass



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River Biomass
- 0 - 100kg/ha
- 100 - 200kg/ha
- 200 - 300kg/ha
- 300 - 400kg/ha
- 400 - 500kg/ha
- >500kg/ha

Waterbody Biomass
- 0 - 100kg/ha
- 100 - 200kg/ha
- 200 - 300kg/ha
- 300 - 400kg/ha

1:2,311,162

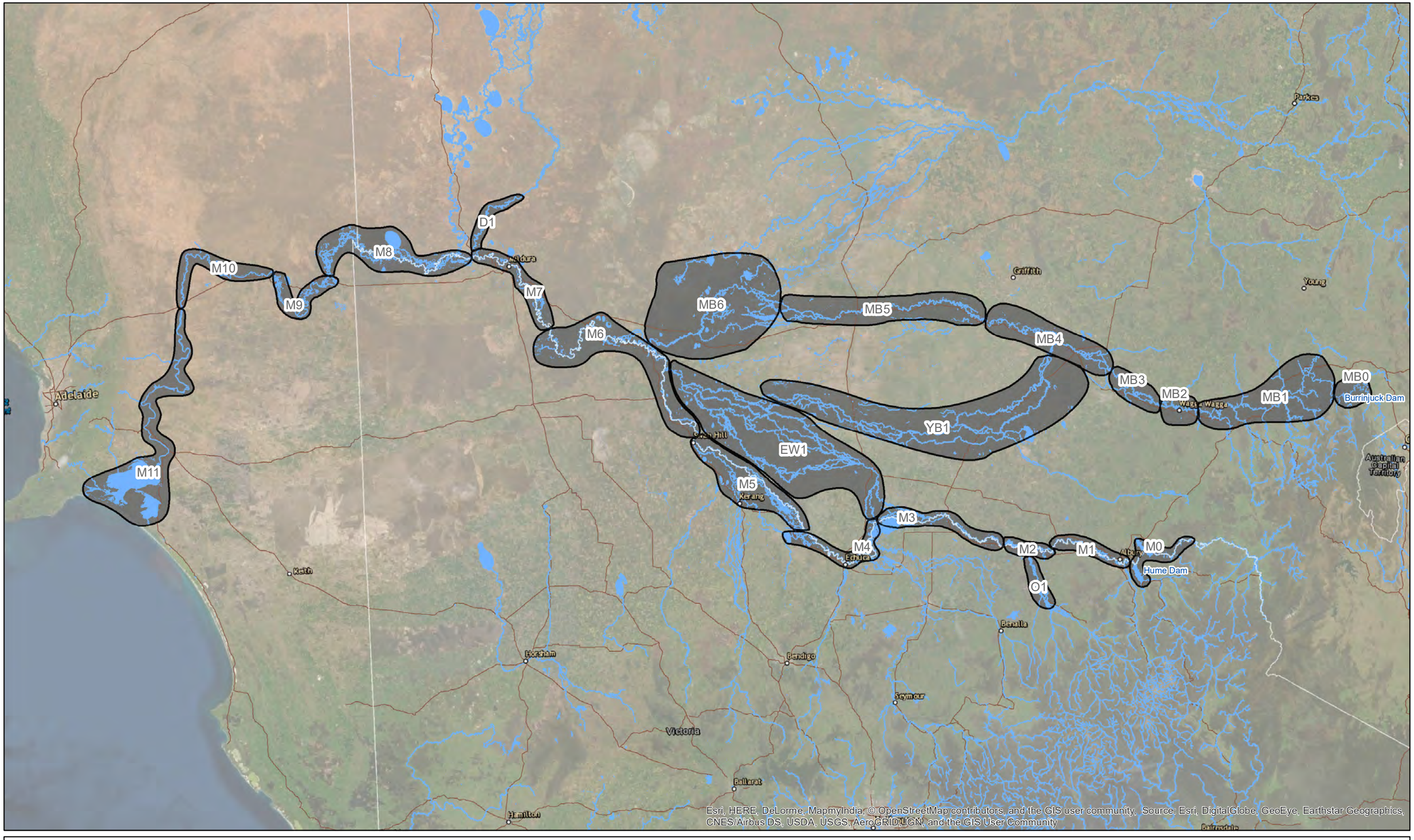
0 20 40 80 mi

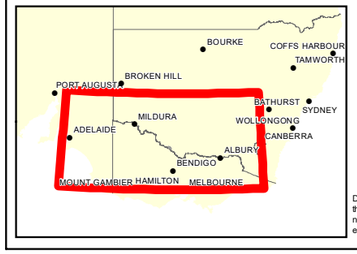
0 37.5 75 150 km

Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

The Wedge Group
Earthstar Geographics | Esri, HERE, Garmin |

Figure 2-3 Murray-Murrumbidgee Biomass Mapping





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Kilometres

Scale 1:2,500,000 @ A3

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Legend

Main Highway

River

Waterbody

Operational Reach

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Figure 2-4

NCCP Murray & Murrumbidgee Case Study
- Operational Reaches

2.2 Mid-Murray and Lower Murray Case Study Biomass

The reach by reach biomass estimates for the Mid-Murray and Lower Murray Case study areas are shown in the following tables. The Mid-Murray reaches contain approximately 10,000 tonnes of carp which is approximately 25% of the total biomass of some 38,000 tonnes across the much larger Lower Murray reaches.

The Lower Murray reaches included in table 2-3 include the section of Murray River below Lock 1 through to and including the Lower Lakes. These areas have per hectare biomass estimates in excess of 300 and 500 kg/ha respectively and contribute significantly to the overall total.

Table 2-2 Mid-Murray Reach by Reach Biomass

Mid-Murray Case Study Biomass				
Reach	**Waterbody Kgs**	**River Kgs**	**Total Kgs**	**Total Tonnes**
M3	3,107,825	394,808	3,502,634	3,503
M4	3,638,884	346,762	3,985,646	3,986
M5	1,961,633	516,416	2,478,049	2,478
Total			**9,966,328**	**9,966**

Table 2-3 Lower Murray Reach by Reach Biomass

Lower Murray (Lock 1-3) Case Study Biomass				
Reach	**Waterbody Kgs**	**River Kgs**	**Total Kgs**	**Total Tonnes**
M9	2,502,421	986,828	3,489,250	3,489
M10	967,513	1,333,318	2,300,831	2,301
M11	29,801,524	1,961,906	31,763,430	31,763
Total			**37,553,511**	**37,554**

2.3 Qualitative Risk Assessment

The second stage of the case study process involved a desk-top assessment of key ecological, social, economic and cultural risks.

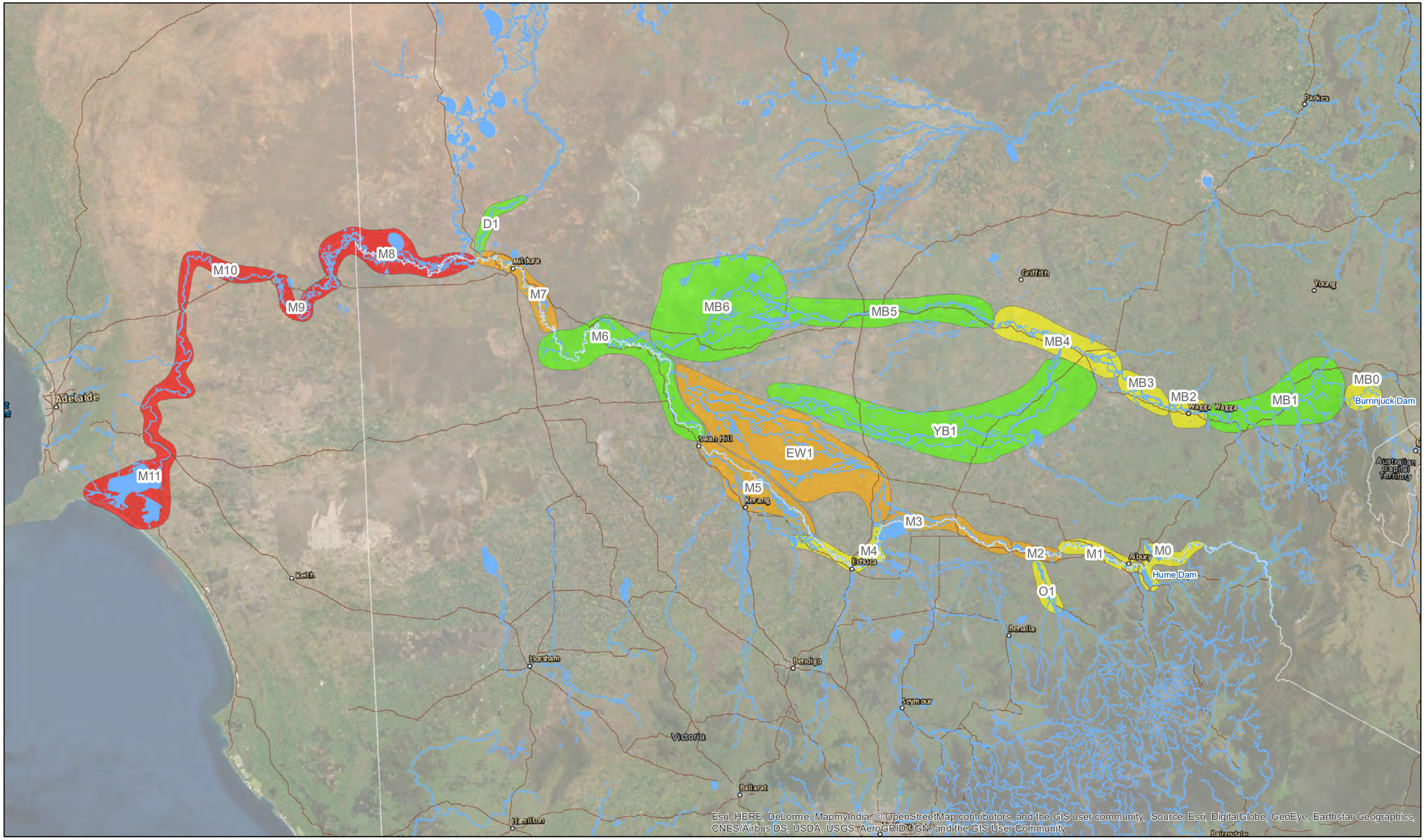
The risk assessment involved 'expert elicitation' workshops with key regional, operational and technical stakeholders arriving at an overall qualitative assessment of risk (ranked and mapped as High, Medium and Low) for each of the reaches investigated.

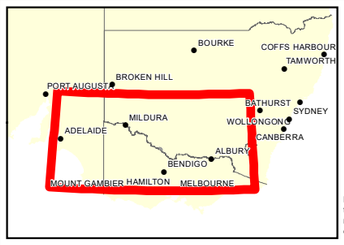
The risk assessment was then used to inform risk mitigation strategies across the case study areas.

The key risk categories are summarised in Table 2-4 with the overall qualitative assessment presented spatially in Figure 2-5. The risk assessment highlights the strong correlation between a high-risk rating for reaches with high to very high biomass and reaches like the Edward-Wakool system (EW1) or lower Murrumbidgee wetlands (MB6) that are characterised as having periods of low flows and moderate biomass. The reach by reach implementation tables in Section 4 contain a summary of key risks for each reach.

Table 2-4 Risk Categories Summary

High Risk Waterbody Types	Risks/impacts	Risk mitigation
Environmental		
High value water bodies – eg. Ramsar or other listed wetlands (Barmah/Millewa, Kerang Lakes, Hattah Lakes etc)	Significant impacts on Endangered species, bird nesting	Regulation of flows Timing of virus deployment Strategic carcass removal Carcass dispersal
High value Regulated creeks and lagoons with known environmental values and or threatened species.	Significant impacts on Bird nesting, wetland ecology	Carcass removal with boats Flow regulation Strategic booms and upstream collection of carcasses. Carcass dispersal
High value Main river channels (Murray, Murrumbidgee, Edward, Wakool etc)	Significant impacts on Threatened fish species (Murray Cod, Trout Cod, Small Bodied Natives	Carcass collection and disposal Flow enhancement during and post event
Social/Cultural		
High cultural value waterbodies – eg Kow Swamp (indicative of many high value cultural sites)	Significant cultural sites (impacts to land and water). Water quality	Flow regulation Strategic booms and upstream collection of carcasses Carcass removal
High social value Flood plain environments (Hattah, Lowbidgee, Chowilla etc)	Significant cultural sites Odour. Amenity.	Strategic booms and upstream collection of carcasses Regular small boat carcass removal
High social value Weir pool environments (particularly those near regional population centers)	Odour. Amenity. Event disruption	Strategic booms and upstream collection of carcasses. Regular small boat carcass removal
Economic		
High value Consumptive water use waterbodies (Urban, S&D, and irrigation)	Odour. Amenity Water quality Infrastructure (O&M, treatment, upgrades, alternate sources)	Screens on intake structures, booms, carcass removal
Waterbodies used for high value Tourism (high reliance on River/Wetland based tourism)	Water quality. Odour. Amenity	Strategic booms and upstream collection of carcasses. Communication





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Kilometres

Scale 1:2,500,000 @ A3

GDA94 Lambert Conformal Conic

Legend

Main Highway — River — Waterbody

Overall Reach Risk

Very High Risk — High — Medium — Low

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Figure 2-5

- Operational Reaches – Risk Rating

3 Implementation Assumptions and Strategies

The following section summarises implementation assumptions and strategies across the case study area. The strategies include assumptions and operational activities based on NCCP research, proposed NCCP implementation strategies and findings from the rage of case study workshops.

Implementation involves virus deployment and carcass management operations.

Implementation assumptions and strategies were then used to develop a resourcing plan and cost estimate for the case study areas (see Section 7).

3.1 NCCP implementation planning

NCCP implementation planning proposes the following timeline of implementation:

i. a three-year active implementation period commencing once all statutory planning, environmental and budgetary approvals have been obtained:
    a. year 1, notionally July – June for implementation planning (establishment of Control Centres and Forward Command Centres), communications and stakeholder engagement activities.
    b. years 2 and 3, active resource mobilisation, management and administration; pre-release surveillance; carp virus release; carcass management; post surveillance; and, demobilisation. The virus release and carcass management activities commence around August and progress through to February with partial demobilisation until the following August February period (refer Section 6, Implementation Schedule, for details).
ii. deployment to occur during a period of average river flows. That is a period following one or more above average inflow seasons (minor to moderate flooding) that sees key storage levels above 70% and NSW General Security Allocation > 50-60%. This will ensure a level of resilience across the various systems and a flow regime that can be manipulated to assist with virus release (flow encouraged aggregation) and carcass/risk management (flow to move carcasses and replenishment flows to mitigate water quality risks).
iii. carp virus release and carcass management will occur largely concurrently across the Murray and Murrumbidgee Rivers system given the relatively narrow temperature driven implementation window.

1.1 Virus deployment assumptions and strategies

As stated in the draft NCCP Implementation strategy, there are four primary biological preconditions that will likely determine the carp virus' impact on carp populations, these are:

i. the permissive water temperature for virus activation of infection (18-23 degrees),
ii. recrudescence of latent infections,
iii. carp aggregation behaviour to achieve virus transmission between fish, and
iv. concentration of virus infection into a carp sub-population.

Taking these preconditions into consideration, the following assumptions and strategies have been identified for the Murray and Murrumbidgee Case study area (inclusive of the Mid-Murray and Lower Murray areas):

i. virus deployment will be concurrent across multiple reaches and river systems with release resources coordinated to target aggregations when water temperatures reach 18 degrees (nominally late Sept/Oct),
ii. in areas of high biomass with cold water pollution, for example down stream of Burrinjuck, fish aggregations are to be targeted with conventional commercial means (netting and electrofishing) to reduce densities,
iii. deployment will target reaches with estimated biomass above the risk threshold of 150kg/ha and target areas of known, or induced, aggregations to maximise skin to skin contact and transmission. This includes weirs, regulators, wetland structures and in some cases fringing Willow trees.
iv. carp virus release will be via direct injection to fish captured (electrofishing) from target aggregations.
v. carp virus deployment will be from upstream to downstream concurrently across multiple reaches and river systems with release resources coordinated to target aggregations when water temperatures reach 18 degrees (nominally late Sept/Oct),
vi. in areas of high biomass with cold water pollution, for example down stream of Burrinjuck, fish aggregations are to be targeted with conventional commercial means (netting and electrofishing) to reduce densities,
vii. deployment will target reaches with estimated biomass above the risk threshold of 150kg/ha and target areas of known, or induced, aggregations to maximise skin to skin contact and transmission. This includes weirs, regulators, wetland structures and in some cases fringing Willow trees.
viii. carp virus release will be via direct injection to fish captured (electrofishing) from target aggregations.
ix. target infection rates are aimed at injecting 3% to 5% of the biomass in each sub-population annually over the two-year active release period (see below for explanation).

The range of numbers of fish required to be infected and associated cost estimates for virus production and storage are shown in Table 3-1, noting that a broad assumption of 3kg per fish (average) has been applied to the deployment phase. In reality the average fish weight will be influenced by the seasonal conditions and breeding events leading into the deployment period. For example, if the virus were deployed following a flood year, or years, it might be expected that the average carp weight would be significantly lower with populations dominated by juvenile carp.

The virus production and storage costs are estimated to range from $2-$5 per fish. These costs do not include the active capture and infection costs which are included in the overall cost estimate presented in Section 7. For year 2 infection targets (and costs) it is assumed the virus achieves a 60% knockdown in year 1, that is to say that the target is to infect a further 3% to 5% of the remaining 40% of any one sub-population in year 2.

The virus production and storage costs included in the overall cost estimate (Section 7) are based on the upper estimate of a 5% infection target.

Table 3-1 Deployment targets and virus costs

Murray and Murraumbidgee Virus Reslease assumptions and Cost				
		Year 1 Reslease		Year 2 Release
Total Biomass (kg)		**85,280,308**		**34,112,123**
No. of fish @ 3kg		**28,426,769**		**17,056,062**
3% Release/Infect Target (No. of fish)		**852,803**		**511,682**
5% Release/Infect Target (No. of fish)		**1,421,338**		**852,803**
Virus production and storage at $2	**$**	**2,842,677**	**$**	**1,705,606**
Virus production and storage at $5	**$**	**7,106,692**	**$**	**4,264,015**

3.2 Carcass Management Assumptions and Strategies

Assumptions applied to the to the carcass management requirements for the case study areas include the following:

i. based on the epidemiological research and modelling undertaken, under optimal conditions, 60% of the biomass in any one sub-population will succumb to the virus (NCCP epidemiology research).
ii. priority carcass management locations include areas above urban water treatment plants, water offtakes, areas around townships and high recreational use areas (marinas, houseboat moorings, ski clubs etc). These have been considered in the determination of resources on a reach by reach basis (Section 4.) and in the cost estimate (Section 6).
iii. production rates and resource applications for carcass management assumes a time-based window (while fish float over a rolling 7 to 10-day period) with resources determined to mitigate risks to acceptable levels across high and medium risk environments. Not all reaches will receive the same intensity of carcass management effort, but all reaches will be monitored with surge capacity across the Control Centres resource mix that can be deployed at short notice in response to need.
iv. carcass management resources will be deployed concurrently across multiple river reaches with a level of surge capacity available to mitigate impacts and risk sites
v. resources from upstream reaches with lower overall biomass will be on-deployed to high risk downstream catchments as the management period progresses
vi. carcass disposal will be to surface composting sites on leased freehold land
vii. resourcing is assumed to be via an (Federally) safety accredited contracting and project management entity
viii. plant and equipment required has been costed at day rates with rates to cover the capital purchase of purpose-built equipment

3.3 Resourcing

The following table summarises the resource units applied to the case study reaches. The unit descriptions, unit rate costs and production rates have been applied in developing the cost estimate presented in Section 7.

Note these operational resources do not include the Year 1 Implementation Planning phase resources that have been applied to each Control Centre. These include incident control, implementation management and administration, communications and engagement officers, signage deployment, training and GIS. These resources are detailed in the cost estimate.

Table 3-2 Operational Resource Units

Indicative Operational Resources	
Resource Type	**Resource Description**
Sign deployment	2-person crew with light truck and minor tools/ equipment
Carp infection (Virus Deployment)	2-person crew with light vehicle and 6m electrofishing boat (3 No.) 4-person crew with light vehicle and mobile cool room for virus storage and distribution (1 No.)
Floating boom deployment/ recovery	2-person crew with light vehicle and 6m tandem trailer 2-person crew with light vehicle and 5m boat
Land-based surveillance	1-person crew with light vehicle (3 No.)
On-water surveillance	2-person crew with light vehicle and 5m boat (1 No.)
Deep water collection	2-person crew with light vehicle and 3m3 bin trailer 2-person crew with light vehicle and 5m boat
Shallow water collection	6-person crew with 6 No. canoes 2 No. light vehicles 1 No. 6m tandem trailer with canoe transport hurdles.
On-water vacuum pump	Tray truck to/ from site Outboard powered floating pontoon with vacuum 2-person crew with light vehicle and 3m3 bin trailer
Bulk-point collection	Plant float to/ from site 20Tn excavator with various attachments/ chains 10m3 tandem tip truck
Composting Operation	Light truck Bob cat with tiller attachment

4 Implementation - Reach by Reach

The following sections provide a summary of the reach by reach assessments and implementation strategies developed during the case study workshops and based on the assumptions and resource units identified in Section 3.

It should be noted that in developing the cost estimate a number of the 23 case study management reaches have been further split in to sub-reaches, particularly in the Lower Murray, enabling a more targeted response to the higher biomass risk across large river reaches or significant off-river waterbodies.

4.1 Murrumbidgee River

Reach	**MB0 Burrinjuck Dam**
Waterbody classification	Lake, cold water
Biomass	Medium
Virus deployment strategy	Targeting spring aggregations, leeward side clean up focus
Environmental/Social values	High social amenity
Resources	
No.	Type
2	Land-based surveillance
2	On-water surveillance
2	Deep water collection
2	Floating boom deployment, for recovery at tributary flows into dam
1	Bulk-point collection

Reach	**MB1 Burrinjuck Dam to Wagga Wagga**
Waterbody classification	Open river, cold water
Biomass	Low
Virus deployment strategy	No deployment, winter and spring “fish down”
Environmental/Social values	High ecological values instream
Resources	
No.	Type
2	Deep water collection

Reach	MB2 Wagga Wagga
Waterbody classification	Wetlands & lakes with open river
Biomass	Medium
Virus deployment strategy	Into urban wetlands, lakes and open river aggregations
Environmental/Social values	High ecological, connected wetlands. High social values (river and lakes)
Resources	
No.	Type
1	Land-based surveillance
1	On-water surveillance
1	Shallow water collection
2	Deep water collection
2	Floating boom deployment, to protect urban water supply offtake

Reach	MB3 Wagga Wagga to Berembed Weir
Waterbody classification	Open river
Biomass	Medium
Virus deployment strategy	Into open river aggregations targeting weir and regulators
Environmental/Social values	High ecological (off river wetlands/birds)
Resources	
No.	Type
1	Land-based surveillance
1	On-water surveillance
1	Deep water collection

Reach	MB4 Berembed Weir to Darlington Point	
Waterbody classification		Regulated river, plus Lake Talbot in Narrandera, MIA offtake, CICL offtake & Tombullen Storage
Biomass		High
Virus deployment strategy		From Gogelderie Weir and other river regulator aggregation points, complete winter drawdown of irrigation canals
Environmental/Social values		High ecological
Resources		
No.	Type	
2	Land-based surveillance, to continue through carcass management phase	
2	On-water surveillance, to continue through carcass management phase	
1	Shallow water collection	
4	Deep water collection	
1	Floating boom deployment/ recovery, to protect urban water/ irrigation supply offtakes	

Reach	YB1 Yanco Billabong Creek System	
Waterbody classification		Regulated river primarily stock and domestic flows to Moulamein
Biomass		High
Virus deployment strategy		Throughout creek system, especially below weirs in spring
Environmental/Social values		Significant local stakeholder interest
Resources		
No.	Type	
1	Land-based surveillance	
1	On-water surveillance	
2	Deep water collection	
1	Bulk-point collection	

Reach	MB5 Darlington Point to Maude Weir	
Waterbody classification		Regulated river includes Hay Weir
Biomass		High
Virus deployment strategy		At Hay & Maude Weirs spring aggregation points
Environmental/Social values		High ecological
Resources		
No.	Type	
2	Land-based surveillance	
1	On-water surveillance	
2	Deep water collection	
1	Floating boom deployment/ recover, to protect urban water/ irrigation supply offtakes	

Reach	MB6 Maude Weir to Murray River	
Waterbody classification		Regulated river, includes Balranald Weir and Nimmie-Caira diversion channel and Lowbidgee Wetlands
Biomass		High
Virus deployment strategy		At Balranald Weir spring aggregation point
Environmental/Social values		High ecological, high social
Resources		
No.	Type	
2	Land-based surveillance	
1	On-water surveillance	
2	Deep water collection	
1	Floating boom deployment/ recovery, to protect urban water/ irrigation supply offtakes and river confluences	
1	Bulk-point collection	

4.2 Murray River System

Reach	**M0 Hume Dam**
Waterbody classification	Lake, cold water
Biomass	Medium
Virus deployment strategy	Targeting winter and spring aggregations, leeward side clean up focus, potential flow manipulation from Dartmouth Dam
Environmental/Social values	High social amenity
Resources	
No.	Type
2	Land-based surveillance
2	On-water surveillance
2	Deep water collection
1	Floating boom deployment/ recovery, at tributary flows into dam
1	Bulk-point collection

Reach	**M1 Hume Dam to Corowa**
Waterbody classification	Open river, cold water
Biomass	High
Virus deployment strategy	At known aggregations
Environmental/Social values	High ecological, high social
Resources	
No.	Type
4	Land-based surveillance, focused away from River Murray main channel due to cold water influence
4	On-water surveillance, focused away from River Murray main channel due to cold water influence
4	Deep water collection
2	Floating boom deployment/ recovery, to protect urban water offtakes/ high social value areas
2	Bulk-point collection, at Kiewa and King Rivers

Reach	M2 Corowa to Yarrawonga Weir	
Waterbody classification		Open River, regulated, weir pool
Biomass		High
Virus deployment strategy		At known aggregations and floodplains in late winter/spring
Environmental/Social values		High social/recreational use. Additional resources for Lake Mulwala
Resources		
No.	Type	
4	Land-based surveillance, to continue through carcass management phase	
4	On-water surveillance, to continue through carcass management phase	
1	Shallow water collection	
4	Deep water collection	
6	Floating boom deployment/ recovery, at upstream end of Lake Mulwala to limit carp entering the heavily wooded areas and upstream of the Weir	
1	Bulk-point collection, near Yarrawonga	
1	On-water vacuum pump	

Reach	O1 Ovens River Lake Mulwala to Wangaratta	
Waterbody classification		Unregulated river
Biomass		Very High
Virus deployment strategy		At Bundalong, among wetlands and aggregation points in late winter/spring
Environmental/Social values		High environmental; High social/recreational use
Resources		
No.	Type	
1	Land-based surveillance	
1	On-water surveillance	
2	Deep water collection, one team to be focussed upstream of Wangaratta	
2	Floating boom deployment/ recovery	
1	Bulk-point collection, at Ovens River	

Reach	M3 Yarrawonga Weir to Edwards River	
Waterbody classification		Open River, regulated
Biomass		High
Virus deployment strategy		At known aggregation pints in late winter/spring
Environmental/Social values		High social
Resources		
No.	Type	
4	Land-based surveillance, to continue through carcass management phase	
4	On-water surveillance, to continue through carcass management phase	
4	Deep water collection	
1	Floating boom deployment/ recovery, at Cobram and Tocumwal	
1	Bulk-point collection, at Cobram and Tocumwal	

Reach	EW1 Edwards River to Wakool Junction	
Waterbody classification		Open river network, regulated, significant off-river irrigation areas
Biomass		Medium
Virus deployment strategy		At known aggregation points and below weirs and regulators in spring
Environmental/Social values		High social, high ecological (Werai Wetlands and Gulpa area)
Resources		
No.	Type	
2	Land-based surveillance, to continue through carcass management phase	
2	On-water surveillance, to continue through carcass management phase	
2	Deep water collection	
2	Floating boom deployment/ recovery, upstream of Mathoura, Deniliquin and Kyalite	
3	Bulk-point collection, at Mathoura, Deniliquin and confluence of Edwards River and Murray Rivers	

Reach	M4 Mid Murray	
Waterbody classification		Open river, regulated
Biomass		Medium
Virus deployment strategy		At known aggregation pints in late winter/spring (Box Creek fishway, Torrumbarry Weir, Moria Regulator)
Environmental/Social values		Very high social values, High ecological, Cultural (Barmah-Milewa, Koondrook-Perricoota-Gunbower, Gunbower Creek/Lagoons and Kow Swamp)
Resources		
No.	Type	
3	Land-based surveillance	
3	On-water surveillance	
3	Shallow water collection	
6	Deep water collection	
3	Floating boom deployment/ recovery	
3	Bulk-point collection	
3	On-water vacuum pump	
1	On-water surveillance	

Reach	M5 Gunbower to Swan Hill, including Little Murray River and Loddon River to Kerang	
Waterbody classification		Open river, regulated
Biomass		High
Virus deployment strategy		Carp collected in spring from wetlands and river aggregation points
Environmental/Social values		High social & high ecological (Gunbower Creek through to Koondrook and Kerang Lakes)
Resources		
No.	Type	
8	Land-based surveillance	
8	On-water surveillance, to continue through carcass management phase	
2	Shallow water collection	
8	Deep water collection	
2	Floating boom deployment/ recovery, upstream of Barham/ Koondrook, Kerang-Gunbower-Leitchville-Cohuna-Barham-Swan Hill urban water supply offtakes	
3	Bulk-point collection, upstream Barham/ Koondrook, Kerang and Loddon River	
1	On-water vacuum pump	

Reach	M6 Swan Hill to Hattah Lakes includes Euston Lakes	
Waterbody classification		Open river, regulated
Biomass		Low
Virus deployment strategy		Complemented by water manipulation through Hattah Lakes, carp collected in rivers and wetlands in late winter/spring
Environmental/Social values		Ecological high (Hattah Lakes), high economic
Resources		
No.	Type	
2	Land-based surveillance	
2	On-water surveillance	
2	Deep water collection	
1	Floating boom deployment/ recovery, for water supply offtake protection	
1	Bulk-point collection, upstream of Lock 15	

Reach	M7 Hattah Lakes to Lock 10	
Waterbody classification		Open river, regulated
Biomass		High
Virus deployment strategy		Carp collected from wetlands and river in late winter/spring
Environmental/Social values		High social amenity (Mildura), high ecological
Resources		
No.	Type	
2	Land-based surveillance	
2	On-water surveillance, to continue through carcass management phase	
2	Deep water collection	
2	Floating boom deployment/ recovery across 5 No. sites (upstream Wentworth, Merbein Pumps, Mildura Weir, Psyche Bend, Collignan, Kings Billabong Pumps)	
2	Bulk-point collection, at Collignan and Wentworth	

Reach	D1 ~30km upstream Darling River confluence with River Murray to Burtundy Weir	
Waterbody classification		Weir influence
Biomass		High
Virus deployment strategy		Carp collected from river and wetland aggregation points
Environmental/Social values		High
Resources		
No.	Type	
0.5	Land-based surveillance	
0.5	On-water surveillance, will collect and dispose as part of water operations	

Reach	M8 Lock 10 to Lock 5 includes Lake Victoria	
Waterbody classification		Open river, regulated
Biomass		Very high
Virus deployment strategy		1) Hold Lake Victoria high, at Lake Victoria inlet structure 2) Via Lindsay River and Lake Walla Walla aggregations 3) In Chowilla Creek system (Pipeclay & Slaney creeks), leave fish on floodplain upstream of Chowilla Regulator
Environmental/Social values		Culturally significant, high ecological (Chowilla floodplain)
Resources		
No.	Type	
2	Land-based surveillance	
2	On-water surveillance	
2	Deep water collection	
1	Floating boom deployment/ recovery	
1	Bulk-point collection at Lake Victoria outlet	
2	Land-based surveillance	
2	On-water surveillance	
2	Deep water collection	
1	Floating boom deployment/ recovery, at Mullaroo inlet	
2	Bulk-point collection, Mullaroo Creek inlet and Lindsay River outfall to Murray River	
1	Land-based surveillance	
1	On-water surveillance	
2	Deep water collection	
1	Floating boom deployment/ recovery, at Lock 6	
1	On-water vacuum pump	

Reach	M9 Lock 5 to Lock 3
Waterbody classification	Open river, regulated
Biomass	Very high
Virus deployment strategy	1) At key floodplain regulators, Lock 4 and Lock 5 2) Lake Bonney water depth problematic, target north western side 3) Off-river wetlands (Watchels Lagoon) weir pool manipulation available to aggregate populations
Environmental/Social values	High social value (tourism), high social and ecological (Lake Bonney), ecological/ economic (Banrock Wetland/ Inlets)
Resources	
No.	Type
5	Land-based surveillance
5	On-water surveillance, to continue through carcass management phase
8	Deep water collection
2	Floating boom deployment/ recovery
3	Bulk-point collection
2	On-water vacuum pump
***	Explore use of lock plant/ equipment to collect fish from river
2	Deep water collection
2	Floating boom deployment/ recovery
2	Bulk-point collection, at boat ramp and north western side

Reach	**M10 Lock 3 to Lock 1**
Waterbody classification	Open river, regulated, significant off-river wetlands, largely manageable
Biomass	Very high
Virus deployment strategy	Fish collected below Lock 1, 2 & 3
Environmental/Social values	High social amenity (marinas at Waikerie, Blanchetown, Morgan), absentee property owners
Resources	
No.	Type
4	Land-based surveillance
4	On-water surveillance, to continue through carcass management phase (provides for off-river wetlands)
4	Deep water collection
2	Floating boom deployment/ recovery, to protect CIT and RIT offtakes including Waikerie, Morgan, Brenda Park @ Murbko
5	Bulk-point collection
1	On-water vacuum pump
***	Explore use of lock plant/ equipment to collect fish from river

Reach	M11 Lock 1 to Mouth includes Lower Lakes
Waterbody classification	Open river, regulated
Biomass	Very high
Virus deployment strategy	1) Lock 1 (> 200 tonnes anticipated), supported by connected wetlands 2) Lower Lakes, Currency Creek/ Finniss River/ Bremer River, known significant aggregations
Environmental/Social values	High social (marina at Mannum)
Resources	
No.	Type
4	Land-based surveillance
4	On-water surveillance, to continue through carcass management phase
4	Deep water collection
4	Floating boom deployment/ recovery, to protect urban water/ irrigation supply offtakes (Murray Bridge, Tailem Bend and possibly at Wellington before carp enter the lower lakes)
1	Bulk-point collection, at boat ramp downstream of Lock 1
4	Bulk-point collection
1	On-water vacuum pump
***	Deploy SA Water Barge (*MV Maratala*), a floating bulk-point collection as required

5 Implementation Coordination

The overall implementation plan for the NCCP encompasses four key phases, being:

i. Planning
ii. Operations (intensive)
iii. Operations (moderated)
iv. Completion (nominally a return to business as usual)

The work undertaking in evaluating the case study area and developing the cost estimate fits into the 'Operations Phase' which is expected to run over a three-year period with planning, engagement and actions taken at a Catchment Control Area (CCA) scale. Given the system connectivity, level of regulation, carp population distribution and the geomorphic characteristics of the two catchments it would seem logical to treat the Murray-Murrumbidgee case study as one CCA in line with planning and resourcing strategies developed under the case study.

The NCCP Technical Paper #6, *Implementation*, describes in detail the implementation structures and systems through to be applied through to the strategies and tactics covering the key implementation activities, including:

i. resource mobilisation.
ii. program management and administration.
iii. pre-deployment surveillance.
iv. carp virus deployment.
v. carcass management.
vi. post surveillance.
vii. demobilisation

A key element of the implementation plan for a particular CCA, in this case the Murray and Murrumbidgee case study area, is the identification of the regional control structure that will drive the overall implementation. At a case study level this involved the identification of Control Centres and Forward Command Centres that are the key functional units for the housing and coordination of resources.

Figure 5-1 below shows the nominated 4 Control Centres and 11 Forward Command Centres for the case study area. They were located based largely on the outcomes of the qualitative risk assessment process and taking further consideration of such things as:

i. located to best coordinate site resources across large geographic area and with good access to infrastructure (i.e. road, rail or air).
ii. proximity to population centres
iii. ability to efficiently reallocate surge capacity to adjoining management reaches.
iv. Providing a representative spread of Control Centres across the three States to provide for efficient cross-jurisdictional coordination.
v. Forward Command Centres located at potentially high-risk locations.

The resources associated with the Control and Forward Command Centres are detailed in the cost estimate with the application of those resources detailed in the implementation schedule.

POONCARIE
D1
WENTWORTH
RENMARK
M8
M10
BARMERA
BLANCHETOWN
M9
MILDURA
M7
M6
MB6
BALRANALD
MB5
GRIFFITH
MB4
MB3
MB2
WAGGA
MB1
MB0
Burrinjuck Dam
YB1
EW1
DENILIQUIN
Swan Hill
M5
KERANG
M3
YARRAWONGA
M4
ECHUCA/MOAMA
M2
M1
M0
ALBURY
Hume Dam
O1
MURRAY BRIDGE
M11
GOOLWA
Adelaide
Parkes
Young
Kerang
Horsham
Bendigo
Seymour
Benalla
Victoria
Ballarat
Hamilton
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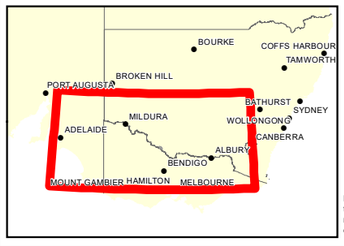


N

0 20 40 60 80 100

Kilometres

Scale 1:2,500,000 @ A3

GDA94 Lambert Conformal Conic

Legend

- Control Centre
- Forward Command
- Control Centre Zone (150km)
- Main Highway
- River
- Waterbody

Overall Reach Risk

- Very High Risk
- High
- Medium
- Low

THE WEDGE GROUP

Figure 5-1

NCCP Murray & Murrumbidgee Case Study
- Proposed Control and Forward Command Centres

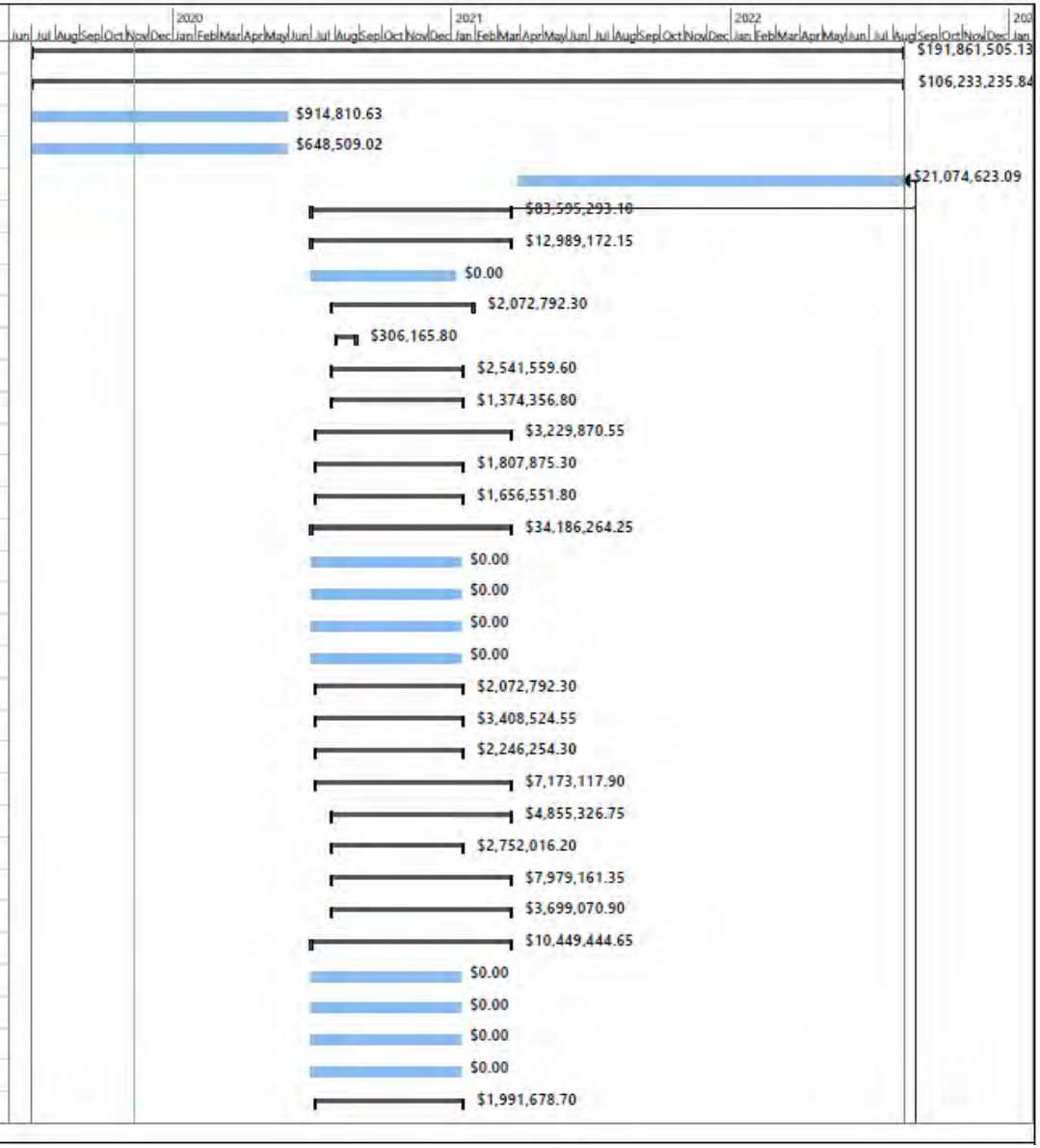
6 Implementation Schedule

This section outlines an implementation schedule including costs for all implementation strategies. The schedule is informed by the epidemiological research which identified the optimal water temperature conditions for virus effectiveness of 18-23 degrees, which corresponds to a September/October time period across the study area.

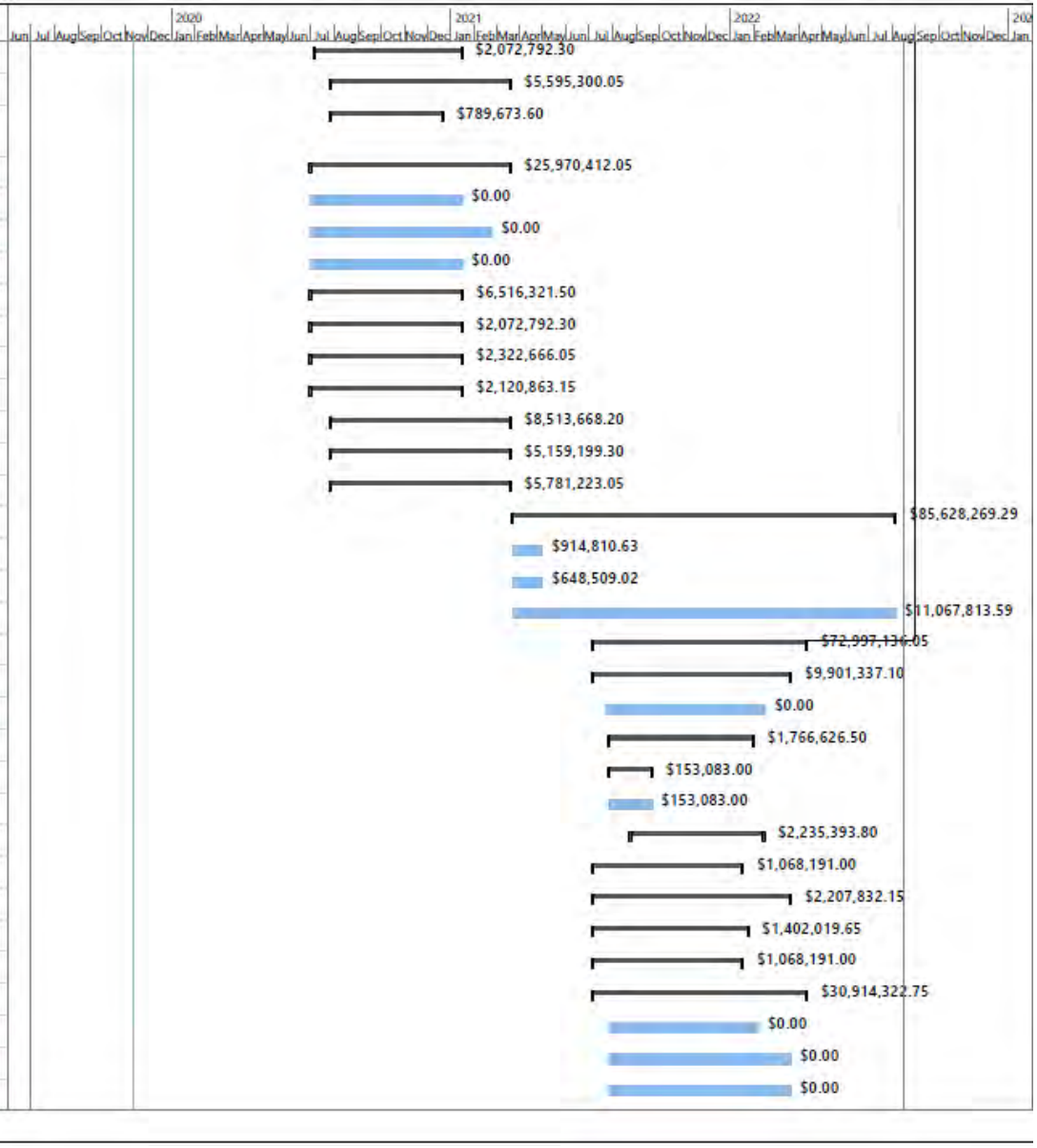
The schedule presented in Figure 6-1 is based on the adopted three-year implementation plan described in Section 3.1. The Schedule also presents the corresponding task and reach cost estimate which are summarised in Table 7-1 and applied to develop the indicative implementation cash flow shown in Figure 7-1.

For presentation/reporting purposes the project schedule shows the tasks and resource application 'rolled up' to a reach by reach level from the start of year 2 with resource application adjusted for the reduction in total biomass going into year 3. The full schedule of some 363 individual line items has been provided to FRDC in Microsoft Project format for future reference.

ID	Task Name	Duration	Start
1	121A_FRDC_NCCP_Murray-Murrumbidgee to SA	816 days	Mon 1/07/19
2	Years 1 & 2	816 days	Mon 1/07/19
3	NCCP Implementation Planning	12 mons	Mon 1/07/19
4	Communication & Engagement	12 mons	Mon 1/07/19
5	NCCP Mobilisation, Management & Administration	18 mons	Tue 30/03/21
6	Year 2	188 days	Wed 1/07/20
7	Griffith Command Centre	188 days	Wed 1/07/20
8	Wagga - Forward Command Post	135 days	Wed 1/07/20
9	MB0 Burrinjuk Dam	135 days	Mon 27/07/20
15	MB1 Burrinjuk Dam to Wagga Wagga	20 days	Mon 3/08/20
17	MB2 Wagga Wagga	125 days	Mon 27/07/20
23	MB3 Wagga Wagga to Berembed Weir	125 days	Mon 27/07/20
29	MB4 Berembed Weir to Darlington Point	185 days	Mon 6/07/20
35	MB5 Darlington Point to Maude Weir	140 days	Mon 6/07/20
41	YB1 Yancko Billabong Creek System	140 days	Mon 6/07/20
47	Echuca/Moama Command Centre	188 days	Wed 1/07/20
48	Albury - Forward Command Post	140 days	Wed 1/07/20
49	Yarrawonga - Forward Command Post	140 days	Wed 1/07/20
50	Deniliquin - Forward Command Post	140 days	Wed 1/07/20
51	Kerang - Forward Command Post	140 days	Wed 1/07/20
52	M0 Hume Dam	140 days	Mon 6/07/20
58	M1 Hume Dam to Corowa	140 days	Mon 6/07/20
64	O1 Ovens River to Wangaratta	140 days	Mon 6/07/20
70	M2 Corowa to Yarra Wonga	185 days	Mon 6/07/20
76	M3 Yarrawonga Weir to Edwards River	170 days	Mon 27/07/20
82	M4 Mid Murray	125 days	Mon 27/07/20
88	M5 Gunbower to Swan Hill	170 days	Mon 27/07/20
94	EW1 Edwards River to Wakool	170 days	Mon 27/07/20
100	Mildura Command Centre	188 days	Wed 1/07/20
101	Balranald - Forward Command Post	140 days	Wed 1/07/20
102	Wentworth - Forward Command Post	140 days	Wed 1/07/20
103	Pooncarie - Forward Command Post	140 days	Wed 1/07/20
104	Renmark - Forward Command Post	140 days	Wed 1/07/20
105	MB6 Maude Weir to Murray River	140 days	Mon 6/07/20



ID	Task Name	Duration	Start
111	M6 Swan Hill to Hattah Lakes incl. Euston Lakes	140 days	Mon 6/07/20
117	M7 Hattah Lakes to Lock 10	170 days	Mon 27/07/20
123	D1 30km upstream Darling River confluence with River Murray to Burtundvi Weir	105.2 days	Mon 27/07/20
129	Murray Bridge Command Centre	188 days	Wed 1/07/20
130	Barmera - Forward Command Post	143 days	Wed 1/07/20
131	Blanchetown - Forward Command Post	170 days	Wed 1/07/20
132	Goolwa - Forward Command Post	143 days	Wed 1/07/20
133	M8 Lock 10 to Lock 5 incl. Lake Victoria	143 days	Wed 1/07/20
134	Lake Victoria Inlet Structure	143 days	Wed 1/07/20
140	Lindsay River and Lake Walla Walla aggregations	143 days	Wed 1/07/20
146	Chowilla Creek system (Pipeclay & Slaney Creeks),	143 days	Wed 1/07/20
152	M9 Lock 5 to Lock 3	170 days	Mon 27/07/20
171	M10 Lock 3 to Lock 1	170 days	Mon 27/07/20
177	M11 Lock 1 to Mouth incl. Lower Lakes	170 days	Mon 27/07/20
183	Final Year	360 days	Mon 22/03/21
184	NCCP Implementation Planning	30 days	Mon 22/03/21
185	Communication & Engagement	30 days	Mon 22/03/21
186	NCCP Mobilisation, Management & Administration	18 mons	Mon 22/03/21
187	Year 3	200 days	Tue 6/07/21
188	Griffith Command Centre	185 days	Tue 6/07/21
189	Wagga - Forward Command Post	150 days	Thu 22/07/21
190	MB0 Burrinjuk Dam	135 days	Tue 27/07/21
196	MB1 Burrinjuk Dam to Wagga Wagga	40 days	Tue 27/07/21
197	Winter & Spring Fish Down	40 days	Tue 27/07/21
198	MB2 Wagga Wagga	125 days	Tue 24/08/21
204	MB3 Wagga Wagga to Berembed Weir	140 days	Tue 6/07/21
210	MB4 Berembed Weir to Darlington Point	185 days	Tue 6/07/21
216	MB5 Darlington Point to Maude Weir	145 days	Tue 6/07/21
222	YB1 Yancko Billabong Creek System	140 days	Tue 6/07/21
228	Echuca/Moama Command Centre	200 days	Tue 6/07/21
229	Albury - Forward Command Post	140 days	Tue 27/07/21
230	Yarrawonga - Forward Command Post	170 days	Tue 27/07/21
231	Deniliquin - Forward Command Post	170 days	Tue 27/07/21



ID	Task Name	Duration	Start	
232	Kerang - Forward Command Post	185 days	Tue 27/07/21	$0.00
233	M0 Hume Dam	140 days	Tue 6/07/21	$1,766,626.50
239	M1 Hume Dam to Corowa	140 days	Tue 6/07/21	$2,537,968.30
245	O1 Ovens River to Wangaratta	140 days	Tue 6/07/21	$1,940,088.50
251	M2 Corowa to Yarra Wonga	170 days	Tue 27/07/21	$6,866,952.10
257	M3 Yarrawonga Weir to Edwards River	170 days	Tue 27/07/21	$3,984,770.50
263	M4 Mid Murray	125 days	Tue 27/07/21	$2,445,850.40
269	M5 Gunbower to Swan Hill	185 days	Tue 6/07/21	$7,672,995.55
275	EW1 Edwards River to Wakool	170 days	Tue 27/07/21	$3,699,070.90
281	Mildura Command Centre	185 days	Tue 6/07/21	$8,660,390.55
282	Balranald - Forward Command Post	140 days	Tue 27/07/21	$0.00
283	Wentworth - Forward Command Post	170 days	Tue 27/07/21	$0.00
284	Pooncarie - Forward Command Post	125 days	Tue 27/07/21	$0.00
285	Renmark - Forward Command Post	125 days	Tue 27/07/21	$0.00
286	MB6 Maude Weir to Murray River	155 days	Tue 6/07/21	$1,403,317.45
292	M6 Swan Hill to Hattah Lakes incl. Euston Lakes	140 days	Tue 6/07/21	$1,484,431.05
298	M7 Hattah Lakes to Lock 10	170 days	Tue 27/07/21	$5,289,134.25
304	D1 30km upstream Darling River confluence with River Murray to Burtundvi Weir	125 days	Tue 27/07/21	$483,507.80
310	Murray Bridge Command Centre	185 days	Tue 6/07/21	$23,521,085.65
311	Barmera - Forward Command Post	125 days	Tue 6/07/21	$0.00
312	Blanchetown - Forward Command Post	125 days	Tue 6/07/21	$0.00
313	Goolwa - Forward Command Post	170 days	Tue 6/07/21	$0.00
314	M8 Lock 10 to Lock 5 incl. Lake Victoria	140 days	Tue 6/07/21	$5,597,824.10
315	Lake Victoria Inlet Structure	140 days	Tue 6/07/21	$1,766,626.50
321	Lindsay River and Lake Walla Walla aggregations	140 days	Tue 6/07/21	$2,016,500.25
327	Chowilla Creek system (Pipeclay & Slaney Creeks),	140 days	Tue 6/07/21	$1,814,697.35
333	M9 Lock 5 to Lock 3	170 days	Tue 27/07/21	$7,595,170.80
334	Lock 4 and Lock 5	170 days	Tue 27/07/21	$4,876,744.85
340	Lake Bonney water depth problematic, target north western side	80 days	Tue 27/07/21	$1,057,027.85
346	Off-river wetlands (Watchels Lagoon)	125 days	Tue 27/07/21	$1,661,398.10
352	M10 Lock 3 to Lock 1	170 days	Tue 27/07/21	$4,853,033.50
358	M11 Lock 1 to Mouth incl. Lower Lakes	170 days	Tue 27/07/21	$5,475,057.25

Figure 6-1 Implementation Schedule and Corresponding Cost Estimate

7 Cost Estimation

The cost estimate was developed by the project team using its *Expert Estimation Genesis* software. The program is used extensively across the major infrastructure projects sector, being regularly applied to the detailed cost estimation for large multifaceted capital works projects. The software was chosen for this project given the it has embedded automated logic that is well suited to multiple sites with similar scope constraints. This reduces exposure to errors often present in complex spreadsheet-based estimates and can easily produce accurate estimate based on the virus deployment and carcass management strategy assumptions and applied resources.

The cost estimate totalling some $191 million, summarised in Table 7-1, is the culmination of a range of assumption relating to the virus deployment and carcass management strategy, documented in Section 3, applied to the risk assessed river reaches and the average biomass for the case study area. These were used to develop and apply a resource strategy and unit costs across a three-year implementation schedule.

Central to the cost estimate was the definition of a common suite of resource types with the likely labour, plant and materials required within each type agreed during the case study workshops. These were then applied to each Central Command Centre, Forward Command Centre and River Reach.

To provide a sense of the scale of operations, a preliminary labour and cash flow projection is shown in Figure 7-1. Whilst more work would need to be done to formalise a program delivery plan, this figure shows a peak daily workforce across the study area of more than 500 people and a daily expenditure of almost $750,000 during the period of maximum virus effectiveness when carcass management requirements will be most intense.

A key message to take form the schedule and cash flow is that the initial implementation will require infection, surveillance and carcass management activities to be undertaken concurrently over a large geographic area in a relatively short time period. To enable this to occur a significant body of work is required to develop and test processes and procedures. This has been reflected in the cost estimate with substantial allowances included for Implementation Planning and Mobilisation, Management and Administration.

Table 7-1 Summary Cost Estimate

Murray and Murrumbidgee Case Study - Cost Estimate Summary	
Description	**Amount**
Year One and Two Total	**106,233,235.72**
Preliminary Items	22,637,942.17
Murrumbidgee River	
MB0 Burrinjuk Dam	2,072,792.30
MB1 Burrinjuk Dam to Wagga Wagga	306,165.80
MB2 Wagga Wagga	2,541,559.60
MB3 Wagga Wagga to Berembed Weir	1,374,356.80
MB4 Berembed Weir to Darlington Point	3,229,870.55
YB1 Yancko Billabong Creek System	1,656,551.80
MB5 Darlington Point to Maude Weir	1,807,875.30
MB6 Maude Weir to Murray River	1,991,678.70
Sub total Murrumbidgee	**14,980,850.85**
Murray River	
M0 Hume Dam	2,072,792.30
M1 Hume Dam to Corowa	3,408,524.55
M2 Corowa to Yarra Wonga	7,173,117.90
O1 Ovens River to Wangaratta	2,246,254.30
M3 Yarrawonga Weir to Edwards River	4,855,326.75
EW1 Edwards River to Wakool	3,699,070.90
M4 Mid Murray	2,752,016.20
M5 Gunbower to Swan Hill	7,979,161.35
M6 Swan Hill to Hattah Lakes incl. Euston Lakes	2,072,792.30
M7 Hattah Lakes to Lock 10	5,595,300.05
D1 30km upstream Darling River confluence with River Murray to Burtundvi Weir	789,673.60
M8 Lock 10 to Lock 5 incl. Lake Victoria	
Lake Victoria Inlet Structure	2,072,792.30
Lindsay River and Lake Walla Walla aggregations	2,322,666.05
Chowilla Creek system (Pipeclay & Slaney Creeks).	2,120,863.15
M9 Lock 5 to Lock 3	
Lock 4 and Lock 5	5,182,910.65
Lake Bonney water depth problematic, target north western side	1,363,193.65
Off-river wetlands (Watchels Lagoon)	1,967,563.90
M10 Lock 3 to Lock 4	5,159,199.75
M11 Lock 1 to Mouth incl. Lower Lakes	5,781,223.05
Sub total Murray	**68,614,442.70**
Year Three	**85,039,908.16**
Preliminary Items	12,631,132.91
Murrumbidgee River	
MB0 Burrinjuk Dam	1,766,626.50
MB1 Burrinjuk Dam to Wagga Wagga	153,083.00
MB2 Wagga Wagga	2,235,393.80
MB3 Wagga Wagga to Berembed Weir	1,068,191.00
MB4 Berembed Weir to Darlington Point	2,207,832.15
YB1 Yancko Billabong Creek System	1,068,191.00
MB5 Darlington Point to Maude Weir	1,402,019.65
MB6 Maude Weir to Murray River	1,403,317.45
Sub total Murrumbidgee	**11,304,654.55**
Murray River	
M0 Hume Dam	1,766,626.50
M1 Hume Dam to Corowa	2,537,968.30
M2 Corowa to Yarra Wonga	6,866,952.10
O1 Ovens River to Wangaratta	1,940,088.50
M3 Yarrawonga Weir to Edwards River	3,984,770.50
EW1 Edwards River to Wakool	3,110,709.65
M4 Mid Murray	2,445,850.40
M5 Gunbower to Swan Hill	7,672,995.55
M6 Swan Hill to Hattah Lakes incl. Euston Lakes	1,484,431.05
M7 Hattah Lakes to Lock 10	5,289,134.25
D1 30km upstream Darling River confluence with River Murray to Burtundvi Weir	483,507.80
M8 Lock 10 to Lock 5 incl. Lake Victoria	
Lake Victoria Inlet Structure	1,766,626.50
Lindsay River and Lake Walla Walla aggregations	2,016,500.25
Chowilla Creek system (Pipeclay & Slaney Creeks).	1,814,697.35
M9 Lock 5 to Lock 3	
Lock 4 and Lock 5	4,876,744.85
Lake Bonney water depth problematic, target north western side	1,057,027.85
Off-river wetlands (Watchels Lagoon)	1,661,398.10
M10 Lock 3 to Lock 4	4,853,033.95
M11 Lock 1 to Mouth incl. Lower Lakes	5,475,057.25
Sub total Murray	**61,104,120.70**
Total for project - Year One, Two and Three	**191,273,143.88**

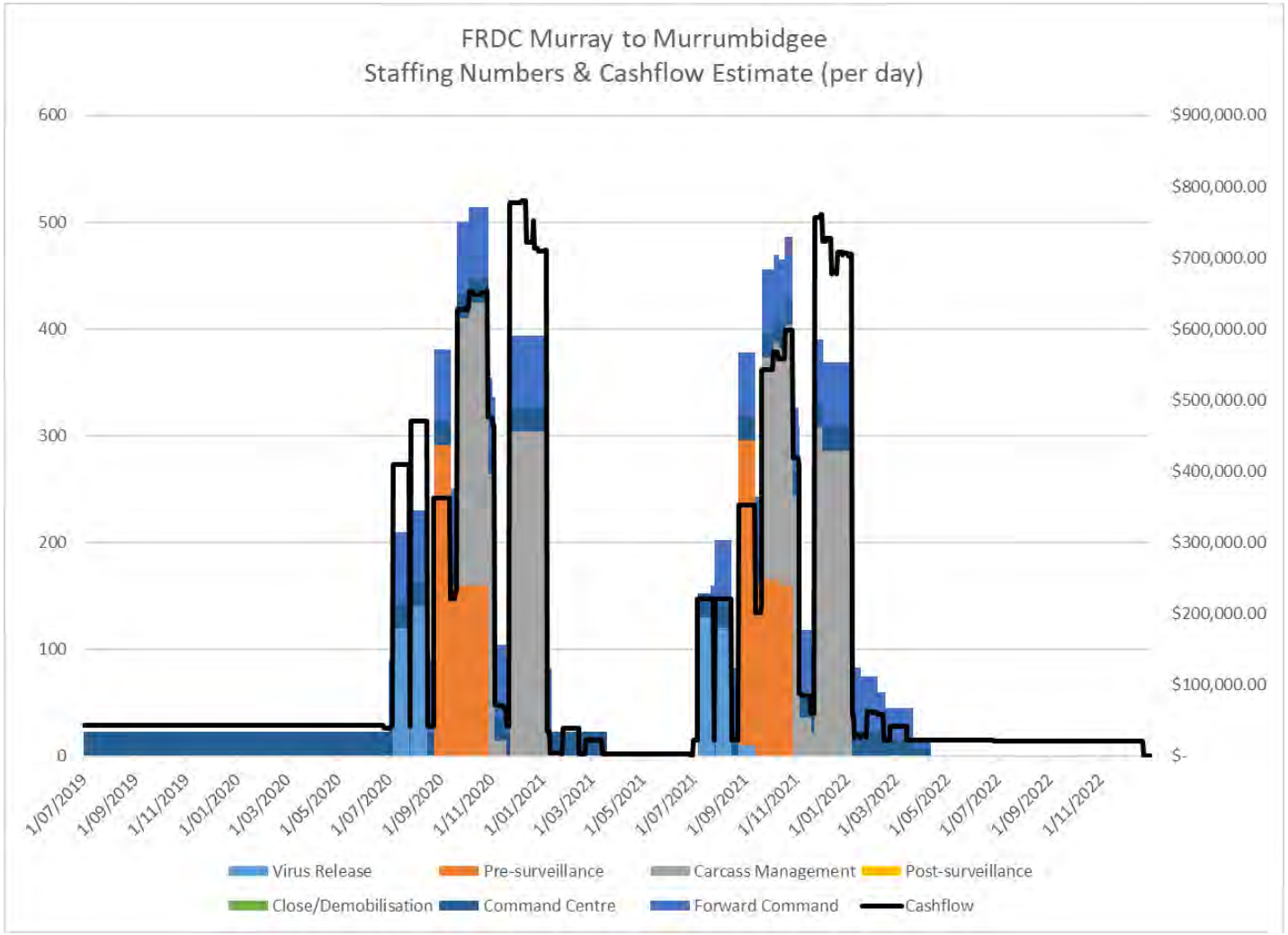


Figure 7-1 Staffing Numbers and Cashflow (per day)

8 Conclusions

The following conclusions can be drawn from the case studies undertaken:

- Overall, the case study investigations undertaken demonstrate that the deployment and carcass management strategies adopted are capable of achieving the desired biomass reductions whilst mitigating the identified risks to acceptable levels. This comes at a significant, but not prohibitive, cost and includes contingencies (such as the second year of virus deployment) to ensure effective initial deployment of the virus consistent with the objectives of the NCCP.

- The scaling up of the initial Mid-Murray and Lower Murray case studies to the wider Murray and Murrumbidgee system has demonstrated that:

    - it is feasible to successfully deploy the virus and mitigate the identified risks at an operational scale, based on the NCCP science and assumptions;

    - cost and resourcing efficiencies can be achieved when addressing system wide implementation, particularly in the areas of regional control structure establishment and resourcing;

    - the system wide approach enables a relative comparison of risk and opportunity to be undertaken between river reaches with resources applied at a scale commensurate to the relative risk. For example, the higher level of amenity risks between Lock 1 and Morgan would see a greater surveillance and rapid response resource deployment when compared with a similar high risk in somewhere like the Gunbower Lagoons in Victoria.

    - a level of surge capacity can be maintained across the region and efficiently deployed to high risk areas providing additional surveillance and carcass management effort, and

    - there are several areas/sectors, such as the major irrigation districts, significant irrigation diverters and the multitude of stock & domestic water users that will need a targeted engagement strategy and specific tools developed so those water users can mitigate any risks to their operations.

- Implementation planning should involve a comprehensive program of assumption and scenario testing. Where possible this should involve both field testing (for example electro fishing at sustained target capture and simulated infection rates) and further desk top resource/schedule optimisation modelling.

- The case studies have highlighted the significant benefit of developing online Geographic Information System (GIS) tools and resources to assists in the planning, implementation and communication of the NCCP. The mapping of carp biomass is fundamental to every aspect of implementation planning and would provide a foundation for the development of similar GIS based operational support tools. This in turn would provide a spatial platform to efficiently monitor, evaluate and report on the effectiveness of the NCCP.

- Based on the average year biomass of some 85,000 tonnes, the case study has shown that with adequate planning and resourcing, an effective three-year program can be implemented for an estimated $191M (2019 dollars). The cost estimate is based on a detailed bottom up approach, applying the necessary resources to address relative sub-population biomass and identified regional (reach by reach) risks. Given the variability in assumptions applied to everything from the input biomass modelling, required infection rates, mortality timing and the antecedent conditions to any potential deployment, no escalation or contingency was applied to the cost estimate.

- The assessment of applied resources and cash flow shows a peak daily workforce across the scaled-up case study area of more than 500 people and a peak daily expenditure of almost $750,000 during the period of maximum virus effectiveness when carcass management requirements will be most intense. This represents a significant resource requirement to be coordinated across a large geographic region, which if considered in the context of natural resource management initiative, may seem challenging. However, when considered in the context of a capital spend (and managed under similar delivery frameworks) comparable to small to medium size linear infrastructure projects, the overall implementation should be relatively easily managed given an appropriate level of planning.

- Implementation will be required to initiate infection, surveillance and clean-up activities concurrently over a large geographic area in a relatively short time period. To enable this to occur a significant body of work is required to develop and test the necessary processes and procedures.

Appendix 1 Detailed Cost Estimate

Item	Description	Unit	Quantity	Unit Rate	Amount
	Year One and Two				
	Preliminary Items				
1	NCCP Implementation Planning	item	1.00	$ 914,810.63	$ 914,810.63
2	Communication & Engagement	item	1.00	$ 648,509.02	$ 648,509.02
3	NCCP Mobilisation, Management & Administration Establishment of central and forward command centres, incident planning, work-specific training of staff (e.g. coxswain certificates, first aid, marine radio, etc.), mobilisation of resources, procurement of major/ minor items, engagement strategy implementation (includes placement of information boards)	item	1.00	$ 21,074,623.09	$ 21,074,623.09
	Murrumbidgee River ----------				
	MB0 Burrinjuk Dam				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 30,616.58	$ 612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 10,522.83	$ 210,456.60
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 25,006.14	$ 1,125,276.30
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 2,072,792.30**
	MB1 Burrinjuk Dam to Wagga Wagga				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00		
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00		
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00		
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00		
	Total for all activities				**$ 430,893.60**
	MB2 Wagga Wagga				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 30,616.58	$ 612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 5,261.41	$ 105,228.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 37,761.60	$ 1,699,272.00
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 2,541,559.60**
	MB3 Wagga Wagga to Berembed Weir				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 30,616.58	$ 612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 5,261.41	$ 105,228.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 11,823.76	$ 532,069.20
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 1,374,356.80**
	MB4 Berembed Weir to Darlington Point				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 30,616.58	$ 612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$ 10,522.83	$ 683,983.95
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 40,196.16	$ 1,808,827.20
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 3,229,870.55**
	YB1 Yancko Billabong Creek System				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 30,616.58	$ 612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 5,261.41	$ 105,228.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 18,094.76	$ 814,264.20
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 1,656,551.80**

Item	Description	Unit	Quantity		Unit Rate		Amount
	MB5 Darlington Point to Maude Weir						
4	Virus release	days	20.00	$	30,616.58	$	612,331.60
	Deployment of virus to strategic locations along waterway using various techniques						
5	Pre-surveillance	days	20.00	$	6,467.15	$	129,343.00
	Land and on-water monitoring of waterways						
6	Carcass management	days	45.00	$	20,921.62	$	941,472.90
	Capture and collection of carcass from waterways and disposal to land, includes land management						
7	Post-surveillance	days	20.00	$	4,055.67	$	81,113.40
	Land and on-water monitoring of waterways						
8	Close/ demobilisation	days	20.00	$	2,180.72	$	43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)						
	Total for all activities					**$**	**1,807,875.30**
	MB6 Maude Weir to Murray River						
4	Virus release	days	20.00	$	30,616.58	$	612,331.60
	Deployment of virus to strategic locations along waterway using various techniques						
5	Pre-surveillance	days	20.00	$	6,467.15	$	129,343.00
	Land and on-water monitoring of waterways						
6	Carcass management	days	45.00	$	25,006.14	$	1,125,276.30
	Capture and collection of carcass from waterways and disposal to land, includes land management						
7	Post-surveillance	days	20.00	$	4,055.67	$	81,113.40
	Land and on-water monitoring of waterways						
8	Close/ demobilisation	days	20.00	$	2,180.72	$	43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)						
	Total for all activities					**$**	**1,991,678.70**
	Sub total Murrumbidgee					**$**	**14,980,850.85**
	Murray River ----------						
	M0 Hume Dam						
4	Virus release	days	20.00	$	30,616.58	$	612,331.60
	Deployment of virus to strategic locations along waterway using various techniques						
5	Pre-surveillance	days	20.00	$	10,522.83	$	210,456.60
	Land and on-water monitoring of waterways						
6	Carcass management	days	45.00	$	25,006.14	$	1,125,276.30
	Capture and collection of carcass from waterways and disposal to land, includes land management						
7	Post-surveillance	days	20.00	$	4,055.67	$	81,113.40
	Land and on-water monitoring of waterways						
8	Close/ demobilisation	days	20.00	$	2,180.72	$	43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)						
	Total for all activities					**$**	**2,072,792.30**
	M1 Hume Dam to Corowa						
4	Virus release	days	20.00	$	30,616.58	$	612,331.60
	Deployment of virus to strategic locations along waterway using various techniques						
5	Pre-surveillance	days	20.00	$	21,045.65	$	420,913.00
	Land and on-water monitoring of waterways						
6	Carcass management	days	45.00	$	50,012.27	$	2,250,552.15
	Capture and collection of carcass from waterways and disposal to land, includes land management						
7	Post-surveillance	days	20.00	$	4,055.67	$	81,113.40
	Land and on-water monitoring of waterways						
8	Close/ demobilisation	days	20.00	$	2,180.72	$	43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)						
	Total for all activities					**$**	**3,408,524.55**
	M2 Corowa to Yarra Wonga						
4	Virus release	days	20.00	$	30,616.58	$	612,331.60
	Deployment of virus to strategic locations along waterway using various techniques						
5	Pre-surveillance	days	65.00	$	21,045.65	$	1,367,967.25
	Land and on-water monitoring of waterways						
6	Carcass management	days	45.00	$	112,624.25	$	5,068,091.25
	Capture and collection of carcass from waterways and disposal to land, includes land management						
7	Post-surveillance	days	20.00	$	4,055.67	$	81,113.40
	Land and on-water monitoring of waterways						
8	Close/ demobilisation	days	20.00	$	2,180.72	$	43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)						
	Total for all activities					**$**	**7,173,117.90**
	O1 Ovens River to Wangaratta						
4	Virus release	days	20.00	$	30,616.58	$	612,331.60
	Deployment of virus to strategic locations along waterway using various techniques						
5	Pre-surveillance	days	20.00	$	5,261.41	$	105,228.20
	Land and on-water monitoring of waterways						
6	Carcass management	days	45.00	$	31,199.26	$	1,403,966.70
	Capture and collection of carcass from waterways and disposal to land, includes land management						
7	Post-surveillance	days	20.00	$	4,055.67	$	81,113.40
	Land and on-water monitoring of waterways						
8	Close/ demobilisation	days	20.00	$	2,180.72	$	43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)						
	Total for all activities					**$**	**2,246,254.30**
	M3 Yarrawonga Weir to Edwards River						
4	Virus release	days	20.00	$	30,616.58	$	612,331.60
	Deployment of virus to strategic locations along waterway using various techniques						
5	Pre-surveillance	days	65.00	$	21,045.65	$	1,367,967.25
	Land and on-water monitoring of waterways						
6	Carcass management	days	45.00	$	61,117.78	$	2,750,300.10
	Capture and collection of carcass from waterways and disposal to land, includes land management						
7	Post-surveillance	days	20.00	$	4,055.67	$	81,113.40
	Land and on-water monitoring of waterways						
8	Close/ demobilisation	days	20.00	$	2,180.72	$	43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)						
	Total for all activities					**$**	**4,855,326.75**

Item	Description	Unit	Quantity		Unit Rate		Amount
	EW1 Edwards River to Wakool						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$	15,784.24	$	1,025,975.60
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	43,023.02	$	1,936,035.90
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**3,699,070.90**
	M4 Mid Murray						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$	15,784.24	$	315,684.80
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	37,761.60	$	1,699,272.00
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**2,752,016.20**
	M5 Gunbower to Swan Hill						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$	42,091.31	$	2,735,935.15
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	100,137.04	$	4,506,166.80
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**7,979,161.35**
	M6 Swan Hill to Hattah Lakes incl. Euston Lakes						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$	10,522.83	$	210,456.60
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	25,006.14	$	1,125,276.30
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**2,072,792.30**
	M7 Hattah Lakes to Lock 10						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$	10,522.83	$	683,983.95
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	92,761.26	$	4,174,256.70
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**5,595,300.05**
	D1 30km upstream Darling River confluence with River Murray to Burtundvi Weir						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$	2,630.71	$	52,614.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00				
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**789,673.60**
	M8 Lock 10 to Lock 5 incl. Lake Victoria						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days					
5	Pre-surveillance Land and on-water monitoring of waterways	days					
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days					
7	Post-surveillance Land and on-water monitoring of waterways	days					
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days					
	Total for all activities						

Item	Description	Unit	Quantity		Unit Rate		Amount
	Lake Victoria Inlet Structure						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$	10,522.83	$	210,456.60
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	25,006.14	$	1,125,276.30
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**2,072,792.30**
	Lindsay River and Lake Walla Walla aggregations						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$	10,522.83	$	210,456.60
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	30,558.89	$	1,375,150.05
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**2,322,666.05**
	Chowilla Creek system (Pipeclay & Slaney Creeks),						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$	5,261.41	$	105,228.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	28,412.79	$	1,278,575.55
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**2,120,863.15**
	M9 Lock 5 to Lock 3						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days					
5	Pre-surveillance Land and on-water monitoring of waterways	days					
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days					
7	Post-surveillance Land and on-water monitoring of waterways	days					
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days					
	Total for all activities						
	Lock 4 and Lock 5						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$	22,133.35	$	1,438,667.75
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	66,826.30	$	3,007,183.50
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**5,182,910.65**
	Lake Bonney water depth problematic, target north western side						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$	5,261.41	$	105,228.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	11,575.69	$	520,906.05
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**1,363,193.65**
	Off-river wetlands (Watchels Lagoon)						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$	5,261.41	$	105,228.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	25,006.14	$	1,125,276.30
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**2,011,178.30**

Item	Description	Unit	Quantity		Unit Rate		Amount
	M10 Lock 3 to Lock 4						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$	17,706.68	$	1,150,934.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	72,693.46	$	3,271,205.70
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**5,159,199.30**
	M11 Lock 1 to Mouth incl. Lower Lakes						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	30,616.58	$	612,331.60
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$	17,706.68	$	1,150,934.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	86,516.21	$	3,893,229.45
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**5,781,223.05**

Item	Description	Unit	Quantity	Unit Rate	Amount
	Year Three				
	Preliminary Items				
1	NCCP Implementation Planning	item	1.00	$ 914,810.63	$ 914,810.63
2	Communication & Engagement	item	1.00	$ 648,509.02	$ 648,509.02
3	NCCP Mobilisation, Management & Administration Establishment of central and forward command centres, incident planning, work-specific training of staff (e.g. coxswain certificates, first aid, marine radio, etc.), mobilisation of resources, procurement of major/ minor items, engagement strategy implementation (includes placement of information boards)	item	1.00	$ 11,067,813.59	$ 11,067,813.59
	Murrumbidgee River ----------				
	MB0 Burrinjuk Dam				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 10,522.83	$ 210,456.60
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 25,006.14	$ 1,125,276.30
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 1,766,626.50**
	MB1 Burrinjuk Dam to Wagga Wagga				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 7,654.15	$ 153,083.00
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00		
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00		
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00		
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00		
	Total for all activities				**$ 153,083.00**
	MB2 Wagga Wagga				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 5,261.41	$ 105,228.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 37,761.60	$ 1,699,272.00
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 2,235,393.80**
	MB3 Wagga Wagga to Berembed Weir				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 5,261.41	$ 105,228.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 11,823.76	$ 532,069.20
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 1,068,191.00**
	MB4 Berembed Weir to Darlington Point				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$ 10,522.83	$ 683,983.95
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 24,287.88	$ 1,092,954.60
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 2,207,832.15**
	YB1 Yancko Billabong Creek System				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 5,261.41	$ 105,228.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 11,823.76	$ 532,069.20
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 1,068,191.00**

Item	Description	Unit	Quantity	Unit Rate	Amount
	MB5 Darlington Point to Maude Weir				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 6,467.15	$ 129,343.00
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 18,706.29	$ 841,783.05
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 1,402,019.65**
	MB6 Maude Weir to Murray River				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 6,467.15	$ 129,343.00
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 18,735.13	$ 843,080.85
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 1,403,317.45**
	Sub total Murrumbidgee				**$ 11,304,654.55**
	Murray River ----------				
	M0 Hume Dam				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 10,522.83	$ 210,456.60
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 25,006.14	$ 1,125,276.30
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 1,766,626.50**
	M1 Hume Dam to Corowa				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 21,045.65	$ 420,913.00
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 37,470.26	$ 1,686,161.70
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 2,537,968.30**
	M2 Corowa to Yarra Wonga				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$ 21,045.65	$ 1,367,967.25
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 112,624.25	$ 5,068,091.25
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 6,866,952.10**
	O1 Ovens River to Wangaratta				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$ 5,261.41	$ 105,228.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 31,199.26	$ 1,403,966.70
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 1,940,088.50**
	M3 Yarrawonga Weir to Edwards River				
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$ 15,308.29	$ 306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$ 21,045.65	$ 1,367,967.25
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$ 48,575.77	$ 2,185,909.65
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$ 4,055.67	$ 81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$ 2,180.72	$ 43,614.40
	Total for all activities				**$ 3,984,770.50**

Item	Description	Unit	Quantity		Unit Rate		Amount
	EW1 Edwards River to Wakool						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	15,308.29	$	306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$	15,784.24	$	1,025,975.60
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	36,752.01	$	1,653,840.45
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**3,110,709.65**
	M4 Mid Murray						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	15,308.29	$	306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$	15,784.24	$	315,684.80
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	37,761.60	$	1,699,272.00
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**2,445,850.40**
	M5 Gunbower to Swan Hill						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	15,308.29	$	306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$	42,091.31	$	2,735,935.15
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	100,137.04	$	4,506,166.80
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**7,672,995.55**
	M6 Swan Hill to Hattah Lakes incl. Euston Lakes						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	15,308.29	$	306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$	10,522.83	$	210,456.60
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	18,735.13	$	843,080.85
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**1,484,431.05**
	M7 Hattah Lakes to Lock 10						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	15,308.29	$	306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$	10,522.83	$	683,983.95
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	92,761.26	$	4,174,256.70
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**5,289,134.25**
	D1 30km upstream Darling River confluence with River Murray to Burtundvi Weir						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	15,308.29	$	306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	20.00	$	2,630.71	$	52,614.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00				
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**483,507.80**
	M8 Lock 10 to Lock 5 incl. Lake Victoria						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days					
5	Pre-surveillance Land and on-water monitoring of waterways	days					
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days					
7	Post-surveillance Land and on-water monitoring of waterways	days					
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days					
	Total for all activities						

Item	Description	Unit	Quantity	Unit Rate	Amount
	Lake Victoria Inlet Structure				
4	Virus release	days	20.00	$ 15,308.29	$ 306,165.80
	Deployment of virus to strategic locations along waterway using various techniques				
5	Pre-surveillance	days	20.00	$ 10,522.83	$ 210,456.60
	Land and on-water monitoring of waterways				
6	Carcass management	days	45.00	$ 25,006.14	$ 1,125,276.30
	Capture and collection of carcass from waterways and disposal to land, includes land management				
7	Post-surveillance	days	20.00	$ 4,055.67	$ 81,113.40
	Land and on-water monitoring of waterways				
8	Close/ demobilisation	days	20.00	$ 2,180.72	$ 43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)				
	Total for all activities				**$ 1,766,626.50**
	Lindsay River and Lake Walla Walla aggregations				
4	Virus release	days	20.00	$ 15,308.29	$ 306,165.80
	Deployment of virus to strategic locations along waterway using various techniques				
5	Pre-surveillance	days	20.00	$ 10,522.83	$ 210,456.60
	Land and on-water monitoring of waterways				
6	Carcass management	days	45.00	$ 30,558.89	$ 1,375,150.05
	Capture and collection of carcass from waterways and disposal to land, includes land management				
7	Post-surveillance	days	20.00	$ 4,055.67	$ 81,113.40
	Land and on-water monitoring of waterways				
8	Close/ demobilisation	days	20.00	$ 2,180.72	$ 43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)				
	Total for all activities				**$ 2,016,500.25**
	Chowilla Creek system (Pipeclay & Slaney Creeks),				
4	Virus release	days	20.00	$ 15,308.29	$ 306,165.80
	Deployment of virus to strategic locations along waterway using various techniques				
5	Pre-surveillance	days	20.00	$ 5,261.41	$ 105,228.20
	Land and on-water monitoring of waterways				
6	Carcass management	days	45.00	$ 28,412.79	$ 1,278,575.55
	Capture and collection of carcass from waterways and disposal to land, includes land management				
7	Post-surveillance	days	20.00	$ 4,055.67	$ 81,113.40
	Land and on-water monitoring of waterways				
8	Close/ demobilisation	days	20.00	$ 2,180.72	$ 43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)				
	Total for all activities				**$ 1,814,697.35**
	M9 Lock 5 to Lock 3				
4	Virus release	days			
	Deployment of virus to strategic locations along waterway using various techniques				
5	Pre-surveillance	days			
	Land and on-water monitoring of waterways				
6	Carcass management	days			
	Capture and collection of carcass from waterways and disposal to land, includes land management				
7	Post-surveillance	days			
	Land and on-water monitoring of waterways				
8	Close/ demobilisation	days			
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)				
	Total for all activities				
	Lock 4 and Lock 5				
4	Virus release	days	20.00	$ 15,308.29	$ 306,165.80
	Deployment of virus to strategic locations along waterway using various techniques				
5	Pre-surveillance	days	65.00	$ 22,133.35	$ 1,438,667.75
	Land and on-water monitoring of waterways				
6	Carcass management	days	45.00	$ 66,826.30	$ 3,007,183.50
	Capture and collection of carcass from waterways and disposal to land, includes land management				
7	Post-surveillance	days	20.00	$ 4,055.67	$ 81,113.40
	Land and on-water monitoring of waterways				
8	Close/ demobilisation	days	20.00	$ 2,180.72	$ 43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)				
	Total for all activities				**$ 4,876,744.85**
	Lake Bonney water depth problematic, target north western side				
4	Virus release	days	20.00	$ 15,308.29	$ 306,165.80
	Deployment of virus to strategic locations along waterway using various techniques				
5	Pre-surveillance	days	20.00	$ 5,261.41	$ 105,228.20
	Land and on-water monitoring of waterways				
6	Carcass management	days	45.00	$ 11,575.69	$ 520,906.05
	Capture and collection of carcass from waterways and disposal to land, includes land management				
7	Post-surveillance	days	20.00	$ 4,055.67	$ 81,113.40
	Land and on-water monitoring of waterways				
8	Close/ demobilisation	days	20.00	$ 2,180.72	$ 43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)				
	Total for all activities				**$ 1,057,027.85**
	Off-river wetlands (Watchels Lagoon)				
4	Virus release	days	20.00	$ 15,308.29	$ 306,165.80
	Deployment of virus to strategic locations along waterway using various techniques				
5	Pre-surveillance	days	20.00	$ 5,261.41	$ 105,228.20
	Land and on-water monitoring of waterways				
6	Carcass management	days	45.00	$ 25,006.14	$ 1,125,276.30
	Capture and collection of carcass from waterways and disposal to land, includes land management				
7	Post-surveillance	days	20.00	$ 4,055.67	$ 81,113.40
	Land and on-water monitoring of waterways				
8	Close/ demobilisation	days	20.00	$ 2,180.72	$ 43,614.40
	Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)				
	Total for all activities				**$ 1,705,012.50**

Item	Description	Unit	Quantity		Unit Rate		Amount
	M10 Lock 3 to Lock 4						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	15,308.29	$	306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$	17,706.68	$	1,150,934.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	72,693.46	$	3,271,205.70
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**4,853,033.50**
	M11 Lock 1 to Mouth incl. Lower Lakes						
4	Virus release Deployment of virus to strategic locations along waterway using various techniques	days	20.00	$	15,308.29	$	306,165.80
5	Pre-surveillance Land and on-water monitoring of waterways	days	65.00	$	17,706.68	$	1,150,934.20
6	Carcass management Capture and collection of carcass from waterways and disposal to land, includes land management	days	45.00	$	86,516.21	$	3,893,229.45
7	Post-surveillance Land and on-water monitoring of waterways	days	20.00	$	4,055.67	$	81,113.40
8	Close/ demobilisation Closure of central and forward command centres, redeployment of resources, community engagement strategy implementation (includes removal of information boards)	days	20.00	$	2,180.72	$	43,614.40
	Total for all activities					**$**	**5,475,057.25**
	Total for project - Year One, Two and Three					***$***	***191,273,143.88***

Appendix 2 Mid-Murray Case Study

The following Mid-Murray Case Study summary has been adapted from the draft NCCP and used extensively to inform the scaled-up Murray and Murrumbidgee case study reported herein.

Description of area

The mid-Murray case study area extends from Picnic Point to the Gunbower wetlands on the Murray River. This section of the Murray forms a highly connected permanent system with large adjoining wetlands including Barmah and Moira Lakes, Gunbower Creek and associated lagoons, and Know Swamp. The area's flow patterns, and geomorphology are ideal for carp.

The carp problem

The region supports high carp densities and spawning hotspots, including Barmah and Moira Lakes and Gunbower Creek. The area's carp population tends to concentrate at these spawning sites during spring/ early summer.

Risks assessment

Figure 0-1 provides a spatial scan of the risks associated with virus deployment in the study area. Table 0-1 summarises these risks at particular locations.

Table 0-1: Risk summary, with mitigation options, for carp biocontrol in the mid-Murray River region (Picnic Point to Gunbower Wetlands).

Risk	Possible impacts	Risk mitigation
Environmental		
Ramsar Wetlands (Barmah)	Endangered species, bird nesting	Regulation of flows, timing of virus deployment, strategic carcass removal, carcass dispersal.
Gunbower Creek and Lagoons	Bird nesting, wetland ecology	Carcass removal with boats
Kow Swamp	Bird nesting	Flow regulation. Strategic booms and upstream collection of carcasses. Carcass removal
Social		
Kow Swamp	Significant cultural site. Water quality.	Flow regulation. Strategic booms and upstream collection of carcasses. Carcass removal
Echuca township and associated tourism and recreation including events	Odour. Amenity.	Strategic booms and upstream collection of carcasses. Regular small boat carcass removal
Torrumbarry weir pool	Odour. Amenity.	Strategic booms and upstream collection of carcasses. Regular small boat carcass removal
Gunbower small landholdings	Odour. Amenity Water quality	Screens on intake structures
National irrigation channel offtake	Water quality	Strategic booms and upstream collection of carcasses.

Implementation constraints

The study area's features and values impose environmental, physical, and social constraints on biocontrol implementation:

- high levels of year-round tourism and recreational use,
- large shallow inaccessible water bodies such as Kow Swamp,
- significant cultural values,
- Ramsar wetlands and endangered species,
- requirement to maintain navigable waterways,
- numerous shallow lagoons with poor physical access and high carp biomass, and
- numerous small adjoining landholders.

Management arrangements

The regional control centre will be located at Echuca with forward command centres at Picnic Point and Cohuna.

CyHV-3 Deployment

Virus deployment is illustrated at Figure 0-2. Eight major carp subpopulations will be targeted.

Carcass management

Carcass management in the region is illustrated at Figure 0-3. Managing high risk zones around the Echuca township and Gunbower and Torrumbarry weirs will require adequate resourcing. Cross- channel booms that corral and direct carp carcasses to collection points would constitute the main management method. Booms would be located upstream of high-risk areas. Around Echuca township regular small boat operations will be required to remove as many carcasses as possible. At Barmah and Moira lakes, risks could be substantially managed by carcass dispersal using flow regulation supplemented by strategic carcass removal at aggregation locations

Conclusions

The mid-Murray case study illustrates that CyHV-3 could be deployed and managed successfully even in a high-use, complex, connected system with important environmental and social values. The case-study area poses some significant challenges to implementation, especially in locations such as Kow Swamp and Gunbower Creek. These locations will require further implementation planning.

Carp biocontrol in the mid-Murray case study area would be relatively costly, reflecting the area's complexity and high carp biomass

RISK SCAN

- Commerical fishers/industry (needs positive agreement)
- Increased odour and insects
- Increased pest species
- Increased anti-social behaviour
- Gaining social licence is critical (eg. Gunbower landholders &c ommunity groups)
- Landholders - Dynamic/suspicious & need to demostrate impacts
- Address downstream impacts & relationships with key adjoining areas (Edward/Wakool Goulburn/Kerang Lakes etc)

ECOLOGICAL

- Refer to Becket etal 2019
- Fish left on floodplain (hunters/shooters/pests)
- Need to consider bird nesting/migratory species
- Vaccine management window
- Threatened species- Trout Cod & Murray Cod,SBN's

ECONOMIC

- Horticulture
- Tourism
- Commerical carp fishers (2)
- Short term (12mth) benefit from injection project $
- Long term benefits from carp reduction

CULTURAL HERITAGE

- Multitude of waterways/sites
- Heritage overlays
- Need tob e congnisant of cultural values (threats &o pportunities)
- Engagement officers in control centres

OPPORTUNITIES ISSUES SCAN

- Whole of catchment release
- Safety (HSE) over project lifecycle
- Social licence is critical
- Tap local/community knowledge
- Irrigation systems (MIL/Moira/GMW) & on farm dams/channels
  - Source of carp and second wave knockdown
- Target spawning hotspots
- Wetlands (restoration outcomes)
- Social risks
- Strategies greater than or less than 100kg/ha
- Where no clean up- keep on floodplain
- Target winter release

DPW/DEW
PID
RCS/CBL/DPW
PFD
CBL
BARMAH/MOIRA LAKES
MOIRA REGULATOR
RCS
PID/PFD
WEIR POOL
RCS/CBL
LOWER GOULBURN
SWB
CAMPASPE
PID

National channels
Gunbower lagoons
Kow swamp
BOX CREEK
TAYLOR CREEK
LWS
GUNBOWER CREEK
Torrumbarry Weir
Gunbower Weir
PICNIC POINT
Intense recreation use (Oct-Apr)
High visitation areas
Picnic point
Goulburn to Torrumbarry weir (Spet- May)
Significant tourism (houseboats/fishing)
Significant locally valued assets
Key events
- Southern 80 (Feb)
- River boat festival (Feb)
- Winter blues (July)

Cohuna
Leitchville
Patho
Torrumbarry
Wharparilla
Moama
Yambuna
Kotupna
Nathalia
Mathoura
Barmah
BROKEN CREEK
MURRAY RIVER
NEW SOUTH WALES
VICTORIA

WATERBODY TYPE

SWB- Small Water Bodies - Urban, Ornamental
DPW- Disconnected Permanent/Semi-Permanent Wetland
DEW- Disconected Ephemeral Wetland
UWS- Urban off-stream Raw Water storages
PID- Off-River Private Irrigation Districts
PFD- Private Farm Dams/Channels/Drains
RCS- River, Creek or Stream
CBL- Connected Backwaters/Lagoons/Lakes/Swamps
LWS- Large Warter Storages - Lakes, Dams, Impoundments
MWS- Medium Water Storages - Lakes, Impoundments
Small Water Bodies - Urban, Ornamental

N

0 2 4 6 8 10
Kilometres

Scale 1:250,000 @ A3

GDA 1994 MGA Zone 55

Legend

- Target Aggregation
- Control Centre
- Town Water Supply
- Irrigation offtakes
- Weir
- Main Highway
- River
- Sub Population
- High Risk- Operational Planning Required
- Medium Risk - High Social/Economic Values
- Low Risk - High Return For Effort

THE WEDGE GROUP

NCCP Mid Murray Case Study - Risk & Opportunities Scan

RELEASE STRATEGY

- **40-60% knockdown Year 1**
- **Target > 100-150kg/ha biomass**
- **Operational planning on conservative/dry year**
- **1-2 years after a flood/ increased storage volumes/ Murray general security allocation > 50-60%**
- **Spatial layer for willow trees would help identify hot spots**
- **D/S release from Hume (Edward/Wakool/Mid Mur ay together)**
- **Sept/Oct release**
- **3 release crews**
- **Target % of sub pop (hundreds per sub pop)**
- **Contain aggregations where possible**

FISH CAN MIIGRATE UP FROM MILDURA/LOWBIDGEE ETC

NEW SOUTH WALES

VICTORIA

SIGNIFICANT SPAWING AREA (GUNBOWER WETLANDS)

Ferricoota State Forest

Burkes Bridge

Wee Wee Rup

SUBP OP-15 0.473T/HA 166ha (dry)

Wombota

Leitchville

BOX CREEK

TAYLORC REEK

Torrumbarry Weir

NO DEAD CARP PAST WEIR

Gunbower

Kow Swamp

Gunbower Weir

GUNBOWER CREEK

LITTLE SPAWNING IN MAIN CHANNEL
STATIC WATER LEVELS
INCREASED TEMP. LATE AUG
--> FISH MIGRATE TO BARHAM/MOIRA

SUBP OP-13 0.337T/HA 785ha (dry)

Patho

Torrumbarry

WEIRP OOL

SUBP OP-19 0.621T/HA 71ha (dry)

Wharparilla

SIGNIFICANT SPAWING AREA
(SPAWN IN GUNBOWER LAGOONS ON LARGE FLOODS
& MOVE BACK AND FORTH THROUGH SYSTEM)

Moama

Echuca

Roslynmead

SUBP OP-9 0.194T/HA 93ha (dry)

CAMPASPE

Mitiamo

Pine Grove

VIRUS WILL SPREAD TO EDWARD/WAKOOL SYSTEM
NEEDS SIMULTANEOUS RELEASE

EDWARD/WAKOOL SYSTEM
SPAWNING AREAS
NUMEROUS WETLANDS

Millewa State Forest

Mathoura

FISH MIGRATION

SUBP OP-11 0.312T/HA 34ha (dry)

(COMPLEX WETLANDS
(SEMI-PERMANENT)

PICNIC POINT

FISH WILL MOVE
DOWN TO M/B LAKES

EDWARD RIVER OFFTAKE

SUBP OP-8 0.757T/HA 169ha (dry)

BARMAH/MOIRA LAKES

SIGNIFICANT SPAWNING AREA
TARGET PRE SPRING AGGREGATORS

MOIRA REGULATOR

Yielima

SUB POP-3 0.104T/HA 40ha (dry)

TARGET FOR RELEASE

MOVEMENT ZONE
OVER WINTER

Barmah

MURRAY RIVER

BROKEN CREEK

Nathalia

SUBP OP-23 0.239T/HA 109ha (dry)

SOUTH WALES

LOWER GOULBURN

VICTORIA

Yambura

Kotupna

GOULBURN RIVER

Torgala

Wyuna

Koyuga

RELEASE OPERATIONS

- **Approx 1000 fish/week**
- **Sept/Oct (Temp determined)**
- **Fish aggregating**
- **Vaccine management window**
- **3 Release teams/ Mid Murray (1-3 Weeks)**

N

0 2 4 6 8 10
Kilometres

Scale 1:250,000 @ A3

GDA 1994 MGA Zone 55

Legend

- Target Aggregation
- Weir
- Main Highway
- River
- Sub Population
- Focus Sub Populations
- Significant Spawning Area

Biomass (Dry Year)

- 0 - 100kg/ha
- 100 - 200kg/ha
- 200 - 300kg/ha
- 300 - 400kg/ha
- 400 - 500kg/ha
- > 500kg/ha

THE WEDGE GROUP

NCCP Mid Murray Case Study - Dry Year Release Strategy

KOW SWAMP (BIOMASS ~ 400t)
- STRATEGY IS TO LEAVE BIOMASS IN SWAMP
- MONITOR WQ
- SURVEILLANCE
- STAKEHOLDER ENGAGEMENT
- DEVELOP PLAN WITH T/O's

FORWARD COMMAND CENTRE

MAJOR CLEANUP LOCATION
BOOM/COLLECT/DISPOSE
USE OVER-SHOT GATES
TO MOVE FISH D/S

U/S GOULBURN JUNCTION
EXCLUDING BARMAH/MOIRA LAKES
SURVEILLIANCE (COMMUNITIES/DRONES/WATR AUTHORITIES)
BOAT COLLECTION AS REQUIRED
TACTICAL USE OF BOOMS

BOOM AT EDWARD & CULPE CK OFFTAKES

FORWARD COMMAND CENTRE

PICNIC POINT

BIOMASS UP TO 100t APPROX 60t DEAD
REMOVE AS MUCH AS POSSIBLE
LIKELY TO BE DISPERSED DEATH ON FLOODPLAIN

WHERE POSSIBLE (GIVEN OPERATIONS)
USE FLOW TO AGGREGATE THEN
MOVE FISH

BARRIERS/MECHANICAL ISOLATION (MI) AT LAKE OUTLETS
-CREATE AGGREGATION POINTS
-HOLD FISH FOR OPTIMUM TEMP
-WINTER DEPLOYMENT
-SURVEILLANCE
-TARGET CLEAN UP AT AGGREGATION SITES
-CLEAN UP RIVER AS REQUIRED

BOX CREEK

BOOM ACROSS OUTLET CHANNEL

BOOM ACROSS IRRIGATION OFFTAKE

BOOM ACROSS IRRIGATION OFFTAKE

BOOM AT COLLECTION POINT

GUNBOWER CREEK

Gunbower Weir

BOOM AT TORRUMBARRY WEIR

Torrumbarry Weir

BARMAH/MOIRA LAKES

MOIRA REGULATOR

CLEAN UP RESOURCES
- BARGE/EXCAVATOR/WEED BUCKET
- ACCESS SITES NSW/VIC FOR TRUCKS
- STRATEGIC USE OF BOOMS
- TRAFFIC CONTROL

CLEAN UP STRATGEY/RESOURCES
- DAILY SURVEILLANCE AND RAPID CLEAN UP
- 1 BOAT / 10KM (UP & BACK)
- COLLECTION POINTS AT EXISTING RAMPS
- 4 COLLECTION TEAMS (2PPL/VEHICLE)
- 4 WEEK PROGRAM

BOOM AT COLLECTION POINT

WEIR POOL

LOWER GOULBURN

PARTIAL BOOM

BOOM AT GOULBURN RIVER

BOOM AT WTP OFFTAKES

CONTROL CENTRE

HIGHEST RISK ZONES
20KMS D/S
10KM U/S
5KM U/S CAMPASPE RIVER

CAMPASPE

GUNBOWER CREEK/ LAGOONS
EXPLORE POSSIBLE KNOCKDOWN BEFORE VIRUS
MANIPULATE LEVELS
HIGHER WATER LEVELS TO ASSIST OPERATIONS
HIGHER NUMBER OF S&D AND IRRIGATION PUPMS
- INCREASED COMMS
- INCREASED SURVEILLANCE
WILL REQUIRE SMALLER BOATS/ MORE RESOURCES

TORRUMBARRY WEIR POOL - GOULBURN
- SIGNIFICANT CLEAN UP EFFORT REQUIRED
- HIGH IN-CHANNEL BIOMASS
- HIGH NUMBER OF BACK WATERS/ CONNECTED LAGOONS

Bunnaloo, Cohuna, Wee Wee Rup, Leitchville, Gunbower, Kow Swamp, Torrumbarry, Thyra, Mathoura, Millewa State Forest, Bullabula, Yielima, Barmah, Wharparilla, Moama, Roslynmead, Terrick Terrick, Terrick Terrick East, Yambura, Kotupna, Nathalia, Tongala, Wyuna, Koyuga, Mitiamo, Pine Grove

VICTORIA, NEW SOUTH WALES, MURRAY RIVER, BROKEN CREEK, GOULBURN RIVER

N

0 2 4 6 8 10
Kilometres

Scale 1:250,000 @ A3

GDA 1994 MGA Zone 55

Legend

- Target Aggregation
- Forward Command Centre
- Control Centre
- Boom_Silt Curtain
- Main Highway
- River
- Weir
- Sub Population
- High Risk Zone

Biomass (Dry Year)

- 0 - 100kg/ha
- 100 - 200kg/ha
- 200 - 300kg/ha
- 300 - 400kg/ha
- 400 - 500kg/ha
- > 500kg/ha

THE WEDGE GROUP

NCCP Mid Murray Case Study - Carcass Management Strategy

Appendix 3 Lower Murray (SA) Case Study

The following Lower Murray Case Study summary has been adapted from the draft NCCP and used extensively to inform the scaled-up Murray and Murrumbidgee case study reported herein.

Description of area

The mid-Murray case study covers the Murray River between Locks 1 and 3, including Lake Bonney. Carp attain high population densities in the case-study area, inhabiting the Murray river channel, adjoining wetlands and oxbows, and Lake Bonney. Commercial activity in the region includes extensive irrigated agriculture, river-based tourism, and commercial carp harvesting in Lake Bonney. Major townships include Waikerie and Morgan.

The carp problem

Over the 2017 – 18 summer, carp densities in the case study area ranged from 200 – 500kg/ha. Carp dominate water bodies such as Lake Bonney.

Risks assessment

Table 0-1 Risk summary, with mitigation options, for carp biocontrol between Locks one and three in the lower Murray River, South Australia.summarises the main risks and impacts associated with carp biocontrol in the Riverland/lower Murray area, with mitigation options. Risks are substantially social risks. There are no significant environmental values in the case study area. The identified Risks and Opportunities are show in Figure 0-1.

Table 0-1 Risk summary, with mitigation options, for carp biocontrol between Locks one and three in the lower Murray River, South Australia.

Risk	Possible impacts	Risk mitigation
Environmental		
Off channel regulated wetlands	Invertebrates and amphibians. Murray Cod	Regulation of flows, carp attractants, carcass removal
Oxbow systems e.g. Devils Pound	Invertebrates and amphibians. Reduced DO, BGA	Carcass removal with boats
Murray River channel	Murray Cod	Strategic booms and upstream collection of carcasses
Social		
Houseboats (100's)		
Waikerie township	Odour. Amenity.	Strategic booms and upstream carcass collection. Small boat carcass removal.
Shacks between Morgan and Blanchetown and off channel marina	Odour. Amenity.	Strategic booms and upstream collection of carcasses
Private irrigation offtakes (domestic use)	Water quality	Screens on intake structures
Major irrigation offtakes	Water quality	Screens on intake structures
Morgan Lagoon	Odour. Amenity	
Lake Bonney	600 tonnes of carp. Odour and amenity	Booms and small boats to coral carcasses to boat ramps and edges for operations

Implementation constraints

This case study area imposes several implementation constraints associated with access and infrastructure. Large shallow wetlands, lakes, and oxbow systems are difficult to access with boats

and shore-based equipment. Lake Bonney also presents a challenge for operations. The lake is large and shallow with high carp biomass, salinity. Lake Bonney is also subject to intensive recreational use. The lake experiences strong winds that will affect carcass management operations by blowing dead carp to downwind locations. The wind also naturally oxygenates the lake, potentially mitigating water-quality impacts.

Major river regulation infrastructure is located at each of the locks. Carp carcasses will likely concentrate at these locations. Carp control operations must be conducted without affecting river operations.

Management arrangements

Operations will involve a control centre located at Waikerie and forward command locations at Lake Bonney and Morgan.

CyHV-3 Deployment

CyHV-3 will be deployed through the whole river system and adjoining wetlands and oxbow systems. The nominal virus deployment and carcass management arrangements are shown in Figure 0-2 below.

Carcass management

Priority carcass management locations include areas above water treatment plants, water offtakes, areas around townships and holiday shacks, locks, spot locations in which carcass accumulation is likely (e.g. Pelican Point), and wetlands holding environmental values.

Conclusion

The Riverland area has high carp biomass that could be substantially reduced by carp biocontrol. Risks in this area are predominantly social, reflecting high levels of tourism and recreational use.

Social risks can be managed with strategic boom placement and collection of carp carcasses. Screens on irrigation intakes provide a simple solution to mitigate risks such as pump blockage. Lake Bonney will require more sophisticated carcass management using corralling and booming in navigable parts of the lake to direct carcasses to convenient collection points. Workshops highlighted the importance of local communication and engagement, especially with the tourism sector.

L3-1 OVERALL HIGH RISK REACH

- High biomass up to 400-500kg/ha in river channel and 300-400kg/ha in adjoining wetlands
- Environment - number of off-channel wetlands with significant flora and fauna vlaues
- Social/Amenity - Tourism industry centered on the river; High recreational use area (marina developments, shacks, houseboats,fishing, water sports)
- Economic - Town water supply off-takes, high number of domestic and stock supplies (1000's), high value irrigated agriculture (trusts & direct diverters)

Water body classifications: Open river, regulated, significant off-river wetlands, largely manageable
Estimated total biomass (modelled 'average year') 2,300t comprising Murray River 1,333t & Water Bodies 967t

Existing commercial carp fishing in Lake Bonney - High level of engagement required

Lake Bonney 1742ha - Carp Biomass 450/600t
High recreational use close to towns
Odour & amenity impacts

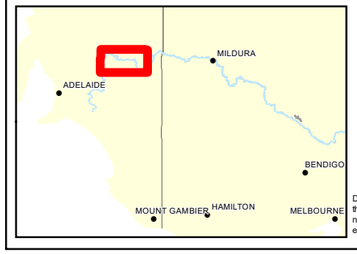
Ecological risks to the majority of off-river wetlands is considered low with minimal impacts to invertabrates and Lignum etc

Majority of wetlands are connected (full) at pool level
A number of wetlands are regulated allowing for level and flow manipulation which could assist virus release and carcass management

Close proximity to Adelaide, significant population spike across holiday periods
Large number of holiday shacks (>2000) across Lock 1-2 reach
3 major houseboat marinas at Blanchetown, Morgan and Waikerie
Water ski clubs

Signifiant long term tripple bottom line benefits from reduction in carp numbers to below 100kg/ha or better

Major carp aggregations and Locks & Weirs
Target sites for virus release and clean-up



N

0 2 4 6 8 10
Kilometres

Scale 1:250,000 @ A3

GDA 1994 MGA Zone 54

Legend

Main Highway | Lock | Marina | Sub Population

River Biomass

0 - 100kg/ha | 200 - 300kg/ha | 400 - 500kg/ha
100 - 200kg/ha | 300 - 400kg/ha | >500kg/ha

Waterbody Biomass

0 - 100kg/ha | 200 - 300kg/ha | 400 - 500kg/ha
100 - 200kg/ha | 300 - 400kg/ha | > 500kg/ha

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Lock 3 to Lock 1 Case Study - Risk & Opportunities

RELEASE STRATEGY

- High biomass throughout reach
- One year planning & engagement program
- Two year active release & carcass management with ongoing surveillance
- Release in a year of average regulated flows in SA (not immediately following a flood)
- Target known aggregations for release (locks, weirs, regulated wetlands)
- Where possible use weir pool manipulation and wetland regulation to create aggregations (explore shutting fish ways to promote aggregation then open post infection to promote movement upstream)
- Optimal release period (temp dependent) September/October and looking to infect up to 5% of fish per sub-population (maybe less given very high populations and known significant aggregations with high skin to skin contact)
- Target 40%-60% knockdown annually over two years
- Virus release resources (in addition to overall program coordination and communication) may include 3 to 5 electro-fishing teams working at strategic locations commencing below Locks 1,2,and 3
- Production rates (to capture, inject and release) are anticipated to be in the order of 1000-2000 fish per week per team

Increase surveillance and clean-up resources through shacks reach and marinas

Use river bathymetry & flow with large booms U/S of Waikerie

A number of adjacent wetlands could be difficult to close and or clean up

Lake Bonney
- small boats to corral dead fish
- booms deployed to move fish to navigable areas
- suction trucks at boat ramps
- lake edges/prevailing winds need greater surveillance
- Forward Command Location

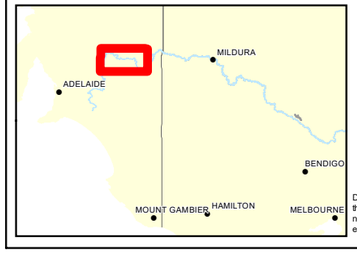
Carcass Management Strategy

- apply additional resources to high risk areas like Morgan Lagoon, Lake Bonney, Waikerie, Shacks reach
- stategic clean-up sites at Lock 1,2 and 3 (Bulk collection points with booms, heavy machinery etc)
- identify up to 3 land based disposal/composting sites, centrally located,

Carcass Management Resources

No.	Type
4	Land-based surveillance
4	On-water surveillance, to continue through carcass management phase (provides for off-river wetlands)
4	Deep water collection
2	Floating boom deployment/recovery, to protect CIT & RIT off-takes including Waikerie, Morgan, Brenda Park@ Murbko
5	Bulk-point collection
1	On-water vacum pump

Explore use of lock plant/equipemnt to collect fish from river



N

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Kilometres

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GDA 1994 MGA Zone 54

Legend

Main Highway | Lock | Marina | Sub Population

River Biomass

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Waterbody Biomass

0 - 100kg/ha | 100 - 200kg/ha | 200 - 300kg/ha | 300 - 400kg/ha | 400 - 500kg/ha | > 500kg/ha

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Lock 3 to Lock 1 Case Study
- Release & Carcass Management Strategy

NATIONAL CARP CONTROL PLAN

The National Carp Control Plan is managed by the
Fisheries Research and Development Corporation

Tel: 02 6285 0400
Post: Locked Bag 222, Deakin West ACT 2600

www.carp.gov.au