East Coast Flood Project: executive summary

Water quality monitoring program

Department of Climate Change,
Energy, the Environment and Water

NSW GOVERNMENT

Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the Traditional Custodians of the lands where we work and live.

We pay our respects to Elders past, present and emerging.

This resource may contain images or names of deceased persons in photographs or historical content.

Artist and designer Nikita Ridgeway from Aboriginal design agency Boss Lady Creative Designs created the People and Community symbol.

Cover photo: Water quality monitoring in Cudgen Lake. Sarah Carrick/DCCEEW

Published by:
Environment and Heritage
Department of Climate Change,
Energy, the Environment and Water
Locked Bag 5022, Parramatta NSW 2124
Phone: +61 2 9995 5000 (switchboard)
Phone: 1300 361 967 (Environment and Heritage enquiries)
TTY users: phone 133 677, then ask for 1300 361 967
Speak and listen users: phone 1300 555 727, then ask for 1300 361 967
Email info@environment.nsw.gov.au
Website www.environment.nsw.gov.au

ISBN 978-1-923285-50-7
EH 2024/0272 November 2024

Find out more at:

environment.nsw.gov.au

Contents

1. Introduction 1
 1.1 Background 1
 1.2 Aims and objectives 2
 1.3 Delivering on the project objectives 3
2. How the project was delivered 5
 2.1 Sampling program 9
 2.2 Engaging with stakeholders and community 11
3. How can floods impact water quality? 14
4. Key findings: understanding flood impacts and recovery in our waterways 17
 4.1 Flood impacts 17
 4.2 Flood recovery 17
 4.3 Spatial trends 20
 4.4 North Coast 20
 4.5 Mid Coast 26
 4.6 Hawkesbury 29
5. Project flood recovery tools 31
 5.1 Project data dashboard 31
 5.2 Framework for identifying contaminants in flood waters 32
6. Project recommendations 33
References 34

List of tables

Table 1	Timeline of project delivery	5
Table 2	Key water quality parameters analysed through the monitoring program	7
Table 3	Water quality grades according to the proportion of guideline value exceedances (%) for flood-impacted waterways presented in this report	10
Table 5	Flood impacts on water quality	15
Table 6	Summary of water quality grades for key indicators of water quality across flood-impacted north coast waterways in the project before (pre-flood), during (flood) and after (post-flood) the 2022 disaster declared flood events	22
Table 7	Summary of water quality grades for key indicators of water quality across flood-impacted mid-coast waterways in the project before (pre-flood), during (flood) and after (post-flood) the 2022 disaster declared flood events	28
Table 8	Summary of water quality grades for key indicators of water quality across flood-impacted waterways in the Hawkesbury-Nepean River (pre-flood), during (flood) and after (post-flood) the 2022 disaster declared flood events	30

List of figures

Figure 1	Delivery framework for the flood recovery program for water quality monitoring – East Coast Project	2
Figure 2	Project sampling regions covered by the water quality monitoring project	4
Figure 3	Project monitoring effort overview	6
Figure 4	Project team members Sarah and Max interrogating data collected on the Richmond River	6
Figure 5	Project sampling design and implementation	8

Figure 6	Sampling methods. A. Manual grab samples collected monthly and during events. B. Manual probe samples collected monthly and during events. C. Flow-through samples collected periodically and during events. D. TWQMS probe samples collected continuously	9
Figure 7	Water quality grade key presenting guideline value exceedances (%) for turbidity (Turb), chlorophyll-a (Chl-a), total nitrogen (TN), total phosphorous (TP) and the faecal indicator bacteria (FIB) – enterococci before (pre-flood), during flood and post flood	10
Figure 8	The Citizen Science Partnerships Program. A. An OzFish volunteer tests water clarity in the Clarence using a turbidity tube (OzFish). B. Richmond Riverkeeper volunteers sort macroinvertebrates at a site on the Richmond River (Richmond Riverkeepers Association). C. Positive Change for Marine Life volunteers conduct a shoreline video assessment of mangrove habitat on the Brunswick River (Positive Change for Marine Life). D. OzGREEN volunteers sort and identify macroinvertebrates during the Bellingen Riverwatch Macro Muster 5 (DCCEEW)	13
Figure 9	Summary of the general catchment characteristics across waterways in the project that were inundated during the 2022 disaster-declared flood events	16
Figure 10	A conceptual diagram displaying the succession of impacts and recovery for water quality parameters during the floods on the NSW east coast is based on the data and observations made through the project	19
Figure 11	The project dashboard showing the Grade page for the North Coast waterways. Numbers refer to the tab content descriptions listed below the screenshot	31
Figure 12	Implementation phase flowchart for the contaminant assessment framework	32

1. Introduction

1.1 Background

The severe storms and major flooding between February and July 2022 caused widespread effects on communities across New South Wales (NSW), damaging properties, public infrastructure, agriculture, businesses and the environment. These communities value their local rivers and estuaries and expressed concern about the flood impacts on these waterways.

In response, the NSW Department of Climate Change, Energy, the Environment and Water's (DCCEEW) Science and Insights Division was asked to develop a project plan for post-flood monitoring in declared flood-disaster local government areas (LGA) as part of the Environment Protection Authority's East Coast flood recovery program for water quality monitoring.

To support environmental recovery, the flood recovery program for water quality monitoring – East Coast Flood Project (the project) delivered a comprehensive water quality monitoring program, prioritising monitoring across flood-affected waterways. In line with the needs of the wider program, the project focused on 3 key objectives:

1. Improve understanding of flood-impacted water quality.
2. Support local capacity to monitor water quality for flood events.
3. Facilitate environmental recovery through the provision of information to communities and stakeholders.

To meet project aims and objectives, a multifaceted project was delivered, built on scientific knowledge, engagement with local and traditional knowledge, and development and delivery of a robust and comprehensive monitoring program that targeted knowledge and data gaps for flood-affected regions (Figure 1).

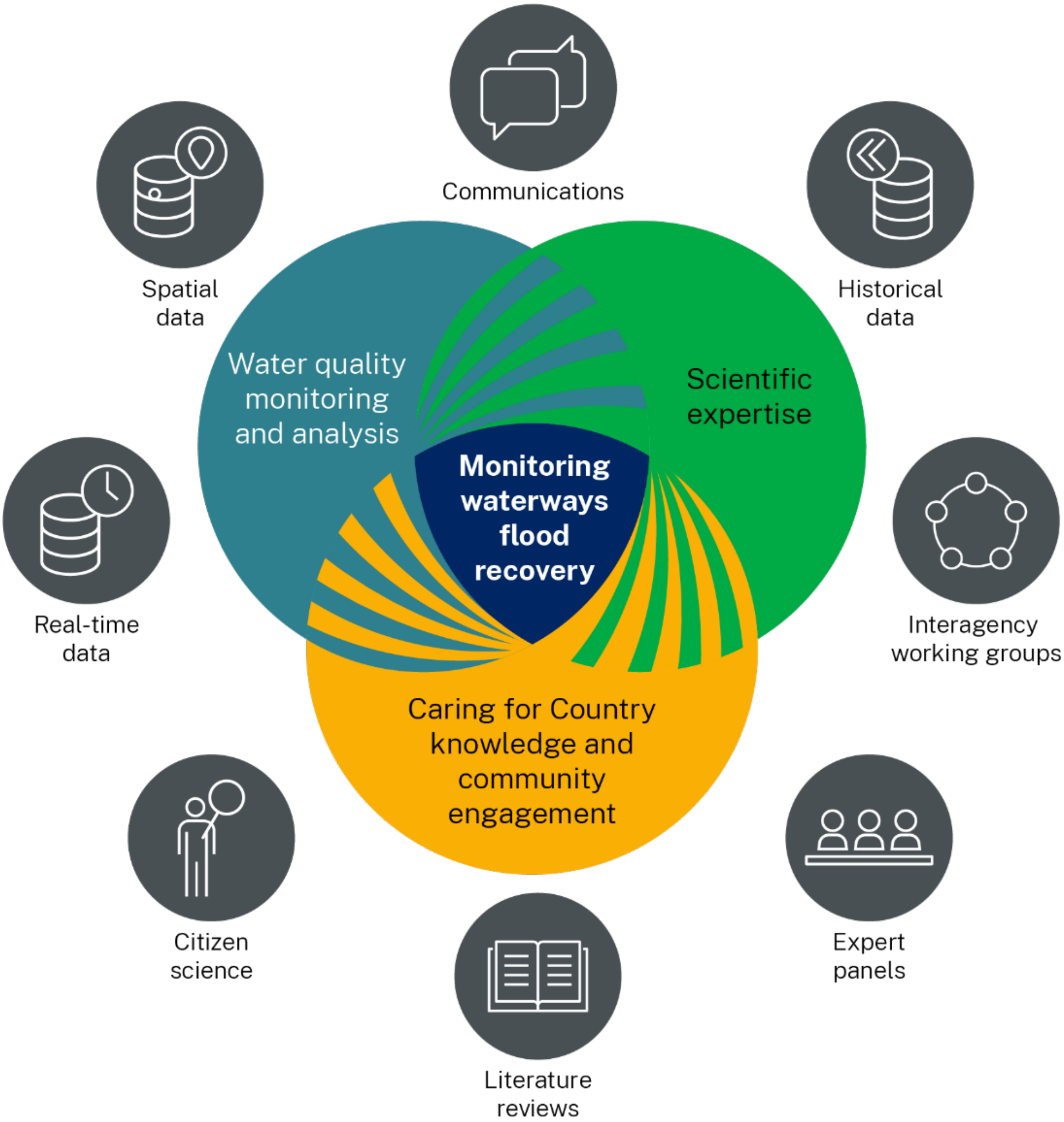


Figure 1 **Delivery framework for the flood recovery program for water quality monitoring – East Coast Flood Project**

1.2 Aims and objectives

The project aimed to deliver a comprehensive and prioritised water quality monitoring program across flood-affected communities listed in Australian Government reference numbers 1012 and 1025 to support environmental recovery.

In line with the needs of the program, the project focused on 3 key objectives:

1. Improve understanding of flood-impacted water quality.
2. Support local capacity to monitor water quality for flood events.
3. Facilitate environmental recovery through the provision of information to communities and stakeholders.

1.3 Delivering on the project objectives

Between September 2022 and February 2024, WWCS undertook water quality monitoring surveys across the North Coast, Mid Coast and Hawkesbury–Nepean regions (Figure 3) to better understand the physicochemical and biological condition of waterways in response to flood impacts.

The project outcomes are documented in this series of technical reports and can be visualised through a dashboard and NSW government open data portal SEED.

To meet project aims and objectives, a multifaceted project was delivered that:

- engaged with local stakeholders to better understand the waterways and ensure that the knowledge generated was shared with each waterway's managers
- consolidated data from existing water quality monitoring programs across the flood-impacted waterways to understand existing water quality data
- developed and delivered a water quality sampling program to fill water quality data gaps within the project extent for identified rivers, creeks and estuaries
- partnered with citizen science programs facilitating community involvement in monitoring waterway health
- developed a dashboard and technical reports containing water quality monitoring results that facilitate understanding of flood-impacted water quality for state and local governments, stakeholders and the community.

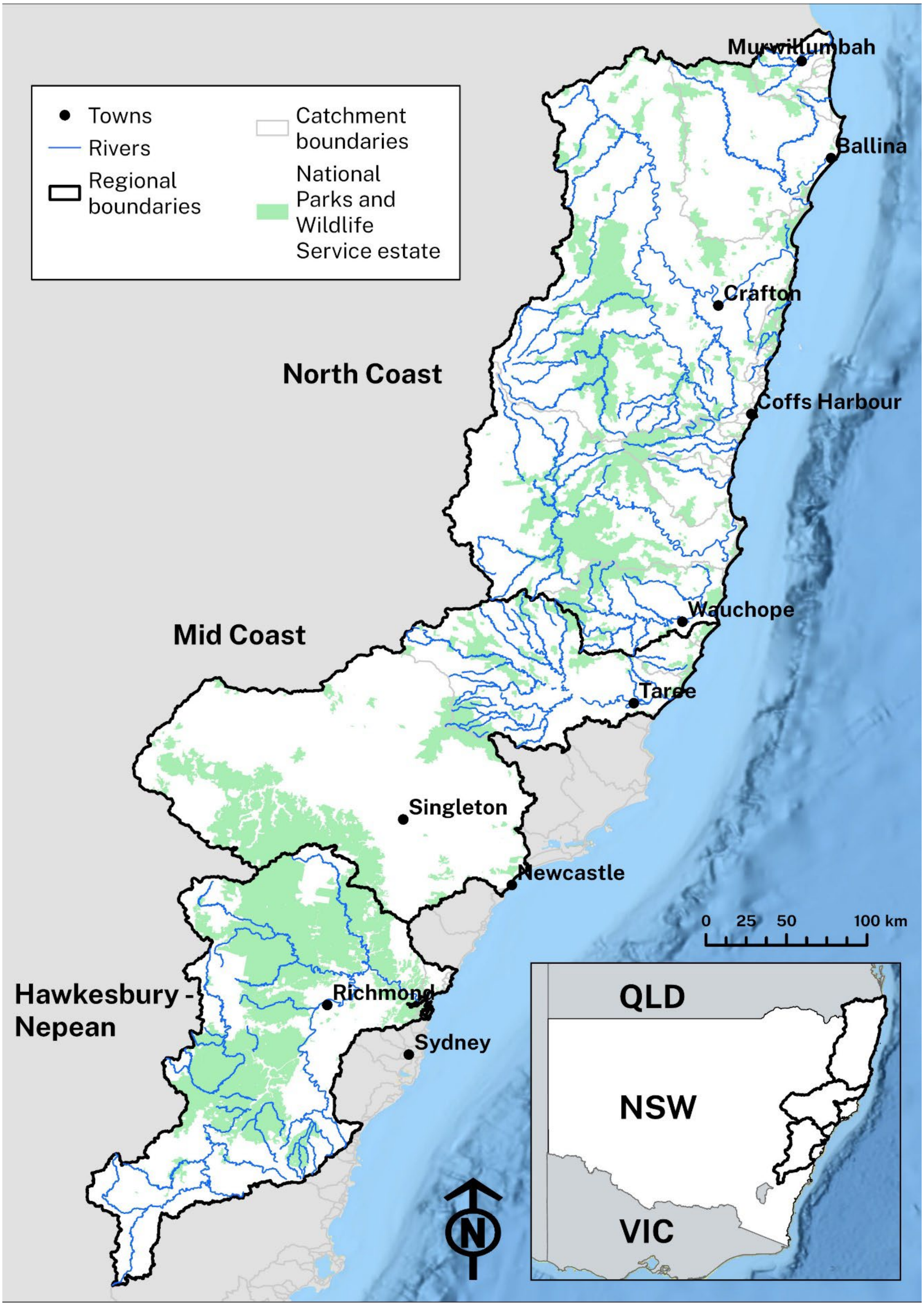


Figure 2 Project sampling regions covered by the water quality monitoring project

2. How the project was delivered

To investigate the effects of floods on water quality and the timescales over which waterways recover, the project collated historical water quality data to understand conditions prior to the 2022 floods and generated new water quality data from after the 2022 floods (Figure 5). Samples were also collected during flood events between September 2022 and January 2024 to provide additional data on water quality during floods.

The project conducted more than 190 trips to monitor water quality across 20 waterways in the North Coast, Mid Coast and Hawkesbury–Nepean regions. Approximately 11,000 samples were collected routinely and in response to significant wet weather events and flooding. Telemetered monitoring stations provided real-time data across 6 waterways to better understand fine-scale changes in water quality. The routine water quality program collected physicochemical (e.g. temperature, pH, salinity, dissolved oxygen and turbidity), total suspended solids (TSS), nutrients (nitrogen and phosphorous), chlorophyll-a and faecal indicator bacteria (FIB) data to better understand water quality in streams affected by floods. Data from historical monitoring programs were also sourced from various stakeholder groups to enable water quality comparisons pre- and post-floods, and to establish a good baseline for future comparisons (Table 1, Figure 3 and Figure 4).

Table 1 Timeline of project delivery

Time	Event
Sept 2022	Flood event sampling begins in the Northern Rivers
Oct 2022	Gaps in available water quality data identified
Dec 2022	First stakeholder workshops: waterway concerns
Jan 2023	Sampling sites investigated
Feb 2023	Routine monitoring by project team begins
Mar 2023	Sampling sites and methodology finalised
Apr 2023	Routine monitoring by consultants begins
Jun 2023	Citizen Science Partnerships Program begins
Aug 2023	Telemetered loggers deployed in 4 waterways
Sept 2023	Second stakeholder workshop: decision-oriented results
Dec 2023	Launch of web-based reporting platform on EPA website
May 2024	Results shared with stakeholders and communities
Jun 2024	Project wrap-up and final reporting

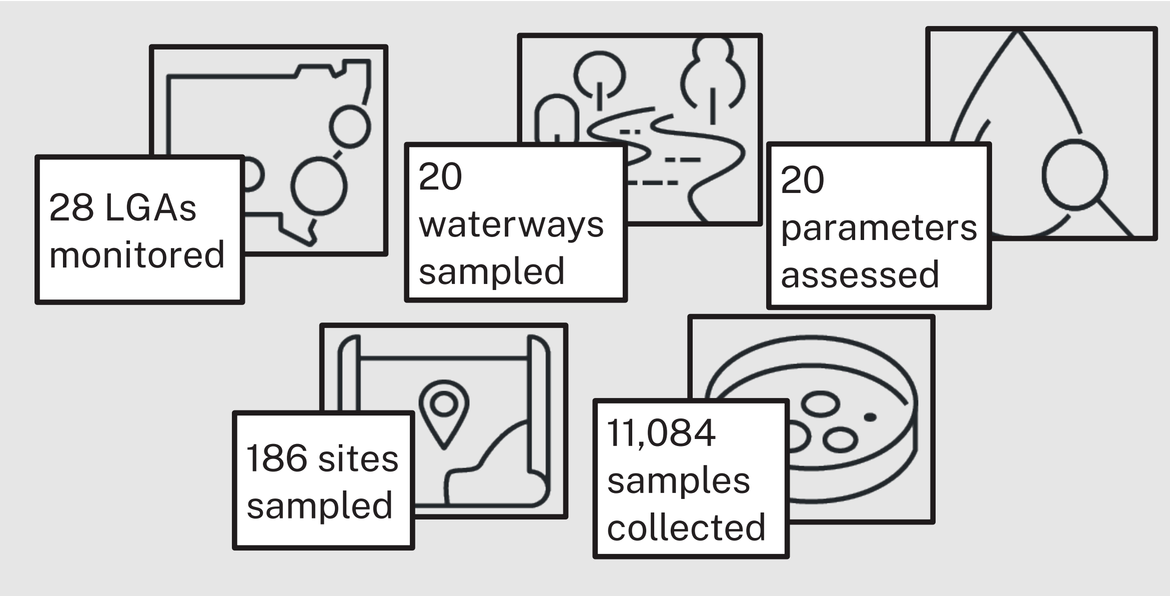


Figure 3 **Project monitoring effort overview**

Figure 4 **Project team members Sarah and Max interrogating data collected on the Richmond River**

Table 2 Key water quality parameters analysed through the monitoring program

Physicochemical	Temperature
	Conductivity
	pH
	Dissolved O_2
	Salinity
	Turbidity
Suspended solids	Total suspended solids
Nutrients	Nitrogen
	Phosphorus
	Silica
Algal biomass	Chlorophyll-a
Faecal indicator bacteria	*E. coli*
	Total coliforms

The types of data used to investigate the impacts of flooding were:

- **Water quality data:** Measurements of water quality parameters that are known to respond to flood events (Table 2).
- **Waterway flow condition:** Hydrological data required to contextualise water quality data in reference to floods e.g. water level and rainfall.
- **Catchment characterisation**: Spatial data for identifying and quantifying key land uses and catchment characteristics that influence water quality e.g. soil and vegetation type, agricultural activities, and sewage treatment facilities.
- **Pesticides:** Measurements of pesticide levels in the water and sediment. Sampled in the Tweed River following the January 2024 minor flood event. The Tweed River was chosen as a case study location for pesticides due to the high proportion of agricultural activities within the catchment, ease of site access, and the minor flood occurring in the catchment in January 2024.

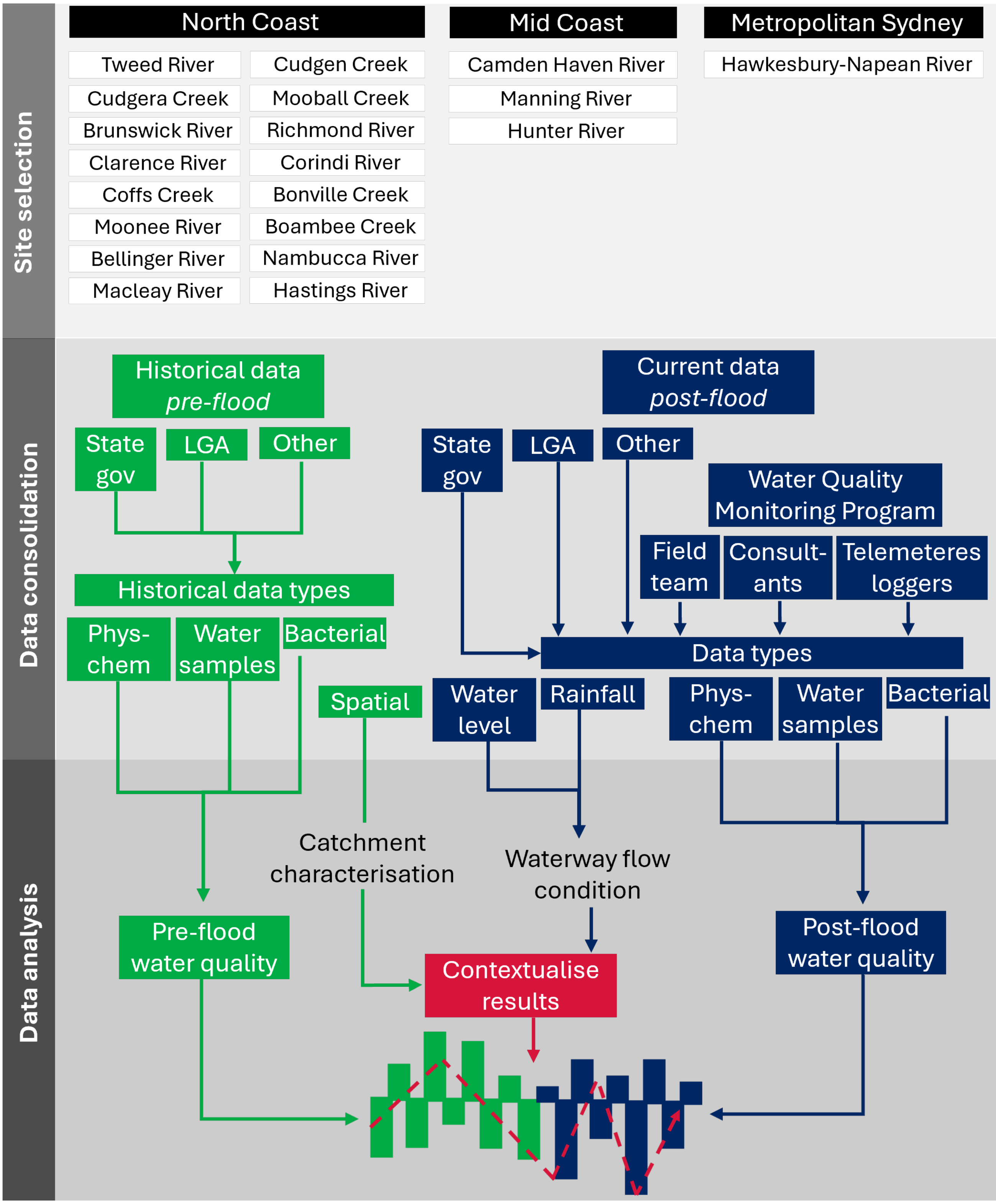


Figure 5 **Project sampling design and implementation. Phys-chem = physicochemical parameters (see Table 2)**

2.1 Sampling program

The project developed a sampling program to collect water quality data post the 2022 floods and following further flood events. This was achieved through:

- monthly and event-based sampling at each site (Figure 6A and 6B)
- water quality transects via flow-through surveys – continuous sampling across the waterway at one timepoint (Figure 6C)
- telemetered water quality monitoring stations (TWQMS) – continuous sampling across time at one site in a waterway (Figure 6D).

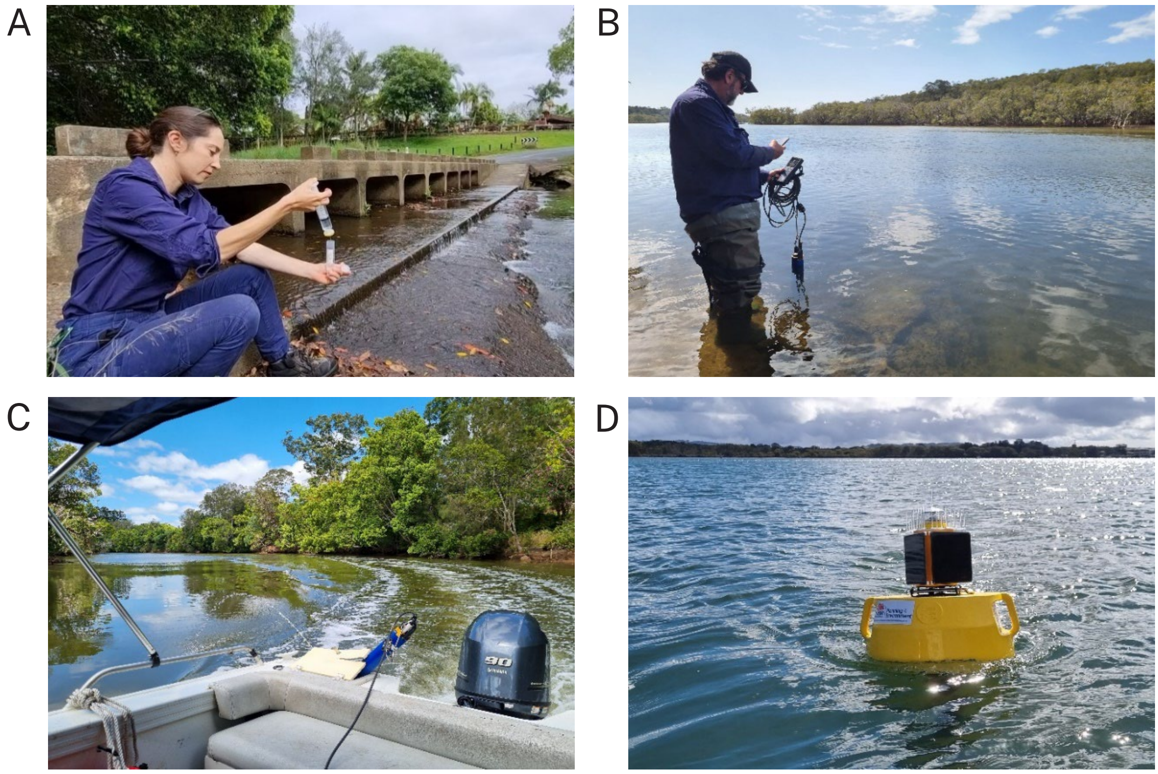


Figure 6 **Sampling methods. A. Manual grab samples collected monthly and during events. B. Manual probe samples collected monthly and during events. C. Flow-through samples collected periodically and during events. D. TWQMS probe samples collected continuously**

Analysing the data

Catchment characterisation: For every waterway, characteristics and land-uses across the catchment were mapped to understand which features are most likely to drive poor water quality, particularly post flood.

Statistical analysis: For 4 waterways, the Tweed, Clarence, Manning and Hawksbury–Nepean rivers, using various statistical models, data was analysed to look at how water quality is related to waterway flow condition.

Water quality grades: For every waterway, pre-flood, flood and post-flood water quality data was assessed against the ANZECC and NHMRC guideline values. The proportion of guideline value exceedances was calculated for key indicators individually to understand flood impacts on indicators of ecological and human health. If a guideline value for a water quality parameter is exceeded, this indicates that water quality is poor and may be having harmful impacts on the aquatic ecosystem, or be a threat to human or animal health. Water quality was graded from 'Very Good' to 'Very Poor' based on the proportion of samples that exceeded the guideline values (Table 3).

The water quality grades were presented using a series of colour wheels to enable the comparison of water quality for individual parameters before (pre-flood), during (flood) and after the 2022 flood events (post-flood) (Figure 6). Grades were only presented for waterways and parameters that met the minimum requirements of grading – being sufficient spatial and temporal replication for the size of the waterway, and the availability of individual grades for all key parameters.

More details of the collection and analysis of water quality and spatial data are provided in the separate Methodology report.

Table 3 **Water quality grades according to the proportion of guideline value exceedances (%) for flood-impacted waterways presented in this report**

Water quality grade	Guideline value exceedance (%)
NA	No data available
Very Good	0%
Good	≤ 25%
Fair	≤ 50%
Poor	≤ 75%
Very Poor	≤ 100%

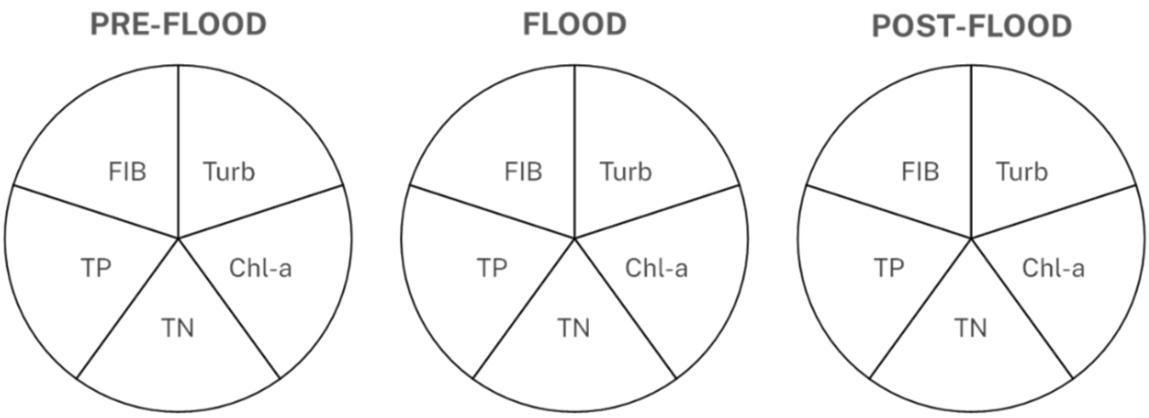


Figure 7 **Water quality grade key presenting guideline value exceedances (%) for turbidity (Turb), chlorophyll-a (Chl-a), total nitrogen (TN), total phosphorous (TP) and the faecal indicator bacteria (FIB) – enterococci before (pre-flood), during flood and post flood**

2.2 Engaging with stakeholders and community

Extensive engagement was undertaken with both internal and external stakeholders to drive project development and delivery. Stakeholders were invited to contribute to the development of the project through involvement in our advisory groups.

Stakeholder groups identified for the project:

- Internal
  - Management
  - Media teams
  - State government groups
- External:
  - Recreational water users
  - Research organisations
  - State-owned corporations
  - Local government
  - Business community
  - Environmental groups
  - Landholders

The project used a variety of communication channels and tools to keep stakeholders and the community updated on project progress, including a quarterly eNewsletter, regular website updates, social media posts, a project video and live presentations.

The project developed 9 communication and engagement objectives to guide our engagement approach, based on 4 of the EPA's 6 engagement principles (EPA 2022): Inform, Educate, Consult and Empower.

Additional information can be found in the Stakeholder engagement report.

Advisory groups

Stakeholder representatives were engaged to provide ongoing advice to the project team through 3 levels of advisory groups (Table 4).

Table 4 Membership and roles of the 3 advisory groups

Advisory group	Membership	Role
Expert advisory panel	Leading researchers in relevant scientific fields	Provide advice on technical aspects of the project
Inter-agency advisory group	Government agency representatives	Promote cross-agency collaboration
Regional stakeholder advisory groups	Local government, industry and community representatives	Provide advice about stakeholder and community information needs

Image 1 Project scientist, Elysha Kennedy, presents water quality results from the first year of the project to the North Coast Stakeholder Advisory Group in Ballina in September 2023

The 3 advisory groups provided advice and feedback over the course of the project, which guided the development of multiple project components including the sampling program, the data analysis approach, the dashboard and the dissemination of results (Image 1).

Citizen Science Partnerships Program

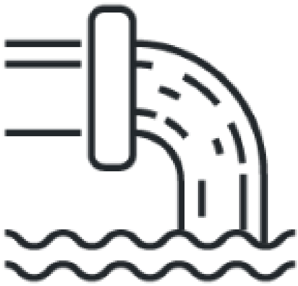
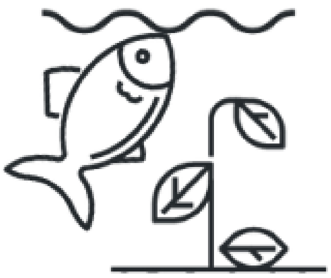
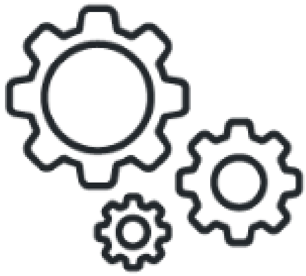
Through our Citizen Science Partnerships Program, we partnered with 4 organisations: Positive Change for Marine Life, the Richmond Riverkeepers Association, OzFish and OzGREEN, to deliver citizen science projects in the Brunswick, Richmond, Clarence and Bellinger rivers (Figure 8). Over 300 community members were involved in monitoring water quality and assessing river health. Projects included monitoring turbidity levels during rainfall, conducting biannual assessments of site condition and water quality, and running surveys of mangrove habitat. Each project produced a community-facing report to build understanding within the community of the issues affecting rivers and the condition of their local waterway.

Figure 8 **The Citizen Science Partnerships Program. A. An OzFish volunteer tests water clarity in the Clarence using a turbidity tube (OzFish). B. Richmond Riverkeeper volunteers sort macroinvertebrates at a site on the Richmond River (Richmond Riverkeepers Association). C. Positive Change for Marine Life volunteers conduct a shoreline video assessment of mangrove habitat on the Brunswick River (Positive Change for Marine Life). D. OzGREEN volunteers sort and identify macroinvertebrates during the Bellingen Riverwatch Macro Muster 5 (DCCEEW)**

3. How can floods impact water quality?

The severity and duration of the impacts shown in Table 5, are likely to depend on the characteristics of each catchment. Natural characteristics such as soil and vegetation types, as well as human land modifications and pollution inputs, can influence how flood water travels over the land and the substances that enter the waterways. To understand the impacts of floods on a given system, it is important to interpret water quality results in the context of these characteristics. Figure 9 shows the results of catchment characteristic mapping for each of the 20 waterways.

Table 5 Flood impacts on water quality

Flood event + first days post-flood	Days to weeks post-flood	Months to years post-flood
Acute impacts	Short-term chronic impacts	Long-term chronic impacts
		
Overland runoff causes the diffuse mobilisation of pollutants, such as sediments, nutrients, and pathogens, due to processes such as infield erosion. Increased stream flow and water levels cause bank erosion/failure and mobilise bed sediments. Inundation of industrial and commercial infrastructure can result in point source pollution, while surcharging of stormwater and sewerage networks causes raw sewage overflows	Shallow groundwater inflows increase leading to acid runoff from acid sulphate soils and nutrient inputs from floodplains, internal recycling of flood sediments leading to algal blooms and hypoxia. Also known as blackwater events.	Sediment distributions change due to scouring and deposition leading to changes to ecological and biogeochemical functions. Erosion and streambank damage caused by floods change the rate of pollutant generation during all subsequent runoff events in affected catchments.

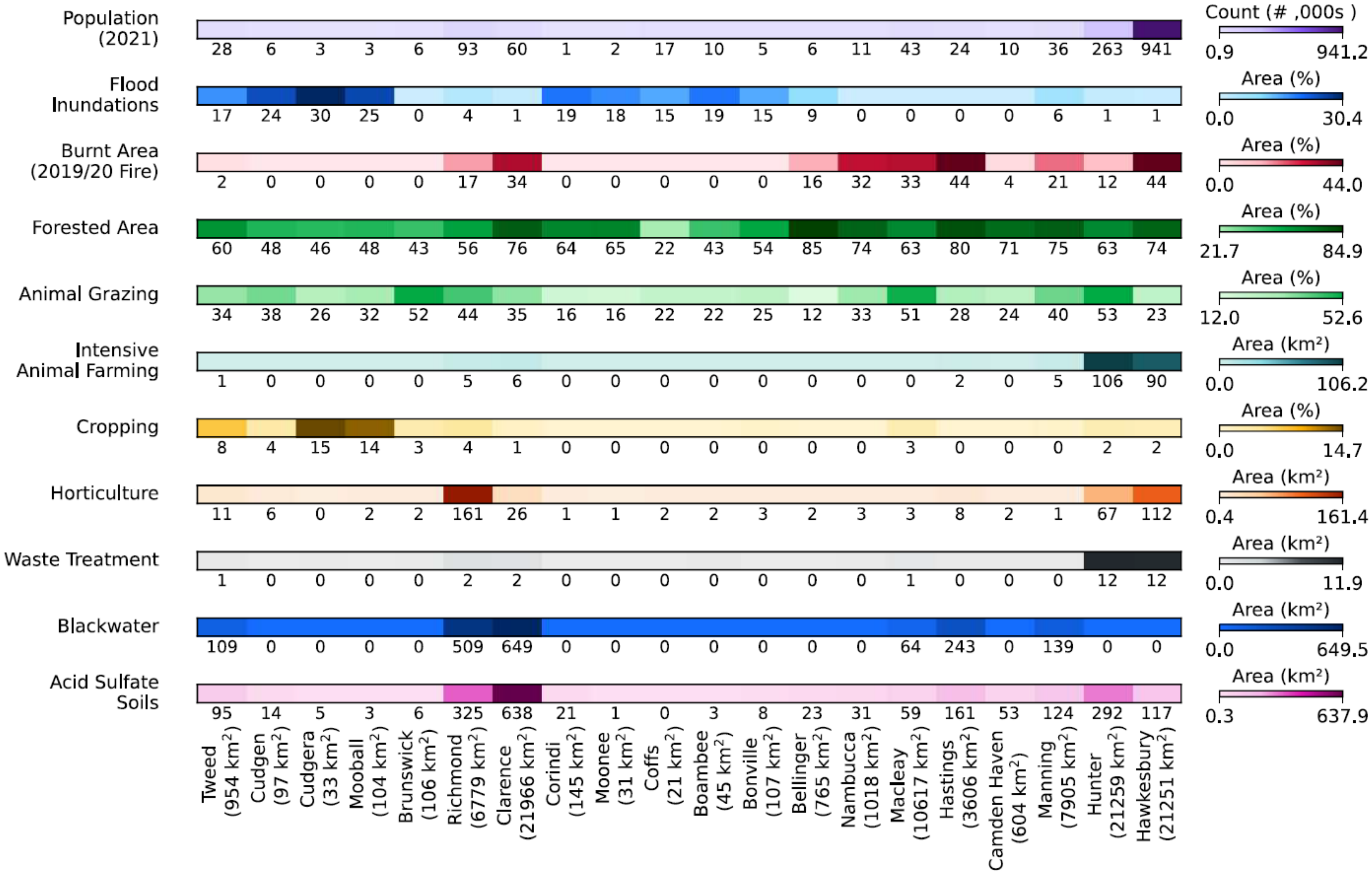


Figure 9 **Summary of the general catchment characteristics across waterways in the project that were inundated during the 2022 disaster-declared flood events**

4. Key findings: understanding flood impacts and recovery in our waterways

4.1 Flood impacts

The impacts of the 2022 floods on water quality varied across waterways. Catchment characteristics and land use pressures were drivers of both impact and recovery. Flooding events were not the primary driver for water quality issues in coastal waterways.

The higher-than-average rainfall and water levels triggering back-to-back flood events in 2022 resulted in declines in water quality in major waterways such as the Tweed, Richmond and Clarence rivers. The heavy rainfall and high-water levels had the opposite effect in small creeks, such as Tweed Coastal Creek, where flood water led to the flushing of sediments and nutrients from these waterways.

The short-term impacts of floods were more pronounced in catchments with less modification, due to greater impacts on water quality grades. These waterways were anticipated to have greater resilience to flooding, due to less disturbance within the catchment. Conversely, flood impacts on water quality grades were less apparent in waterways with chronically poor water quality, likely due to land use pressures having a greater effect on water quality than floods.

Generally, turbidity and nutrients increased immediately during flooding, signifying the first flush of catchment inputs during rainfall and inundation, as well as turbulence and resuspension. Salinity and chlorophyll-a, and to a lesser extent pH, decreased immediately during floods due to freshwater dilution. During the falling stages of the flood hydrograph, fDOM generally increased, while dissolved oxygen decreased, representing the influence of freshwater inputs and catchment runoff on water quality in the short-term (days to weeks) post-floods.

4.2 Flood recovery

Following recession of flood waters to baseline water level, the first parameters to recover were turbidity and nutrients, and salinity for estuaries.

For estuarine sites, recovery is initiated by tidal flushing, which drives the return of the tidal signature and semi-diurnal tides, leading to recovery of salinity levels and the reestablishment of estuarine zones. In the short-term post-flood (days to weeks), flushing by marine waters leads to improved water clarity and increased sunlight penetration.

In the longer-term post-flood (weeks to months), chlorophyll-a levels increase due to increased photosynthetic activity, resulting in increased turbidity levels. Recovery from the 2022 floods varied across waterways, depending on their catchment characteristics, land uses and pre-flood condition.

Analysis of floods in most waterways was limited by a lack of pre-flood data, for example, Brunswick River, Richmond River, Clarence River, Corindi River, Moonee Creek, Coffs Creek, Boambee Creek, Bonville Creek, Bellinger River, Nambucca River, Macleay River, Hastings River and Camden Haven River. The project successfully generated a new post-flood water quality baseline to underpin future analyses of flood impacts on water quality for these waterways. The only waterways with sufficient data for pre-, during and post-flood grading were the Tweed waterways, due to the long-standing monitoring program.

For waterways with sufficient data, some waterways improved in their overall grade during the floods and returned to pre-flood baselines (recovered), while others did not appear to be impacted due to consistent water quality grades. Additionally, declines in water quality grades were not observed for these waterways during or post-flood, indicating that the impacts of the 2022 floods were not long-lasting.

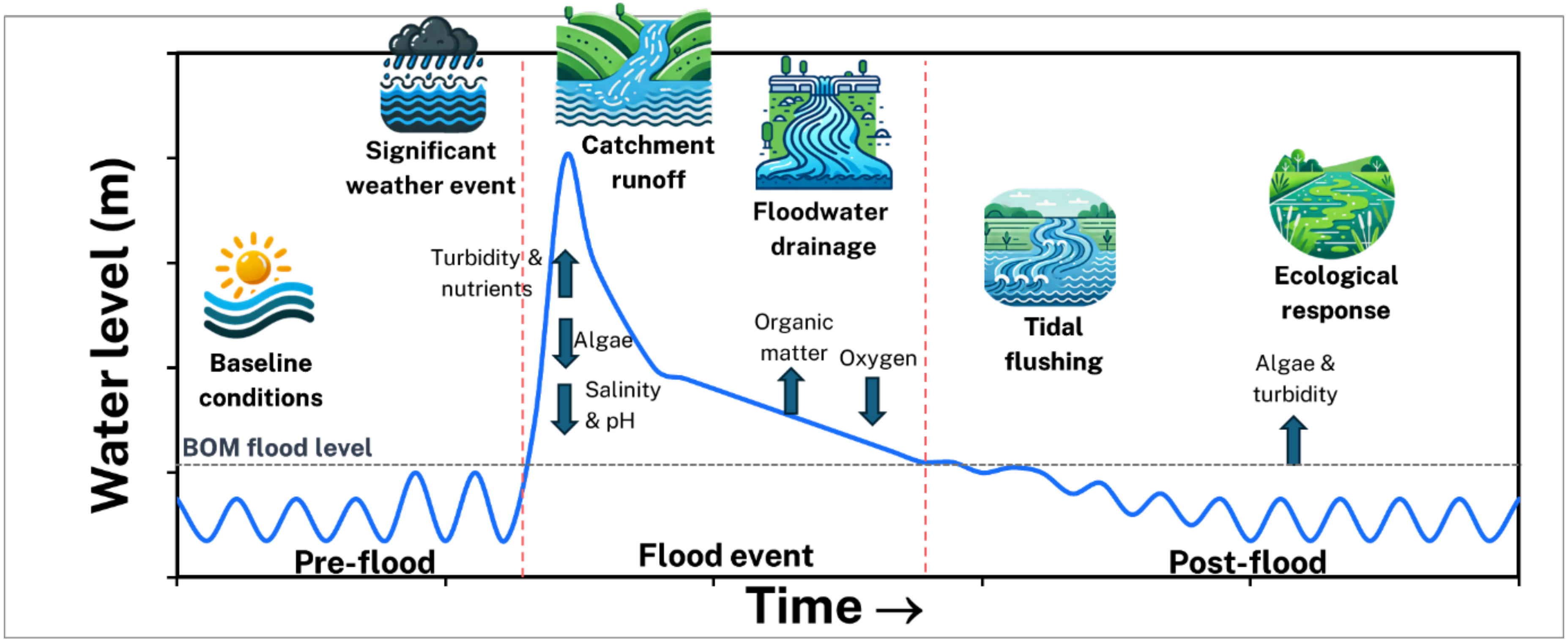


Figure 10 A conceptual diagram displaying the succession of impacts and recovery for water quality parameters during the floods on the NSW east coast is based on the data and observations made through the project

4.3 Spatial trends

Overall, water quality was poorer at estuarine versus catchment sites, attributed to greater land use pressures and increased populations closer to the coast, compared with increased vegetation cover in the upper catchments.

Floods appear to have a greater impact on water quality within catchments, whereas catchment characteristics and land use pressures appear to have more influence on water quality in estuarine receiving waters.

Land uses and catchment characteristics influencing water quality include:

- improved water quality – greater vegetation cover in catchments and macrophyte communities in estuaries, fewer and less intensive land use pressures, estuarine influence (tidal flushing)
- poorer water quality – agricultural activities, animal grazing, high population, urbanisation, high risk of erosion/mass movement/ASS/BW, highly modified catchments, multiple intensive land use pressures.

4.4 North Coast

What were the impacts of the 2022 floods on water quality? Did water quality improve/decline or remain constant following the floods, and how is the waterway recovering?

The Tweed River and Tweed coastal creeks' overall ratings were 'Fair' for pre, during and flood time periods, with the exception of Cudgera and Mooball creeks, which both had overall ratings of 'Good' during the flood period. This same trend occurred in some parameters in the Tweed River and Cudgen Creek, suggesting land-use pressures across the catchments mask the effects of flooding, while the apparent improvement in water quality during the flood period could be attributed to dilution.

The rest of the waterways had limited pre and during-flood data; therefore, flood impacts and waterway recovery could not be directly assessed. Clarence, Corindi, Moonee Creek, Bellinger and Hastings rivers were graded as 'Good' post floods while Coffs Creek, Boambee Creek, Bonville Creek, Nambucca River and Macleay River were graded 'Fair'.

The lack of enterococci data in the Richmond and Brunswick rivers prevented overall grading.

What are the predominant land use pressures in the catchment, and how intensive are they?

The Tweed and Richmond rivers predominant land use in the upper catchment is animal grazing while in the Clarence, forestry manages a large portion. All 3 waterways have extensive flood plains used for cropping (primarily sugarcane) which poses a blackwater and ASS risk. The Richmond catchment also has considerable horticulture land uses in the mid-catchment.

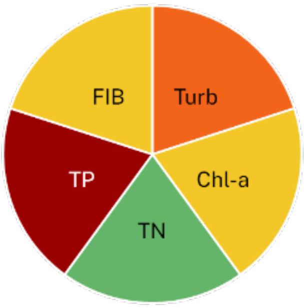
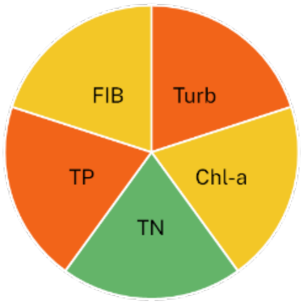
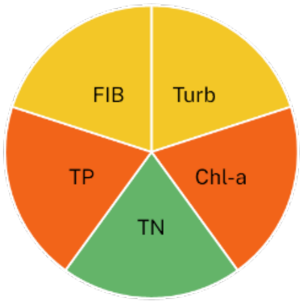
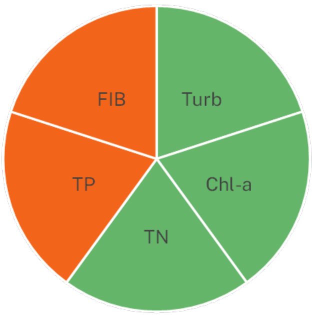
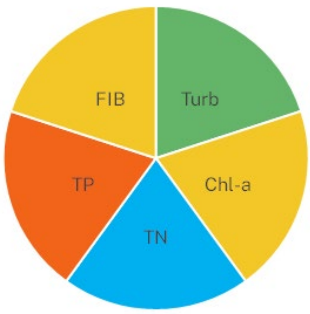
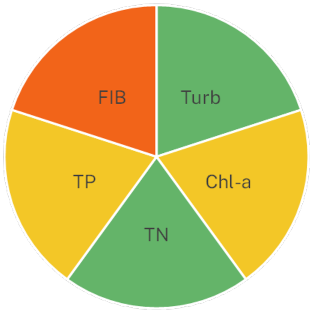
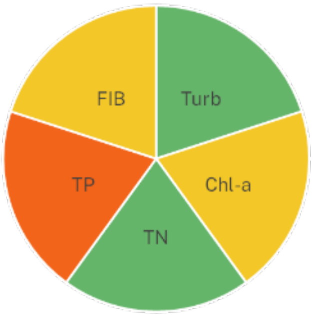
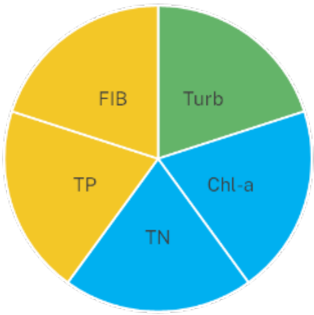
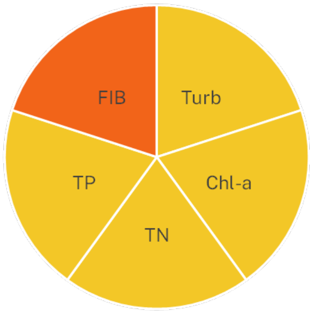
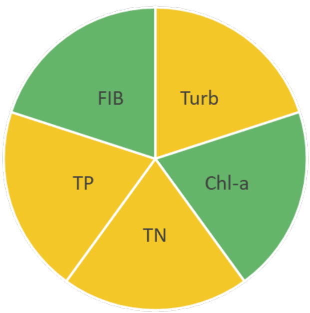
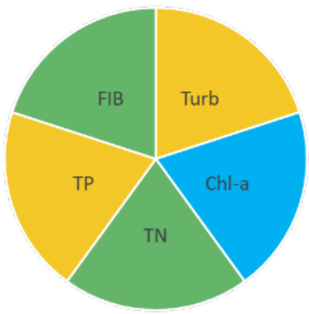
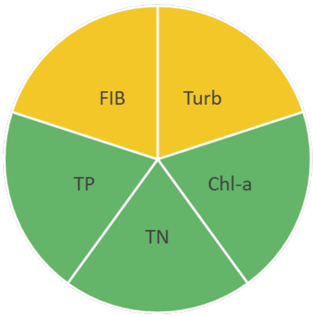
The Tweed coastal creeks and the Brunswick River have relatively low populations, concentrated around the lower catchment and estuary. Animal grazing in the upper catchment is seen across all of these systems as is cropping and ASS risk in the lower catchment/estuary.

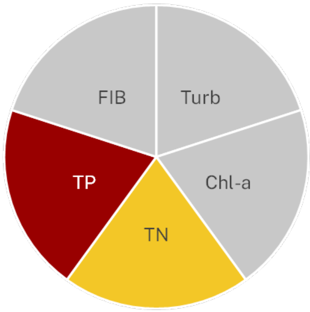
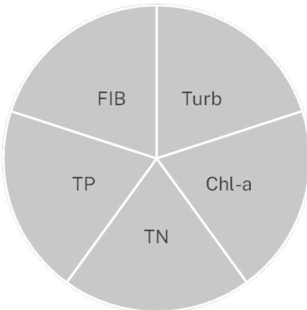
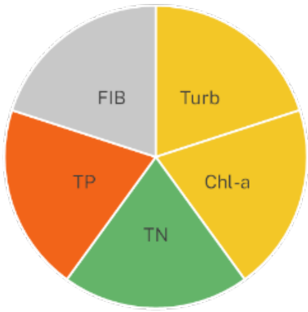
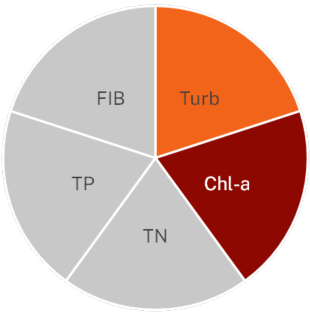
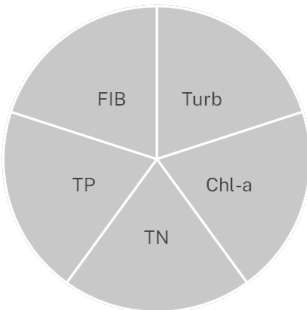
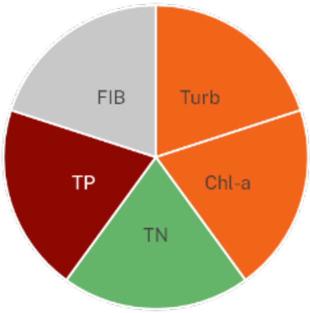
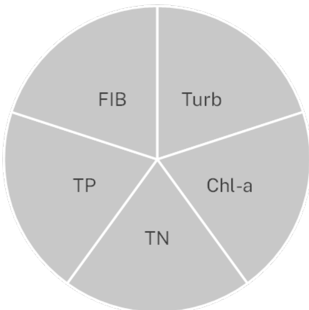
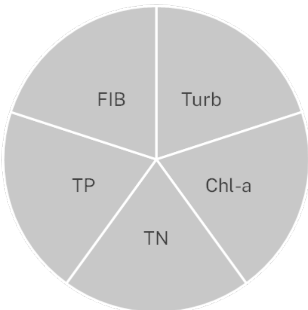
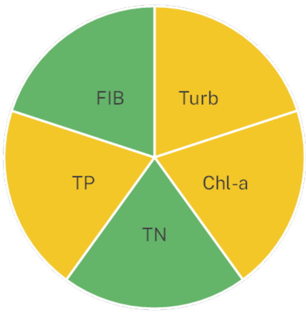
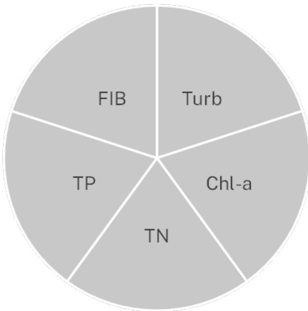
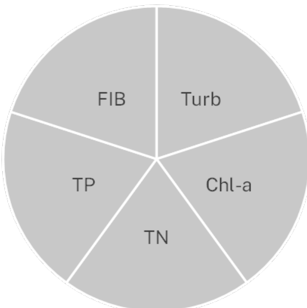
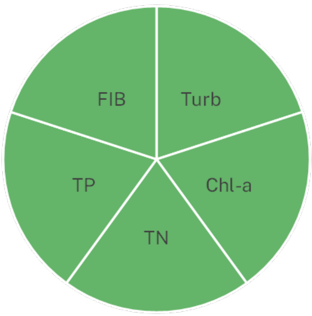
Catchments from Corindi River in the north to Hastings River in the south are characterised by large, forested areas in the upper catchments, animal grazing in the mid to lower catchments, and relatively low populations. Coffs Creek is an exception to this, with high population density in the mid and low catchments.

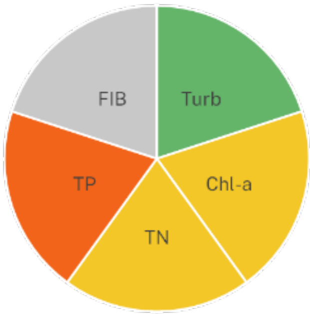
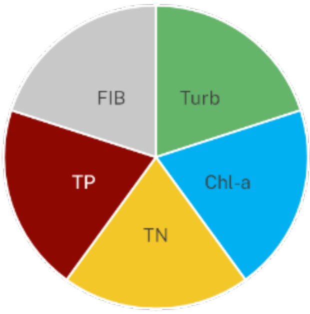
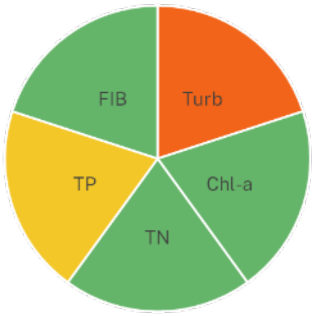
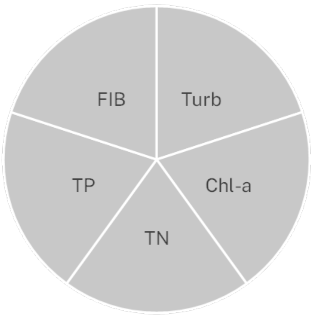
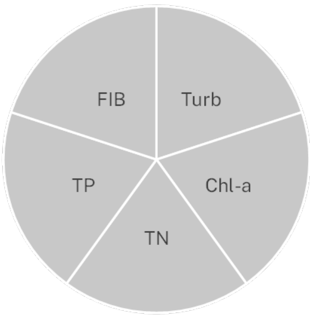
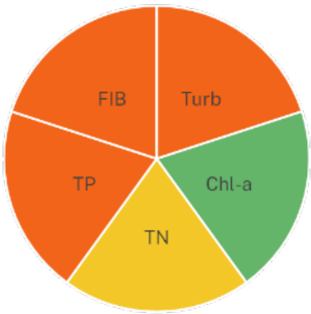
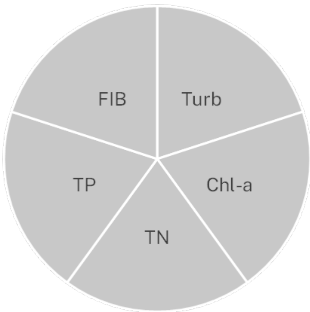
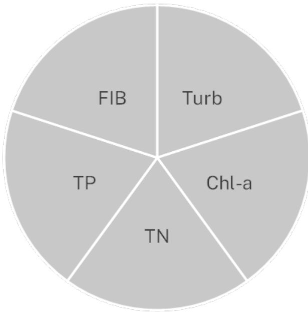
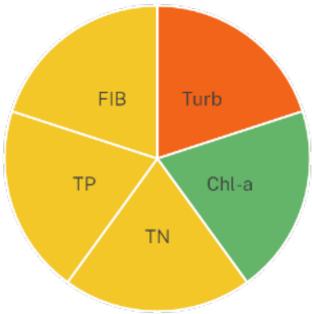
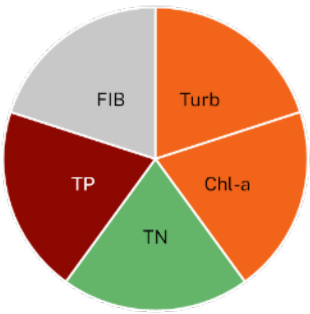
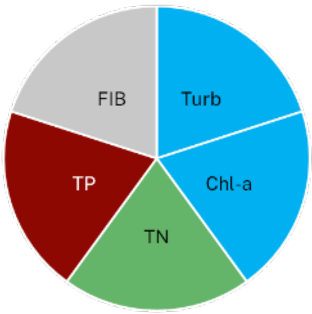
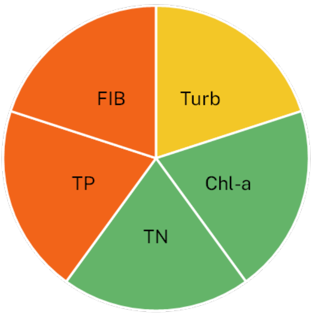
Were particular areas of the waterway associated with poorer water quality, and if so, where? For example, catchment/floodplain/estuary?

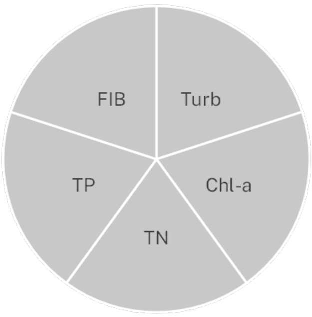
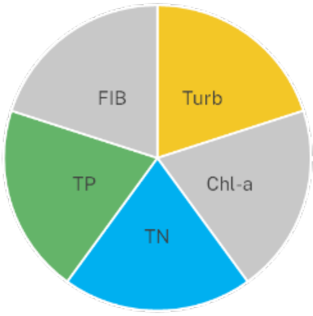
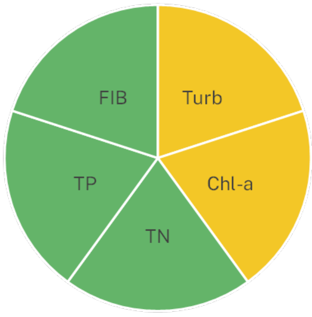
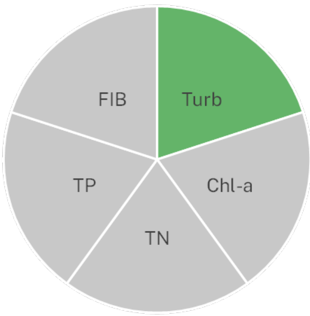
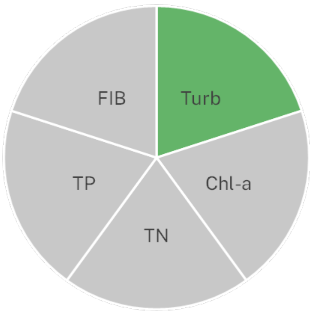
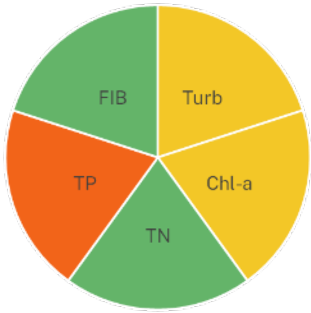
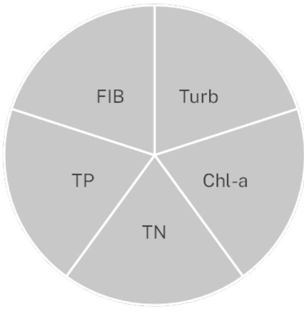
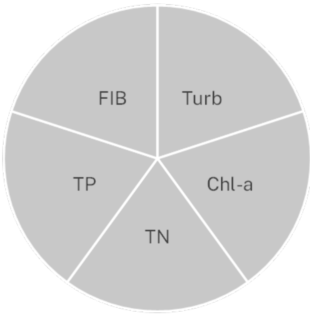
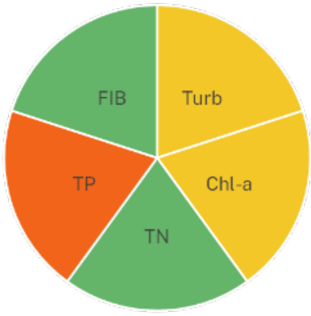
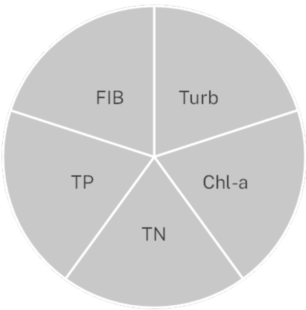
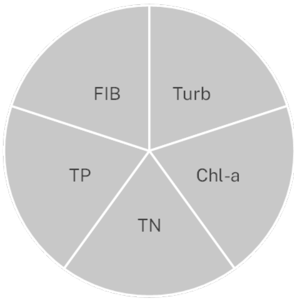
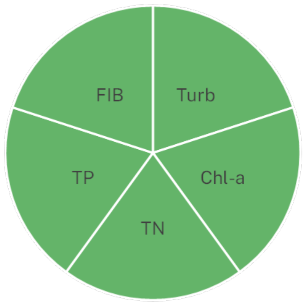
Greater number of exceedances in estuarine versus catchment sites. This can be attributed to greater land use pressures and increased populations closer to the coast, compared with increased vegetation cover in the upper catchments.

Table 6 **Summary of water quality grades for key indicators of water quality across flood-impacted north coast waterways in the project before (pre-flood), during (flood) and after (post-flood) the 2022 disaster declared flood events. Turb = turbidity, Chl-a = chlorophyll-a, TN = total nitrogen, TP = total phosphorous and FIB = enterococci. Colours indicate: Very good (≤0.00, 0%), Good (0-25%, 0-25%), Fair (≤0.5, 25-50%), Poor (≤0.75, 50-75%), Very Poor (≤1, 75+%)**

<table>
<tr><th>Waterway</th><th>Pre-flood</th><th>Flood</th><th>Post-flood</th></tr>
<tr><td>Tweed River</td><td></td><td></td><td></td></tr>
<tr><td>Cudgen Creek</td><td></td><td></td><td></td></tr>
<tr><td>Cudgera Creek</td><td></td><td></td><td></td></tr>
<tr><td>Mooball Creek</td><td></td><td></td><td></td></tr>
</table>

Waterway	Pre-flood	Flood	Post-flood
Brunswick River			
Richmond River			
Clarence River			
Corindi River			

Waterway	Pre-flood	Flood	Post-flood
Moonee Creek			
Coffs Creek			
Boambee Creek			
Bonville Creek			

Waterway	Pre-flood	Flood	Post-flood
Bellinger River			
Nambucca River			
Macleay River			
Hastings River			

4.5 Mid Coast

The Camden Haven and Manning rivers were rated 'Good' post floods. However waterway recovery could not be directly assessed due to the limited availability of water quality data prior to the project commencement. The Hunter River suffered chronic poor water quality and was rated 'Poor' post floods.

What were the impacts of the 2022 floods on water quality? Did water quality improve/decline or remain constant following the floods, and how is the waterway recovering?

Camden Haven River: Water quality was graded 'Good' in the Camden Haven River following the 2022 floods. Flood impacts and waterway recovery could not be directly assessed due to the limited availability of water quality data prior to the project commencement. Ongoing monitoring is recommended to enable future assessments of flood impacts on water quality in the Camden Haven River. This project created a post-flood water quality baseline to improve understanding of the waterway condition following the 2022 floods. Water quality was graded 'Good' post-floods, which was likely attributed to the high vegetation cover, low population and relatively low land use pressures within the Camden Haven River catchment.

Manning River: Water quality was graded 'Good' in the Manning River following the 2022 floods. Turbidity levels were poorest during the floods but improved in 2023. Total nitrogen levels improved during the floods and remained low during 2023. Total phosphorous was consistently elevated across the waterway irrespective of the 2022 floods. Floodplain drainage influenced water quality in the estuary, with high levels of turbidity and chlorophyll-a associated with floodplain tributaries. Further declines in water quality are expected during future flood events. All parameters improve except for Chl-a and TN which stays the same.

Hunter River: Available parameters were 'Poor' pre- and post-floods. No improvement was seen in any parameters in the Hunter River across pre-, during and post-flood periods.

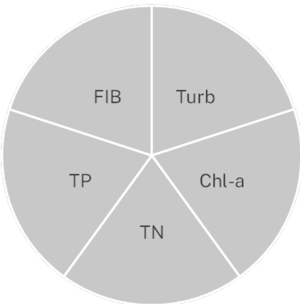
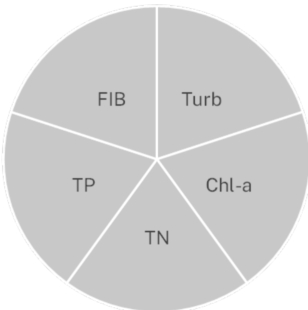
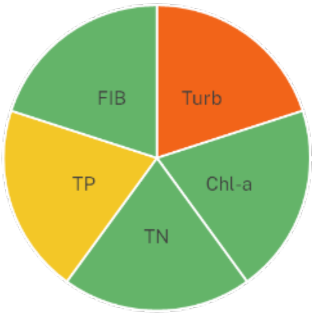
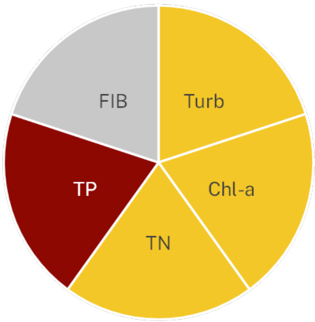
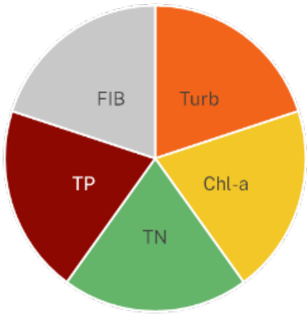
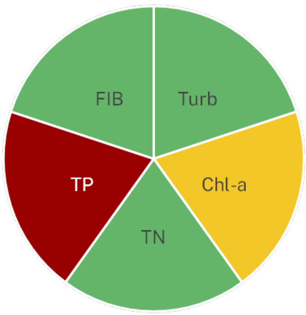
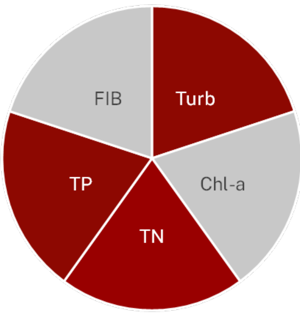
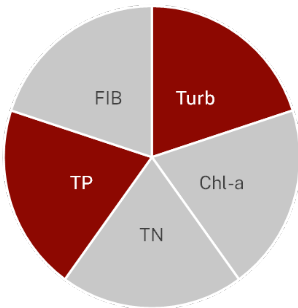
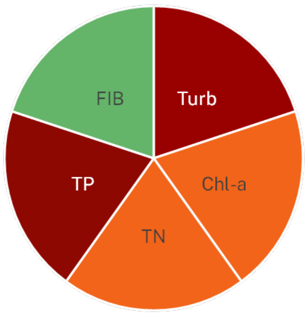
What are the predominant land use pressures in the catchment, and how intensive are they?

The 'Good' water quality in the Camden Haven and Manning rivers can potentially be attributed to a relatively high level of vegetation and low to moderate level of land use pressures. In contrast, the consistently 'Poor' water quality in the Hunter River is likely due to multiple intensive land use pressures, including mining and agriculture in the catchment.

Were particular areas of the waterway associated with poorer water quality, and if so, which? For example, catchment/floodplain/estuary?

There were a greater number of exceedances in estuarine versus catchment sites. This can be attributed to greater land use pressures and increased populations closer to the coast, compared to increased vegetation cover in the upper catchments.

Table 7 **Summary of water quality grades for key indicators of water quality across flood-impacted mid-coast waterways in the project before (pre-flood), during (flood) and after (post-flood) the 2022 disaster declared flood events. Turb = turbidity, Chl-a = chlorophyll-a, TN = total nitrogen, TP = total phosphorous and FIB = enterococci. Colours indicate: Very good (≤0.00, 0%), Good (0-25%, 0-25%), Fair (≤0.5, 25-50%), Poor (≤0.75, 50-75%), Very Poor (≤1, 75+%)**

Waterway	Pre-flood	Flood	Post-flood
Camden Haven River			
Manning River			
Hunter River			

4.6 Hawkesbury

What were the impacts of the 2022 floods on water quality? Did water quality improve/decline or remain constant following the floods, and how is the waterway recovering?

The impact of the 2022 floods on water quality and waterway recovery in the Hawkesbury–Nepean River varied depending on location in the catchment, land use activities, flow condition and time of year.

Turbidity and total phosphorous levels increased under high flows/floods and improved post-flood due to dilution and flushing by flood waters. In contrast, total nitrogen levels increased post-floods, particularly downstream of wastewater treatment plants during low flow conditions, emphasising the influence of wastewater effluents on water quality in the Hawkesbury–Nepean River.

Ongoing impacts on turbidity and nutrient concentrations are likely to be observed in the Hawkesbury–Nepean River due to stormwater and wastewater inputs, and the long-lasting effects of erosion and sediment deposition during the 2022 floods.

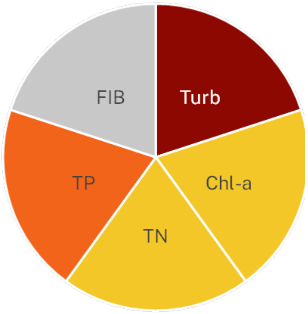
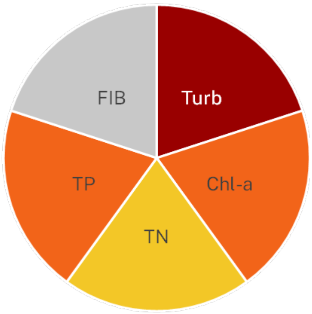
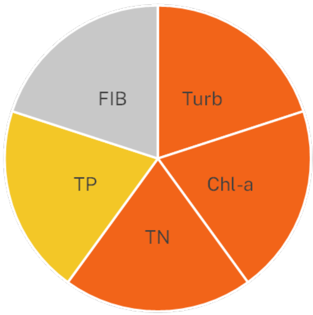
What are the predominant land use pressures in the catchment, and how intensive are they?

The catchment is predominantly forested and was largely burnt during the 2019–20 bushfires. Animal grazing and cropping occurs in the upper catchments, which coincides with poor river condition, poor water quality, and gully erosion. Intensive animal farming and horticulture mostly occurs in the lower catchment and the estuarine system has risks associated with acid sulphate soils. The catchment has a relatively high population.

Were particular areas of the waterway associated with poorer water quality, and if so, which? For example, catchment/floodplain/estuary?

There were more nutrient exceedances in the upper catchment, and turbidity exceedances in the estuary. The Macdonald River was identified as a source of poor water quality in the lower catchment.

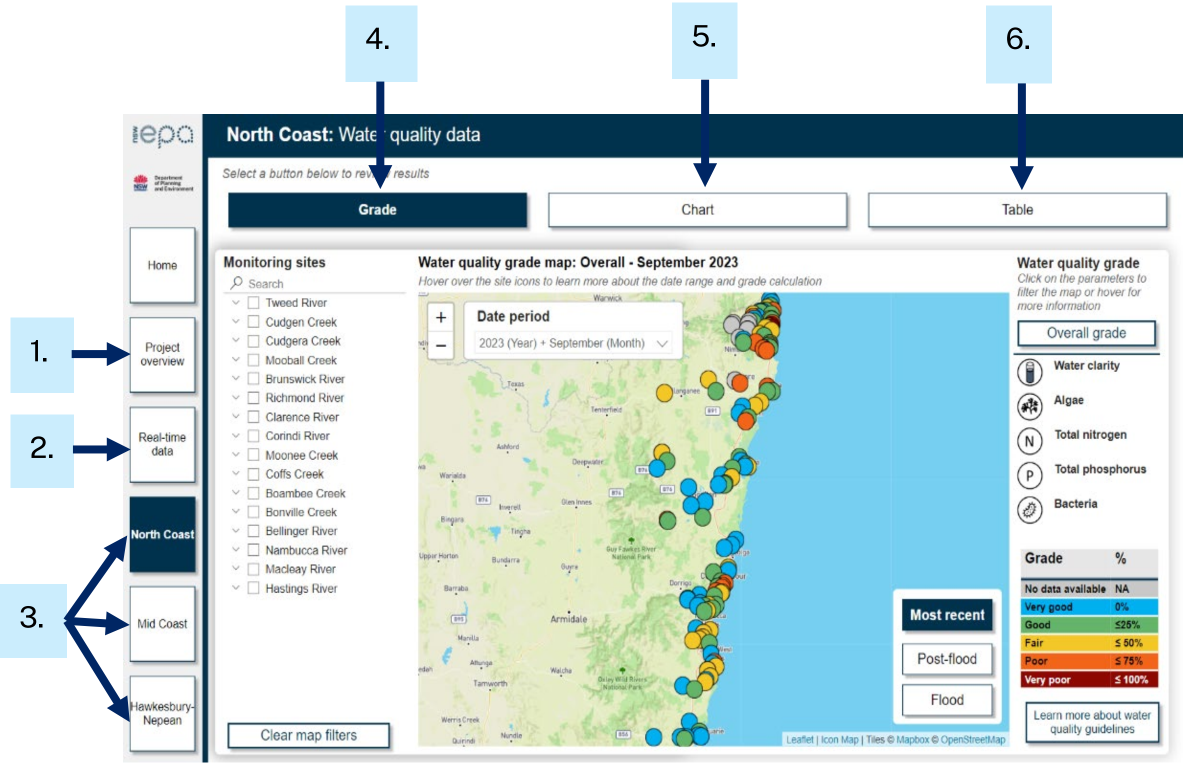
Table 8 **Summary of water quality grades for key indicators of water quality across flood-impacted waterways in the Hawkesbury-Nepean River (pre-flood), during (flood) and after (post-flood) the 2022 disaster declared flood events. Turb = turbidity, Chl-a = chlorophyll-a, TN = total nitrogen, TP = total phosphorous and FIB = enterococci. Colours indicate: Very good (≤0.00, 0%), Good (0-25%, 0-25%), Fair (≤0.5, 25-50%), Poor (≤0.75, 50-75%), Very Poor (≤1, 75+%)**

Waterway	Pre-flood	Flood	Post-flood
Hawkes-bury–Nepean River			

5. Project flood recovery tools

5.1 Project data dashboard

In December 2023 the project launched a data dashboard and supporting webpage to make project data and results available to the community (Figure 11). The main aim of the dashboard was to provide a community resource that would improve understanding of how water quality has trended since the 2022 major flood events.



1. Sampling metrics and a map of all sampling sites.
2. Map of telemetered loggers with links to live data.
3. Data for waterways in each of the 3 regions presented as grades, charts or tables.
4. Water quality grades for each site based on guideline value exceedances.
5. Charts showing change over time for a chosen water quality parameter and site.
6. Tables of raw data for chosen parameters with guideline value exceedances highlighted.

Figure 11 The project dashboard showing the Grade page for the North Coast waterways. Numbers refer to the tab content descriptions listed below the screenshot

5.2 Framework for identifying contaminants in flood waters

The project developed a framework for identifying contaminants of concern (CoC) that may be dispersed in flood waters during and after flood events (Figure 12). The framework is designed to be applied during the emergency management cycle planning and prevention stages, to assist in managing the impacts of CoCs when a flood occurs (DoJ 2018). The framework is intended for use across any waterways within NSW and provides steps and technical advice on how to identify CoCs during different stages of flooding, depending on land uses within each waterway's catchment. For more information, see the separately published *Conceptual framework for flood event water quality contaminant assessment* report.

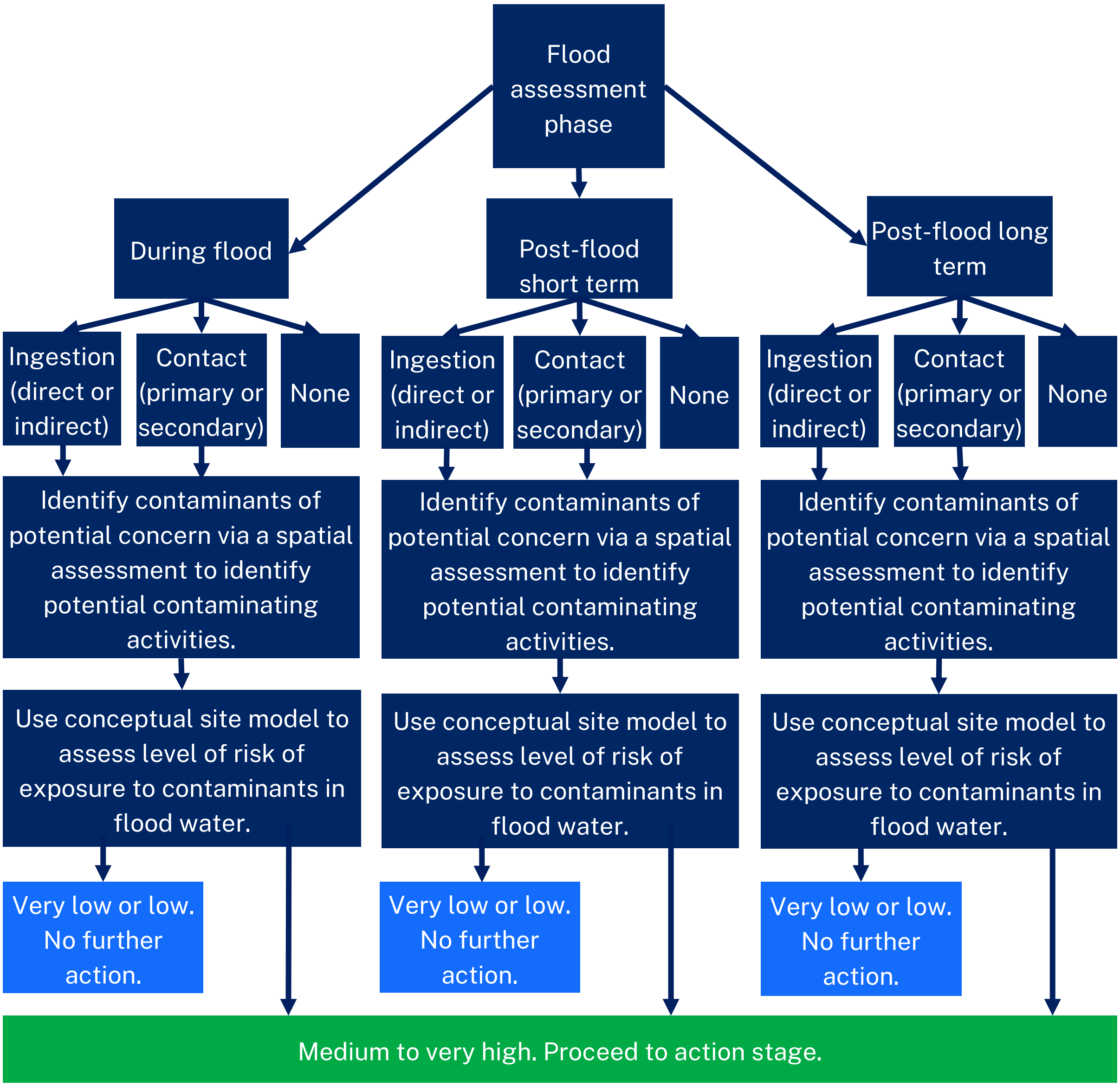


Figure 12 **Implementation phase flowchart for the contaminant assessment framework**

6. Project recommendations

Water quality monitoring across NSW waterways, particularly long-term monitoring programs, is highly valuable in helping to understand long-term trends, impacts and recovery. To better understand future trends, it is important to continue these long-term water quality monitoring programs, particularly those programs that incorporate real-time data.

In addition to water quality monitoring, future studies should be underpinned by comprehensive spatial analysis to identify gaps in sampling effort and the needs of individual waterways, stakeholders and communities. Future monitoring programs should also seek to understand system resilience, including:

- monitoring to understand how management actions build resilience
- monitoring and research to understand how land use contributes to waterways impacts over the short term and long term, and during natural hazard events (e.g. bushfires, floods).

	**Long-term water quality monitoring is critical to understanding waterway health and responses to events, such as floods.**
	**Whole-of-system monitoring is important. What happens upstream impacts downstream. Links between land use and water quality are well understood, but more local data is needed to understand local trends.**
	**Spatial analysis and water-quality monitoring results should be utilised to target restoration and management of degraded sub-catchments.**

References

DoJ (NSW Department of Justice) (2018) New South Wales State Emergency Management Plan (PDF 877KB), NSW Government.

EPA (NSW Environment Protection Authority) (2022) Engagement Framework, EPA website.

GHD (2024) *Conceptual framework for flood event water quality contaminant assessment: NSW flood recovery program for water quality monitoring – East Coast Project*, report prepared for the Department of Climate Change, Energy, the Environment and Water.

NSW Government open data portal (SEED)