11. Case studies

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Introduction

Overview of this chapter

Chapter 11 provides case studies of recent waterway monitoring projects conducted in Queensland, most of which are community-based projects. The examples demonstrate the three main types of monitoring projects:

- ambient (routine) monitoring
- load-based monitoring
- restoration assessment

The chapter shows how different projects have been designed to meet their objectives. By reading the case studies, you can learn about best-practice study design, monitoring methods, data management, data interpretation and reporting.

Why this chapter is important

This chapter will be especially useful for the planning stages of a monitoring project because it describes examples of recent best-practice monitoring projects and the approaches taken in their design. These projects can be used as a guide when developing your own monitoring plan. They also demonstrate how objectives are defined based on the issues identified and how decisions about monitoring plans (particularly study design, methods and data interpretation) are made.

How to use this chapter

Chapter 11 gives examples of best-practice monitoring projects, covering the twelve monitoring plan questions (see Table 11–1).

The chapter is separated into three common types of waterway monitoring projects. For each monitoring type, one or two examples of best-practice projects are described. You may choose to read all of the case studies to get an idea of how processes vary for different monitoring types. Alternatively, you may decide to focus on only those relating to your chosen monitoring type.

The following examples of each monitoring type are included in this chapter:

- ambient (routine) monitoring
  - o *Community water quality monitoring report for the Maroochy River, January 2003 to June 2004* (Fawns et al. 2004)
  - o *Ecosystem Health Monitoring Program for freshwater, estuarine and marine regions of South East Queensland: annual technical report 2004–05* (EHMP 2006)
- load-based monitoring
  - o *Fresh and marine water quality in the Mackay Whitsunday region 2004/2005* (Rohde et al. 2006)—the event monitoring component of the Mackay Whitsunday Healthy Waterways integrated monitoring program
- restoration assessment
  - o *Implementing the Mary River and Tributaries Rehabilitation Plan: monitoring and evaluation report 2003* (Watson, Maskall & Wedlock 2003).

Background, project objectives, study design, monitoring methods, data management, data interpretation and reporting are summarised for each project.

Table 11–1 Steps in developing a monitoring plan

Key steps	Monitoring plan questions
Set monitoring objectives	Q1 Why are you monitoring? Q2 Who will use your data? Q3 How will the data be used? Q4 What data quality do you require?
Develop a study design	Q5 What is your study type? Q6 What will you monitor? Q7 Where will you monitor? Q8 When and how often will you monitor?
Chose monitoring methods and procedures	Q9 What methods will you use?
Plan data management, interpretation, reporting and communication	Q10 Who will be involved and how? Q11 How will the data be managed and reported? Q12 How will you ensure confidence in your data?

Ambient (routine) monitoring

Ambient monitoring is often undertaken to monitor trends through time and to detect a decline or improvement in the condition of a waterway. It is also used by many community-based groups to identify pollution events and pest species outbreaks. The methods used for ambient monitoring can also be successfully used when undertaking snapshot (once-off) monitoring.

Two examples of ambient monitoring projects are detailed below.

Community water quality monitoring for the Maroochy River

Background

This case study focuses on community-based waterway monitoring undertaken by Maroochy Waterwatch from 2003 to 2004. Monitoring was undertaken by community volunteers, financial support was provided by Maroochy Shire Council, and technical support was provided by the then Environmental Protection Agency and the Department of Natural Resources and Mines (now combined as the Department of Environment and Resource Management).

The Maroochy River catchment covers the eastern area of the Maroochy Shire, which is located approximately 100 kilometres (km) north of Brisbane. The Maroochy River drains a natural basin covering an area of approximately 400 square kilometres (km^2), and is one of very few river systems in Queensland to be contained entirely within the one local council boundary. Over the past 20 years, the area has experienced a high rate of residential growth, with the population now exceeding 136 000.

In recent times, several water quality issues have been identified in the area including:

- urban stormwater run-off from unprotected building sites, gardens and roads
- unvegetated and eroding water courses
- rural run-off from agriculture and grazing land
- water from sewage treatment plants.

Project objectives

Project objectives, developed in response to the identified water quality issues, were to:

- collect sufficient data in order to provide a general characterisation of water quality
- determine the specific cause of variations in water quality away from the norms
- identify priority areas to address in order to improve the water quality of the Maroochy catchment.

Study design

The study was conducted throughout the Maroochy River catchment from January 2003 to June 2004. A key component of the project was community involvement, with close to 100 volunteers contributing to the data collection. The catchment was divided into 11 subcatchments, with over 140 sampling sites spread throughout the area. The sites were chosen based on their:

- representativeness of variation in the catchment
- strategic location
- custodial connection to members of the community
- accessibility.

Level one physico-chemical tests (including pH, conductivity and salinity, dissolved oxygen, turbidity and temperature) were conducted by volunteers on a monthly basis. A minimal amount of training in conducting tests was required to produce quality data. Additional macro-invertebrate and nutrient monitoring was conducted at a number of sampling sites, which provided data on ecosystem processes to complement the interpretation of tests.

Monitoring methods

Level one physio-chemical tests were carried out by Waterwatch volunteers using Horiba U-10 multi-probe water analysers. Each volunteer was trained in using the Horiba probe. Readings were taken either directly from the water body if depth allowed, or from a carefully collected bucket sample representative of the water body. Readings were taken at approximately the same time each day. Data was recorded on record sheets that circulated with sampling kits as well as on the volunteer's personal record sheet. Personal records were used to detect any inconsistencies with the monitoring instruments, to act as a data back-up and for verification once the data was centrally collated and reported. All test kits were cleaned and calibrated weekly by the coordinator. Volunteers were alerted to problems with instruments through the monthly newsletter.

Macro-invertebrate samples were taken as biological indicators of the Maroochy River catchment from ten sites within the five major subcatchments. Sites were selected to represent the range of different land uses—including agricultural, commercial and residential—along waterways. An insect net was used to sample four habitat types—edge, riffle, pond and riparian vegetation—within each site. The macro-invertebrates caught were transferred into separate sorting trays and their classification was aided by the use of identification sheets and reference books. Total taxa richness (TR) and pollution sensitivity index (PSI) was calculated for each site. Further explanation of methodologies used can be found in the monitoring report.

To ensure data confidence, quality control checks (shadow testing) were undertaken with the Environmental Protection Agency at a number of sites on an annual basis.

Data management

Blank data sheets were compiled in separate folders for each water testing equipment unit. All folders and units were labelled for consistency. As the kit circulated, each volunteer added their completed data sheets to the envelope. During weekly and monthly calibration by the program coordinator, the completed forms were removed from the folder, arranged in chronological sequence and placed in the office folder for all raw data.

Once a month, raw data was entered into a Microsoft Excel spreadsheet. The data was then checked for any obvious outliers by the coordinator. A pivot table with the number of times collected, maximum and minimum was then used to find discrepancies and these were rectified. Ten random spot checks of data records were also undertaken to check for accuracy and validity. Values were identified as outliers if they were outside the 'normal' range—between maximums and minimums—from previous years' monitoring.

The data was then graphed and any further discrepancies identified and rectified. Also at this point in time, the calibration logs were entered into the computer in a similar fashion. Data was deleted if it lay outside the pre-determined tolerable error range or was found to be from malfunctioning equipment.

Once all the accuracy and validity checks had been undertaken, notes were made on data sheets to indicate why any data was changed or deleted in the spreadsheet. The data sheets were then returned to the office folder for storage. The spreadsheet was resaved under a different name to indicate that data had been checked and verified. At the end of the reporting period, the monthly datasets were combined into a single spreadsheet for statistical analysis, graphing and data interpretation.

Data interpretation

Data interpretation in this project was aided by tools such as:

- modified box and whisker plots illustrating the maximum, minimum and median results of the physio-chemical parameters recorded at each subcatchment for
  - pH
  - turbidity
  - dissolved oxygen
  - temperature
  - salinity
- histograms showing
  - change in the pollution sensitivity index over the four seasons of the study for each habitat (edge, riffle, pond, vegetation) at selected catchments
  - macro-invertebrate taxa richness for sites within the Maroochy catchment
  - macro-invertebrate pollution sensitivity index for sites within the Maroochy Catchment.
- a map of the Maroochy River Catchment area showing monitoring sites, subcatchment boundaries, waterways and urban areas
- tables showing
  - macro-invertebrates sampled at each habitat (edge, riffle, pond, vegetation) at selected sites
  - the pollution sensitivity index and taxa richness rating at selected sites
  - cumulative scores and ratings for pollution sensitivity index and taxa richness
  - site codes and descriptions of sites
  - rainfall and temperature data for the region.

The data collected at each site was only compared to that collected at other sites within the same subcatchment. This enabled an individual assessment of each subcatchment to be made.

Reporting

The monitoring results and associated information were collated into a report, *Community water quality monitoring report for the Maroochy River, January 2003 to June 2004*, which was distributed to a wide range of stakeholders.

To access the report, which includes full details of the monitoring methodologies and actual monitoring results, see the Maroochy Catchment Centre website <www.maroochycatchmentcentre.org.au>.

Ecosystem Health Monitoring Program

The following case study is based on an ongoing government agency monitoring program. Although a number of the methods used would be beyond the capabilities of most community groups, several elements of this study could be used as a framework when designing a community-based monitoring program.

Background

The Ecosystem Health Monitoring Program (EHMP) covers an area of 22 672 km^2 that is bounded by Noosa in the north, the New South Wales border in the south and the Great Dividing Range in the west. The area includes eighteen major river catchments and supports a population of over 2.5 million people. The EHMP is managed by the Moreton Bay Waterways and Catchments Partnership ('the partnership'), a cooperative entity involving the Queensland Government, local governments and universities, CSIRO and industry groups. A large range of experts from partnership members contribute to the operation of the EHMP.

The operating philosophy of the partnership consists of four key elements:

- continually improving the knowledge base for management
- applying adaptive management
- ensuring stakeholder involvement
- implementing at the most appropriate level within an integrated regional planning framework.

The EHMP includes both freshwater and estuarine monitoring. This case study focuses on the freshwater monitoring component undertaken by the Department of Environment and Resource Management since 2003.

Project objectives

Based on the four key operating elements, the project objectives were to:

- deliver a cost-effective and integrated regional assessment of the ecosystem health of South East Queensland waterways
- provide effective evaluation and communication of monitoring results
- assess trends using a variety of ecosystem health indicators to evaluate the effectiveness of environmental protection and management measures
- facilitate improved access to monitoring information through maintaining and enhancing a data management system
- enhance stakeholder capacity to contribute to monitoring programs.

Study design

The freshwater assessment divides South East Queensland into 18 subcatchments, with 127 sites spread across these subcatchments. Representative sites were chosen to provide regular spatial coverage within the study area to ensure that results would typify the health of streams within the catchment. Each site is monitored twice a year—once in spring (pre-wet) and once in autumn (post-wet). These monitoring periods allow stream health following the drier winter months to be compared with that following the wetter summer months.

Indicators of freshwater health were selected following an extensive scientific study (Smith & Storey 2001) that trialled numerous indicators against a known disturbance gradient. The results of this study recommended five indicator types that responded well to disturbances associated with land clearing, industry, and urban development and would be suitable for the freshwater EHMP assessment. The five indicator types are:

- water chemistry measures (including water temperature, pH, dissolved oxygen and conductivity)
- nutrient cycling (a measure of ecosystem function)
- ecosystem processes (of production and respiration—a measurement of ecosystem function)
- macro-invertebrate communities (a measurement of ecosystem structure)
- fish communities (a measurement of ecosystem structure).

All five indicators are considered to be of equal importance, as each responds to different forms of disturbance and expresses information about different ecosystem attributes.

Monitoring methods

A combination of established and novel methods for measuring freshwater health is used to obtain data for each of the five key indicator types mentioned above. In total, 18 individual (listed below) are assessed.

Indicators of water chemistry include:
- pH
- conductivity
- water temperature
    - o diel (daily) maximum temperature
    - o diel temperature range
- dissolved oxygen
    - o diel minimum dissolved oxygen
    - o diel dissolved oxygen range.

Indicators of nutrient cycles include:
- nitrogen stable isotopes (δ15N)
- algal bio-assay (NP:C).

Indicators of ecosystem processes include:
- algal growth (chlorophyll *a*)
- carbon cycling (δ13C)
- respiration (R24)
- gross primary production (GPP).

Indicators of macro-invertebrate community include:
- number of macro-invertebrate taxa
- Plecoptera-Ephemoptera-Trichoptera (PET) taxa richness
- SIGNAL score.

Indicators of fish community include:
- proportion of native species expected (PONSE)
- observed to expected species (O/E50)
- proportion of alien fish species.

Tables 11–2 and 11–3 briefly outline the methods used to monitor the macro-invertebrate and water chemistry indicators. More detailed information on the methods used for these and the other three indicator types can be found in the *EHMP Annual Technical Report 2004–05*, downloadable from the EHMP website <www.ehmp.org>.

Table 11–2 Methods used to monitor chemical indicators

Indicator	Monitoring method
Water temperature	A TPS WP-82Y meter with extended memory and inbuilt thermistor is used to measure temperature. The probe is placed into the stream at a depth of approximately 20 cm and temperature is logged every 10 minutes. Equipment is deployed for 24 hours, with the maximum and minimum temperatures identified and a 24-hour range calculated.
pH	A TPS WP-81 meter with pH probe is used to measure pH. The probe is lowered into the stream at a depth of approximately 20 cm, and a pH measurement is recorded once the reading stabilises.
Dissolved oxygen	A TPS WP-82Y meter with extended memory and an oxygen probe is used to measure dissolved oxygen. The probe is fitted with a recirculating pump to ensure constant water flow across the probe membrane, and is placed into the stream at a depth of approximately 20 cm. Dissolved oxygen concentrations are logged every 10 minutes. Equipment is deployed for 24 hours, with the maximum and minimum values identified and a 24-hour range calculated.
Conductivity	Conductivity is measured with a TPS WP-81 water chemistry meter with conductivity probe. The probe is placed into the stream at a depth of approximately 20 cm and a conductivity measurement is recorded once the reading stabilises.

Table 11–3 Methods used to monitor macro-invertebrate indicators

Indicators	Monitoring method
Total taxa richness PET family richness SIGNAL score	All samples are collected from edge habitat to maintain consistency between sites and monitoring events. Macro-invertebrates are collected using a D-framed pond net, based on AUSRIVAS collection methods. The net is swept through the water several times at right angles to the bank. First sweeps dislodge bottom-dwelling fauna while the ensuing sweeps collect them from the water column. Following collection, the animals are sorted by 2 x 30-minute live picks (two people sorting the sample for 30 minutes each) using forceps and pipettes. Up to ten representatives from each taxon are collected with the exception of the family Chironomidae, where 30 specimens are collected. All specimens are placed in a labelled vial containing 70% alcohol for laboratory processing.

Quality assurance and quality control

A range of quality assurance and quality control measures are applied throughout the freshwater EHMP program to ensure a high quality of data. Listed below are the minimum quality procedures for water quality and macro-invertebrate monitoring. Further measures are implemented for the other indicator types used in the program.

In relation to staffing:

- project personnel have relevant tertiary qualifications and/or experience
- all field personnel are provided with appropriate training in theoretical and practical aspects associated with the project
- all personnel are made aware of and follow health and safety procedures.

In relation to methods:

- the methods used are standardised and documented in detail
- all personnel are provided with documentation of the methods and techniques to be used (standard operating procedures).

When monitoring for conductivity and pH:

- meters are calibrated daily using a two-point calibration method (tests the meter at two different values) and all calibration results are recorded.
- the range of meter readings is checked against the expected range for the parameter, and the meter is recalibrated and retested if the reading is outside the expected range
- the meter readings are checked against what would be logical for the site, and the meter is recalibrated and retested for unexpected results.

When monitoring for 24-hour water temperature and dissolved oxygen:

- data loggers are calibrated daily and all calibration results are recorded
- range checks and logic checks are applied to data from equipment immediately prior to 24-hour deployment
- range checks and logic checks are applied to data from equipment immediately following 24-hour deployment.

When conducting macro-invertebrate assessment:

- a minimum of 10% of residues from live-picked samples processed by each individual are collected and stored
- aquatic macro-invertebrates picked by different individuals are collected and stored in different, labelled vials
- up-to-date nomenclature and taxonomic keys are maintained and used for macro-invertebrate taxa identification
- 10% of the samples processed (taxonomic identification) by each individual are checked by an accredited person for accuracy of identification. A tolerable error range of ≥ 90% Bray-Curtis similarity is required for identification.

In relation to data management:

- accuracy of data entry is confirmed using a double-entry procedure
- logic checks and range checks are applied to all data for unusual or unexpected results prior to storage
- all freshwater EHMP data and numeric results are stored in a secure Microsoft Access database
- copies of the database used to store data and numeric results are kept secure.

In relation to data analysis and reporting:

- the preceding year's data is reanalysed prior to analysing new data to confirm accurate operation of the computer software used for analysis
- logic checks and range checks are applied to data analysis input files immediately prior to analysis.

Data analysis

The key data analysis steps are as follows:

1. Calculate standardised scores, accounting for major spatial variation and differences in measurement scale across indexes using the equation given in the report.
2. Summarise scores at various levels—for example, as per the ‘Reporting’ section opposite.
3. Create box and whisker plots to display natural variation.
4. Create ecosystem health (EcoH) plots (see Figure 11–1)

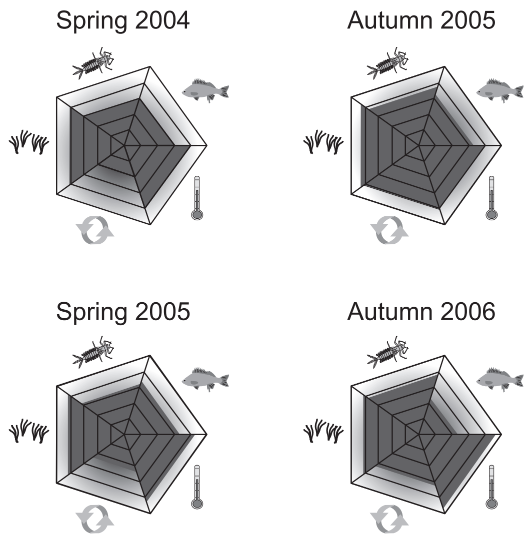

Figure 11–1 Examples of ecosystem health plot pentagons (reproduced with permission from the Moreton Bay Waterways and Catchments Partnership)

The EHMP data undergoes four mathematical analyses to determine catchment condition. These results are then interpreted in terms of landscape features known to influence condition, in order to separate human-influenced condition from natural state. Not all catchments are naturally the same. The data from physico-chemical and macro-invertebrate indexes are combined to calculate:

- data summary by index. These are box and whisker plots (one for each index) showing
  - amount of available data
  - median score
  - variability in scores
  - presence of unusually high or low scores
  - number of values available for each index
  - condition of each reporting area in terms of each index
  - degree of change in the results from the previous year
- summary reporting area ranks. These are calculations (shown for both spring and autumn) standardised for spatial variation (regional and subregional scale)
- ecosystem health (EcoH) plot pentagons. These are specially designed pentagons that visually summarise the results of each indicator
  - Each wedge of an EcoH plot represents a single indicator. Results are presented by filling the wedge solid green to the value of the corresponding mean score. The spring and autumn results are presented separately
  - The area of each wedge shaded in green is the (subregion) mean score, derived from all the indexes for that indicator
  - The more area of a wedge is shaded, the better the condition of that indicator.

A grade is given to each catchment using the following seven step process:

1. Spring results are compared with regional ecosystem guidelines to produce a table of 127 sites × 16 standardised scores.
2. This is converted to a table of 127 sites × 5 standardised scores by taking the average of the scores for each of the five indicator types.
3. Each site is then assigned to one of the 18 subcatchments and the average of all sites within a catchment is taken, to produce a table of 18 × 5 standardised scores.
4. Steps 1 to 3 are repeated for the autumn data to create a second 18 × 5 table of standardised scores.
5. Spring and autumn scores are averaged to produce a single 18 × 5 table.

6. The five standardised scores for each catchment are averaged to give a single overall score for each catchment.
7. These scores are then ranked from highest to lowest and report card grades are assigned using an A to F grading system.

Data interpretation

A number of resources are used to aid interpretation of the results of the above analyses. These include maps of the South East Queensland region and catchment areas showing major types of land use within the catchments, and histograms showing annual rainfall in the Sunshine Coast, Gold Coast and Brisbane River catchments.

Further information on how each measure is calculated can be obtained via the EHMP website <www.ehmp.org>.

Reporting

Two main documents are used to report results:
- annual report card—a brief, easy-to-interpret summary of annual results based on a grade (A to F) for each reporting area with salient comments. An annual report card is produced based on results from the previous 12 months. Report card grades for 2004–05 were derived for 18 catchments using the seven-step process outlined above
- annual technical report—a detailed technical document providing sufficient information to demonstrate that data interpretation is scientifically robust.

For further information, including a detailed analysis of each catchment and a regional overview of freshwater health, refer to the E*HMP 2004–05 Annual Technical Report*, available from the EHMP website <www.ehmp.org>.

Load-based monitoring

Load-based monitoring is used to estimate sediment and nutrient inputs during high-flow events. It is performed during elevated flows, usually due to a rainfall event that has created overland flow into the waterway network. Water quality components such as sediment and nutrient concentrations are primarily the result of overland flow events. The following case study is a best practice example of an event monitoring project.

Fresh and marine water quality in the Mackay–Whitsunday region

Background

This case study focuses on community-based event monitoring undertaken from 2004 to 2005 as part of the Mackay Whitsundays Healthy Waterways integrated monitoring program. The program was an initiative of the Mackay Whitsunday Natural Resource Management Group (MWNRMG now called Reef Catchments Mackay Whitsunday Inc.). The event monitoring program was coordinated by the then Department of Natural Resources and Water, on behalf of MWNRMG, and undertaken by community volunteers.

The Mackay–Whitsunday region spans 300 km along the Central Queensland coast, comprising an area of approximately 9000 km^2. The region consists of three major river systems, along with numerous smaller streams, that discharge into the Great Barrier Reef and western Coral Sea.

Over the last decade, a number of high-profile water quality issues have been reported across the region, including:
- fish kills
- low dissolved oxygen levels in lower catchment water bodies
- mangrove dieback in the Pioneer estuary, and in other tidal creeks
- blue-green algae (cyanobacteria) blooms, at times, in storages
- relatively high rate of use of chemicals (particularly herbicides) in the region
- extensively modified estuaries
- relatively high concentrations of herbicides in estuarine sediments and storm flows
- declining coral reef health, which has been linked to river pollutant discharge and sewage

treatment plant effluent discharge.

Project objectives

Based on these water quality concerns, the objectives of this study were to:

- quantify pollutants generated by the major land uses in rainfall run-off events in the Mackay–Whitsunday region
- quantify pollutants discharging to the inshore areas of the Great Barrier Reef lagoon
- obtain baseline data to support regional and local target-setting, and water quality improvement plans
- increase awareness of water quality and aquatic ecosystem issues in the Mackay–Whitsunday region by involving the community in event sampling.

Study design

The study was conducted in the Mackay Whitsunday Natural Resource Management region in Queensland, which consists of four major hydrological basins: the Plane, the Pioneer, the Proserpine and the O'Connell. A total of 21 sites were monitored across the region. Sites were selected on streams that drained subcatchments dominated by a single land use. These included forest (rainforest), sugar cane, grazing (sclerophyll and cleared grassland) and urban (existing and developing). Catchments of mixed land use were also monitored.

Two major rainfall events, in early and late January 2005, generated run-off. Sampling was completed during the major flow events—including the rising, peaking and falling stages—at each site. Another smaller rainfall event occurred in April, producing some minor flows in the Pioneer and Proserpine basins.

Monitoring methods

This event monitoring project had an emphasis on community involvement. Sampling was conducted with the assistance of landholders, local and state government staff, students and other interested individuals. Volunteers were trained in the correct sampling and quality procedures, and each volunteer received a sampling kit with all necessary sampling equipment. Volunteers were visited while sampling to provide them with assistance and to ensure that correct procedures were followed. Freshwater sampling was conducted by volunteers, while marine sampling was only conducted by project staff.

Samples were collected from flowing water, where possible. This was done using a triple-rinsed bucket (with water from the site). Subsamples from the bucket were analysed for total suspended solids (TSS), total nutrients (unfiltered), dissolved nutrients (filtered on-site through 0.45 µm filters) and pesticides. Samples from urban sites were also tested for total organic carbon (TOC), total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH). Chlorophyll *a* and phaeophytin samples were collected from flood plumes. These were filtered within 12 hours and frozen, while TSS, pesticides, TOC, TPH and PAH samples were kept dark and chilled until analysis. Nutrient samples were frozen as soon as possible. The report, *Fresh and marine water quality in the Mackay Whitsunday Region 2004/2005*, published by the Mackay Whitsunday Natural Resource Management Group, gives further details of laboratory methodologies for TSS, electrical conductivity, nutrients, chlorophyll *a*, phaeophytin, TOC, pesticides and hydrocarbons, as well as quality assurance procedures used.

Marine samples were collected in a dispersed pattern within and outside the visible plume area on 27 and 28 January. The plume area was mapped using an aerial survey, observations from sampling vessels and satellite imagery. Surface samples only were collected from the top 0.5 m of the water column. A sample within a *Trichodesmium* spp. bloom was taken, as were duplicate pesticide samples (for photosynthetic inhibition assay and chemical quantification of herbicide concentrations). Salinity of samples was measured using a hand-held refractometer in the field, although samples were collected for electrical conductivity measurements in the laboratory.

Samples for TSS, electrical conductivity, nutrients, chlorophyll *a*, phaeophytin and TOC were analysed at the Australian Centre for Tropical Freshwater Research (ACTFR) Water Quality Laboratory, James Cook University, Townsville. Samples for pesticide and hydrocarbon analyses were analysed at the Queensland Health Scientific Services laboratory, Brisbane. Methodologies for each parameter are listed in the report.

To ensure data confidence, the following quality control checks were undertaken:

- in the field
    - triplicate samples were taken at one site on one sampling occasion. The results of these were compared, to ensure that the results were within the pre determined tolerable error range

   - o distilled and deionised water ‘field blanks’ were sampled using the same sampling technique to that used in the field. This was to ensure that no contamination was involved in the sampling process
- in the laboratory
   - o annual national low-level nutrient compliance testing was conducted
   - o routine shadow testing was conducted with other laboratories.

In addition, steps were taken to further validate the TSS monitoring protocol of taking a single sample at one point (middle or edge) in the stream. On one sampling occasion, additional water samples were collected at one of the monitoring sites. Three samples were taken from the edge and three from the middle. These samples were compared to one another to prove that the variation within the stream was not significant enough to warrant sampling at more than one point in the stream.

Data interpretation

Data interpretation was carried out with the aid of resources such as:

- maps of the Mackay–Whitsunday region showing
   - o major basins, towns and streams
   - o event rainfall
   - o waterway monitoring sites in each basin
   - o plume sampling sites
   - o Landsat image of regional flood plume
   - o MODIS satellite image of visible brown suspended sediment plume and phytoplankton plume
- photographs showing
   - o contents of a sampling kit
   - o distinct edge of the flood plume in the coastal Great Barrier Reef lagoon (aerial photograph)
   - o commencement of turbid run-off water
- line graphs of comparisons—between land-use subcatchments (forest, sugar cane and grazing)—of flow rate (m3/s) and
   - o total suspended solids concentration (mg/L)
   - o nitrogen concentrations (µg/L)
   - o phosphorus concentrations (µg/L)
   - o herbicide residue concentrations (µg/L)
- box and whisker plots of the distribution of water quality parameters in the event run-off from various land-use subcatchments (forest, grazing, sugar cane, urban development and urban drainage, and some mixed land-use catchments). The water quality parameters include
   - o filterable reactive phosphorus (FRP) concentrations (µg/L)
   - o ammonia concentrations (µg N/L)
   - o NO_x (nitrate + nitrite) concentration (µg N/L)
   - o Diuron residue concentrations (µg/L)
   - o particulate phosphorus (PP) concentrations (µg P/L)
   - o total suspended solids concentration (mg/L)
   - o Tebuthiuron residue concentrations (µg/L)
- scatterplots (mixing curves) of plumes of
   - o filterable reactive phosphorus
   - o Diuron
- histograms of rainfall (mm), run-off (mm) and sediment loss (t/ha) for an event for forest, sugar cane and grazing subcatchments.

Continuous time series flow data from the hydrographic gauging stations and point source water quality data was entered into the Brolga database of the Department of Natural Resources and Mines. Loads were calculated using linear interpolation. To calculate loads across the entire hydrograph, point concentrations were extrapolated to the start and end of the hydrograph. For those sites and events where data gaps existed (for example, where the second peak was not sampled), point concentrations were estimated to improve the load calculation.

Reporting

Results were presented in the report *Fresh and marine water quality in the Mackay Whitsunday Region 2004/2005*. In addition, key findings were communicated through public forums, press releases, presentations at scientific and land management meetings, and scientific publications. For further information, including the discussion, conclusions and recommendations of the study, download the full report from the Reef Catchments Mackay Whitsunday Inc. reports and downloads web page <www.reefcatchments.com.au>.

Restoration assessment

Restoration assessment is undertaken to assess the effectiveness of a management action. An example of a catchment restoration assessment project is outlined in the following case study.

Mary River and Tributaries Rehabilitation Plan monitoring and evaluation

Background

This case study outlines catchment restoration assessment (monitoring and evaluation) undertaken by the Mary River Catchment Coordinating Committee (MRCCC) from 2002 to 2003. MRCCC is a community-based organisation, therefore monitoring was largely undertaken by community volunteers.

The Mary River catchment covers 9400 km^2 from Maleny to Fraser Island, encompassing 12 shires with a total population of over 75 000. Much of the 2947 km of waterways in the catchment contains communities of remnant riparian vegetation of conservation significance. These riparian communities provide habitat for a range of flora and fauna, including numerous rare and endangered species. The State of the Rivers report for the Mary River catchment found 40% of the riparian vegetation to be very poor, while a further 23% was rated as poor. High levels of exotic species were identified in poor riparian areas.

Project objectives

Based on these findings, the objectives of this project were to:

- assess Rivercare grant properties using the Index of Stream Condition in order to assess the physical parameters influencing vegetation health, stream bank stability and in-stream health of monitored sites
- assess riparian plant species diversity and condition using the Corridors of Green data sheet (Greening Australia Tiaro) in order to assess riparian vegetation condition and assessment
- gauge landholder attitudes and commitment to the Rivercare grant scheme via an attitudinal survey
- establish baseline data to be used for comparisons over time
- establish a fixed methodology for the Rivercare project site-monitoring procedures
- offer practical advice and information on issues highlighted by monitoring, in order to correctly maintain the project.

Study design

Monitoring took place at 20 established Rivercare sites from December 2002 to February 2003 throughout the Mary River Catchment, with the purpose of gathering baseline data on the state of the various sites. Sites for monitoring were decided with the assistance of landholders. Before monitoring at each site, volunteers conducted an attitudinal survey, containing ten questions ranging from the landholder's major riparian issues to their satisfaction level with the Rivercare grant. This survey acted as an icebreaker and helped to gain information needed to accurately complete the monitoring, such as appropriate positions for transects. Further comments were also given and taken into account. Landholders who did not complete the survey on the monitoring day were sent a copy and asked to post the completed form back to the MRCCC.

Monitoring sites were located centrally along the Rivercare project areas, with 200 m of riparian land upstream and downstream of the central transect (Transect 1). Transects 2 and 3 were positioned 200 m upstream and 200 m downstream of Transect 1 at each site. A photographic strategy was used to differentiate between sites, and between transects within sites. To ensure that future monitoring activities were carried out in the same location, a star picket was hammered into place at the toe of the bank, and another at the top of the streamside zone.

Monitoring methods

The Corridors of Green (COG) assessment technique was undertaken along Transect 1 only. This technique involves assessing and combining four parameters relating to riparian condition (for example, foliage protective cover) and five parameters relating to plant diversity (for example, tree species diversity). Each parameter was given a score from 1 to 5, with a total score out of 45 given to each site.

The condition of a particular stream reach was calculated using the Victorian-designed Index of Stream Condition (ISC) assessment techniques. A full ISC score contains five elements, with a rating score of 1 to 10 given to each of the elements.

The five elements are:

- hydrology
- aquatic life
- water quality
- streamside zone
- physical form.

Both hydrology and aquatic life were omitted from this report due to their time requirements and lack of availability in Queensland. This resulted in a score out of thirty rather than fifty, which was in turn converted to a percentage (for comparison purposes).

Water quality was monitored at Transect 1 only, using the parameters of water temperature, pH, conductivity, turbidity, phosphate and nitrate.

The streamside zone parameters used were bank stability, width of streamside zone, structural intactness, cover of exotic vegetation, regeneration of indigenous woody vegetation and livestock access.

Physical form parameters included bed stability, in-stream physical habitat, longitudinal continuity and other observations.

A comprehensive outline of methodologies, including a description of both the COG and ISC assessment techniques, appears in the *Implementing the Mary River and Tributaries Rehabilitation Plan: monitoring and evaluation report 2003.*

Data interpretation

Data interpretation was carried out with the aid of:

- histograms showing
  - o physical form, streamside zone and water quality of the Mary catchment in comparison to selected Victorian catchments
  - o comparisons of mean ISC and COG scores of the upper and lower Mary catchment
  - o total ISC scores at each monitoring site
  - o comparisons of COG condition and diversity scores at each site
  - o a comparison of ISC and COG scores at each site
  - o the relationship between vegetation and bank position at each site
  - o comparisons of revegetation and regeneration sites using ISC and COG scores
  - o priority ratings for major riparian issues for each land-use category
- pie charts showing
  - o ISC bank erosion scores for Rivercare project sites
  - o levels of catchment bank stability
  - o land use of Rivercare project properties
  - o major landholders' riparian zone issues
- an aerial photograph illustrating ISC assessment techniques at a particular site
- tables showing
  - o priority reach of each of the sites
  - o combined ISC and COG scores
  - o degree of variance in the streamside zone widths
  - o leaf litter cover and soil condition at each site
  - o weed species abundance
  - o biophysical parameters affected by livestock access
  - o chemical parameters of sites
  - o attitudes of landholders towards the Rivercare grant scheme.

Comparisons were made between the Mary catchment and three selected Victorian catchments using ISC data. To do so, the average scores for physical form, streamside zone and water quality for each catchment were combined. The sites monitored within the Mary catchment were 'high priority' and 'high conservation' sites on freehold land, whereas the Victorian ISC results were obtained from evenly spaced strategic sites. This led to some limitations in comparisons of the data.

The mean values for ISC and COG scores in the Mary Catchment were converted to a mutual score out of 100 to enable comparisons to be made between the two methods.

Reporting

The results of the study were compiled into a detailed report, *Implementing the Mary River and Tributaries Rehabilitation Plan: monitoring and evaluation report 2003*, which was distributed to a wide range of stakeholders. To access the report (including further information on the study findings, highlights and monitoring methodology), see the MRCCC website <http://mrccc.org.au/publications.html>.

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