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Regional Council
TE RAUHĪTANGA TAIAO

Environmental Targets for the Urban Coastal Marine Area

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Environmental Targets for the Urban Coastal Marine Area

Prepared for
Auckland Regional Council

Contents

1 Introduction

Network operators throughout the Auckland Region have applied to the ARC for resource consents to allow the continued operation and development of their wastewater and stormwater networks. These consent applications will be processed under a Regional Discharges Project (RDP). The issues involved in the RDP are complex, with the potential to have a major effect on all residents and ratepayers in the region.

The overall strategic aim of the project is to ensure that, taking into account public expectations and affordability, discharges from stormwater and wastewater networks are managed so as to minimise adverse effects on the environment.

As part of the Regional Discharges Project, the ARC wishes to develop environmental targets for the coastal marine area and fresh water resources that will indicate whether or not stormwater and wastewater discharges are leading to environmental degradation. These targets will also be used to aid the assessment of stormwater and wastewater consent applications. It is likely that these guidelines will be developed through a regional planning process involving Variations to the Regional Plan: Coastal and the Regional Plan: Air, Land and Water. This will allow for the input of all interested parties.

The Auckland Regional Plan: Coastal defines environmental targets and policies for the coastal marine area. These provisions have been subjected to a wide range of public input and scrutiny and provide comprehensive general policy guidance to both the ARC and resource users. However, the ARC considers that additional policy guidance is required to provide stormwater and wastewater network operators with greater certainty regarding acceptable effects on the quality of the coastal marine receiving environment.

Accordingly, ARC with the help from a consultant developed some primary and secondary aims for the urban coastal marine area derived from environmental issues associated with stormwater and wastewater discharges, and from the existing objectives and policies of the Regional Plan: Coastal (Larcombe 2001). These long-term aims were used to develop a suite of environmental targets for key parameters that if met, would denote a healthy receiving environment. The key parameters are indicators of water quality, sediment quality and benthic ecology.

The targets were, in turn, used to choose and develop objective guidelines for each of the key parameters. Targets will be used in further statutory processes such as regional plans. Some or all the environmental targets may be used in future resource consent processes.

In addition, monitoring indicators and methods have been outlined to facilitate the design of a long-term impact monitoring programme that will allow the ARC and resource users to determine whether or not the identified environmental targets are being met over time. The detailed monitoring programme is described elsewhere (Blueprint for Monitoring Urban Receiving Environments ARC 2002)

In order to provide a robust outcome, the environmental targets, guidelines and monitoring methods were supported by technical investigations, analyses and reports by the following:

- National Institute of Water and Atmospheric Research Ltd
- University of Auckland

- Diffuse Sources Ltd, and
- Dr M.F.Larcombe
- Auckland Regional Council

To assess the receiving environment, a compliance rating protocol has been developed. This is analogous to traffic lights that is green, amber and red. The level of metal and organic contaminants in sediments, the health of the ecological community and diagnostic water quality of settling zones and bathing beaches will be measured and a compliance category score allocated. This protocol will allow prioritization, appropriate action and the means to follow the results of any management measures. The details of the protocols for compliance and monitoring the marine receiving environment will be set out in the Blueprint for Monitoring Urban Receiving Environments report.

2 Tools Used to Guide the Monitoring Programme

2.1 Division of the receiving environment within the urban coastal marine area

Monitoring stormwater and wastewater impacts requires a pragmatic and sensible sampling strategy that takes into account the characteristics of the inputs and the nature of the receiving environment. It also requires that monitoring results can guide subsequent management action, i.e., there is a feasible management response to a monitoring result. The inputs are catchment runoff through streams, drains and outfalls, and are the potential sources of contaminants to be managed. The marine receiving environments in Auckland cover a wide range of types, from sheltered tidal creeks to coastal bathing beaches. The impact of any stormwater or wastewater input depends on the nature of its receiving environment.

In considering what to monitor and where in urban marine receiving environments that monitoring should occur two types of primary impact have been identified:

- Ecosystem health
- Human health

To address ecosystem health two types of important urban receiving environments are identified:

- Settling zone – where a range of contaminants settle
- Outer zone – where contaminants are more widely dispersed

For human health, the important receiving environments are bathing beaches and shellfish gathering areas.

Numerical target values have been adopted from existing guidelines for the receiving environments. Three values are given, analogous to green, amber and red traffic lights.

A green signal is an contamination "all clear", amber and red denote increasing levels of; investigation, identification of the source and the process and timeframes for remediation or possibly mitigation.

To identify Settling and Outer Zones, recourse was made to a classification scheme for the coastal marine environment, which is based on connections to the land and sea. This classification (Green et al. 2000) was developed for the ARC to provide a regional framework to understand the fate of contaminants discharged from the land. This framework (see Box A Estuary Classification) has underpinned our choice of sampling strategy and guidelines in the Regional Discharge Project.

Within estuaries, catchments commonly discharge to sheltered estuarine arms (tidal creeks) or embayments. Catchment-derived suspended solids tend to settle and be trapped here, along with any associated contaminants. This area is called the Primary Deposition Area (PDA) (See Box A Estuary Classification). It is possible to define a sub-area of a PDA where a significant proportion of catchment-derived sediments accumulate, which we have termed the **Settling Zone** (see Box B Settling Zone). Here, concentrations in the sediment are highest and the estuarine processes cause the concentrations of contaminants to be reasonably homogeneous spatially, which is very useful for monitoring purposes, because samples that are representative of the catchment inputs are easy to collect and can be related to these inputs.

Immediately beyond this Settling Zone, deposition and accumulation may still be the primary process, but accumulation is slower because contaminants are mainly trapped further upstream. Beyond the PDA, the estuary widens or discharges to the coast. In these areas, hydrodynamic energy is higher because they are more exposed, and is subject to larger and more frequent waves, so contaminants are more widely dispersed and moved on. These areas are Secondary Redistribution Areas (SRA).

Settling Zones are defined simply on the basis of morphology, catchment size and extent of intertidal zone. The marine areas beyond the **Settling Zone** have been termed the **Outer Zone**, which includes the rest of the PDA and the SRA. The reasons for separating the Auckland receiving environment in terms of **Settling Zones** and **Outer Zones** instead of the more scientifically rigorous **PDAs** and **SRAs**, is because the former are simpler to define and understand and these definitions can be applied to the whole of the Auckland region in a relatively simple manner. Further, the accumulation of contaminants can also be modeled in a relatively simple way.

While the Settling Zone concept is primarily for sediment quality, it also provides the basis for the location of ecology monitoring sites within estuaries. The concept is also useful for locating water quality monitoring sites because near-field effects of discharges would usually be stronger in the Settling Zone. However, it would also be sensible to locate these near ecology sites and in some cases in the Outer Zone adjacent to urban areas.

Settling Zones have been delineated for the Auckland region and maps have been produced. (ARC 2002 Regional Maps of Settling Zones and Outer Zones TP 170). This was carried out based on case studies undertaken on the Tamaki Estuary and Upper Waitemata Harbour (Williamson & Green 2001).

The Settling Zone represents the minimal reporting unit for monitoring in the Auckland Region urban marine receiving environments.

2.2 Prediction of Future Concentrations in Receiving Environments

The concentrations of the major contaminants Cu, Zn and PAH are predicted to increase in the estuarine sediments in the future. This is because these contaminants will continue to be discharged from urban areas. These parameters are currently perceived to be the most important contaminants in urban stormwater. Lead discharges will gradually decline due to the removal of leaded petrol. These are the major potentially toxic contaminants in stormwater. While there are many other toxic substances in runoff, they occur at much lower concentrations and their impact is unknown.

Contaminant concentrations in the sediments measured at the present time do not tell you what the concentration may be at some time in the future. For effective stormwater management, predictions need to be made on the rate of increase in contaminants, in order to:

- anticipate if and when Environmental Targets are exceeded
- to indicate the seriousness of the exceedance
- help prioritise a management response

- indicate the magnitude of source control or treatment needed to prevent exceedance of Environmental Targets.

Prioritisation should not be based solely on current or monitored levels. Estuaries with more rapid increase in contamination may justify a higher priority than those with lower rates of increase in contamination (all other factors being equal).

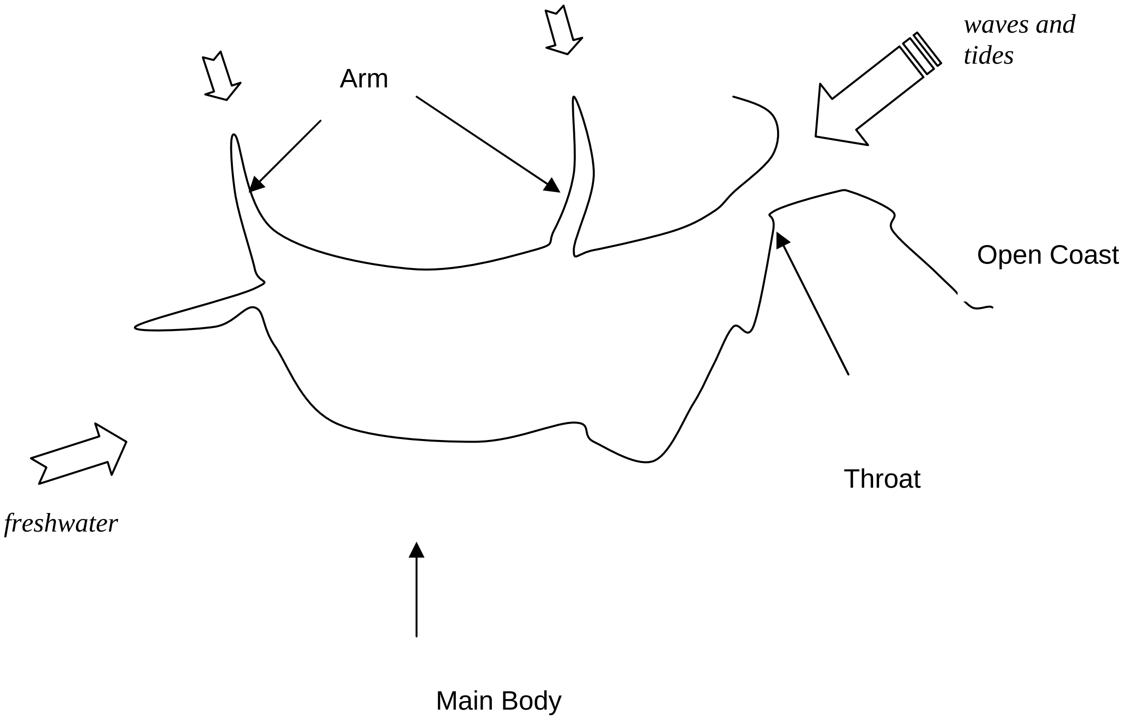
The Urban Stormwater Contaminants (USC) model can be used to make predictions on future concentrations of contaminants in receiving environments (see Box C).

Box A: Auckland Estuary Classification

(Summarised from Green et al. 2000, "Prediction of contaminant accumulation in estuaries").

An estuary classification scheme has been developed for Auckland estuaries that combines our understanding of estuarine geomorphology and the processes that disperse sediments/contaminants.

We recognise an Auckland estuary archetype, which is shown below.



The archetype displays several elements, which are defined in terms of "connections". The **arm** *(tidal creek, embayment, inlet)* connects directly to the land, and the **throat** (*mouth, channel*) connects directly to the coastal ocean. Between the two, and therefore with indirect connections to both the land and to the ocean, is the **main body** (*harbour*) of the estuary. Beyond the throat is the **open coast**.

The primary process in Arms in respect to contaminant fate is deposition and these have been termed **Primary Deposition Areas** (PDA). Land-derived fine sediments and associated contaminants settle here during storms, are mixed over small distances by small waves, but tend to remain in the PDA. The PDAs can stretch into sheltered parts of the main body. The dominant process in bodies, throats and open coast is resuspension by waves, dispersal by currents and redeposition over wider areas. Such areas have been termed **Secondary Redistribution Areas** (SRA).

Box B: Description of the Settling Zone and Outer Zone

The Settling Zone is a specific area where catchment-derived contaminants settle and accumulate. It is based on the fact that many contaminants are associated with suspended sediments, which settle and accumulate in the sheltered tidal creeks and embayments.

Hence the highest sediment contaminant concentrations occur in these settling areas. A simple model has been developed to predict this accumulation (see Box C: Prediction of Future Concentrations), which required that the settling area is precisely defined and located.

In an ideal estuary, the Settling Zone is envisaged to trap 75% of contaminants in an area equivalent to 4% of the fully-developed, contributing catchment area (sometimes termed the "4% rule"). This SZ concept was modified to take into account less efficient settling encountered in Auckland intertidal estuaries, such as the change degree of shelter and the tidal excursion. This has been carried out for the Auckland Region (ARC Regional Maps of Settling Zones and Outer Zones TP 170).

The Settling Zone concept is useful for the Regional Discharges Project because it assists in the location of representative sample sites, simplifies sampling because of the underlying homogeneity of the SZ, helps determine the quality of the receiving environment and provides a basis for predicting changes in concentrations with changes in land use and catchment management. It identifies an area that is most strongly impacted (at least in terms of concentration in water and sediments), where, for pragmatic purposes, there may have to be some acceptance of environmental degradation. It also identifies those areas beyond the SZ, where there are greater benefits of protection from environmental degradation. These areas are more sensitive, more extensive and, being beyond the SZ, there is a high probability that these can be protected.

Note that the "4% rule" is a simple rule and is meant as a general guidance only. It does not deal with large complex estuaries, but estuarine **arms** (see Box A Estuary Classification) which have clearly defined catchment inputs and a clearly definable receiving water body.

Also note that the assumed settling area in an estuary receiving imputs from for pasture areas is nominally assumed to be smaller at 2% because of the lower rate of rain event runoff.

Outer Zone.

Is the area beyond the Settling Zone that is still impacted by stormwater runoff, but to a lesser extent. It is often "downstream" from several settling zones. It may also receive runoff directly from stormwater discharges when these discharge directly to exposed shorelines, such as the open coast (e.g., East Coast Bays, Beaches). This is because Settling Zones can only be defined for sheltered estuaries, so when urban streams discharge directly to high-energy areas, such as the open coast, there are no settling zones for these discharges, or only very small settling areas.

Box C: Prediction of Future Concentrations

The simple Settling Zone concept allows predictions to be made on future catchment concentrations for any given urban development scenario (Auckland Regional Council 2000, Williamson et al. 1999, Williamson & Morrisey 2000, Morrisey et al. 2000a) using the Urban Stormwater Contaminant (USC) model. At the present time, simple rapid predictions can be made for the Settling Zones (Williamson & Mills 2001).

The model can be used to make predictions for existing land use and for changing land use. Such predictions are useful to check how rapidly a SZ is deteriorating, identifying the relative importance of sources, investigating catchment development options and assessing BPO or stormwater treatment options

The USC model takes basic information about land use, development history, specific catchment yields for contaminants and sediments. It then calculates the concentration in the estuary sediments assuming simple mixing within the sediment, the SZ area and tidal excursion. This is carried out on a spreadsheet, and so is a relatively simple model to implement.

A revised Urban Stormwater Contaminants (USC) Model to calculate contaminant build-up over time in a semi-quantitative way across a wider range of settling areas and beyond the SZ is currently being tested. It is based on the PDA and SRA conceptual model. This revised model will provide more precise predictions of concentrations in the settling zone, as well as information on contaminant gradients. It requires information from hydrodynamic modelling, however. Such information is available from hydrodynamic models developed for Mahurangi, Okura, Waitemata, Whitford and parts of Manukau Harbour.

Note that it is not feasible to calculate contaminant build up with hydraulic numerical models. Firstly, over the timescales that are of interest here, the computational resources required make numerical models prohibitively expensive. Secondly, the use of numerical models for long-term prediction presents formidable technical problems that are not always solvable.

3 Key Steps of the Regional Monitoring Programme

3.1 Outline of Steps

- Step 1: Monitoring

Monitor to assess the quality of Settling Zones and Outer Zones (see Box B) in the urbanised part of the Region, by measuring and evaluating water and sediment quality and benthic ecology.

- Step 2: Scoring

Use the monitoring results to determine the status of the site by comparing concentrations with appropriate guidelines and evaluating the ecological health using statistical methods.

To do this, three broad compliance categories are recognised.

Status	Indicates
Green	Relatively uncontaminated and likely to remain so in the foreseeable future.
Amber	In danger of exceeding targets in the foreseeable future.
Red	Exceed targets at the present time.

To achieve "green" status, all monitored parameters have to be "green". If one of the primary contaminants scores "amber" or one "red" classification this is enough to classify the site as "amber" or "red".

- Step 3: Further investigation

Use the "score" to determine the need and priority for further investigations.

For "Green" sites

No further investigation is needed, and monitoring is maintained to check if the area remains at a low level of contamination or at a less than minor effects level. No improvements in stormwater and wastewater infrastructure will be required with respect to environmental targets for marine water quality.

For "Amber and Red" sites a series of questions need to be addressed:

Are the contaminants/effects stormwater/waste water related?

If so, then which contaminants are involved, if the site is amber what is the rate of change, and if the site is red then are the levels of contaminants toxic?

Investigate sources of contaminants by considering point source discharges and land use.

If contamination is not due to stormwater discharges or wastewater overflows, then it becomes a land management pollution abatement issue.

- Step 4: Management

Undertake appropriate management action.

For “Amber” sites

Amber denotes an alert value, and the need to assess whether the situation will get worse. Sediment quality trends in the Settling Zone can be investigated using the simple USC model and to predict timeframes for individual parameters to increase towards the appropriate Guideline red value. Other investigations could include measurement of contaminant concentrations in dated profiles from sediment core samples and evaluation of existing Long Term Baseline monitoring data.

For “Red” sites

For receiving environments in which the guidelines are not met at present, and existing stormwater discharges are shown to be a major cause of non-compliance, a staged process of stormwater quality improvement will probably be required. In this situation, interim receiving environment quality guidelines that would apply at the end of an improvement stage could be defined, with perhaps two or three improvement stages and associated sets of short-term guidelines, leading towards achievement of the final guidelines.

For ‘quality’ indicators that do not comply at present it will be necessary to determine the relationship between the period of non-compliance and rainfall intensity, and to compare that relationship with the relevant guideline. Improvements in stormwater quality would then be directed towards achieving reductions in the frequency and duration of non-compliance

3.1.1 Guidelines Used

Guidelines from the MoH (1995), MoH/MfE (2001), Long et al (1995), MacDonald (1996), CCME (1999) and ANZECC (2000) have been used. ARC commissioned NIWA and University of Auckland to develop a healthy communities model for benthic ecology.

Following the ANZECC philosophy, sediment quality guidelines for the Auckland Region have been prepared using a combination of existing guidelines. Long et al (1995), MacDonald (1996) and Canadian Council of Ministers for the Environment (1999) and default values within ANZECC (2000) have all been used for sediment quality targets.

It is very important to note that the ANZECC Guidelines are trigger levels, not pass/fail numbers. If concentrations exceed the trigger values, then further investigation is required to see if there is a problem or not. For toxicants, this will require an understanding of the bioavailability of the potential toxicant. This is described later in the appropriate sections.

For the key indicators for which there is no guideline it will be necessary to develop local guidelines. At present there is limited data on the ‘health’ of benthic communities in the Outer Zone, especially in coastal areas, and the wider application of the “healthy community model’ through scoping studies will define “guidelines” that are representative of a coastal marine area with an urban catchment.

The protocol for meeting the compliance categories “green”, “amber” and “red” condition has been designed following a scoping project. The scoping project has set tentative conditions based on the Guidelines and then tested them against existing water quality, sediment quality and ecology data.

3.1.2 Monitoring

The location of monitored marine receiving environments will be defined on the basis of land catchment boundaries, or zones of influence of catchment inputs. For example, within the Upper Waitemata Harbour estuary, Lucas Creek, Te Wharau Inlet, Paremoremo Creek, Rangitopuni Estuary, Rarawaru Creek, Hellyer's Creek, Wairohia Inlet and Brighams Creek are separate receiving environments (Williamson and Green, 2001).

Initially there might be a need for a higher monitoring effort overall to determine the current status or quality of the receiving environments. Later, the monitoring effort would be concentrated on those receiving environments that did not comply, that is where a site is assessed amber or red (see above) based on monitoring indicators which did not comply with the relevant guideline.

For those effects of stormwater which are largely related to rainfall intensity, monitoring effort will need to be put into the determination of the duration of non compliance following rainfall events of different intensity.

The number of stations to be monitored for sediment and water quality and the indicative station location within a receiving environment has been indicated through the Settling Zone and Outer Zone classification (Williamson & Green 2001). Additional guidance can be found ARC Regional Maps of Settling Zones and Outer Zones TP 170.

Monitoring can also rely on published data for the some well-studied estuaries, and it may not be necessary to undertake actual measurement in the initial assessment at these areas. Regional water quality, sediment quality and ecology data collected by ARC and other organisations will be compiled into the 'Snapshot 2' database and report. This will be available from ARC in May 2002.

4 General Quality Aims for Urban Coastal Marine Areas

4.1 Introduction

This section outlines the general quality aims for urban coastal marine areas for the main value categories Ecology, and Human Use. These aims represent higher-level community aspirations. These aims are derived from Larcombe 2001.

For those aims that are appropriate, quantitative targets and guidelines for managing urban stormwater and wastewater overflows in the urban receiving environments in the region (see Chapter 5) have been developed. Targets and guidelines for some parameters that are important indicators for ecosystem and human use were not developed because their inclusion requires a much higher level of understanding than is present available. These include nutrient enrichment, nuisance species, water clarity, and maintenance of healthy communities of plankton, birds, and fish.

Other important considerations for urban coastal marine areas such as physical characteristics of seabed habitats, hydrography, hydrology, Maori values, public access are subject to other regional plans and policy statement provisions. Specific targets and guidelines are not applicable in these cases.

4.2 Primary Aims

4.2.1 Ecology

To maintain saltwater ecosystems of high quality in urban coastal marine areas, and to improve the condition of ecosystems in which existing adverse effects are present.

4.2.2 Human Use and Value

To protect human values and sustainable uses of urban coastal marine areas and to enhance human values and uses in areas where there are existing adverse effects.

4.3 Secondary Aims

These aims expand the primary aims to cover potential issues within the major environmental quality categories of Ecology, and Human Use and Value.

These aims recognise that areas of high quality should be maintained in this condition, and that efforts should also be made to improve the quality of degraded areas. In addition the application of the environmental targets must also recognise that:

Enhancement or restoration of degraded areas may have severe practical limitations. (Given the permanent consequences of modifications in land-use that accompany urbanization.)

In some circumstances decisions may be made that meet the general requirements of the Resource Management Act (1991) while not completely restoring degraded areas. An example of this could be the head of urbanised estuaries that are already degraded. In these cases, the best management option might be to limit the area of degradation and implement infrastructure upgrades within certain timeframes as agreed by all parties.

4.3.1 Water Quality-Ecosystems

To maintain or enhance water quality appropriate to support natural, healthy and high quality ecosystems.

Reason: Although some changes in urban coastal marine water quality are inevitable as a result of urban uses of the land catchment, the degree of change should be limited to avoid unacceptable averse effects on marine ecosystems.

4.3.2 Sediment Quality

To restrict the degree of accumulation of organic matter, nutrients, and toxic substances in sediments to levels which do not threaten the integrity of communities of seabed organisms.

Reason: Although some accumulation of urban stormwater contaminants in urban coastal marine area sediments is to be expected, the degree of accumulation should be limited to levels at which significant adverse effects on biota and food chains do not occur.

4.3.3 Fauna and Flora of Seabed Habitats

To ensure that healthy benthic communities of high quality occur in seabed habitats.

Reason: Healthy benthic communities have high intrinsic value, and are a major component of the urban coastal marine area food web. Healthy benthic communities are relatively stable, and if maintained or enhanced, will perform important functions in the wider coastal marine ecosystem.

4.3.4 Water Quality-Contact Recreation

To maintain or enhance urban coastal water quality suitable for contact recreation in all areas designated for contact recreation.

Reason: Contact recreation is a major human use of most of the urban coastal marine area waters.

4.3.5 Water Quality-Shellfish and Seafood.

To avoid degradation of the distribution and abundance of shellfish, and other seafood caused by discharges of stormwater and wastewater to the urban coastal marine area.

Reason: The presence and abundance of shellfish and other edible organisms, are important indicators of environmental quality to humans. It is important to maintain habitat quality suitable to support these species and to prevent the accumulation of contaminants to unacceptable levels within these species.

No targets for shellfish quality are included because they are practicably unachievable. In an urban receiving environment seafood species may never be able to be eaten by humans due to extreme sensitivity to even low or intermittent levels of some contaminants. These species in urban areas should be valued for their intrinsic role in the ecosystem.

5 Key Parameters

In Chapter 3 the four key steps of the regional monitoring programme are outlined, they are:

- Monitoring targets for the Settling Zone and the Outer Zone.
- Scoring of the Settling Zones and Outer Zones and allocating them to Green, Amber or Red levels of contamination.
- Further Investigations are proposed for the amber and red sites.
- The management response to amber and red will include appropriate remedial action.

This chapter looks at the key parameters that will be used to determine the status of a Settling Zone and an Outer Zone.

Key parameters chosen:

1. Reflect ecosystem and human health
2. Reflect stormwater impacts and management
3. Are feasible to monitor
4. Have a feasible management response

Some parameters that are important for ecosystem and human health are excluded because their inclusion requires a much higher level of understanding than is presently available. Those excluded were:

- water clarity,
- nutrient enrichment,
- fish and shellfish healty,
- quality.

5.1 Sediment Quality

5.1.1 Toxic substances

Monitoring sediment quality is the clearest indication and the most reliable long-term integrator of the effects of urban stormwater discharges,. although it should be remembered that sediment quality has a slow response to management changes. Current long term monitoring has demonstrated that there is a sediment quality problem in the Auckland region. (see Box D Present Status of Auckland Marine Sediments).

Box D: Present Status of Auckland Marine Sediments

At present ANZECC ISQG-low guidelines are exceeded in some Auckland estuarine sediments as follows, Williamson & Mills (2001).

Guidelines for heavy metals (Zn, Pb and Cu) are sometimes exceeded in sediments in sheltered muddy settling area (SZ) whose contributing catchment is strongly urbanized (e.g., Pakuranga, Meola Creek).

Guidelines for organic contaminants are exceeded:

- In most places for dieldrin, because the ISQG value is very low, probably close to background levels.
- In some places where there has been a history of industrial pollution or spills, for example the middle reaches of the Tamaki Estuary, Mangere Inlet, Henderson Creek.
- In muddy inner zones of estuaries receiving stormwater from old, predominantly urbanised catchments, for example Motions Creek, Upper Whau.

Target 1: In the Settling Zone, prevent significant adverse toxic effects of sediment-associated toxic contaminants, but allow the possibility of some ecological degradation because of pragmatic reasons (see Box B).

Guideline 1:

The concentrations of contaminants in surficial sediments (to a depth of 20mm), within the Settling Zone are less than the ANZECC (2000) guidelines for "slightly-moderately degraded ecosystems", the Interim Sediment Quality Guideline-Low (ISQG-Low see Box E ANZECC Sediment Quality Guidelines.).

Note that for the sediment quality guideline the numerical value is a 'trigger' value, because if exceeded, it is a prompt for further investigation. The basis for site assessment in the ANZECC Guideline is a risk-based decision tree (Box F) that progresses through a hierarchy of measurements of increasing complexity to reach a decision as to whether the sediment concentrations are likely to be toxic or not, the final arbitration being toxicity tests.

Box E: ANZECC sediment quality guidelines

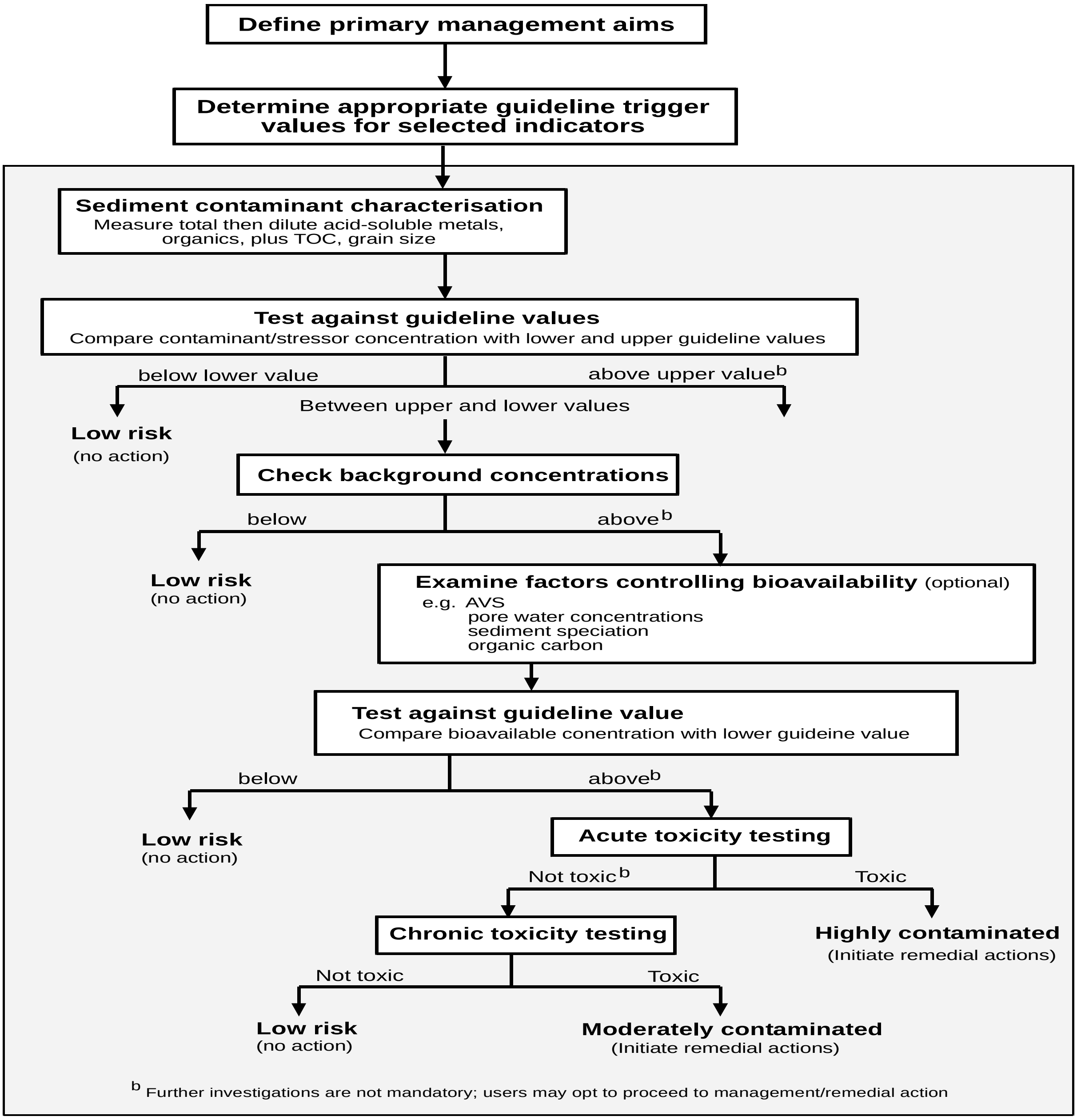
The ARC recognises that there is an allowance for some degradation of Settling Zones because these areas are strongly affected by land runoff, are very muddy with low biodiversity and mostly robust animals, and this is reflected in the respective Environmental Target.

The current ISQG-Low and the accompanying decision tree are designed to ensure that there is a low probability of situations where "guideline exceeded but sediment not toxic". (The apparent ambiguity "guideline exceeded but sediment not toxic" arises because of the uncertainty associated with toxicity assessment and derivation of guidelines). However, this could result in the possibility of "sediment toxic to some animals but guideline not exceeded".

The ANZECC ISQG-Low therefore offers a measure of protection but allows for the possibility of some ecological degradation, which is consistent with RMA and the Environmental Target for the Settling Zone and with the ANZECC philosophy of these trigger values being for "slightly-moderately degraded ecosystems". The ANZECC ISQG-Low is not completely protective because the final arbitrator in the decision tree is toxicity testing, and at present, there are only 3 toxicity test organisms available for sediment testing. If after following the risk-based decision tree, a toxic response is encountered, it is highly likely that the sediments will have an adverse ecological effect. However, if a non-toxic response is encountered, there is no surety that adverse ecological effects will not occur. Therefore the present level of ecosystem protection from sediment toxicity testing is not high.

The default values given in the ANZECC Guidelines were sometimes amended to suit local conditions and information. This is general agreement with ANZECC philosophy to develop local guidelines.

Box F: The decision tree used in the ANZECC guidelines to determine whether or not sediments are toxic (reproduced from ANZECC 2000)



Target 2:

In the Outer Zone, prevent any significant ecological effect of sediment-associated toxic contaminants.

Guideline 2:

The concentrations of contaminants in surficial sediments (to a depth of 20mm) of Outer Zones, will comply with specifically developed sediment quality guidelines.

For the Outer Zones, the Environmental Targets seek to prevent any ecological effect. These environments are much more sensitive to degradation than Settling Zones, and are more remote from sources so arguments for partial degradation based on pragmatism do not apply. Consequently more stringent guidelines are required. They are usually much larger areas, and are generally seen to be more important. The results of the Benthic Invertebrate Scoping Survey (Anderson et al 2002) indicate that adverse ecological effects can be observed even though concentrations of contaminants are less than ISQG-low values for these ecosystems. Therefore the ANZECC approach, which is based on the laboratory toxicity of whole sediments, does not provide adequate ecosystem protection.

Consequently, a specific set of guidelines will need to be developed for sediment quality in Outer Zones. Williamson & Mills (2001), on the basis of currently available information, tentatively recommended trigger values that are based on the concentrations of contaminants in the mud fraction, rather than the whole sediment. This is discussed fully in their report. The rationale for using the mud fraction is summarised in Box G, Sediment Quality Guidelines for the Outer Zone.

Box G: Sediment Quality Guidelines for the Outer Zone

(Summarised from "Sediment Quality Guidelines for Regional Discharges Project", Williamson & Mills, 2001)

For the Outer Zone, where Environmental Targets do not allow any environmental degradation, much more stringent criteria are required. Therefore the ANZECC approach, which is based on the laboratory toxicity of whole sediments, is not adequately protective. In this report Williamson & Mills (2001) examined the possibility of having trigger values that are based on concentrations in the mud fraction rather than in the whole sediment. This proposal is based on the following reasoning:

The fine fraction is the most ecologically important component of sediments, since it is more likely that benthic animals will ingest or be in intimate contact with fine rather than coarse materials

Sandy areas are likely to contain more pollution-sensitive organisms than muddy areas.

The mud fraction of the OZ sediments is roughly equivalent to the 'total' sediment in muddy areas of the OZ. So in sheltered areas (see Green et al. 2001), the ISQG-low of the mud fraction approximately equates to the ISQG-Low for the total sediment.

If toxicity to benthic organisms in the OZ is due to ingestion of mud particles, then such a trigger value is sensible.

Sandy sediments have a lower capacity to bind heavy metals and organic contaminants, because of smaller specific surface areas, and lower concentrations of adsorbing phases iron oxide (FeOOH), acid volatile sulphides (AVS), and organic matter.

Sandy sediments contain few stable burrows (at least in the Auckland region) and there is less irrigative flushing of sediments. While permeability is relatively high in sandy sediments, movement of interstitial water is slow

There are definite advantages in using the mud fraction where there are large changes in sediment texture, as occurs in the OZ. This greatly simplifies monitoring (Williamson & Green 2001).

A guideline based on the mud fraction is probably not feasible for sandy sediments with low mud content (<5%) because of uncertainty and complexities associated with the nature of the fine material in such sediments (e.g., high algal proportion) and how chemical contaminants interact with these materials.

For these reasons then, using the ISQG-low in the mud faction as a Target Value for the OZ could be appropriately protective for these ecologically sensitive areas, and such a precautionary approach should be taken until the many uncertainties about the ecological effects of low levels of contaminants in such environments are resolved.

Application of this Guideline would require separation and measurement of metals in the mud fraction. For organics, however, because trigger values are calculated from the organic carbon content, this step in unnecessary and analysis is made on the whole sample. The lower organic content in sandy sediments effectively lowers the trigger value for organic contaminants for the OZ. Conversely, the higher organic content in muddy sediment increases the trigger value.

5.2 Benthic ecology

As discussed in section 5.1 sediment quality is a reliable long-term integrator of the effects of stormwater discharges and subsequent effects of management strategies in the Settling Zones and the Outer Zones. Benthic ecology enables us to look at the effects of contaminants in these zones on community 'health' and assign the site to green, amber and red, so that scores for sediment quality and ecology at the same location can be compared. The location of ecological monitoring sites is based on a specific protocol outlined below and described more fully in the 'Blueprint' report. The purpose of the 'healthy community model' is set out below.

Target 1: Within the Settling Zone

To maintain healthy communities of benthic organisms within estuarine Settling Zones.

Guideline 1: Settling Zone

A "healthy community model" for areas within settling zones has been developed, based on data obtained from case studies of community structure in receiving environments with both intensively urbanised and undeveloped catchments.

Target 2: Outer Zones

To maintain healthy communities of benthic organisms within Outer Zone receiving environments.

Guideline 2: Outer Zones

A "healthy community model" for areas within Outer Zones has been developed, based on data obtained from case studies of community structure in receiving environments with both intensively urbanised and undeveloped catchments.

The "Healthy Community Model" (Assessment of Ecosystem Health)

The measurement of the current condition of benthic ecology and the monitoring of change over time requires reliable criteria that enable the location of particular benthic invertebrate community on a pollution gradient. In the past various metrics such as abundance, diversity and summary indexes have been used. However, these indicators are comparatively insensitive to changes in composition of the communities. This is a particular problem where there is natural variability and small differences between some of the community conditions of interest. This could well be the case when attempting to detect improvements in benthic ecology following improvements in stormwater treatment.

NIWA and University of Auckland have developed new criteria for urban coastal marine areas which allows the identification of a gradient of 'healthy' v 'polluted' communities of benthic organisms. They have used a new multivariate analysis over a range of biological and environmental variables from estuarine receiving environment data sets held by ARC and other regional agencies. The analyses have been able to usefully determine differences between communities found in healthy and polluted sites. This model will form the operational basis of the guideline for benthic ecology (see Box H).

Box H: Healthy Community Model

Community structure and changes in community structure through time were assessed using modern multivariate techniques initially developed in the late 1970's and 80's for terrestrial vegetation, but further developed by Anderson, Hewitt and Thrush (2002). These analyses enable assessment of existing status and detection of changes in community structure, by reference to a baseline condition defined by numerically ranking sites from 'clean' to 'grubby' in the Inner and Outer Zone receiving environments.

Results suggest that there is a significant pollution gradient between sites and a model of ecosystem health can be constructed for estuaries. New observations of fauna can be placed in this model, and they can be assessed for their relative 'health' along the gradient. A further study is needed to test the method for open coastal receiving environments.

Detailed testing of key assumptions and consideration of potential confounding factors showed:

- Spatial and temporal scale.

Although the size of variation in community structure through time and space is relatively large, the direction of community changes along the pollution gradient was distinctive. Importantly, this means that the status of a particular site or estuary can be assessed on an ongoing basis for monitoring through time using the gradient model.

- Sample (replicate) numbers

The work to date had included many data sets where sample size was small (n=3). Although the model using n=3 is less precise, it is not biased in any way and can be used in the first instance to create the model. Increasing the sample size would enhance the model, most particularly by increasing its classification accuracy and precision, by using at least 7 replicates, with n=12 being preferable.

- Optimizing for subsets of species and taxa.

It is possible that the pollution gradient can be characterised by changes in certain subsets of the assemblages and that not all the taxa need to be included in the model. In fact including extra variables may increase 'noise' and make the 'signals' harder to detect. Several types of subsets of taxa gave results nearly as accurate as those obtained using the full data set. However, optimization of the model for subsets of species and taxa requires further study.

- Removing effects of natural gradient in salinity and sediment composition.

Distinctive pollution gradients remained after statistical elimination of these confounding factors. Thus, the presence of these covariates does not jeopardize the utility of the pollution gradient model.

- Regional data

The power of the analyses can be improved by splitting the data set into discrete harbours and estuaries. For example, analysis of the Waitemata estuarine data alone reduced variability by 30%.

Results for the assessment phase monitoring and subsequent monitoring visits can be translated into 'traffic light' grades for a site. It would be possible to assign a condition to a site and an indication of which direction the site is moving over time. For example a site in 2002 might be green (healthy) then following land use change, future monitoring of sediment chemistry and ecology might show that this site moves to amber. This would be a signal that the sediments and community structure are responding to increased contaminant loads and that localised infrastructure upgrades are required.

5.3 Water Quality

Water quality samples will be collected as part of the assessment of a Settling Zone or Outer Zone. Because water quality provides a snapshot of receiving environment health and is often event related these samples will be limited to dissolved oxygen, ammonia, zinc and copper. Water quality could be used to help identify sources of contaminants should a site score amber or red for sediment quality and ecology.

5.3.1 Dissolved Oxygen

Target: To maintain dissolved oxygen at sufficiently high concentration to prevent significant adverse effects on marine organisms.

Guideline: The receiving environment average dissolved oxygen concentration for all samples except the bottom samples(within 0.5m of depth), is to remain above 80% saturation at all times. At any single sampling station the depth averaged DO saturation will remain above 65% at all times, and the average bottom sample DO saturation in the sediment deposition areas is to be above 65% at all times.

5.3.2 Toxic Substances in Water

Target: To prevent significant adverse toxic effects on urban coastal area aquatic organisms.

Guideline 1: The ANZECC water quality guidelines for toxic substances are not to be exceeded for local receiving environment depth averaged samples taken about the time of half-tide falling. Consideration of density stratification effects will need to be made in estuaries. Total ammonia (NH_4 –N), zinc (Zn) and copper (Cu) are the three key indicators most likely to exceed water quality guidelines in marine receiving environments.

Note that the ANZECC Guidelines (2000) for toxicants in water are not "pass/fail" numbers but a risk-based decision tree. The first step in this assessment is to compare concentrations with numerical trigger values. If concentrations exceed these trigger values then further investigations are made to determine whether the sample is likely to be toxic or not. This involves assessments of bioavailability and ultimately toxicity tests to laboratory organisms.

For total ammonia toxicity, temperature, salinity and pH data must be measured on site.

For copper and zinc an initial scoping study to determine the likelihood that concentrations of copper and zinc in urban coastal receiving environments will exceed water quality guidelines is recommended. This would consist of sampling a representative set of marine receiving environments, including those with intensively urbanised, and unurbanised catchments as described in the 'Blueprint' report. Existing published data as well as data currently being collected under existing consents and consent applications will also be consulted. Requirements for ongoing monitoring would be defined after completion of the scoping study.

5.4 Human Use and Value Targets and Guidelines

5.4.1 Contact Recreation

Target: To provide conditions for contact recreation in all urban coastal marine areas that comply with health guidelines as measured by the suitably for recreation grade..

Guideline: The Ministry for the Environment/Ministry of Health Guideline (Draft October 2001), Suitability for Recreation beach grades may be undertaken by Local Authorities for all urban coastal marine waters that are used for recreational purposes. Guideline Bathing beach grades are Very good, Good, Fair, Poor and Very poor.

The beach grading system ranges from "very good" to "very poor" and the risk of becoming sick from swimming at these beaches increases as the Suitability for Recreation Grade decreases. It is recommended that weekly monitoring be carried out across the year for the middle range bathing beaches with beach grades Good, Fair and Poor. On most occasions the Good beaches will comply with the guidelines but occasions such as high rainfall increase the risk of contamination levels from stormwater runoff. Ongoing microbiological monitoring should be carried out for Good, Fair and Poor beaches. If one sample exceeds 277 enterococci/100mL then a second sample must be collected within 24 hours as in the Action box below.

The box below sets out how the monitoring results are interpreted as surveillance, alert and action modes (green, amber and red analogous to traffic lights).

- SURVEILLANCE/GREEN MODE: No single sample greater than 136 enterococci/100 mL.
  - Continue routine (e.g. weekly) monitoring.
- ALERT/AMBER MODE: Single sample greater than 136 enterococci/100 mL
  - Increase sampling to daily. (Initial samples will be used to confirm if a problem exists.)
  - Consult CAC to assist in identifying possible sources.
  - Undertake a sanitary survey, identify sources of contamination.
- ACTION/RED MODE: Two consecutive single samples (resample within 24 hours of receiving the first sample results, or as soon as is practicable,) greater than 277 enterococci/100 mL.
  - Increase sampling to daily. (Initial samples will be used to confirm if a problem exists.)
  - Consult CAC to assist in identifying possible sources
  - Undertake a sanitary survey, identify sources of contamination.
  - Erect warning signs.
  - Inform public through the media that a public health problem exists.

6 Summary

The urban receiving environment is subjected to stormwater discharges and wastewater inflows.

The consequence of these discharges and overflows is contamination of the urban coastal marine environment.

In some cases this will lead to the deterioration of ecological health of these areas and threats to human health from bathing in these areas. Eating shellfish collected adjacent to urban areas is likely at times to carry a significant health risk.

It is proposed that these discharges and overflows are managed through a responsive, interactive monitoring programme.

Key steps in this programme are monitoring key parameters, comparison with guidelines, assessment of compliance and or appropriate management response.

The key parameters measure sediment quality, benthic ecology, water quality and human health.

The programme has adopted a number of tools to aid the assessment process:

Guidelines are formulated in terms of a compliance rating protocol analogous to traffic lights where green means "no problem", amber means "on watch" and red means remediation required.

Division of the urban coastal environments into Settling and Outer Zones

Prediction of future levels of contamination in receiving environments.

Details of the proposed monitoring programme will be presented in the "Blueprint for Monitoring Urban Coastal Receiving Environments".ARC, TP 168.

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