Identification of degraded marine receiving environments – Draft Report

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1.0 Introduction

Degraded areas were identified on the basis of three measures of ecosystem health and one relating to human health, using data from existing region wide monitoring programmes.

- Marine Water Quality: Monitors marine quality water in Auckland's harbours, estuaries and at open coastal areas
- Sediment Contamination: monitors the concentrations of contaminants in marine sediments in Auckland's harbours and estuaries
- Benthic Health: monitors soft sediment communities and uses information from the Sediment Contamination program to assess the ecological health of Auckland's harbours and estuaries
- Bathing Beach Water Quality: monitors the concentration of bacteria at selected Auckland swimming beaches and tidal lagoons to provide a measure of risk to public health

Degraded areas have been identified for each of these programmes separately (detailed later in this summary).This is important as the sources of degradation and management responses for each may be quite different and it is therefore important to have a full understanding of the spatial distribution of scores for each measure.

An overall degraded areas map was created using the three ecosystem measures (marine water quality, sediment contamination and benthic health). Where an area was identified as degraded for any one of the above three measures, it was designated as degraded. Bathing beach water quality was not included in the overall assessment as this measure relates to human health rather than ecosystem health. Discharges affecting bathing beach water quality are best addressed through consideration of the infrastructure network. This is because the source of bathing beach degradation relates to waste-water and storm-water infrastructure. In comparison the three ecosystem health measures are also affected by diffuse discharges from a range of different land uses, as well as direct impacts such as dredging. In addition to the measures of ecosystem health used, a layer showing existing marinas and ports was also used to designate areas as degraded, as there is a large body of evidence to support this from research and consent monitoring in these areas.

On both the individual and overall maps, areas are shown as both 'Degraded 1' (solid fill) and 'Degraded 2' (hashed fill). **Degraded 1** areas, are those areas where monitoring data shows a high level of degradation, or that we can identify with high certainty. **Degraded 2**

areas are those areas where monitoring data shows a moderate level of degradation, or that we can identify with a reasonable certainty. This distinction is shown to provide clarity and transparency to the process.

However, the recommendation is that 'Degraded 1' and 'Degraded 2' areas are amalgamated. Firstly, because in most areas the division occurs partway along a receiving environment (e.g. an estuary) and addressing the issue would likely require a whole of catchment approach anyway. Also, marine systems are open and connected so degradation levels in a 'Degraded 1'area are likely to extend out into the 'Degraded 2' areas over time, increasing their level of degradation. That is, there will be an expansion of the footprint of effect over time. Secondly, from a precautionary approach, while 'Degraded 2' areas may have a lower current level of degradation, unless they are addressed now they are likely to continue to degrade over time. Furthermore, there is substantial evidence that even 'moderate' levels of degradation can result in detectable ecosystem level changes, and it is not yet known how reversible these changes might be, particularly if these areas continue to be put under further stress.

The degraded status relates only to the state of the receiving environment as measured by monitoring data. It does not imply a ranking of degradation or priority for action. To do this would require further analysis of the issues driving the degraded status, the likely required interventions and the scale, cost and feasibility of those interventions. For example, if an area is identified as having degraded or unhealthy ecology, you would then need to identify the primary driver of that degradation (e.g. sediments or contaminants), identify the source and scale of inputs and then decide what management actions might be put in place to address this. There would then be a further process of assessing the feasibility of those actions, costs and benefits and other catchment priorities.

This exercise only sought to identify degraded areas and did not examine the relative value of the receiving environments, which is a much more complex question. It is therefore extremely important to note that a degraded area designation in no way implies 'no value'. It is entirely possible and likely that degraded areas contain valuable habitats, support important species or form critical connections with other systems.

Globally, our knowledge and understanding of the marine environment is incomplete and while locally our knowledge of the marine environment and understanding of ecological processes has increased substantially through monitoring and research carried out by the Auckland Council (and formally Auckland Regional Council) and other agencies and institutions, our knowledge is still incomplete and many areas of the Auckland region remain unsurveyed and unstudied. The inherent complexity of Auckland's marine environment makes it very difficult to generalise across the region. Monitoring has focused around harbours and estuaries as these are where the majority of issues related to land management are felt, due to their proximity to the source and also the way in which

they function to trap and store sediments and contaminants. There are some areas for which monitoring data does not exist, and so these areas have not currently been identified as degraded, particularly as you move out onto more exposed coasts and to open coastal waters. A fuller assessment using expert opinion and other sources of data could be undertaken to further grade these areas, however, it is likely that the most degraded areas have been sufficiently captured by the current monitoring data.

2.0 Identification of individual measures

2.1 Marine Water Quality

The marine water quality programme monitors contaminants associated with erosion, nutrients and biological wastes in the water column. Marine water quality is sampled at each of 40 sites every month near the high tide. A two litre water sample is collected at each site and is used to represent the ambient water quality conditions at each site at a single point in time. Only after a minimum of five years of continuous sampling can trends in water quality be determined. Nineteen water quality parameters are measured at each site. Degraded areas were identified using seven of these 19 variables. The seven variables include; dissolved oxygen, pH, turbidity (or water clarity), suspended sediment, total phosphorus, ammonia, nitrate nitrite and chlorophyll a. The chosen variables principally describe water clarity and appearance, nutrient status, biological productivity (in response to nutrient inputs) and physical conditions important for supporting aquatic life. Furthermore, the data used to identify these degraded areas are based on three years of the most recent data (2010, 2011 and 2012) and have been ranked on a four point scale (excellent, good, fair and poor) using a water quality index developed by the Canadian Council of Ministers for the Environment (CCME 2001). For the purpose of identifying degraded areas the lowest two categories (fair and poor) have been used to define a degraded state. 'Degraded 1' areas were designated using sites that have been consistently graded as either fair or poor. Where sites display variability in water quality and oscillate between a good and fair ranking, there areas were classified as 'Degraded 2'. These oscillating sites tend to be near the mouths of our large harbours.

Water quality can vary over a range of spatial and temporal scales. Therefore, monitoring water quality can be difficult and without multiple sites to cover a stretch of coastline or Harbour coupled with long term sampling, such information is limited. This is not the case for Auckland which has a long term and well establish marine water quality program which has collected a considerable amount of data, especially in the near shore environment. However, due to the vast expanse of Auckland's marine area there are still large stretches of water that are not currently monitored. As a consequence, generalisations have been made in areas where there is no data is available by using information from the nearest monitored site.

The marine water quality program is not event based i.e. it does not capture large storms. However, the program does capture post storm events when storms coincide with the routine sampling timetable.

Patterns in marine water quality are related to hydrodynamic processes and catchment development and associated discharges. The poorest water quality is typically found in

estuaries and harbours that receive discharges from urbanised catchments, for example Tamaki Estuary and parts of the Manukau and Central Waitemata Harbour. More rural catchments with agricultural land use or forestry such as Mahurangi Harbour and Kaipara Harbour are degraded by sediment and nutrient inputs. The best water quality is found at locations that are more exposed to open ocean water currents and have less development or intensive rural land use in their catchments such as East Coast Bays and north of Orewa (Figure 1).

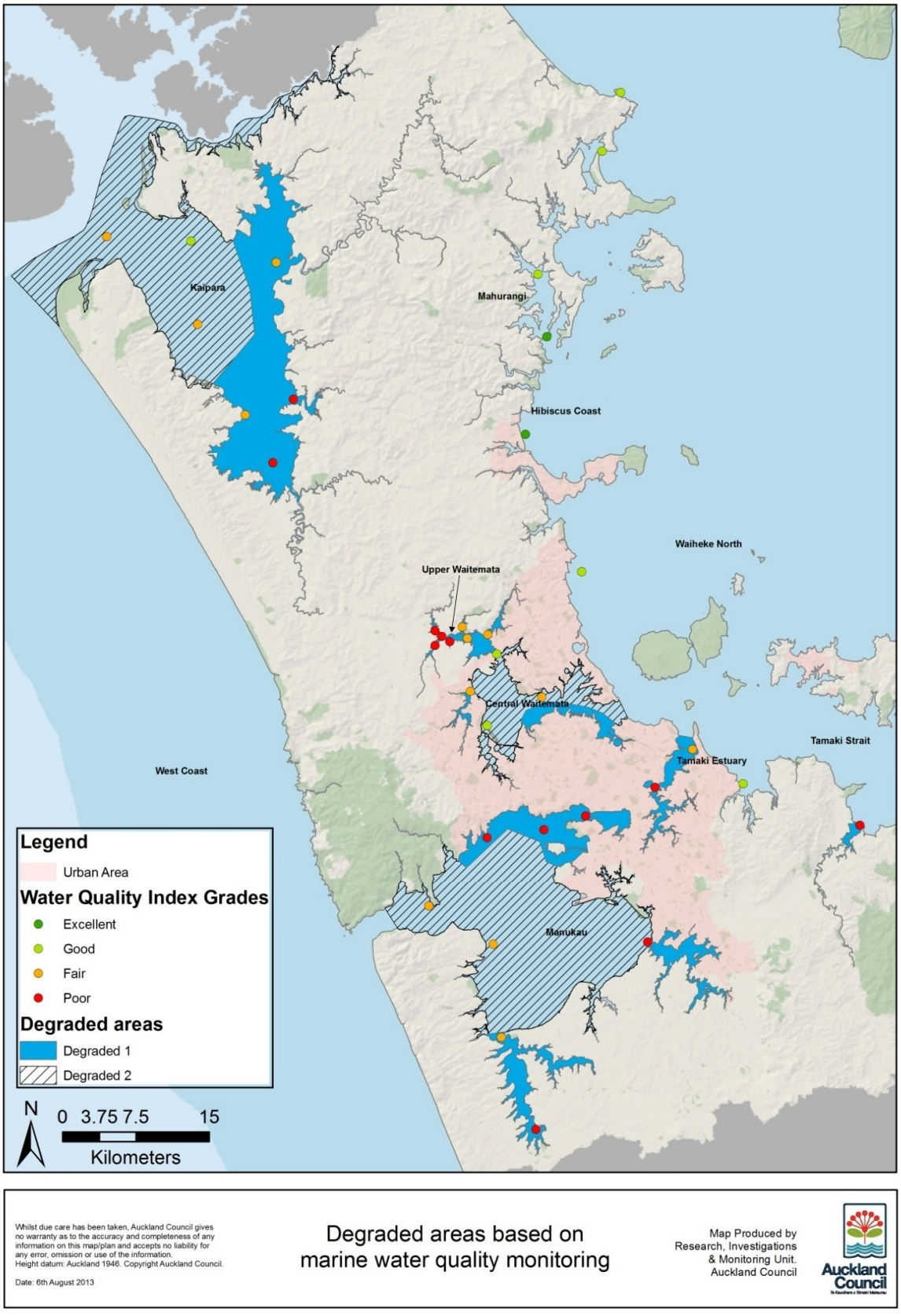

Figure 1 Degraded areas based on marine water quality monitoring (2010-2012)

2.2 Sediment Contaminants

The level of heavy metal and organic contaminants in intertidal marine sediments is monitored across the Auckland region. The Environmental Response Criteria (ERC) were developed by Auckland Regional Council (now Auckland Council) to provide an Auckland relevant set of criteria to assess whether concentrations of contaminants present in receiving-water sediments are likely to result in adverse environmental effects. The ERC are trigger values, in that breaches are meant to trigger further investigations. They are not pass–fail numbers, but benchmarks for action (ARC 2004).

ERC Green conditions (<TEL) reflect a relatively low level of impact based on an individual contaminant. ERC Amber (>TEL but <ERL) conditions reflect contamination above a level at which adverse effects on benthic ecology may begin to show (the TEL). ERC Red conditions (>ERL) reflect conditions where significant degradation has probably already occurred (see ARC 2004 for further explanation).

While the guidelines outlined above are useful for assessing the effects of individual contaminants they do not take into account the cumulative effect of multiple contaminants or other stressors present at the same time (Thrush et al 2008), so it is still entirely possible for ecological health to be affected under ERC green conditions (Hewitt et al. 2009). Therefore contaminants in sediment provide a relative comparison of the levels of pollution among sites rather than a definitive measure of effect. On this basis, areas containing sites with either red or amber conditions were classified as degraded, where areas with ERC red sites or a high number of ERC amber sites were classified as ‘Degraded 1’ and areas with some ERC amber sites were classified as ‘Degraded 2’ (Figure 2). The Cheltenham Beach site (ERC amber) has been classified as Degraded 2 rather than Degraded 1, as its amber status is based only on polycyclic aromatic hydrocarbon (PAH) data, for which there is less certainty.

The distribution of heavy metals and organic contaminants follows a well-described spatial pattern in Auckland. Highest concentrations are generally found in estuaries receiving runoff from the older, intensively urbanised and/or industrialised catchments, particularly in the Tamaki Estuary, Mangere Inlet and the Waitemata Harbour (Figure 2). Lowest concentrations are found in rural/forested catchment estuaries, and on open coastal beaches (Mills et al. 2012).

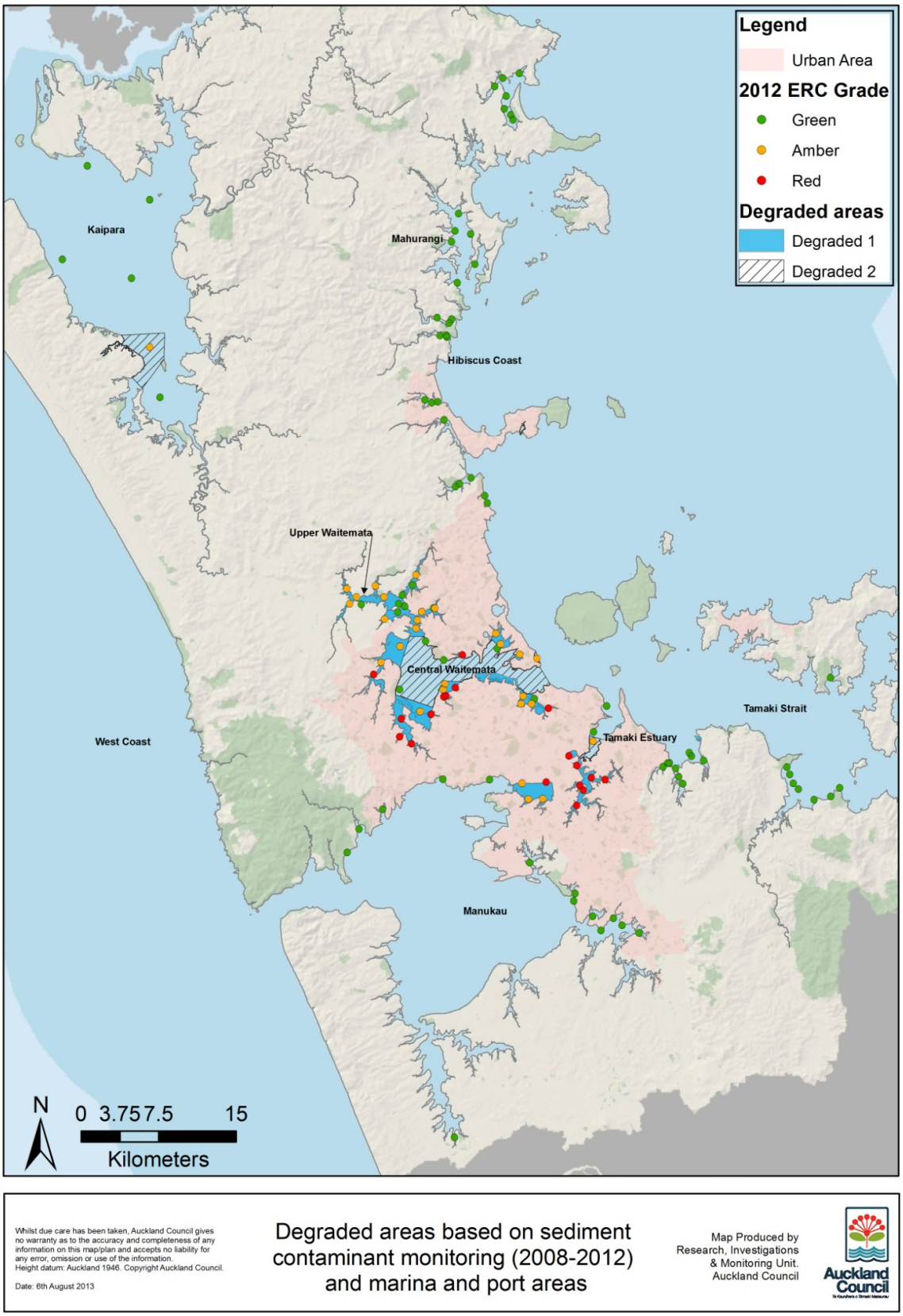

Figure 2 Degraded areas based on sediment contaminant monitoring (2008-2012) and marina and port areas

2.3 Benthic Ecological Health

The benthic health groups are derived from the Benthic Health Model (BHM) which provides a means to assess intertidal sites on a regional basis according to categories of relative ecosystem health, based on community composition and predicted responses to stormwater contamination (BHMmetals), or muddiness (BHMmud) (Hewitt and Ellis 2010). Benthic health is grouped along a five point scale with 1 being healthy and 5 being polluted (either by sediments or contaminants).

For the purposes of classifying degraded areas, both the benthic health group for metals and mud were calculated. Where these groups differed for a site, a precautionary approach was taken and the lowest group (most degraded) was used to produce one benthic health group. For the smaller east coast estuaries (Whangateau, Wairewa, Orewa, Okura, Mangemangeroa, Turanga and Waikopua), only the mud grade was used as the benthic health model (metals) is a poor fit for these areas and metals are at very low or non detectable levels in these estuaries.

While sites in benthic health groups 1 or 2 can be considered healthy, changes in community structure can begin to be detected within these groups. Furthermore, recent work on the development and implementation of a functional traits based indicator (TBI) suggests that the resilience of an ecosystem becomes compromised around benthic health group 4 and that very little if any resilience to further stressors is left in the system once benthic health group 5 is reached (Lohrer and Rodil 2011). Therefore, from the perspective of resilience, benthic health scores of 4 and 5 should be avoided, especially group 5. As an ecosystem becomes more degraded it is also likely to become more difficult to restore that environment, a phenomenon termed restoration hysteresis (Hewitt, et al. 2009). Therefore, benthic health group 3 should be considered as an important group with respect to protection and potential remedial management action. On this basis areas containing sites within groups 5 and 4 were identified as ‘Degraded 1’, while areas containing sites within group 3 were identified as ‘Degraded 2’ (Figure 3).

As with the sediment contaminants, benthic health follows a fairly well defined spatial pattern in Auckland. The worst benthic health groups (4 and 5) are generally found in estuaries receiving runoff from the older, intensively urbanised and/or industrialised catchments, particularly in the Tamaki Estuary, Mangere Inlet and the Waitemata Harbour (Figure 3). However, unlike sediment contaminants and water quality, the benthic health model detects a degree of degradation in all of the smaller east coast estuaries (e.g. Okura and Mangemangeroa) which is likely related to the high sediment accumulation rates in these estuaries which is a function of their size and shape but also reflects historic and ongoing land disturbance from rural activities in their catchments (Figure 3).

It is of note, that despite Whangateau Harbour routinely being described as a ‘pristine’ estuary it is also classified as a ‘Degraded 2’ area, due to there being a number of monitoring sites with ‘moderate’ ecosystem health. This reflects the fact that truly pristine environments in Auckland are extremely rare and its ‘pristine’ status is more of a relative status when compared to other east coast estuaries – all of which include monitoring sites in groups 4 or 5.

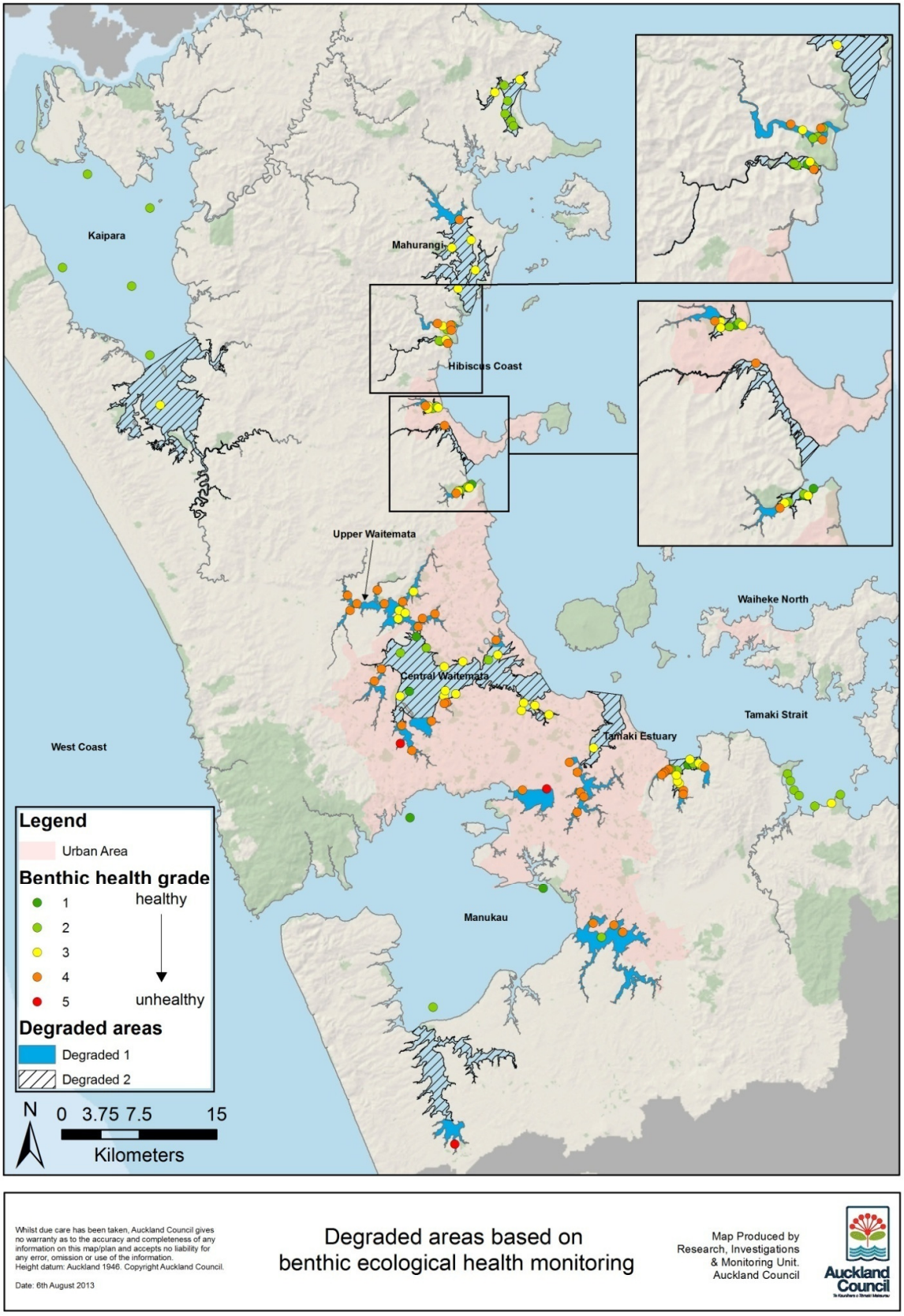

Figure 3 Degraded areas based on benthic ecological health monitoring (2009-2012)

2.4 Bathing Beach Water Quality

For the identification of degraded areas bathing beach data from the 2012-13 bathing beach water quality program (reported as SafeSwim) was analysed. Data was selected from sampling information for 65 beaches and 4 lagoons to identify marine degraded areas. The bathing beach monitoring program operates only during the summer months (November to April). A single water sample is collected at each beach every week and analysed for a single indicator bacterium (enterococci). This typically results in 20 samples for each beach. However, the number of samples per beach can increase when follow up water samples are required, which occurs when the initial water quality results exceed the Ministry for the Environment recreational guidelines for water quality. Therefore, the bathing beach monitoring program only monitors bacterial contamination, which is typically associated with wastewater and stormwater discharges near recreational marine areas.

To identify degraded areas the Ministry for the Environment microbiology assessment criteria (MAC) was calculated to categorise beaches into a four point scale (A, B, C and D) this was then changed to the same grading system used for the Marine water quality data (as discussed above). The bathing beach monitoring program is not event based i.e. it does not capture large storms. However, the program does capture post storm events when storms coincide with the routine sampling time table.

Patterns in bathing beach water quality are related to rainfall and the condition of and type of network (stormwater, wastewater or combined) found in the surrounding catchment. The poorest bathing beach water quality is typically found at beaches that are influenced by urbanised areas that have older network infrastructure. The best water quality is found at locations that are more exposed to open ocean water currents and have less development in their catchments, or have received upgrades to the network infrastructure (Figure 4).

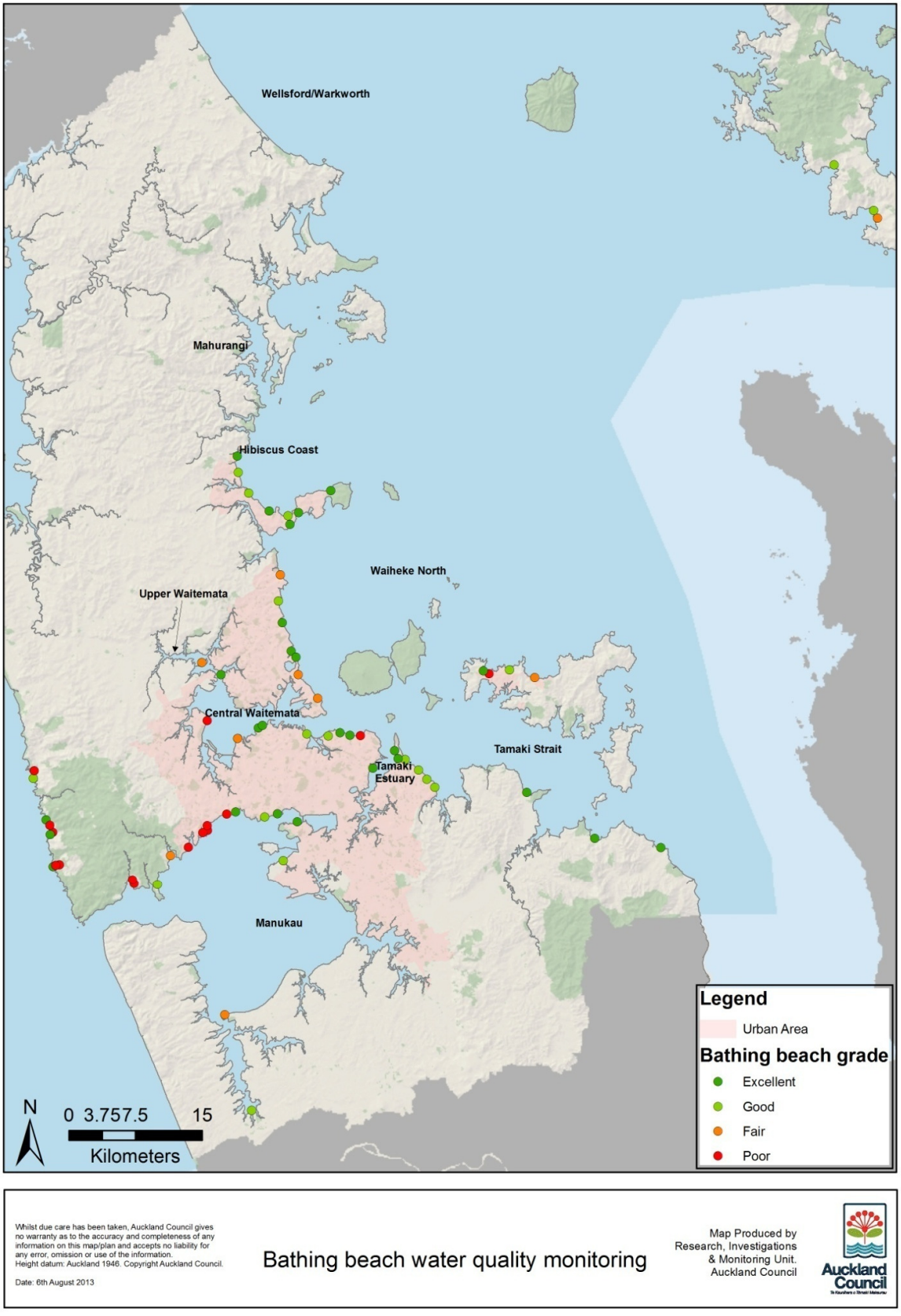

Figure 4 Bathing beach water quality monitoring (2012-13 season)

2.5 Marina and port areas

Marinas and ports are particularly impacted by the use of antifouling paints and other vessel related contaminants as well as often receiving inputs of urban stormwater. Furthermore, ports and marinas are often subjected to high sedimentation rates created by their enclosed environment and as a result are often dredged.

There is a large body of evidence from research projects and consent monitoring in port and marina areas to support the classification of these areas as 'degraded' (e.g. Gadd and Cameron 2012, Williamson et al. 1995). Therefore, where contaminant and sedimentation levels were known to be high, or significant dredging occurs, these areas were classified as 'Degraded 1'. This resulted in all sites except Bayswater and Gulf Harbour marinas being classified as 'Degraded 1'. For Bayswater and Gulf Harbour marinas contaminant levels were either more moderate or less information was available, and therefore these marinas were classified as 'Degraded 2' (Figure 2).

3.0 Overall Degraded Areas Identification

An overall degraded areas map was created using the three ecosystem measures (marine water quality, sediment contaminants, benthic health) as well as known ports and marinas. If an area was degraded for any one of these measures, it was designated as degraded (Figure 5). Bathing beach water quality was not included in the overall assessment as the measurement relates to human health, rather than the three ecosystem health measures and is best dealt with through infrastructure and network discharge considerations. "Degraded 1' areas (filled), are those areas where monitoring data shows a high level of degradation, or that we can identify with high certainty. 'Degraded 2' areas (hashed), are those areas where monitoring data shows a moderate level of degradation, or that we can identify with reasonable certainty. The degraded areas identified for each of the ecological measures were merged and the outer-most line was used.

As noted in the introduction, the identification of degraded areas was based on monitoring data and known ports and marinas. There are large areas of the Auckland region where we do not have monitoring data and these areas were therefore not graded. In general, all enclosed estuaries and harbours around mainland Auckland were graded (except Matakana Estuary), while the open waters of the Hauraki Gulf, Tamaki Strait and areas around offshore islands were not. Grading of these areas could be undertaken as a separate exercise using other sources of data (e.g. modeling or special surveys).

However, the monitoring data is likely to have covered the most degraded areas of Auckland. This is reinforced by the fact that all areas covered by monitoring data, except Wairoa Bay, were classified as either 'Degraded 1' or 'Degraded 2' areas. Intertidal monitoring data for Wairoa Bay grouped the ecology as 2 (good). However information from subtidal surveys suggests that the subtidal area is highly impacted by sediment (Lohrer et al. 2012) so this designation could be revised.

Overall, the distribution of 'Degraded 1' and 'Degraded 2' areas follows the spatial pattern that we would expect, with the most degraded areas generally found in estuaries receiving runoff from the older, intensively urbanised and/or industrialised catchments, particularly in the Tamaki Estuary, and the tidal arms of the Manukau Harbour (particularly Mangere Inlet) and the Waitemata Harbour. Other degraded areas receive runoff from intensive agricultural or forestry catchments such as in the southern parts of the Kaipara and Manukau Harbours and in the upper part of Mahurangi Estuary. The main bodies or central parts of the Manukau, Waitemata and Kaipara Harbours tend to be less degraded due to their size and natural flushing, whereas estuaries and tidal arms tend to act as natural traps for sediments and contaminants.

This exercise sought only to identify degraded areas and did not examine the relative value of the receiving environments, which is a much more complex question. It is therefore extremely important to note that a degraded area designation in no way implies 'no value'. It is entirely possible and likely that degraded areas contain valuable habitats, support important species or form critical connections with other systems.

In addition this exercise has looked only at identifying degraded areas, not at ranking these or determining priorities for catchment management or restoration potential. To do this would require further analysis of the issues driving the degraded status, the likely required interventions and the scale, cost and feasibility of those interventions.

Potentially, by looking at both the BHMmetals and BHMmud values it may be possible to tease out if metals, mud or a combination of the two stressors is driving ecological health. Furthermore, the Traits Based Indicator (TBI) can provide information on what ecological functions remain or have already been compromised. The Traits Based Indicator (TBI) was developed based on the richness of species in seven functional groupings, with changes in index values reflecting potential shifts in ecological resilience (Lohrer and Rodil 2011). In conjunction with the Benthic Health Model, the TBI offers a useful way of assessing some of the elements of ecosystem health in our harbours and estuaries. Therefore, using these three indices together could provide for more targeted management intervention as well as a greater understanding of restoration potential. This approach however requires more research and consideration than the current timeframes allow.

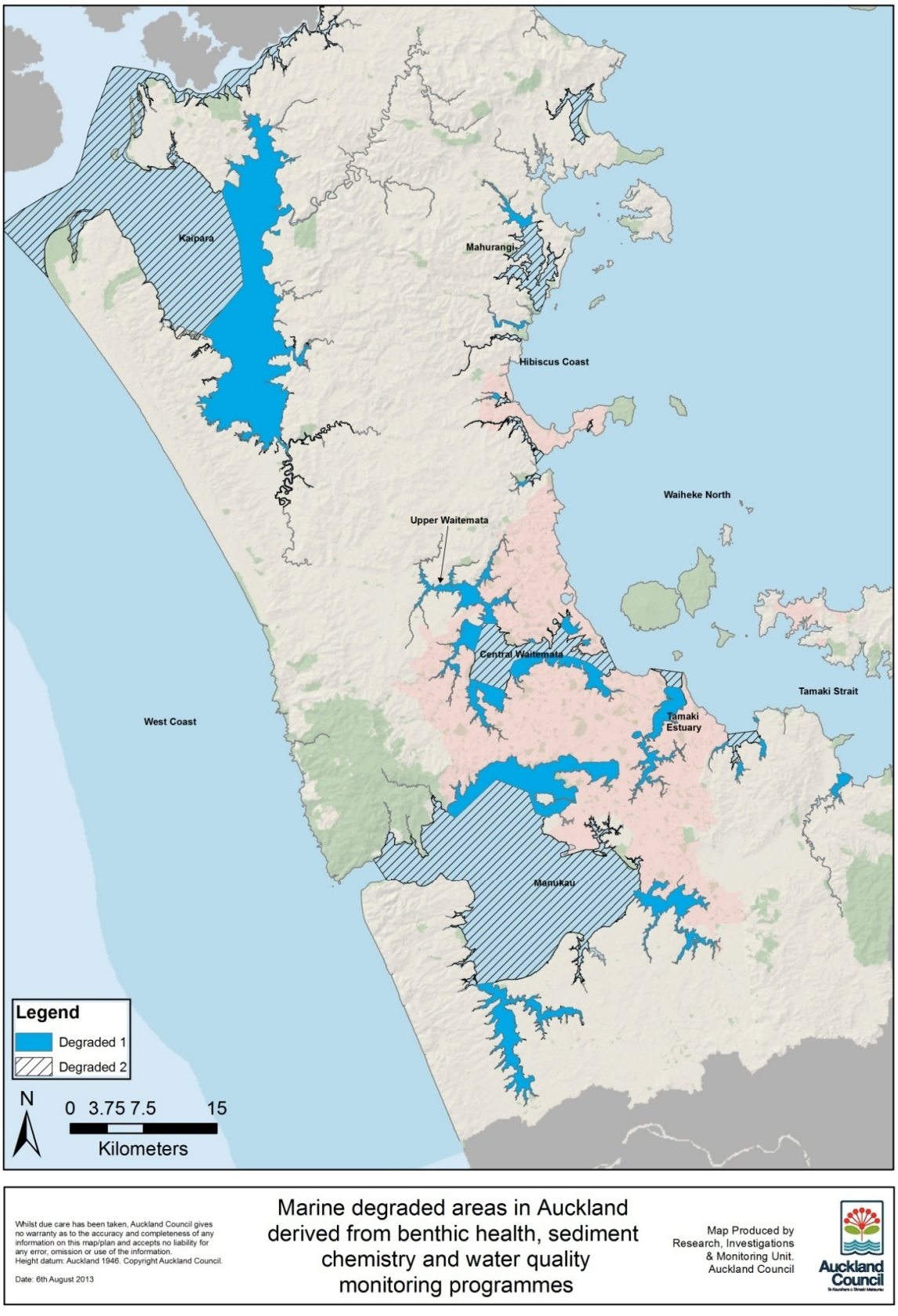

Figure 5 Marine degraded areas in Auckland

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