Updating the Methodology Used to Calculate Overall Water Quality Scores at Marine Water Quality Sites in the Auckland Region

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RIMU Research and Evaluation Unit

Auckland Council
Te Kaunihera o Tāmaki Makaurau

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Executive summary

Auckland Council (and Auckland Regional Council prior to 2010) has been reporting overall water quality scores since 2007 using the water quality index (WQI) developed by the Canadian Council of Ministers of the Environment. Prior to the use of this index, water quality was reported using individual parameters. As individual parameters can show different trends (some increasing, some decreasing), it can be difficult to interpret what the overall state of water quality is.

The WQI index helps to simplify communications around water quality by providing a single score for overall water quality that takes into account fluctuations in individual parameters. It also provides one simple metric for communication of water quality state and changes to a wide audience. Methods for calculating the WQI have evolved over time. Standardising how the WQI score is calculated is important for assessing water quality against static guidelines, as well as for analysing water quality trends in the Auckland region.

This report documents how methods for calculating the WQI have changed over time, proposes new methods for future calculations, and compares the outcomes of both methods. Using the new method does produce some different state results to those reported previously, particularly for open coast sites. However, the overall patterns in water quality generally remain the same. Scores at sites that were in poor condition using the previous methods stayed in the poor category with the new method although scores declined slightly due to more stringent objectives. Sites that were in good to fair condition had broadly similar scores for the two methods between 2014 and 2017.

Using the new method to calculate water quality back to 2007, water quality scores increased across most sites, consistent with the state and trends analysis on individual parameters for this same period of time (Foley et al. 2018).

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1.0 Introduction

An index is a tool frequently used to simplify how we communicate the state or changes in complex systems. There are very few instances in the natural world where one factor determines how an ecosystem is structured or how it will change, so looking at a single factor is generally not a good way to assess current state or predict future changes. An index solves this problem by incorporating multiple factors into a single number or score. Indices are ubiquitous in our lives, including economic, social, and ecological applications. For instance, the NZX and Nasdaq are economic indices used to express the monetary value of multiple companies; the Happiness Index measures social wellbeing of countries around the world (Helliwell et al. 2018); and the Ocean Health Index is used to assess the health of ocean ecosystems based on multiple factors (Halpern et al. 2012).

A water quality index can be used in much the same way to simplify our communications around the health of waterbodies. At Auckland Council, we evaluate water quality by measuring multiple qualities – or parameters – of the water that are important for the health and survival of aquatic plants and animals, as well as for human health. Over time, these parameters often fluctuate and can develop significant trends – sometimes in opposite directions. Changes in one parameter may be good for the ecosystem, while a change in another parameter may be detrimental to the ecosystem. Opposing changes in individual parameters make it difficult to communicate the overall patterns in water quality. A water quality index, therefore, can help us better understand and communicate overall water quality based on the changes in individual parameters.

2.0 The Canadian water quality index

In 2001, the Canadian Council of Ministers of the Environment (CCME) developed a water quality index (WQI) that uses multiple water quality parameters to generate a single water quality score (Neary et al. 2001). The index uses numerical objectives to assess how often (frequency) those objectives are exceeded, how many water quality parameters per sample (scope) exceed those objectives, and by how much those objectives are exceeded (magnitude). By assessing the frequency, scope, and magnitude of exceedance, this index also assesses the cumulative effects[1] of multiple stressors on water quality. The WQI score is calculated as follows:

$$\boldsymbol{F1(scope)} = \left(\frac{Number\ of\ failed\ tests}{Total\ number\ of\ tests}\right) x\ 100$$

$$\boldsymbol{F2\ (frequency)} = \left(\frac{Number\ of\ failed\ tests}{Total\ number\ of\ tests}\right) x\ 100$$

$$\boldsymbol{F3\ (magnitude)} = \left(\frac{nse}{0.1nse + 0.1}\right)$$

where “nse” is the normalised sum of the excursions (or the extent of the exceedance) above or below the objective, yielding a range between 0 and 100.

$$\boldsymbol{CCME\ WQI} = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}\right)$$

where the constant 1.732 is used to bring the resulting WQI score between 0 and 100.

In order to use an index such as the CCME WQI, thresholds or guidelines (also called objectives) for parameters of interest need to be selected so measured values can be assessed against them. Thresholds are often used to regulate activities and are used as triggers for action because harm is likely to occur if they are exceeded (ANZECC 2000). Setting realistic thresholds for water quality requires a lot of data showing how the ecosystem responds to single or multiple stressors. Many ecosystems do not have enough data to set thresholds so guidelines are used instead. Guidelines can be narrative descriptions or numerical values for water quality parameters and are typically used to assess management performance. Most often, guidelines are set to support and maintain designated water uses (e.g., contact recreation, fishing, aquaculture) and/or environmental values (e.g., biological diversity).

[1] Cumulative effects are defined as effects resulting from multiple stressors that overlap in time and/or space.

Guidelines differ from thresholds in that they are used to signal when further investigation is needed to determine if conditions above (or below) objective levels are having ecosystem impacts. Guidelines can also be aspirational and more stringent than thresholds in order to ensure that water quality does not decline over time and designated uses (current and/or future) are maintained.

Defining guidelines for water quality parameters that are non-toxic but still affect aquatic organisms (e.g., sediment and nutrients) is challenging because it can be difficult to measure their biological effect. In addition, there needs to be a buffer around the objectives so that management action can be taken in time to prevent irreversible harm. This buffer should be larger when the consequences of harm are greater than when the consequences of harm are low; when the detection of effect lags behind management action; or when an ecosystem is more sensitive to change than expected. Furthermore, guidelines often incorporate social, cultural, and economic concerns. As a result of these complexities, there are very few numerical objectives for physical and chemical marine water quality parameters around the world.

The Australia and New Zealand Environmental and Conservation Council (ANZECC) published narrative and numeric water quality guidelines for open coast and estuarine waters in Australia and New Zealand in 2000 (Table 1). These guidelines have not been widely used in New Zealand, however, because some were determined in the absence of data from New Zealand sites. To develop guidelines specific to New Zealand, the best approach would be to determine the response of aquatic plants and animals to individual or multiple parameters and set guidelines based on those responses. In the absence of data on biological effects, local reference data can be used to define water quality guidelines.

To define local guidelines for water quality, ANZECC recommended using the 80th percentile value (i.e., 80% of measured values fall below the guideline value) for Condition 2 sites (these are sites defined as having slightly to moderately disturbed ecosystems). The 80th percentile values should ideally be derived from local reference sites so that the guidelines are meaningful and based on conditions that are achievable. Guidelines can be changed over time if necessary if biological effects are occurring when conditions are below the 80th percentile guideline value.

Table 1: Water quality guidelines developed for Southeast Australia and New Zealand by the Australia and New Zealand Environmental and Conservation Council (ANZECC 2000).

Parameter	Marine	Estuary
Chlorophyll-a (mg/L)	0.001	0.004
Total phosphorus (mg/L)	0.025	0.030
Soluble reactive phosphorus (mg/L)	0.010	0.005
Total nitrogen (mg/L)	0.120	0.300
Nitrate + Nitrite (mg/L)	0.005	0.015
Ammonium (mg/L)	0.015	0.015
Dissolved oxygen (% saturation)	90 to 110	80 to 110
pH	8.0 to 8.4	7.0 to 8.5
Turbidity (NTU)	0.5	10

3.0 Auckland Council's historic application of the Canadian water quality index at marine water quality sites

Auckland Council started using the CCME WQI in 2007 to calculate overall water quality at our state of the environment monitoring sites. Because Auckland Council has been collecting water quality data in the region since 1987 at some sites, we had enough data to examine what our water quality guidelines based on local conditions looked like compared to the generic guidelines provided by ANZECC (2000).

However, the timeframe used to define the water quality guidelines for our sites changed over time and the 98th percentile value from reference sites was used to define the guidelines (Table 2), as opposed to the 80th percentile recommended by ANZECC for local guidelines at Condition 2 sites (ANZECC 2000). In 2007 and 2008, data from 2002 to 2006 were used to define the guidelines for the WQI. In 2009, that approach was modified and a rolling five-year timeframe was used to define the guidelines based on values from the highest water quality sites (specific sites used varied year to year) in the Auckland region. At the time of the change, there were concerns that using a static guideline would not capture trends in water quality nor account for improved sensitivity of analytical instruments. These are valid concerns, but defining water quality objectives using different reference sites each year and a rolling five-year average makes it impossible to compare WQI scores from year to year because the baseline is always moving (Table 2).

Table 2. Previous thresholds derived from reference site data in the Auckland region used for calculating the WQI guidelines and WQI score from 2007 to 2016. Chl-a = chlorophyll-a (mg/L); NO_3NO_2 = nitrate + nitrite (mg/L); NH_3NH_4 = ammoniacal nitrogen (mg/L); TP = total phosphorus (mg/L); DO = dissolved oxygen (% saturation); TSS = total suspended solids (mg/L); Turb = turbidity (NTU); Entero = enterococci (CFU/100 mL).

Years	Threshold	Chl-a	NO_3NO_2	NH_3NH_4	TP	DO	pH	TSS	Turb	Entero
2007	98th percentile (2002 to 2006)	0.005	0.068	0.046	0.062	81.40	7.63-8.30	25.0	8.35	140
2008	98th percentile (2002 to 2006)	0.005	0.068	0.046	0.062	81.40	7.63-8.30	25.0	8.35	140
2009	98th percentile (2004 to 2008)	0.006	0.105	0.089	0.062	78.00	7.63-8.20	25.0	7.74	140
2010	98th percentile (2005 to 2009)	0.006	0.080	0.070	0.060	75.00	7.40-8.30	19.6	7.84	140
2011	98th percentile (2006 to 2010)	0.007	0.110	0.062	0.063	82.10	7.48-8.26	25.0	7.84	140
2012	98th percentile (2007 to 2011)	0.006	0.081	0.055	0.059	83.80	7.45-8.47	25.0	7.91	42

Years	Threshold	Chl-a	NO_3NO_2	NH_3NH_4	TP	DO	pH	TSS	Turb	Entero
2011-2013	98th percentile (2008 to 2012)	0.004	0.065	0.051	0.042	85.99	7.50-8.32	18.9	7.81	42
2012-2014	98th percentile (2009 to 2013)	0.005	0.043	0.025	0.038	91.27	7.50-8.40	18.9	7.81	31
2013-2015	98th percentile (2009 to 2014)	0.004	0.042	0.024	0.040	91.84	7.59-8.38	20.0	7.87	42
2014-2016	98th percentile (2011 to 2015)	0.006	0.065	0.023	0.034	92.41	7.73-8.29	23.0	7.60	31

As a result of using shifting guidelines to assess overall water quality, the WQI score appeared to change from year to year at many of our sites (Table 3), largely as an artefact of these moving guideline values, when there was often no actual significant trend in water quality. In some cases, sites went from poor to excellent in a single year (e.g., see Tāmaki site in Table 3). When the guidelines are static, there is still variability in the WQI score over time, but there are fewer fluctuations and they are less extreme.

Table 3. Comparison of water quality index scores based on the varying methods outlined in Table 2 versus a static guideline. The top row for each site is the WQI score that has been reported in our annual reports, generated using changing guidelines. The bottom row for each site is the WQI score generated using the guidelines from 2008 for all years (that specific year chosen for illustration purposes only). Green = excellent (> 90); yellow = good (75-90); orange = fair (60-75); red = poor (< 60).

Site	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
East Coast (open coast sites)										
Browns Bay	87.1	80.6	93.6	87.1	93.5	100	80.7	92.8	100	100
	100	93.6	93.6	93.6	100	100	100	100	100	100
Goat Island	87.1	80.6	100	100	80.6	93.6	93.5	92.8	92.3	92.8
	93.6	100	93.6	93.6	93.6	100	100	100	100	100
Orewa	80.5	87.1	93.6	93.6	93.5	100	93.6	92.7	100	100
	100	100	100	100	100	100	100	100	100	100
Ti Point	93.6	87.0	100	93.6	93.4	93.5	87.1	92.8	92.4	100
	100	100	100	100	93.6	100	100	100	100	100
Kaipara Harbour										
Hoteo River Mouth	-	-	73.7	73.2	60.6	80.5	61	63.4	63.2	39.7
			-	-	73.4	73.6	73.8	74.2	80.7	87.0
Kaipara Heads	-	-	93.5	67.8	61.3	93.6	80.7	100	78.3	100
			-	-	80.7	100	100	100	100	100

Site	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Kaipara River	-	-	53.8	56.6	49.5	56.7	47.7	45.8	42.8	33.1
			-	-	47.3	48.7	49.7	55.9	55.7	61.7
Makarau Estuary	-	-	72.0	65.6	60.9	59.7	53.8	52.2	54.9	46.0
			-	-	66.3	60.2	60.9	60.5	67.2	66.4
Omokoiti Beacon	-	-	87.1	66.9	87.1	93.6	74.1	85.2	100	-
			-	-	87.1	93.6	100	100	87.1	
Shelly Beach	53.9	42.4	66.4	72.1	67.3	80.6	79.9	69.6	56.1	56.3
	52.7	46.7	49.3	58.0	66.3	80.3	67.7	87.1	80.6	74.2
Tauhoa Channel	-	-	93.5	74.1	80.7	93.6	74	85.4	85.4	78.2
			-	-	87.1	87.1	93.6	93.6	93.6	93.6
Mahurangi Harbour										
Dawsons Creek	67.5	67.3	87.1	80.7	87.1	79.9	80.7	78.1	78.2	92.7
	78.2	65.0	74.1	80.6	93.6	93.6	93.6	80.7	87.1	93.5
Mahurangi Heads	80.5	50.1	100	100	93.5	100	93.6	91.9	100	92.8
	79.5	52.9	60.6	60.6	100	100	100	93.6	93.6	93.5
Manukau Harbour										
Clarks Beach	69.7	66.8	67.6	59.7	67.0	73.9	57.2	60.6	55.3	40.3
	59.1	59.3	60.6	67.1	66.5	72.9	66.5	66.6	66.6	73.4
Grahams Beach	67.2	80.2	80.6	54.3	67.7	93.6	65	69.5	78.0	70.8
	74.0	73.9	80.5	74.1	80.6	74.2	74.1	80.5	80.5	80.6
Mangere Bridge	41.7	45.4	53.2	43.0	47.5	43.6	41.1	36.1	26.7	33.2
	44.3	45.2	46.5	46.9	42.6	47.5	47.5	41.4	41.1	39.3
Manukau Harbour Mouth	-	-	87.1	67.7	74.2	93.6	74.1	92.8	70.8	78.3
			-	-	87.1	93.6	100	100	100	100
Puketutu Point	43.0	50.3	49.3	46.7	54.3	52.3	49.5	40.8	30.6	43.2
	45.6	47.1	55.6	55.9	51.2	51.2	51.5	49.0	50.8	49.4
Shag Point	50.7	61.1	65.7	52.2	52.4	66.5	50.1	43.0	51.8	41.2
	52.9	52.8	55.5	51.2	51.1	57.8	58.4	58.5	57.8	58.1
Waiuku Town Basin	-	-	-	-	-	59.9	47.4	43.1	36.9	30.2
						-	-	-	48.3	38.4
Weymouth	62.5	56.4	58.6	56.2	58.1	45.5	46	49.1	48.2	39.4
	50.8	56.0	56.8	51.3	50.8	56.8	55.8	55.6	49.8	56.1

Site	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Tāmaki Estuary										
Panmure	53.9	33.7	80.3	51.7	55.9	52.6	49.3	45.7	45.6	44.6
	47.0	51.6	52.4	50.5	46.7	54.7	55.2	57.1	58.0	62.6
Tāmaki	74.2	58.0	93.6	80.5	58.5	100	86.9	78.2	84.9	63.2
	74.0	66.8	67.3	61.1	79.8	91.4	91.4	93.6	93.5	86.9
Tāmaki Strait										
Turanga Estuary Mouth	-	-	93.6	86.9	93.5	93.6	80.7	92.7	78.0	-
			-	-	93.5	93.5	100	100	100	
Wairoa River Mouth	-	-	86.9	65.8	52.4	80.5	67.7	70.8	55.4	85.5
			-	-	66.5	66.5	73.8	87.1	93.4	93.5
Waitematā Harbour										
Brighams Creek	36.6	46.6	73.1	51.8	46.0	37.4	36.4	47.0	37.9	31.1
	50.0	50.2	45.0	45.4	57.5	38.9	46.2	44.4	39.9	37.3
Chelsea	87.1	80.7	87.0	87.1	54.3	93.2	93.5	85.3	85.5	85.5
	100	100	100	100	93.6	100	100	100	100	100
Confluence	55.9	60.3	80.4	55.2	61.2	64.2	47.2	-	-	-
	67.5	67.2	67.3	71.6	59.3	58.2	67.3			
Henderson Creek	67.7	61.1	86.8	57.2	65.9	76.8	66.5	76.5	56.1	46.4
	67.7	61.2	80.6	79.3	79.5	85.1	87.0	73.9	74.1	73.7
Hobsonville Jetty	80.7	93.3	93.6	74.2	93.5	80.1	67.7	77.7	92.8	85.5
	93.6	93.6	93.6	93.6	100	100	93.6	93.6	100	100
Lucas Creek	60.5	60.0	86.6	52.8	67.2	44.9	46.7	62.2	55.0	36.0
	54.3	54.0	67.0	60.3	66.9	64.3	53.3	71.3	74.0	60.2
Paremoremo Ski Club	60.9	53.7	80.4	66.5	80.6	51.4	53.9	61.6	54.6	38.5
	60.9	54.3	67.3	67.0	73.8	71.1	77.5	65.4	73.8	66.5
Rangitopuni Creek	44.0	52.5	73.9	44.8	45.9	55.4	37	52.4	37.6	31.1
	54.9	48.7	51.3	53.0	52.0	44.7	51.6	46.1	43.4	41.8
Rawawaru Creek	60.7	60.0	67.5	53.6	39.9	61.5	38.8	54.9	54.1	-
	60.4	60.7	67.3	66.6	47.0	52.8	53.6	67.0	80.5	
Waimarie Road	80.5	61.1	87.1	67.2	80.6	73.0	54.2	63.1	69.9	-
	80.5	73.9	80.6	80.6	67.8	67.7	87.1	80.5	100	
Whau	80.5	67.7	61.0	87.0	93.6	57.5	74.2	78.2	78.1	85.5
	93.6	87.0	74.2	93.6	100	93.5	87.1	93.5	100	100

4.0 Improved method for use of the WQI in the Auckland region

In order to move away from guidelines that change every year, we developed a set of static guidelines using data from the least modified sites (Condition 2 sites; slightly to moderately disturbed ecosystems) in the Auckland region from 2007 to 2016, as well as the existing ANZECC guidelines (ANZECC 2000) (Table 4). Defining guidelines based on sites in Auckland is reflective of conditions present in our waterbodies and represent guidelines that are achievable. We split our sites into open coast and estuary sites due to the differences in hydrodynamics (i.e., open coast versus semi-enclosed basins) that affect flushing times (i.e., hours versus days). For open water sites, the least modified sites were Ti Point and Goat Island; the least modified estuary sites included Chelsea, Hobsonville, and Manukau Harbour @ Mouth.

Guidelines were defined using the 80th percentile value for each parameter (and the 20th percentile value for parameters with lower and upper bounds, such as dissolved oxygen) for open coast and estuary sites, respectively. We then compared these values to the existing ANZECC guidelines (2000). Similar to the approach taken by the Northland Regional Council (Griffiths 2016), we used local values for our guidelines when they were more permissive than the ANZECC guidelines (Tables 1 and 4). The Auckland data had much higher concentrations of chlorophyll-a, nitrate + nitrite, ammonia (estuary only), and soluble reactive phosphorus (estuary and open coast) than was outlined in the ANZECC guidelines (2000). Where the ANZECC guidelines were nearly the same or more permissive than the Auckland data we used the ANZECC guidelines in our calculations of the WQI scores.

In addition to defining static guidelines, we also changed the parameters used to calculate the WQI, reducing the number of parameters from nine to six (Tables 2 and 4). We dropped enterococci from the parameter list because we stopped measuring it in our water samples in 2015. We dropped pH because it is highly variable, particularly in estuaries so it isn't a useful parameter for overall water quality. We dropped total suspended solids (TSS) because we include turbidity, which would count doubly against the overall score for a site. We dropped total phosphorus and added soluble reactive phosphorus (SRP) because SRP is the form of phosphorus that is immediately available to aquatic plants so it is a better parameter to include for an estimation of overall water quality.

Table 4. Water quality index guidelines for marine and estuary water in the Auckland region. Guidelines were defined using data from reference sites in the Auckland region (Source = Auckland Council) and/or the ANZECC guidelines for marine water quality (Source = ANZECC 2000).

Parameter	Threshold marine	Threshold estuary	Source
Dissolved oxygen (% sat)	> 90%, < 110%	> 90%, < 110%	ANZECC 2000
Turbidity	< 1 NTU	< 10 NTU	Auckland Council / ANZECC 2000
Chlorophyll-a	0.023	0.031	Auckland Council
Ammoniacal nitrogen	< 0.015 mg/L	< 0.015 mg/L	ANZECC 2000 / Auckland Council
Nitrate + nitrite nitrogen	< 0.027 mg/L	< 0.029 mg/L	Auckland Council
Soluble reactive phosphorous	< 0.012 mg/L	< 0.021 mg/L	Auckland Council

To calculate the WQI score using these new guidelines, we averaged each water quality parameter value by month (and each site if reporting at the regional level) using the last three years of data. Previously, we used every data point. However, because we are using a percentile value for our guidelines, using every data point would likely result in very low WQI scores. An average value provides a more robust descriptor of conditions at a site (or in a sub-region) than a single data point, which could be affected by weather condition on the days prior to or day of sampling. We also used this approach because our objectives are not triggers or thresholds but guidelines for further investigation, so a single value that exceeds the objective is not necessarily cause for action. In addition, we also divided the scores into five categories (excellent, good, fair, marginal, poor) as originally outlined in the CCME WQI publication (2001) instead of the four categories (excellent, good, fair, poor) we previously used (Table 5).

Table 5. Categories and scoring ranges used by Auckland Council for reporting over the period of 2007 to 2016 compared to those recommended in the CCME WQI report (2000). Auckland Council will use the five categories defined by CCME for WQI scoring in our annual reports and state and trends reports commencing with the 2017 annual report.

Score range	Category	Meaning
Auckland Council categories and scoring range (2007 to 2016)		
90-100	Excellent	
75-90	Good	
60-75	Fair	
<60	Poor	
CCME WQI recommended categories and scoring range		
95-100	Excellent	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels. These index values can only be obtained if all measurements are within guidelines virtually all of the time.
80-94	Good	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels or water quality guidelines.
65-79	Fair	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels or water quality guidelines.
45-64	Marginal	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels or water quality guidelines.
0-44	Poor	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels or water quality guidelines.

In light of these changes in methodology, we recalculated all WQI scores from 2007 onwards (Table 6). WQI scores for open coast sites declined significantly using our new methodology compared to the old methodology. By splitting open coast from estuary sites, guideline values declined for nearly all parameters in open coast waters (Tables 1 and 4), meaning that many more samples failed to meet the guideline values. In addition, water quality has improved in the Auckland region over time so scores from 2007 will be lower than using previous methods. There were fewer changes in water quality scores for estuary sites than open coast sites. Where changes did occur, they tended to be lower in the early years the index was used (i.e., 2007 to 2010) using the new methodology. Similar to open coast sites, water quality has improved at multiple estuary sites since 2007 so the guidelines we tested the data against were more strict than guidelines used previously.

Using the new objectives, we saw increasing water quality scores across most sites, which is consistent with that state and trends analysis that was just completed for this same period of time (Foley et al. 2018). Scores at sites that were in poor condition using the previous methods stayed in the poor category but scores declined slightly due to more stringent objectives. Sites that were in good to fair condition had broadly similar scores for the two methods between 2014 and 2017.

Table 6. WQI scores for 2007 to 2016 using static guidelines based on the 80th percentile values from reference sites in the Auckland region, using data from 2007 to 2016. Scores are broken into five categories: blue = excellent (> 95); green = good (80-94); yellow = fair (65-79); orange = marginal (45-64); red = poor (< 45).

Site	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
East Coast (open coast sites)											
Browns Bay	38.3	36.8	38.7	47.4	58.6	67.5	58.1	57.4	59.5	78.0	68.9
Goat Island	50.6	40.8	40.9	41.5	51.3	61.0	80.3	80.6	80.6	80.1	70.6
Orewa	48.7	38.5	39.3	48.8	68.9	68.6	78.1	78.5	79.4	80.1	70.4
Ti Point	50.1	39.6	49.9	40.9	70.7	70.7	80.3	80.3	90.1	70.7	70.7
Kaipara Harbour											
Hoteo River Mouth	-	-	-	-	55.1	56.6	57.8	67.8	67.1	65.0	64.7
Kaipara Heads	-	-	-	-	70.3	70.8	70.9	80.6	70.9	90.3	71.0
Kaipara River	-	-	-	-	39.7	47.5	49.5	49.4	49.7	48.3	49.1
Makarau Estuary	-	-	-	-	54.9	56.4	47.8	47.3	56.3	55.0	55.8
Omokoiti Beacon	-	-	-	-	67.5	69.0	69.1	69.9	69.7	-	-
Shelly Beach	25.5	23.8	28.3	33.3	56.4	66.6	67.1	68.0	67.5	67.5	67.3
Tauhoa Channel	-	-	-	-	68.9	79.4	78.6	79.8	70.2	70.2	70.0
Mahurangi Harbour											
Dawsons Creek	48.1	48.2	59.4	59.9	70.5	80.3	70.7	70.7	89.8	80.3	70.8
Mahurangi Heads	60.6	40.4	41.5	60.9	90.3	100	100	100	100	100	90.3
Manukau Harbour											
Clarks Beach	34.1	33.4	34.7	44.4	44.4	44.1	44.5	46.2	46.5	54.8	44.3
Grahams Beach	66.4	57.2	57.9	56.9	58.7	58.9	59.9	60.4	60.7	70.3	69.4
Mangere Bridge	15.6	15.0	16.7	25.2	25.3	25.2	18.2	17.1	16.9	23.8	16.8

Site	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Manukau Harbour Mouth	-	-	-	-	78.7	79.6	79.7	80.1	80.3	70.6	70.6
Puketutu Point	16.3	24.6	32.2	27.4	27.2	19.7	20.4	26.4	18.4	25.9	20.8
Shag Point	28.2	27.9	31.7	35.9	28.2	27.4	36.3	37.8	29.7	36.8	29.0
Waiuku Town Basin	-	-	-	-	-	-	-	-	23.0	29.4	29.2
Weymouth	34.0	23.7	23.2	32.8	33.1	25.6	34.1	36.1	37.6	37.2	35.6
Tāmaki Estuary											
Panmure	28.3	25.9	28.4	28.8	25.9	24.3	23.4	30.6	32.6	31.9	42.3
Tāmaki	45.7	35.6	56.2	57.9	50.8	60.4	50.7	59.7	58.9	67.6	67.6
Tāmaki Strait											
Turanga Estuary Mouth	-	-	-	-	70.8	80.2	90.3	80.6	100	-	-
Wairoa River Mouth	-	-	-	-	49.1	48.4	50.0	51.5	60.8	60.9	59.1
Waitematā Harbour											
Brighams Creek	23.0	23.7	27.1	28.5	25.9	23.3	24.7	31.5	31.2	27.5	25.2
Chelsea	50.7	49.4	50.5	50.5	80.5	90.3	80.7	71.0	80.6	80.7	79.9
Confluence	31.5	32.7	36.3	33.7	35.0	34.9	38.2	48.0	-	-	-
Henderson Creek	56.3	48.1	40.5	40.7	70.8	61.0	70.9	60.9	60.8	58.6	48.2
Hobsonville Jetty	50.3	50.0	50.9	50.4	70.9	80.5	80.3	70.9	70.9	70.7	70.4
Lucas Creek	34.5	33.6	37.0	37.6	38.7	45.8	45.7	37.7	38.4	35.9	33.8
Paremoremo Ski Club	43.1	33.1	37.2	37.6	39.4	57.8	50.0	39.4	38.8	35.9	34.2
Rangitopuni Creek	22.4	23.7	27.3	30.5	31.4	29.1	28.9	30.2	26.5	25.0	24.8
Rawawaru Creek	33.6	32.8	36.4	37.1	36.9	36.5	35.2	37.5	47.1	-	-
Waimarie Road	45.5	44.6	48.3	49.0	50.0	68.9	60.0	41.1	48.7	-	-
Whau	49.7	49.7	41.4	41.1	70.8	71.0	80.7	70.9	70.7	70.1	69.2

5.0 Summary

The methodology for calculating the WQI score for marine water quality sites in the Auckland region has varied since the index was first used in 2007. In order to standardise guideline values and to ensure index scores can be compared across years, an updated methodology is presented here to address those issues. Rather than calculating new guidelines every year, standardised guidelines were calculated using the 80th percentile values from the best quality sites remaining in the Auckland region. When compared to previously reported scores, it will appear that water quality has declined or improved at some sites. It is important to recognise that water quality at these sites has not changed; we are changing the measuring stick for assessing water quality.

We chose to use data from 2007 to 2016 because this represents a timeframe when water quality in the Auckland region was improving at many sites and pollutant concentrations were lowest in the region. While guidelines can be adjusted in the future to reflect increased data availability, certainty around ecological harm, or emerging designated water uses, having a constant standard is important for clearly communicating overall water quality and appropriately interpreting changes over time. Reviewing water quality guidelines periodically is important and could be done as part of the state and trends reporting process that is completed every five years. They should also be reviewed if ANZECC guidelines are updated or if water quality guidelines are developed for marine and estuary waters in New Zealand.

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