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Dear Susie

NRC Coastal Aquifers Study – Oakura

Introduction

Sinclair Knight Merz (SKM) was commissioned by Northland Regional Council (NRC) to undertake hydrogeological reviews of ten coastal aquifers in the Northland region, with particular emphasis on determining likely groundwater recharge rates and reviewing aquifer management boundaries. The work was commissioned to partially fulfil NRC's knowledge requirements following the release of a discussion document by the Ministry for the Environment's (MfE) in March 2008 on Proposed National Environmental Standard (NES) on Ecological Flows and Water Levels.

The Proposed NES sets interim default allocation limits for shallow coastal aquifers of whichever is the greater of,

- *15% of the average annual recharge as calculated by the regional council; or*
- *The total allocation from the groundwater resource on the date that the standard comes into force less any resource consents surrendered, lapsed, cancelled or not replaced.*

This report presents the results of the hydrogeological review undertaken for the **Oakura sand and greywacke aquifers**.

Methodology

The review of the aquifer management areas and determination of the recharge rate was achieved through compilation and review of various data sources, primarily provided by NRC. These datasets are summarised as follows:

- Geological borelogs;
- Geological maps;

- Legal property boundaries (cadastral);
- Topographical contours;
- Rivers;
- Meteorological data; and
- Existing NRC aquifer management boundaries.

In addition to these site specific datasets, a compilation of recharge estimates from previous coastal aquifer studies in the Northland region has been undertaken to categorise the range in likely recharge rates by aquifer type. This data is presented in **Appendix A** and has been used to assist recharge calculations within the current study, particularly in those areas where there is insufficient local data (e.g. stream flow records) to permit more detailed analysis such as the development of a Soil Moisture Water Balance Model (SMWBM), or other method with similar outcomes.

For the purpose of this study, aquifer management boundaries have been refined where appropriate to coincide with cadastral boundaries. This was implemented to avoid potential conflict with and between landowners resulting from future management decisions based on these extents.

Aquifer Description

Oakura is located near the head of Whangaruru Harbour, approximately 30 km south east of the Bay of Islands (**Figure 1**). The geology for the area is described on the 1:250,000 Geological Map Sheet 1 for North Cape (Kear and Hay, 1961). The aquifer predominantly comprises Waipapa Group greywacke and argillite basement rocks with cherts and marbles, overlain by a thin strip of undifferentiated Quaternary sand along the low lying valley and coastal fringe.

NRC records indicate initial drilling at Oakura occurred in 1953 with records for approximately 70 bores in the area to date. The approximate locations of the boreholes are shown in **Figure 1** and **Figure 2.** A number of these bores do not have geological information available and have not been specifically labelled in the figures. Summary geological and bore construction information from available borelogs is provided in **Appendix B**.

- **Figure 1. Oakura Sand Aquifer Management Map**
  (See A4 attachment at rear)
- **Figure 2. Oakura Greywacke Aquifer Management Map**
  (See A4 attachment at rear)

In general, the borelogs correlate with the regional geological map with the majority of bores having a thin layer of sand overlying greywacke. Further inland these deposits become progressively thinner and with increasing alluvial clay content.

The bores in the Oakura area are all shallow ranging in depth from 5.6 to 30.1 metres below ground level. The majority of bores abstract from the greywacke with the upper weathered greywacke surface generally encountered between 5 and 10 metres below ground level (mBGL).

Static groundwater levels for the sand range between 1.0 mBGL (bore 202173) and 3.5 mBGL (bore 202144). Groundwater levels in the greywacke are similar with a slightly greater range of 0.8 mBGL (bores 202032, 202093 and 202099) and 7.5 mBGL (bore 202142).

The available test pumping information indicates that the bores in the Oakura area have the following hydraulic characteristics:

- Three bores have test pumping results within the overlying sand and alluvial material with very low to low yields ranging between 5.0 m^3/day (0.06 L/s) and 29.5 m^3/day (0.34 L/s);
- 28 bores have been tested within the greywacke, again with very low to low yields ranging between 6.4 m^3/day (0.08 L/s) and 60.0 m^3/day (0.69 L/s); and
- Maximum drawdown measurements recorded during these tests indicate that bore specific capacities for the greywacke are also low, ranging between 0.3 m^3/day/m and 21.6 m^3/day/m (16 tests).

Aquifer Extent

The previous management area for the Oakura sand aquifer (obtained from NRC) was based on the overlying undifferentiated sand as defined in a previous SKM report (SKM, 2000) which covered an area of 0.55 km^2. Following review of additional borelogs in the Oakura area, the regional geology map and with an increased number of cadastral boundaries, the management area has been extended to an area of 0.97 km^2. The revised management area is shown in **Figure 1**. In this instance, the management boundary was unable to coincide with all cadastral boundaries (where these were sparse) and two properties have been bisected to match the geological boundary.

The physical aquifer extent based solely on geology is approximately 17 % larger than the management boundary at 1.14 km^2 (**Figure 1**, red dashed line). The physical aquifer extent of the sand aquifer has been used in the recharge estimations in the following sections.

The available borelog information indicates that the majority of bores abstract water from the greywacke. The management area for the greywacke is shown in **Figure 2** and is approximately 5.03 km^2. The management boundary has been defined by the geology and anticipated groundwater recharge area, and adjusted to coincide with the cadastral boundaries where possible. Due to sparse cadastral boundaries in the south west of the aquifer, this area has been defined by the topographic divide and consequently one property has been intersected.

The management area is approximately 0.1 km^2 larger than the groundwater recharge area (**Figure 2)**, although the latter area (4.90 km^2) is used for the recharge estimations.

Recharge Estimate

Groundwater recharge is a function of the rainfall and evapotranspiration regimes, as well as geomorphological characteristics of a catchment (e.g. slope, soil and land cover characteristics, etc.).

Local rainfall data was obtained from two rainfall stations located approximately 25 km north and 15 km south of the Oakura area, respectively. These two stations have similar rainfall statistics which are summarised in **Table 1.** A combined average annual rainfall from the two stations was used for the Oakura groundwater recharge estimates (**1230 mm/yr**).

Table 1. Summary rainfall statistics

	Matapouri - 1221	Cape Brett Lighthouse - 1197
Location	Approx. 25 km south	Approx. 19.5 km north
Data period	1967 - 2008	1935 - 1978
Minimum	787 mm/yr	772 mm/yr
Maximum	2131 mm/yr	1815 mm/yr
Average	1360 mm/yr	1100 mm/yr

In the absence of streamflow data to calibrate a Soil Moisture Water Balance Model (SMWBM) groundwater recharge has been estimated for Oakura sand and greywacke aquifers using previous studies in similar aquifers in the Northland region.

Sand Recharge Estimate

Groundwater recharge estimates for the Oakura sand were based on various calibration studies undertaken in the Northland region. These previous studies are summarised in **Appendix A** and provide a range of groundwater recharge rates.

A study undertaken at Mangawhai (SKM, 2005b) provided a groundwater recharge rate of 16% for a similar sand aquifer. This recharge rate was based on calculations of estimates from previous experience pro-rated by area. An earlier study in the Russell gravel aquifer (SKM, 2001), located approximately 25 km to the north west provided a groundwater recharge estimate of 26 -52% for the sand and gravel aquifer. This study of the Russell aquifer utilised the SMWBM, which was adjusted during calibration of a numerical groundwater model to provide the most likely estimate of groundwater recharge in accordance with measured aquifer hydraulic properties assigned.

Based on the nature of the sediments described from the bores drilled within the Oakura sand aquifer, a range of **20 - 30 % of annual average rainfall** has been used to estimate the most

likely range of rainfall recharge. This account for a proportion of gravelly and shelly material reported in a number of bores, but is at the lower end of the Russell gravel aquifer recharge rates due to the predominance of sand. The physical aquifer extent provides a conservative approach as the calculation assumes the majority of recharge will be from direct rainfall recharge. Additional recharge to the aquifer but not specifically incorporated in this assessment includes seepage from greywacke, foothill runoff, and stream bed leakage.

Likely annual groundwater recharge to the Oakura sand aquifer based on the local rainfall record and the physical aquifer boundary, as a percentage of annual rainfall is given in **Table 2**.

- **Table 2. Oakura sand groundwater recharge volume**

Average Annual Rainfall (mm/yr)	Aquifer Extent (km^2)	Total Recharge Volume (m^3/yr)	% GW Recharge	GW Recharge Volume (m^3/yr)
1,230	1.14	1,402,200	20% (min.)	280,440
1,230	1.14	1,402,200	30% (max.)	420,660

The groundwater recharge assessment for the Oakura sand aquifer indicates that annual recharge is likely to be between 280,440 and 420,660 m^3/year for the 20% and 30% recharge proportions, respectively. Accordingly, the interim default allocation limit under the NES (15% of groundwater recharge) would be between **42,066** and **63,100 m^3/year**.

Greywacke Recharge Estimate

The greywacke recharge estimate utilises recharge rates previously determined for the Russell greywacke aquifer located approximately 25 km north west of Oakura. This study (SKM, 2001) utilised the SMWBM, which was adjusted during calibration of a numerical groundwater model to provide the most likely estimate of groundwater recharge in accordance with measured aquifer hydraulic properties assigned in the groundwater model. The resulting groundwater recharge estimate was between **1-5 % of annual average rainfall** which has also been applied to this study.

Likely annual groundwater recharge to the Oakura greywacke aquifer based on the local rainfall record and the groundwater recharge area, as a percentage of annual rainfall is given in **Table 3.**

- **Table 3. Oakura greywacke groundwater recharge volume**

Average Annual Rainfall (mm/yr)	Recharge Area (km^2)	Total Recharge Volume (m^3/yr)	% GW Recharge	GW Recharge Volume (m^3/yr)
1,230	4.90	6,027,000	1% (min.)	60,270
1,230	4.90	6,027,000	5% (max.)	301,350

The groundwater recharge assessment for the Oakura greywacke aquifer indicates that annual recharge is likely to be between 60,270 and 301,350 m^3/year for the 1% and 5% recharge proportions, respectively. Accordingly, the interim default allocation limit under the Proposed NES (15% of groundwater recharge) would be between **9,040** and **45,202 m^3/year**.

Yours sincerely

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Appendix A. Summary of recharge rates by aquifer type

Aquifer	Type	Recharge estimate	Recharge Method	Reliability	Source
Glenbervie	Weathered Taheke Basalt	5 - 15%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2005a)
Coopers Beach	Tangihua Basalts	5 - 15%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2005c)
Tara	Parahaki Volcanics?	7 - 10%	Estimate		NRC Report
Kaikohe	Horeke or Taheke Basalt	13.2%	SMWBM	HIGH Calibrated to stream flow.	SKM (2007a)
Monument Hill	Horeke or Taheke Basalt	16.5%	SMWBM	HIGH Calibrated to stream flow.	SKM (2007a)
Maungakaramea	Taheke Basalt	22 - 44%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2006a)
Three Mile Bush	Taheke Basalt	28 - 49%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2006b)
Maungakaramea	Scoria Cone	55 - 65%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2006a)
Ruawai	Alluvium	30%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2003)

Aquifer	Type	Recharge estimate	Recharge Method	Reliability	Source
Awanui	Alluvium	4.2%	SMWBM	MODERATE Calculated indirectly during calibration of a groundwater model.	SKM (2007b)
Awanui	Dune Sands	43.7%	SMWBM	MODERATE Calculated indirectly during calibration of a groundwater model.	SKM (2007b)
Mangawhai	Sand	10.2 - 16%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2005b)
Russell	Gravel	26 - 52%	SMWBM	MODERATE Calculated indirectly during calibration of a groundwater model.	SKM (2001)
Mangawhai	Sandstone	1 - 10%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2005b)
Russell	Greywacke	1 - 5%	SMWBM	MODERATE Calculated indirectly during calibration of a groundwater model.	SKM (2001)

Appendix B. Summary of geological borelogs

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
202032	Q5 324-446	0.0 – 2.1 2.1 – 5.5 5.5 – 18	Soil and grey alluvial clays Yellow soft clays Firm rock fractured in places	18.0 m	PVC casing (0 - 13 m) Open hole (13 – 18 m)	Greywacke	SWL = 0.8 mBGL Q = 27.3 m^3/day
202033	Q5 327-446	0.0 – 11.8 11.8 – 30.1	Gravel and shingle Greywacke	30.1 m	Galvanised steel (0 – 19.2 m) Open hole (19.2 – 30.1 m)	Greywacke	Q = 6.9 m^3/day
202034	Q5 328-447	0.0 – 1.2 1.2 – 2.4 2.4 – 10.4	Sand Weathered greywacke Hard greywacke	10.4 m	*Unknown*	*Not used*	
202037	Q5 328-449*	0.0 – 12.2 12.2 – 22.8	Gravel, sand and mud Brown greywacke	22.8 m	Galvanised steel (0 – 13.5 m) Open hole (13.5 – 22.8 m)	Greywacke	Q = 25.9 m^3/day
202039	Q5 328-449*	0.0 – 2.4 2.4 – 20.0	Sand and gravel Brown greywacke	20.0 m	Galvanised steel (0 – 3.6 m) Open hole (3.6 – 20 m)	Greywacke	
202041	Q5 328-449*	0.0 – 3.3 3.3 – 10.0	Clays, gravel and sand Greywacke	10.0 m	PVC casing (0 – 3.5 m) Open hole (3.5 – 10 m)	Greywacke	Q = 38.2 m^3/day
202043	Q5 328-449*	0.0 – 8.5 8.5 – 15.8	Sand and gravel Hard rock	15.8 m	PVC casing (0 – 6.1 m) Open hole (6.1 – 15.8 m)	*Not used*	Q = 5.0 m^3/day
202047	Q5 328-449*	0.0 – 8.5 8.5 – 21.3	Gravel Brown greywacke	21.3 m	Galvanised steel (0 – 9.7 m) Open hole (9.7 – 21.3 m)	Greywacke	
202049	Q5 328-449*	0.0 – 16 16 – 23.4	Sands, gravel and rock Brown greywacke	23.4 m	PVC casing (0 – 16.3 m) Open hole (16.3 – 23.4 m)	Greywacke	Q = 27.4 m^3/day
202052	Q5 328-449*	0.0 – 11 11 – 21.3	Sands and gravels Brown greywacke	21.3 m	PVC casing (0 – 12.2 m) Open hole (12.2 – 21.3 m)	Greywacke	Q = 43.6 m^3/day
202056	Q5 328-446	0.0 – 10.6 10.6 – 22.0	Gravel and sand Greywacke	22.0 m	PVC casing (0 – 13 m) Open hole (13 – 22 m)	Greywacke	SWL = 3.4 mBGL
202057	Q5 328-452	0.0 – 2.75 2.75 – 5.0 5.0 – 18.0	Soil and clay Greywacke Hard, blue greywacke	18.0 m	Galvanised steel (0 – 6.15 m) Open hole (6.15 – 18.0 m)	Greywacke	SWL = 1.7 mBGL Q = 18.2 m^3/day
202059	Q5 329-447	0.0 – 9.4 9.4 – 10.4	Sand and shells Gravel	10.4 m	Galvanised steel (0 – 9.7 m) Open hole (9.7 – 10.4 m)	Gravel	Q = 10.9 m^3/day

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
202060	Q5 329-453	0.0 – 9.1 9.1 – 19.8	Sand and gravel Brown greywacke	19.8 m	PVC casing (0 – 9.1 m) Open hole (9.1 – 19.8 m)	Greywacke	Q = 54.7 m^3/day
202062	Q5 332-443	0.0 – 3.0 3.0 – 6.0 6.0 – 18.5	Soil and sand Clay and weathered greywacke Greywacke	18.5 m	Galvanised steel (0 – 6.0 m) Open hole (6.0 – 18.5 m)	Greywacke	SWL = 1.6 mBGL Q = 22.7 m^3/day
202093	Q5 324-447	0.0 – 4.0 4.0 – 17.0	Clay Brown greywacke	17.0 m	PVC casing (0 – 9.0 m) Open hole (9.0 – 17.0 m)	Greywacke	SWL = 0.8 mBGL
202098	Q5 325-446	0.0 – 5.0 5.0 – 15.0	Sand and mud Greywacke	15.0 m	PVC casing (0 – 7.0 m) PVC screen (7.0 – 15.0 m)	Greywacke	SWL = 1.8 mBGL Q = 36.3 m^3/day
202099	Q5 323-465	0.0 – 4.5 4.5 – 9.0 9.0 – 16.3	Sand, mud and gravel Firm brown greywacke Hard blue greywacke	16.3 m	PVC casing (0 – 6.0 m) PVC screen (6.0 – 16.3 m)	Greywacke	SWL = 0.8 mBGL Q = 36.3 m^3/day Sc = 5.2 m^3/day/m
202100	Q5 329-449	0.0 – 6.2 6.2 – 9.0 9.0 – 15.5	Sand, shell and gravel Clays Greywacke	15.5 m	PVC casing (0 – 6.5 m) PVC screen (6.5 – 15.5 m)	Greywacke	SWL = 2.2 mBGL Q = 29.1 m^3/day Sc = 4.2 m^3/day/m
202101	Q5 324-467	0.0 – 17.8 17.8 – 22.7 22.7 – 24.6	Sand, shell and mud Firm brown greywacke Hard blue greywacke	24.6 m	PVC casing (0 – 19.0 m) Open hole (19.0 – 24.6 m)	Greywacke	SWL = 2.0 mBGL Q = 13.6 m^3/day Sc = 1.5 m^3/day/m
202102	Q5 323-437	0.0 – 5.0 5.0 – 25.0 25.0 – 26.0	Clay Soft to hard brown greywacke Hard chert-like rock	26.0 m	PVC casing (0 – 15.0 m) Open hole (15.0 – 26.0 m)	Greywacke	SWL = 3.0 mBGL Q = 43.2 m^3/day Sc = 21.6 m^3/day/m
202142	Q5 331-456	0.0 – 3.5 3.5 – 6.0 6.0 – 12.0	Yellow Clay Firm brown greywacke Hard brown to blue greywacke	12.0 m	PVC casing (0 – 6.0 m) PVC screen (6.0 – 12.0 m)	Greywacke	SWL = 7.5 mBGL Q = 14.4 m^3/day Sc = 7.2 m^3/day/m
202144	Q5 323-464	0.0 – 5.2 5.2 – 5.6	Sands and gravels Hard greywacke	5.6 m	PVC casing (0 – 4.0 m) PVC screen (4.0 – 5.6 m)	Sand/Gravel	SWL = 3.5 mBGL
202147	Q5 332-442	0.0 – 5.8 5.8 – 10.0	Clay and hard consolidated gravel Hard brown to blue greywacke	10.0 m	Casing (0 – 6.0 m) Open hole (6.0 – 10.0 m)	Greywacke	SWL = 1.7 mBGL Q = 31.2 m^3/day Sc = 5.2 m^3/day/m
202168	Q5 331-442	0.0 – 3.2 3.2 – 13.0 13.0 – 27.5	Gravel Sand, silt and vegetation Brown to blue greywacke	27.5 m	Casing (0 – 13.5 m) Open hole (13.5 – 27.5 m)	Greywacke	SWL = 1.7 mBGL Q = 7.3 m^3/day Sc = 0.3 m^3/day/m

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
202169	Q5 323-467	0.0 – 15.0 15.0 – 20.0 20.0 – 27.0	Sand Weathered brown greywacke Brown to blue greywacke	27.0 m	Casing (0 – 20.0 m) Open hole (20.0 – 27.0 m)	Greywacke	SWL = 1.0 mBGL Q = 18 m^3/day Sc = 1.6 m^3/day/m
202171	Q5 322-466	0.0 – 17.0 17.0 – 20.5	Sand Greywacke	20.5 m	Casing (0 – 17.5 m) Open hole (17.5 – 20.5 m)	Greywacke	SWL = 1.0 mBGL Q = 24 m^3/day Sc = 5.3 m^3/day/m
202173	Q5 323-464	0.0 – 5.0 5.0 – 6.0	Sand Gravel and shells	6.0 m	Casing (0 – 5.0 m) Open hole (5.0 – 6.0 m)	Gravel	SWL = 1.0 mBGL Q = 24 m^3/day Sc = 8.9 m^3/day/m
205297	Q5 328-449	0.0 – 4.2 4.2 – 10.4	Sand and gravel Brown greywacke	10.4 m	Galvanised steel (0 – 8.0 m) Open hole (8.0 – 10.4 m)	Greywacke	Q = 27.4 m^3/day
205709	Q5 321-465	0.0 – 9.3 9.3 – 12.0 12.0 – 16.5	Clay and brown rock Brown rock and soft sandy rock Hard brown and blue rock	16.5 m	Casing (0 – 11.5 m) Open hole (11.5 – 16.5 m)	Greywacke	SWL = 1.0 mBGL Q = 24 m^3/day Sc = 2.0 m^3/day/m
205872	Q5 332-447	0.0 – 3.5 3.5 – 8.0	Clay Hard brown to blue greywacke	8.0 m	Casing (0 – 4.5 m) Open hole (4.5 – 8.0 m)	Greywacke	SWL = 3.0 mBGL Q = 60 m^3/day Sc = 15.0 m^3/day/m
209251	Q5 327-447	0.0 – 5.0 5.0 – 11.6	Fill, topsoil and blue-grey clays Hard brown to blue greywacke	11.6 m	Casing (0 – 6.0 m) Open hole (6.0 – 11.6 m)	Greywacke	SWL = 1.4 mBGL Q = 28.8 m^3/day Sc = 3.6 m^3/day/m
209456	Q5 328-453	0.0 – 3.0 3.0 – 12.0	Clay and gravels Hard brown to blue greywacke	12.0 m	PVC casing (0 – 4.0 m) Open hole (4.0 – 12.0 m)	Greywacke	SWL = 3.0 mBGL Q = 16.8 m^3/day Sc = 3.4 m^3/day/m
209593	Q5 328-454	0.0 – 2.5 2.5 – 6.7	Alluvial clays and gravels Hard brown to blue greywacke	6.7 m	PVC casing (0 – 3.0 m) Open hole (3.0 – 6.7 m)	Greywacke	SWL = 1.5 mBGL Q = 38.4 m^3/day Sc = 8.5 m^3/day/m
209601	Q5 327-454	0.0 – 5.2 5.2 – 14.0	Alluvial clays Hard brown greywacke	14.0 m	PVC casing (0 – 6.0 m) Open hole (6.0 – 14.2 m)	Greywacke	SWL = 1.3 mBGL Q = 60 m^3/day Sc = 8.0 m^3/day/m

Notes: * Identical coordinate references – only one bore displayed at this location on figure. * *Locations are approximate only. *Italics* refer to incomplete information given on borelogs. **SWL** is static water level measured in metres below ground level. **Q** is discharge rate measured during test pumping. **Sc** is specific capacity. Borelogs that did not contain geological information have not been included in this table, or labelled with NRC references in Figure 1 and Figure 2.

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