Soils and soil data – Kaipara District Council Region Topo-climate Study

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Soils and soil data – Kaipara District Council Region Topo-climate Study

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1 Introduction

Manaaki Whenua – Landcare Research is subcontracted to NIWA to provide soil and land information for the Kaipara District Council region topo-climate study.

2 Background

Manaaki Whenua – Landcare Research's soil and NZ Land Resource Inventory data can be used to produce maps for areas of crop suitability and inform the Topo-climate report.

3 Objectives

- Provide information on soils and soil data in the Kaipara District Council region study area.
- Write a section on soil variation in the Kaipara District Council region study area.

4 Methods

New Kaipara District Council region-specific data were generated by updating relevant fundamental soil datasets and relevant NZ Land Resource Inventory data for the Kaipara District Council region study area.

5 Results

5.1 Description of the soil maps

This section describes the soil maps produced for the Kaipara District Council area. Fieldwork to generate the soil maps used in this study was undertaken in the mid-1950s with soils developed in similar rocks aggregated into 'soil suites'. It is unlikely we would use the same methods today as soils within the soil suites can show considerable variation in properties such as drainage class. The region is not covered by Manaaki Whenua – Landcare Research's more recent S-map product and associated soil information. Table 1 lists all the soil maps and derivatives generated for this study and gives them identifier numbers, which will be referred to in this section. The maps are in Appendix 1.

Table 1. List of soil maps produced for the Kaipara District Council region

Map identifier	Map description
1	Soil terrains
2	Soil series, types and phases (the soil name)
3	Slope class
4	Subsoil acidity
5	Potential rooting depth
6	Soil drainage classes
7	Profile total available water

5.2 Soil Terrains

Nine soil terrains are depicted in the Atlas of Soil Information, and each terrain represents a broad division of the landscape according to the general type of soil parent material and slope. Sloping land is divided into land with slopes less than 15° (flat to rolling) and land with slopes greater than 16° (strongly rolling to steepland). Soil terrains give a spatial framework to the soil and climate-related themes. There are over 120 soil types in the project area, with a little over half the area being sand country, flood plains or downland terrains. (Map 1).

The following soil terrains are recorded:

1 Sand country (655 km^2, 21%)

2 Flood plains (379 km^2, 12%)

3 Peatland (61 km^2, 2%)

4 Downland from sedimentary rocks – most slopes <16° (475 km^2, 15%)

5 Downland from volcanic rocks – most slopes <16° (134 km^2, 4%)

6 Hill country from weathered sedimentary rocks (444 km^2, 14%)

7 Hill country from mixed crushed & sheared rocks (410 km^2, 13%)

8 Hill country and occasional steepland from volcanic rocks (483 km^2, 16%)

9 Hill country and steepland from greywacke and argillite (18 km^2, 1%).

5.3 Soil Series, Types and Phases (the Soil Name)

The soil series, type and phase provide a link to soil attributes that require consideration when investigating land-use opportunities and management requirements. The attributes (such as potential plant rooting depth) can be represented spatially because their values have been attached to soil map units. The mapped soils and names are listed in Table 2. For improved understanding of these soils, it is essential to refer to the published legend of soils (Cox et al. 1983), where soil series, type, and phase are set out in suites according to parent material, and further arranged into leaching regimes.

Soils are grouped into *series* of similar soil profiles, similar temperature, moisture regime and parent material. The series is frequently given the name of a locality where it is well developed. *Soil types* within a series are defined by topsoil texture, and so textural terms are placed after the series name. *Soil phases* are an informal subdivision of soil types to reflect a soil property of potential importance to land use and management.

Soils according to soil terrains

Sand country: Sand country soils often include those mapped as Bare Rock and occur all the way up the west coast of the study area (Map 1). Sand country soils become older and more weathered away from the coast (Map 1). The sequence begins seaward with areas of sand dunes which show minimal soil development being delineated as Bare Rock followed by soils with very weak soil development–Pinaki soils (86 km^2, 3%). Red Hill soils (93 km^2, 3%) generally occur inland from Pinaki soils. Red Hill soils have enough soil development to provide one of the better opportunities for land-use intensification, although subsoil acidity would need checking that it is not too low (Map 4). Tangitiki soils (225 km^2, 7%) are slightly older and show high variability over short distances, with some sites strongly podzolised ('egg cup podzols' where large kauri trees once grew). This variability would make general crop predictions unreliable at a broad scale. Podzols named Te Kopuru soils (128 km^2, 4%) occur furthest inland on the oldest dunes. These soils are uniformly poor in many attributes, affecting the growth of deeper rooting and soil water sensitive crops.

Flood plains: About 12% of the project land area comprises flood plains (Map 1) and these may be well suited to some high value land uses. The poorly drained clays and peaty clays of the Kaipara soil suite (207 km^2, 7%) are already well understood and widely used for kumara growing – with highly specialised management. The narrower flood plains of the hill country are generally not used for cropping. Whakapara soils from alluvium derived from sedimentary rocks occur in valleys throughout the study area (81 km^2, 3%), whereas Mangakahia soils from alluvium derived from volcanic terrains are generally mapped in valleys north of Dargaville (63 km^2, 2%). Although both soils are well supplied with plant nutrients, they can be imperfectly drained (Map 6) and may also be subject to flooding. Careful site assessments are required when considering soil water sensitive crops.

Peatland: About 50 km^2 of Parore peaty sandy loam occurs in small valleys in the sand country of the west coast and smaller areas of Otonga peaty loam in backswamp positions (Map 2). While these soils are generally very poorly drained (Map 6), with shallow rooting depth (Map 5), they may provide growing environments for a limited range of crops.

Downland from sedimentary rocks (most slopes <16°): The easy slopes in this soil terrain make it a potential area for land-use intensification or diversification. The terrain is scattered throughout the study area (Map 1). The terrain is dominated by Aponga and Waikare soils developed in claystone, mudstone or shale. Potential plant rooting depth (Map 5) is generally about 90–120 cm for Aponga soils (71 km^2, 2%) and slightly less (60–90 cm) in Waikare soils (78 km^2, 2%). Arapohue and Rockvale soils from argillaceous limestone have heavy clayey subsoils. The potential plant rooting depth (Map 5) is about

60–90 cm in Rockvale soils (35 km^2, 1%), but is shallow (25–45 cm) in Arapohue soils (46 km^2, 1%). Most soils in this terrain are imperfectly drained, suggesting some impediment to soil water sensitive plants.

Downland from volcanic rocks (most slopes <16°): generally, this terrain occurs near Tutamoe and north of Lake Taharoa. Rolling slopes on andesitic and basaltic volcanics, together with terraces from redeposited volcanic material, offer good opportunities for crop production. Soils are naturally well supplied with plant nutrients and have good structure. While upper subsoils can be firm and plant rooting slightly restricted (Map 5), the soils do not become firmer with increasing depth (unlike soils of the sedimentary downlands). Tutamoe, Whatoro, Aranga, Katui, Waimatenui, Rangiuru, and Kohumaru soils at least appear to provide an opportunity for land-use intensification, (together, covering 106 km^2, 3%; Map 2). Some of the soils, especially those in higher rainfall areas or receiving drainage water, contain a localised iron pan, while others are imperfectly drained, so detailed site investigation is recommended.

Hill country from weathered sedimentary rocks (most slopes 16–25°): In the study area, contiguous areas generally occur south west of Dargaville. This soil terrain is underlain by stable rocks (not crushed or sheared), and they are mostly sandstones. The main soil series is Waiotira. On rolling slopes, the soils are imperfectly drained but on hilly slopes the drainage may improve, and the soils are moderately well drained (Map 6). They have few root restrictions above about 60 cm depth (Map 5) but may need checking for subsoil pH (Map 4). Slope generally precludes arable land uses (Map 3).

Hill country from mixed crushed and sheared rocks (most slopes 16–25°): While this terrain occurs throughout the study area, larger contiguous areas occur south west and north east of Dargaville. This soil terrain is underlain by tectonically disturbed and finer grained sedimentary rocks (Map 1). The rock masses are mixed and unpredictable, and often subject to earthflow and gully erosion. Soils likewise form complex patterns. While this land has limited cropping potential (too hilly, erodible, infertile, etc.) small, low slope-angle areas of Waiotira should not be discounted where soil water sensitive plants are not considered (Map 2).

Hill country and steepland from volcanic rocks (most slopes16–35°): Very large contiguous areas of Tangihua Volcanics and Waipoua Basalts exist in the north of the project area (Map 1). Where the land is steep and rocky it is often scrub-covered, with limited productive potential beyond environmental protection and biodiversity preservation.

Hill country and steepland from greywacke/argillite (most slopes16–35°): Greywacke covers just 18 km^2 (<1%), and generally lies along the foothills north of Mangawhai Heads (Map 1). Soils are predominantly Te Ranga steepland soils (10 km^2) where slope steepness (Map 3) constrains land-use options, and the hilly Marua soils (4 km^2, Map 3). Marua soils are versatile but some show evidence of short periods of waterlogging in the upper part of the subsoil. Plant rooting depth (Map 5) is very deep (to about 90–120 cm). Rangiora soils (3 km^2) are less versatile, being more strongly weathered on the easier slopes, imperfectly drained (Map 6), and have more restricted plant rooting (although still moderately deep at 60–89 cm, Map 6).

Table 2. List of soil names and their area in the Kaipara District Council region

Soil code	Soil series	Soil type	Soil phase	Area (km^2) of series
Water bodies				32
Town				5
Bare rock (sand dune)				120
AK	Awapuku	clay loam		2
AKH	Awapuku	clay loam	hill	11
AP	Aponga	clay		100
APH	Aponga	clay	hill	39
AR	Aranga	clay		21
AU	Arapohue	clay		36
AUd	Arapohue	clay	deep	16
AUH	Arapohue	clay	hill	36
C1	C1 complex			3
C4	C4 complex			<1
C8	C8 complex			15
HI	Hihi	clay		2
HK	Hukerenui	silt loam		6
HKa	Hukerenui	sandy loam		1
HKH	Hukerenui	silt loam	hill	3
KB	Kiripaka	silt loam	bouldery	3
KBe	Kiripaka	boulder silt loam	bouldery	1
KBH	Kiripaka	silt loam	hill	<1
KM	Kohumaru	clay		12
KN	Konoti	clay		15
KNH	Konoti	clay loam	hill	2
KNr	Konoti	clay		11
KNrH	Konoti	clay	hill	2
KO	Kamo	clay loam		3
KP	Kaipara	clay loam		188
KPy	Kaipara	peaty clay loam		20
KR	Kara	silt loam		20
KRa	Kara	sandy loam		2
KRe	Kara	clay		2
KT	Katui	clay loam		16
KTH	Katui	clay loam		31
MA	Mata	clay loam		5
ME	Maungarei	clay		3

Soil code	Soil series	Soil type	Soil phase	Area (km^2) of series
MEH	Maungarei	clay	hill	1
MF	Mangakahia	clay		19
MFm	Mangakahia	clay loam		44
MO	Maungatoroto	clay		16
MRH	Marua	clay loam	hill	4
MRuH	Marua	clay loam	hill	<1
MT	Motatau	clay		14
MV	Mahurangi	fine sandy loam		63
MVH	Mahurangi	fine sandy loam	hill	14
OA	Okaka	clay		24
OAH	Okaka		hill	28
OG	Otonga	peaty clay loam		4
OM	Omu	clay loam		15
OMH	Omu	clay loam	hill	50
ON	Omanaia	clay loam		4
OPH	Otaika	silt loam	hill	<1
OT	One tree point	peaty sand		7
PBuH	Puhoi	light brown clay loam	hill	8
PC	Pakotai	clay		2
PD	Puketitoi	sandy loam		1
PES	Parakiore	stony clay loam	steep	4
PFH	Piroa	clay	hill	12
PM	Pukenamu	silt loam		1
PN	Pinaki	sand		46
PNH	Pinaki	sand	hill	39
POS	Pukekaoro	clay loam	steep	15
PZ	Parore	peaty sandy loam		50
RA	Rangiora	clay		2
RAH	Rangiora		hill	<1
RAI	Rangiora	silty clay loam		<1
RL	Red Hill	sandy loam		19
RLa	Red Hill	sandy clay loam		48
RLaH	Red Hill	sandy clay loam	hill	6
RLH	Red Hill	sandy loam	hill	20
RP	Riponui	clay		20
RPa	Riponui	silty clay loam		6
RPaH	Riponui	silty clay loam	hill	5
RPH	Riponui	clay	hill	4

Soil code	Soil series	Soil type	Soil phase	Area (km^2) of series
RU	Rangiuru	clay		18
RUH	Rangiuru	clay	hill	10
RV	Rockvale	clay		98
RVe	Rockvale	clay	coarse subsoil	10
TC	Takahiwai	clay		4
TCa	Takahiwai	sand		<1
TEK	Te Kopuru	sand		128
TErS	Te Kie	reddish clay loam		61
TES	Te Kie	clay loam		75
TN	Tanoa	sandy clay loam		2
TNaH	Tanoa	sandy loam		6
TNH	Tanoa	sandy clay loam	hill	9
TO	Tutamoe	clay		70
TP	Tinopai	sandy loam		5
TRS	Te Ranga	clay loam	steep	11
TT	Tangitiki	sandy loam		56
TTH	Tangitiki		hill	170
TU	Takitu	clay loam	gravelly	5
TUH	Takitu	gravelly clay loam	hill	39
WA	Warkworth	clay, sandy clay loam		8
WAH	Warkworth	clay, sandy clay loam	hill	24
WCS	White cone	sandy clay loam	steep	6
WE	Waitemata	silt loam		2
WF	Whakapara	sand		11
WFm	Whakapara	clay	mottled	70
WK	Wharekohe	silt loam		8
WKa	Wharekohe	sandy loam		1
WNH	Whirinaki	clay loam	hill	2
WO	Whaeora	clay loam		4
WR	Whangaripo	clay loam		4
WRe	Whangaripo	clay		3
WReH	Whangaripo	clay	hill	26
WRH	Whangaripo	clay loam	hill	15
WT	Whatoro	clay		27
WTH	Whatoro	clay	hill	23
WU	Waipuna	clay		8
YC	Waiotira	clay loam		77
YCe	Waiotira	clay		38

Soil code	Soil series	Soil type	Soil phase	Area (km^2) of series
YCeH	Waiotira	clay	hill	35
YCgH	Waiotira	gravelly sandy loam	hill	3
YCH	Waiotira	clay loam		253
YCr	Waiotira	brownish clay loam		<1
YCrH	Waiotira	brownish clay loam	hill	<1
YK	Waikare	silt loam		103
YKH	Waikare	silt loam	hill	20
YN	Waimatenui	clay		24
YNH	Waimatenui	clay	hill	107
YP	Waipoua	clay		2
YPH	Waipoua	clay	hill	13
YR	Wairiki	clay loam		1
YU	Waipu	clay		3
YUy	Waipu	peaty silt and clay		2

5.4 Slope Class

Slopes of New Zealand Land Resource Inventory (NZLRI) polygons are recorded as one or a complex of two slope classes defined by an upper and lower slope angle and expressed in degrees of slope: A (0–3°), B (4–7°), C (8–15°), D (16–20°), E (21–25°), F (26–35°), G (>35°). Each class is important for particular aspects of land management, for example, the use of wheeled vehicles is appropriate up to and including slope C; hill country that can be cultivated using tracked or four wheel drive tractors lies in class D; hill country that cannot be cultivated using tracked or four wheel drive tractors is in class E. Cultivation for cropping is not feasible for E slopes and steeper. Consideration of slope underpins almost every land-use and management decision.

Slopes are generally subdued (<20°), in the study area (Map 3). The only significantly steep and very steep country is where Tangihua Volcanics form craggy mountain slopes to the west of Pukehuia. Other areas of steepland slopes are scattered throughout the study area but cover only 5% of the area. Over seventy percent of the area has slopes of less than 20°, and these can be cultivated, although with a significant risk of erosion and soil loss on slopes greater than about 12°.

5.5 Subsoil Acidity (minimum pH over the depth range 0.2−0.6 m)

Soil acidity is a measure of whether the soil solution is acid, neutral or alkaline, and is expressed in pH units (Table 3). Where solutions contain equal concentrations of H^+ and OH^- ions, pH 7 is neutral; pH values <7 indicate acidity, and pH >7 indicate alkaline conditions. Because the pH scale is logarithmic, pH 6 is 10 times more acid than pH 7, and so on. Classes are given for the 20−60 cm soil depth range, because adverse pH can have a significant effect on root growth at these depths and pH is very difficult to alter below the topsoil. The pH affects plant growth largely through its influence on nutrient availability, the presence of toxic ions, and soil biological composition, including the amount and type of bacteria present. For example, several essential elements such as iron, manganese, and zinc tend to become less available as the pH is raised to >7.5. Molybdenum availability, on the other hand, is higher at the higher pH levels. At pH values below 5.0 to 5.5, aluminium, iron, and manganese may be soluble in sufficient quantities to be toxic to the growth of some plants. Although most plants tolerate a wide range of pH, each has a narrower range for optimum growth, and pH is not the same for all soils.

Subsoil pH over much of the project area is moderately low to very low (over nearly 70% of the land area, Map 4). Amelioration of low subsoil pH is usually impractical, so taking account of existing subsoil pH becomes important when crop/soil matching. Soils with a high cation exchange capacity, such as those rich in clay (as are many soils in Northland) or organic matter, have greater reserves of acidity or alkalinity than do soils with lower cation exchange capacity such as sandy soils. Consequently, their pH values are less easily changed and are said to be 'well buffered'. Such soils would therefore require significant additions of lime to raise pH levels.

A review of soils of the project area according to the New Zealand soil Classification (Hewitt 1998) reveals a 'pH alert' list (Table 4) of soils with likely low or very low pH in some part of their subsoils. The list is comprehensive, but not necessarily exhaustive.

Table 3. pH classes and their area for soils in Kaipara District Council region

pH class	Range of min pH	Description	Notes on plant growth relationships	Project area (km^2, %)
1	7.6–8.3	High	May seriously interfere with plant growth	0, 0
2	6.5–7.5	Moderately high	May depress growth, possible deficiencies of some nutrients may be induced	0, 0
3	5.8–6.4	Near neutral	Satisfactory pH for many plants.	615, 20
4	5.5–5.7	Moderately low	Earthworm numbers, microbial activity, and nutrient cycling may be restricted	1183, 38
5	4.9–5.4	Low	Al often toxic and probably limits growth	724, 23
6	4.5–4.8	Very low	Both Al and Mn are likely to be toxic	416, 13
7	2.5–4.4	Extremely low	Both Al and Mn are probably toxic	0, 0
B		Not rated (bare sand)		158, 5

Table 4. Subsoil pH 'alert' list of soils in the Kaipara District Council region

Soil names and symbols	Subsoil pH observations
Parore peaty sandy loam (PZ)	The organic material to a depth of 60 cm from the soil surface, or to its base if shallower, has pH of 4.5 or less throughout the major part
Otonga peaty clay loam (OG) Waiotira series (YC, YCe, YCeH, YCH) Waipu series (YU, YUy) Takahiwai clay (TC)	pH of 4.8 or less in some part between 20 and 60 cm from the mineral soil surface, or, a horizon within 60 cm of the mineral soil surface with pH less than 4.8
Rangiuru series (RU, RUH) Waipoua series (WP, WPH)	pH of less than 5.1 in the major part of the B horizon to 60 cm from the mineral soil surface
Tutamoe friable clay (TO) Aranga clay (AR)	pH of less than 5.1 in some part of the B horizon to 60 cm from the mineral soil surface
Waipu clay (YU) Kara series (KR, KRa, KRe, KRp)	pH of less than 5.5 in some part from the base of the A horizon to 60 cm from the mineral soil surface
Hukerenui series (HK, HKa, HKgH, HKH, HKr) Wharekohe series (WK, WKa, WKap, WKfp) Aponga series (AP, APH) Rangiora series (RA, RAH) Okaka series (OA, OAH) Waikare series (YK, YKH) Puketitoi series (PD, PDH) Riponui series (RP, RPa) Tangitiki series (TT, TTH) Omu series (PM, OMH) Pukemanu series (PM, PMH) Red Hill series (RLa, RLaH) Mata clay (MA) Rockvale series (RV, RVe) Wairiki clay loam & silt loam (YR) Puhoi series (PBuH) Rockvale series (RV) Warkworth series (WA, WAH) Pukekaroro series (POS) Otaika series (OP, OPH) Mahurangi series (MV, MVH) Whangaripo series (WR, WRe, WRH, WReH) Maungarei series (ME, MEH, MEbH) Piroa series (PFH) Tanoa series (TNH)	All soils belonging to the Ultic Soil Order are on 'pH alert', because an accessory property of the Order is that KCl-extractable aluminium levels in B horizons are usually more than 1 cmol (+)/kg and Al-toxicity is possible.
Te Kopuru series (TEK) Tinopai series (TP) One Tree Point series (OT)	In Podzols, KCl-extractable-aluminium levels are high, and aluminium in soil solution may be toxic to some plants.

5.6 Potential Rooting Depth

Potential rooting depth (PRD) is the depth to a layer that may physically or chemically impede root extension. It is the depth of soil that can be potentially exploited by the rooting systems of most common crops, providing a medium for root development, water and nutrient uptake. The presence of toxic chemicals, such as high levels of aluminium, may also limit root depth, and chemical criteria can be used to determine PRD when critical limits of the chemical species are known (such as using pH values below 5.5). Soil physical characteristics known to influence root development are penetration resistance, aeration, water retention, sharp contrasts in soil properties including pans, waterlogged horizons, stiff and slowly permeable clays, and stony horizons with few or no fines <2 mm. PRD can be assessed by measurements of penetration resistance or by packing density estimates. A penetration resistance of >3000 kPa (Taylor et al. 1966) and a packing density critical limit of 1.85 Mg m^{-3} define the potential rooting depth (Jones 1983).

Plant root penetration is seriously restricted in Kaipara soils, Otonga soils (because of poor drainage), Te Kopuru soils (because of subsoil pans and poor drainage), some Arapohue soils and Konoti soils (rock at shallow depth) with root extension being limited to the soil volume above 45 cm (Map 5). These soils account for most of the shallow to very shallow rooting soils. Soils in class 4 (17% of the land area) may restrict root extension in some tree crops, and a large area (classes 1, 2, and 3—61%) is not limited by this soil attribute (Table 5).

Table 5. Potential rooting depth and area of soils in Kaipara District Council region

PRD Class	PRD Class range (m)	Description	Project area (km^2, %)
1	1.20–1.50	Very deep	195, 6
2	0.90–1.19	Deep	498, 16
3	0.60–0.89	Moderately deep	1206, 39
4	0.45–0.59	Slightly deep	534, 17
5	0.25–0.44	Shallow	378, 12
6	0.15–0.24	Very shallow	128, 5
B	Bare sand – not rated		120, 5

5.7 Soil Drainage Classes

Soil drainage classes (Table 6) provide a qualitative indication of the likely wetness status of the soil and its seasonal aeration constraints. Drainage classes are visually assessed from the presence or absence of grey soil matrix colours, the colour, size and percentage of mottles (blotches of greyish or reddish colour), and the position of the water table. Grey colours are generally reliable indicators of oxygen-deficient conditions. Waterlogging of pores markedly reduces gas exchange rates and induces seasonal anaerobic or partially anaerobic conditions. The classes may also be used to understand water availability, drainage requirements and trafficability/workability constraints.

Well- and moderately well-drained soils provide favourable environments for plant roots. Imperfectly drained soils present some problems for soil water sensitive crops. Poorly drained and very poorly drained soils present serious problems to most crop plants.

Table 6. Drainage classes and their area for soils in the Kaipara District Council region

Drainage class	Description	Project area (km^2, %)
1	Very poor	194, 6
2	Poor	372, 12
3	Imperfect	1455, 47
4	Moderately well	442, 14
5	Well	475, 15
B	Bare sand – not rated	120, 4

Nearly half the project area has imperfectly drained soils (Map 6), which this is not unusual for Northland soil environments because of the clayey subsoil conditions. Imperfect or poor drainage of soils is a normal condition for almost all flood plains in the region. A further fifth of the area is more poorly drained. Poorly drained Kaipara soils occur on the wide Wairoa River flood plain, Mangahakia mottled clay loams occur in narrow river valleys in the study area, and Whakapara mottled clay loams occur in narrow rivers valleys draining the non-volcanic hill country of Kaipara. Imperfectly drained soils also occur on strongly weathered sedimentary rock terrains, and in the older inland dunelands where Tangitiki and very poorly drained Te Kopuru soils are recorded. Better drainage status occurs with Pinaki and Red Hill soils in the younger coastal dunelands, and soils associated with volcanic material.

5.8 Profile Total Available Water

Profile total available water (PAW) is the total amount of water available to plant roots within the potential rooting depth, or to a depth of 0.9 m, whichever is shallower, expressed as mm of water. It is water that occurs between the field capacity and wilting point and, as such, is estimated as the difference in volumetric water content between −10 kPa (the pressure level at field capacity) and −1500 kPa (the pressure level at wilting point). Only a portion of the PAW is considered to be readily available. Readily available water is the difference in volumetric water content between −10 kPa and −100 kPa. Much of the PAW is held more tightly in the soil micropores at suctions greater than −100 kPa and becomes more difficult for plants to absorb the closer the soil water potential moves towards wilting point. As a result, while plants do not wilt, plant growth becomes increasingly restricted because the soil water held at lower potentials is not readily available for plant use. For most clayey soils of the project area, readily available water would be about one quarter of the PAW.

Eighty-nine percent of the project area has soils with moderate to high levels of PAW (Map 7).

Table 7. Profile Available Water (PAW) classes and their area for soils in the Kaipara District Council region

PAW class	PAW class range (mm)	Description	Project area (km2, %)
1	250–350	Very high	0, 0
2	150–249	High	106, 3
3	90–149	Moderately high	1216, 39
4	60–89	Moderate	1470, 47
5	30–59	Low	123, 4
6	0–29	Very low	4, <1
B	Bare sand – not rated		121, 4

5.9 Water Options Report

The Water Options Report (Mawer et al. 2019) develops a desktop analysis of potential water supplies capable of supporting small-scale horticultural development. It was not contracted to identify soil and land suitability for horticulture but can be used in conjunction with such assessments. When climate/crop interaction information is combined with soil and land information and potential water supplies, a powerful dataset can be created and options for intensifying land use identified.

6 Conclusions

Relevant soil and land data have been extracted from Manaaki Whenua – Landcare Research's Fundamental Soils Layer and NZ Land Resource Inventory databases, described and maps of the layers for the Kaipara District Council region generated.

7 Recommendations

Where climatic data suggests land use could be intensified, more detailed soil assessment including field site assessment by a qualified soil surveyor is required to ascertain soil variability within the soil map unit and the suitability of the soil for the proposed land use.

Fieldwork to generate the soil maps used in this study was undertaken in the mid-1950s with soils developed in similar rocks aggregated into 'soil suites'. It is unlikely we would use the same methods today as soils within the soil suites can show considerable variation in properties such as drainage class.

8 Soil references and further reading

Cox JE, Taylor NH, Sutherland CF, Wright ACS 1983. Northland Peninsula soil legends: A Legend of soil mapping units arranged physiographically. B. Legend of Taxonomic units arranged pedologically. C. Suite chart – Legend of soil mapping units arranged by parent materials and in genetic group sequences. Lower Hutt, NZ: Soil Bureau, DSIR. 1 Sheet.

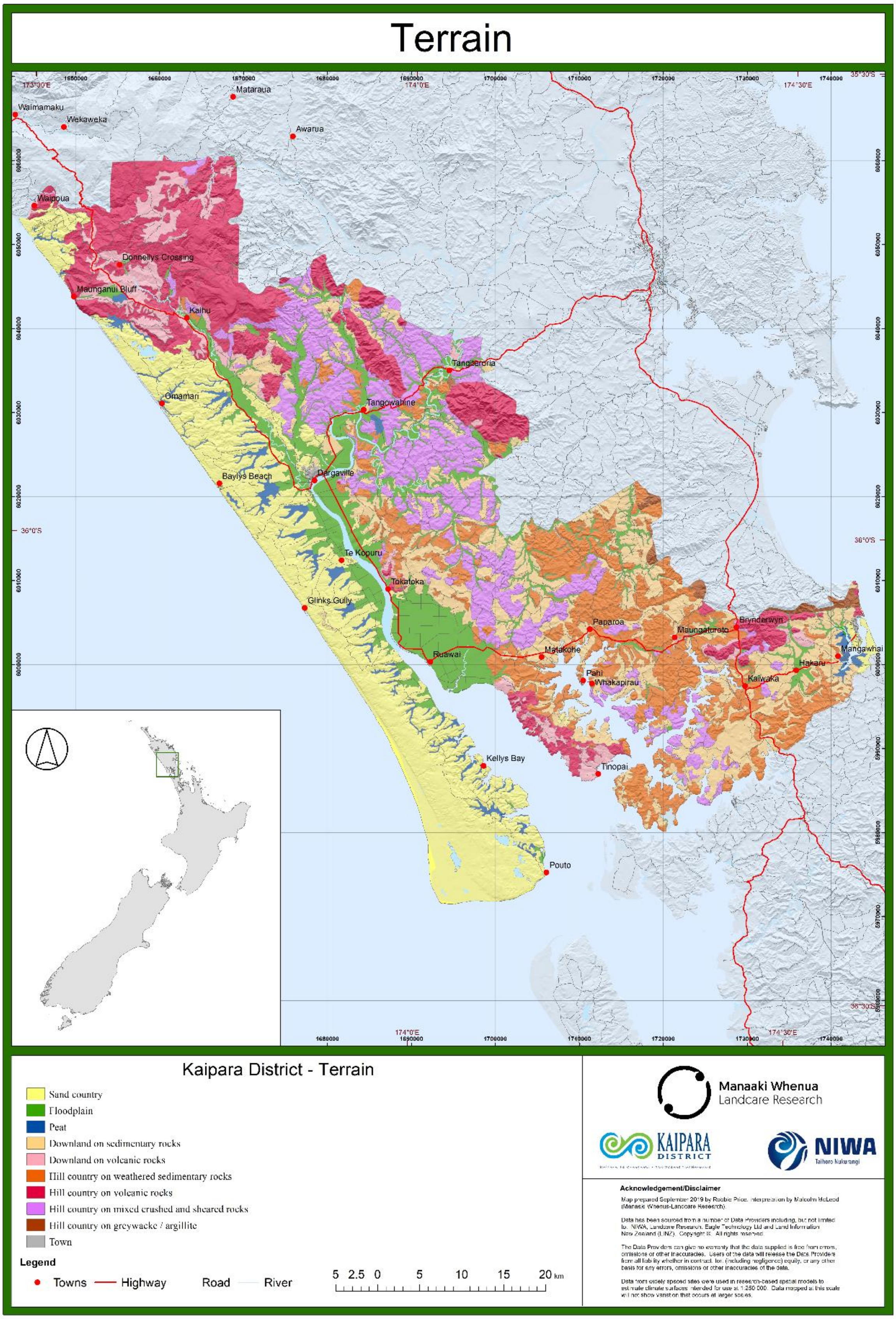
Hewitt AE 1998. New Zealand Soil Classification. *Landcare Research Science Series* 1, 2nd edn. Lincoln: Manaaki Whenua Press. 133 p.

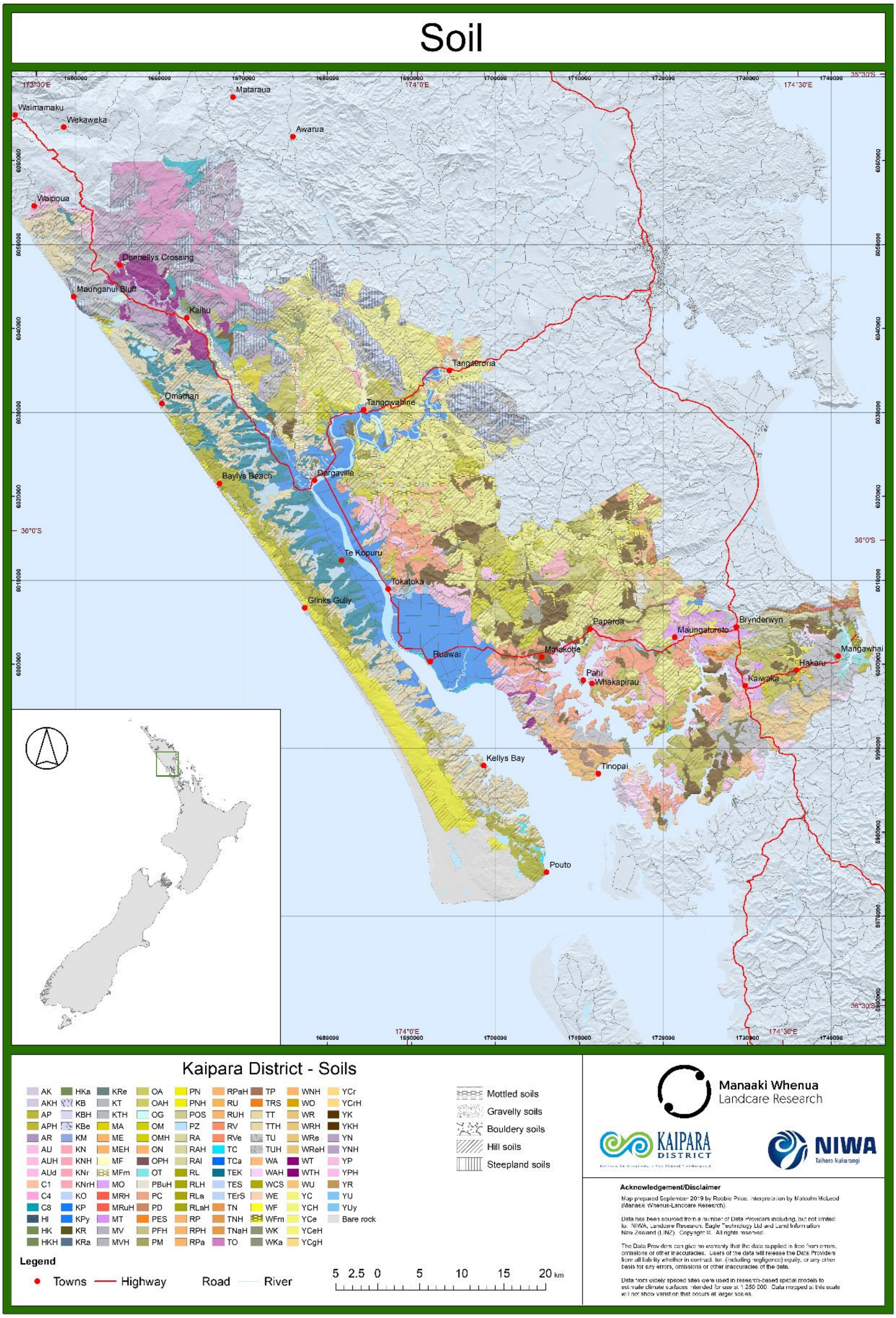
Jones CA 1983. Effect of soil texture on critical bulk densities root growth. Soil Science Society of America Journal 47: 1208–1211.

Taylor HM, Robertson GM, Parker JJ 1966. Soil strength-root penetration relations to medium to coarse textured soil materials. Soil Science 102: 18–22.

Mawer J, Soltau L, Scheberg J 2019. Kai For Kaipara – water resource assessment. Williamson Water & Land Advisory contract report WWLA0158 Rev. 1 prepared for Kaipara District Council. 41 p.

Appendix 1 – Soil and land maps





Soil
Waimamaku
Wekaweka
Mataraua
Awarua
Waipoua
Donnellys Crossing
Maunganui Bluff
Kaihu
Tangiteroria
Omamari
Tangowahine
Dargaville
Baylys Beach
Te Kopuru
Tokatoka
Glinks Gully
Paparoa
Maungaturoto
Brynderwyn
Mangawhai
Hakaru
Matakohe
Ruawai
Pahi
Whakapirau
Kaiwaka
Kellys Bay
Tinopai
Pouto
173°30'E
174°0'E
174°30'E
36°0'S
Kaipara District - Soils
AK AKH AP APH AR AU AUH AUd C1 C4 C8 HI HK HKH
HKa KB KBH KBe KM KN KNH KNr KNrH KO KP KPy KR KRa
KRe KT KTH MA ME MEH MF MFm MO MRH MRuH MT MV MVH
OA OAH OG OM OMH ON OPH OT PBuH PC PD PES PFH PM
PN PNH POS PZ RA RAH RAI RL RLH RLa RLaH RP RPH RPa
RPaH RU RUH RV RVe TC TCa TEK TES TErS TN TNH TNaH TO
TP TRS TT TTH TU TUH WA WAH WCS WE WF WFm WK WKa
WNH WO WR WRH WRe WReH WT WTH WU YC YCH YCe YCeH YCgH
YCr YCrH YK YKH YN YNH YP YPH YR YU YUy Bare rock
Mottled soils
Gravelly soils
Bouldery soils
Hill soils
Steepland soils
Legend
Towns
Highway
Road
River
5 2.5 0 5 10 15 20 km
Manaaki Whenua
Landcare Research
KAIPARA DISTRICT
NIWA
Taihoro Nukurangi
Acknowledgement/Disclaimer
Map prepared September 2019 by Robbie Price. Interpretation by Malcolm McLeod (Manaaki Whenua-Landcare Research).
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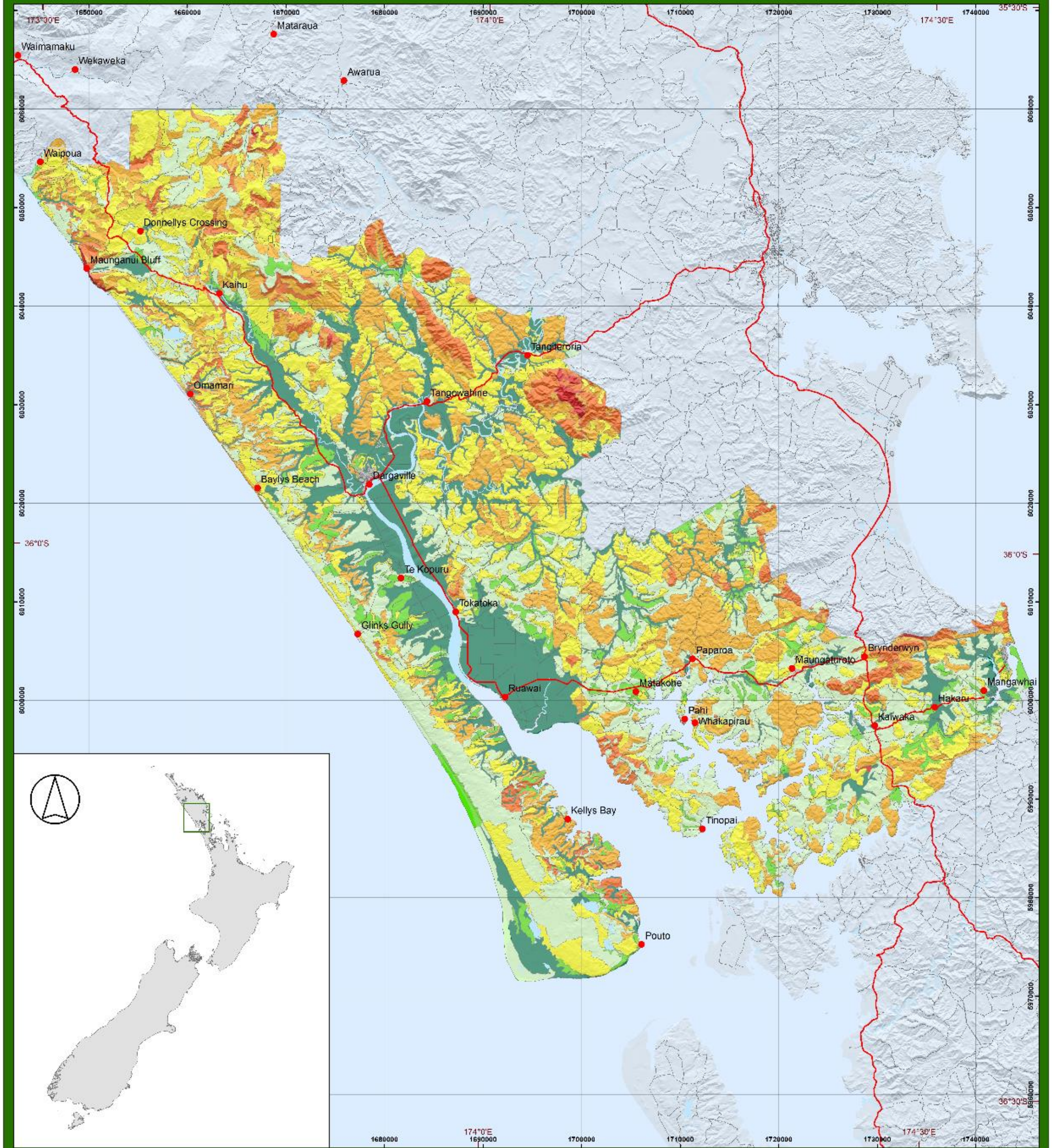
Data from widely spaced sites were used in research-based spatial models to estimate climate surfaces intended for use at 1:250 000. Data mapped at this scale will not show variation that occurs at larger scales.

Slope Class



Kaipara District - Slope Class

- Flat to gently undulating (0 - 3 degrees)
- Undulating (4 - 7 degrees)
- Rolling (8 - 15 degrees)
- Strongly rolling (16 - 20 degrees)
- Moderately steep (21 - 25 degrees)
- Steep (26 - 35 degrees)
- Very steep (> 35 degrees)
- Town

Legend

Towns Highway Road River

5 2.5 0 5 10 15 20 km

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KAIPARA DISTRICT

NIWA Taihoro Nukurangi

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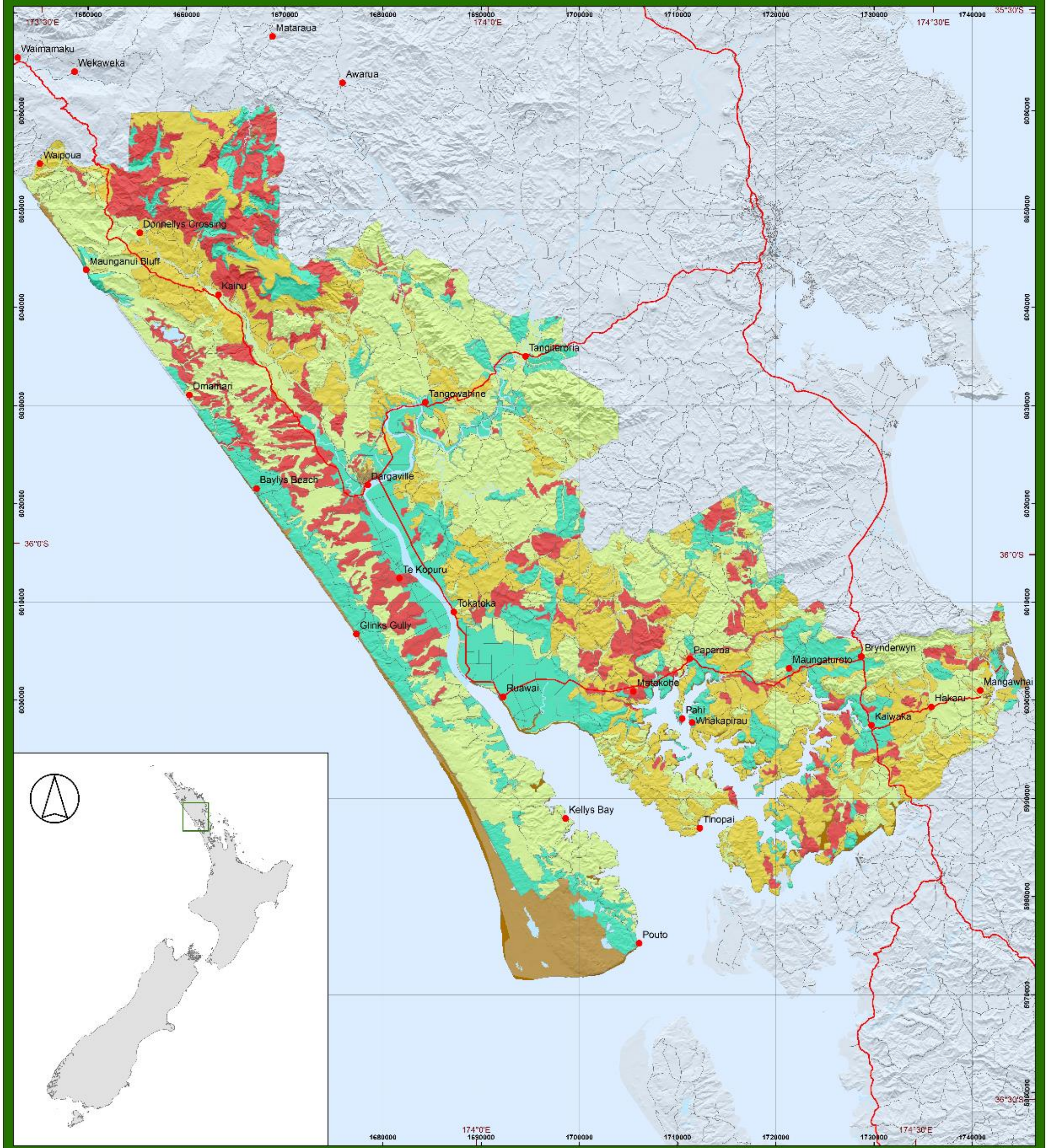
Subsoil Acidity (Minimum pH 0.2 - 0.6 m)



Kaipara District - Subsoil Acidity

- Near neutral (5.8 - 6.4)
- Moderately low (5.5 - 5.7)
- Low (4.9 - 5.4)
- Very low (4.5 - 4.8)
- Not Rated

Legend

Towns | Highway | Road | River

5 2.5 0 5 10 15 20 km

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KAIPARA DISTRICT

NIWA Taihoro Nukurangi

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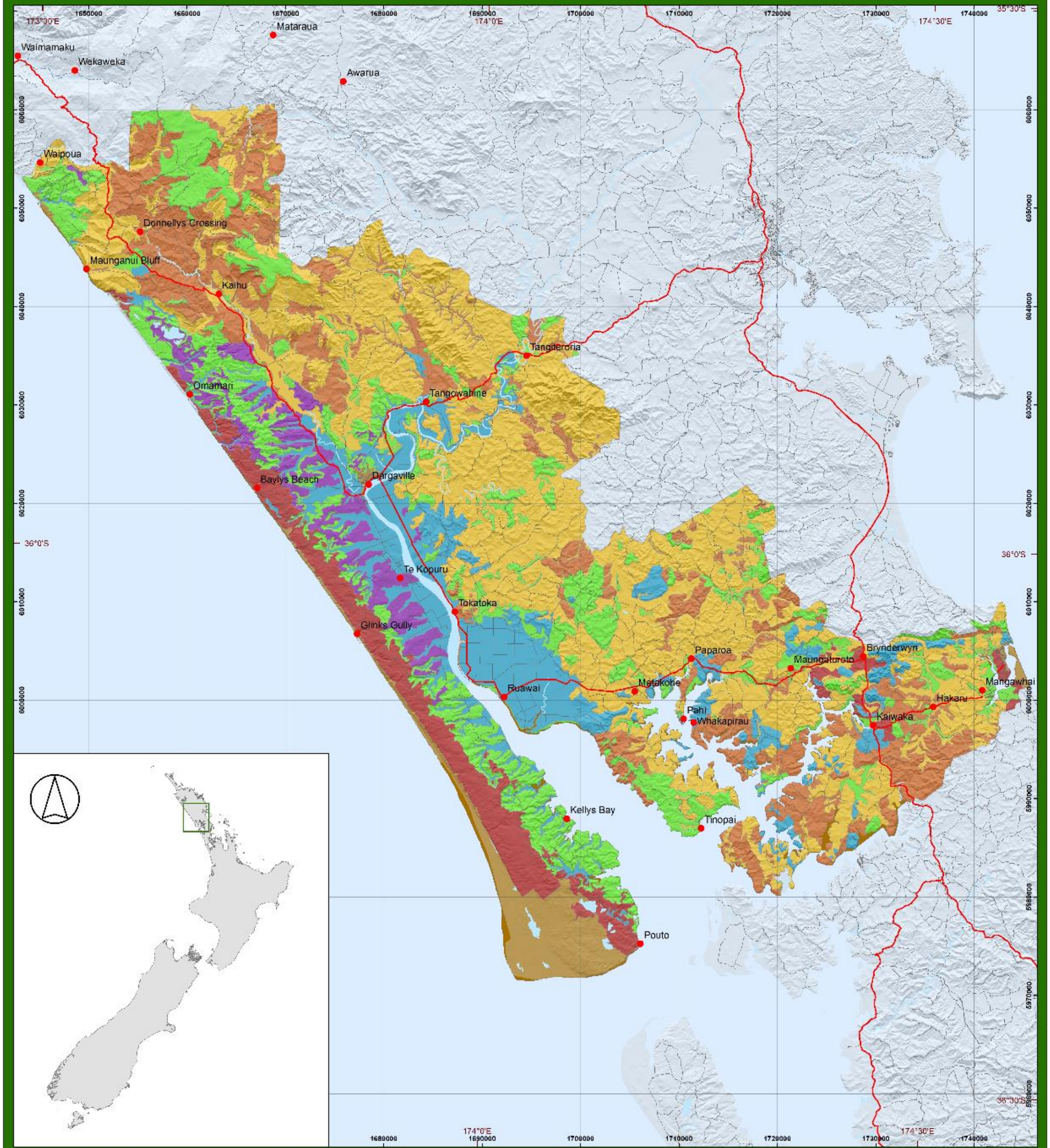
Potential Rooting Depth



Kaipara District - Potential Rooting Depth

- Very deep (1.2 - 1.5 m)
- Deep (0.9 - 1.2 m)
- Moderately deep (0.6 - 0.9 m)
- Slightly deep (0.45 - 0.6 m)
- Shallow (0.25 - 0.45 m)
- Very shallow (0.15 - 0.25 m)
- Not Rated

Legend

Towns — Highway — Road — River

5 2.5 0 5 10 15 20 km

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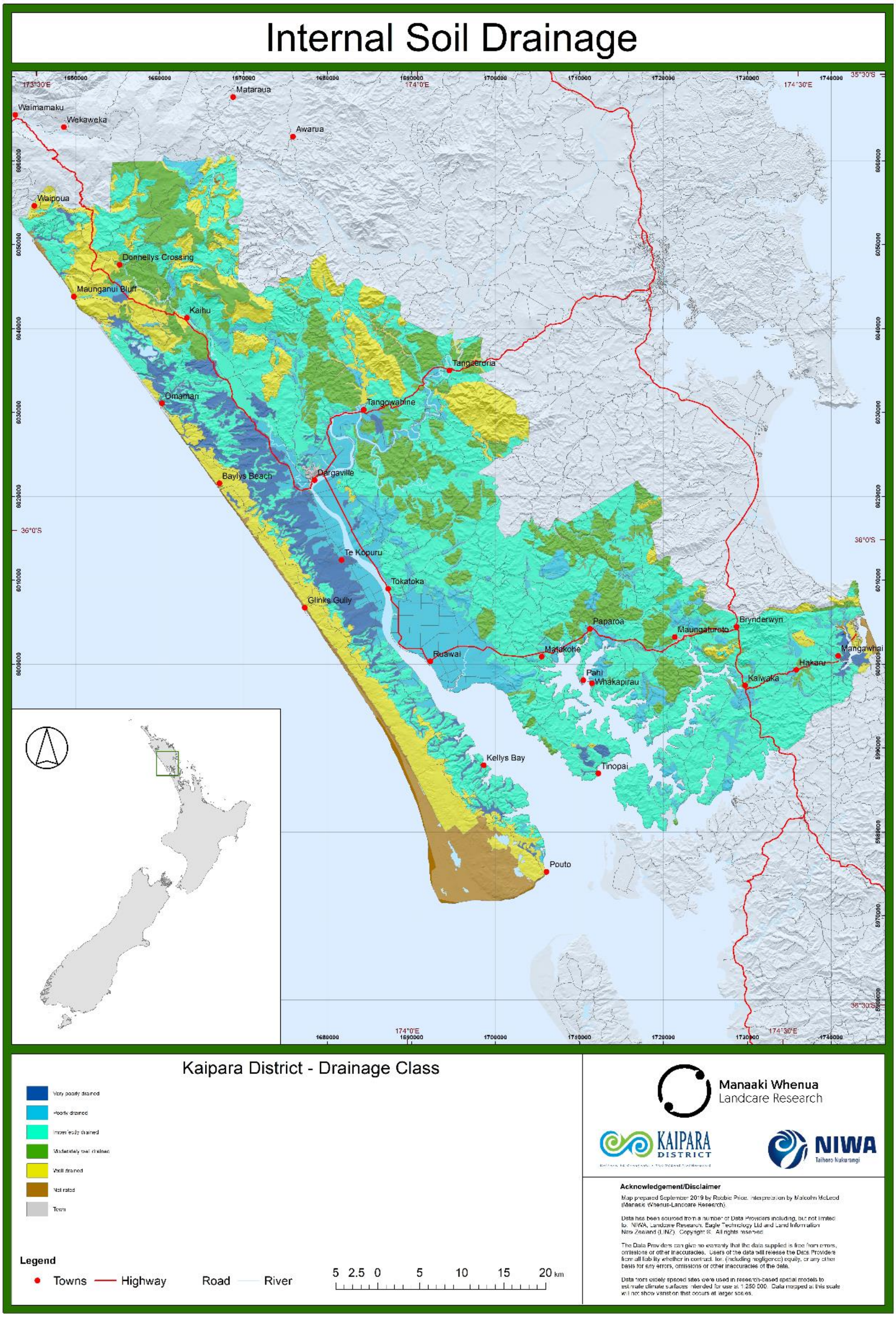
Internal Soil Drainage
Mataraua
Waimamaku
Wekaweka
Awarua
Waipoua
Donnellys Crossing
Maunganui Bluff
Kaihu
Tangiteroria
Omamari
Tangowahine
Dargaville
Baylys Beach
Te Kopuru
Tokatoka
Glinks Gully
Paparoa
Maungaturoto
Brynderwyn
Mangawhai
Matakohe
Ruawai
Pahi
Whakapirau
Hakaru
Kaiwaka
Kellys Bay
Tinopai
Pouto
173°30'E
174°0'E
174°30'E
35°30'S
36°0'S
36°30'S
Kaipara District - Drainage Class
Very poorly drained
Poorly drained
Imperfectly drained
Moderately well drained
Well drained
Not rated
Town
Legend
Towns
Highway
Road
River
5 2.5 0 5 10 15 20 km
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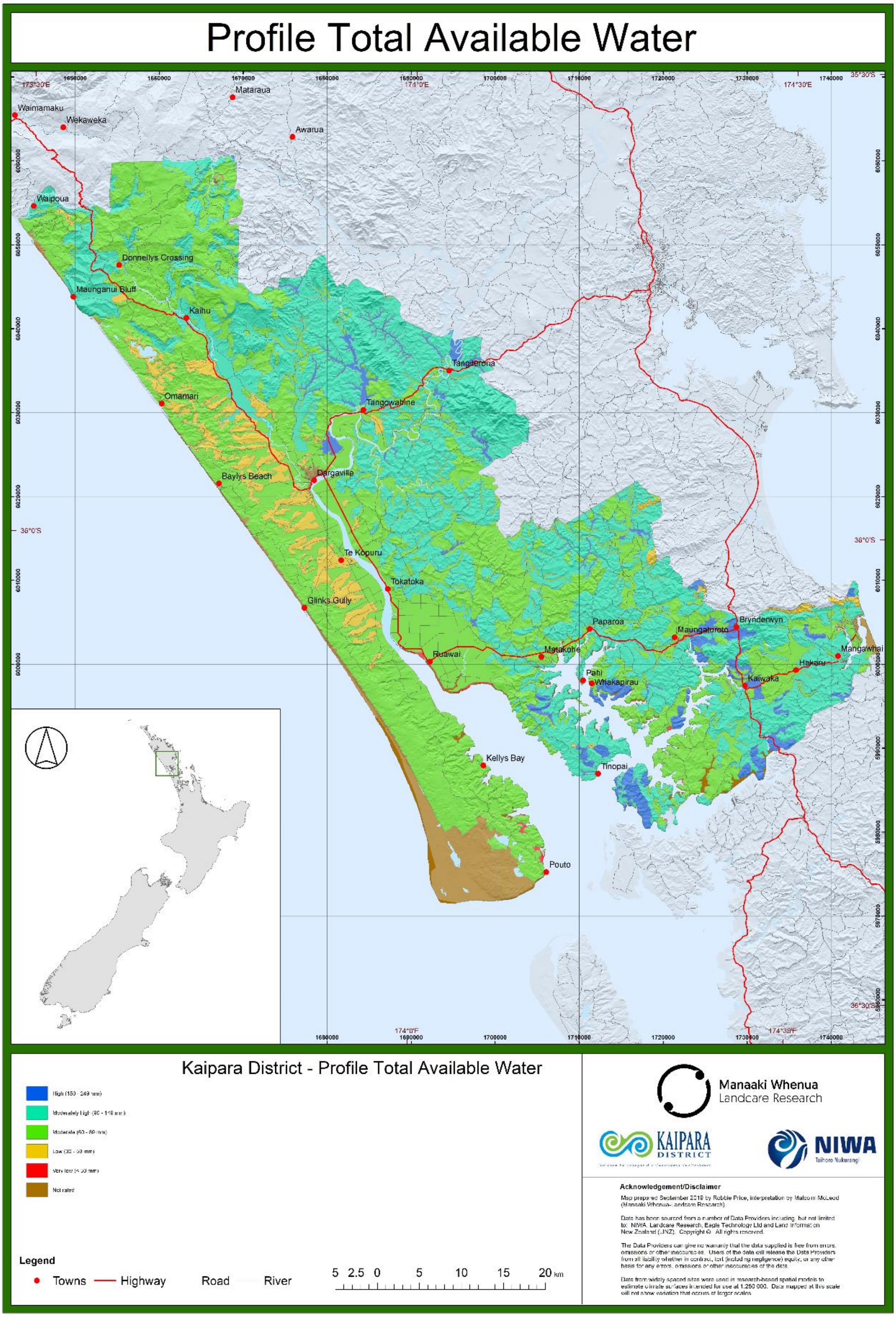
Profile Total Available Water
Waimamaku
Wekaweka
Mataraua
Awarua
Waipoua
Donnellys Crossing
Maunganui Bluff
Kaihu
Tangiteroria
Omamari
Tangowahine
Baylys Beach
Dargaville
Te Kopuru
Tokatoka
Glinks Gully
Paparoa
Maungaturoto
Brynderwyn
Mangawhai
Matakohe
Ruawai
Hakaru
Pahi
Whakapirau
Kaiwaka
Kellys Bay
Tinopai
Pouto
173°30'E
174°0'E
174°30'E
35°30'S
36°0'S
36°30'S
Kaipara District - Profile Total Available Water
High (150 - 249 mm)
Moderately High (90 - 149 mm)
Moderate (60 - 89 mm)
Low (30 - 59 mm)
Very low (< 30 mm)
Not rated
Legend
Towns
Highway
Road
River
5 2.5 0 5 10 15 20 km
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