PROTECTION OF DRINKING-WATER SOURCES UNDER A MULTI-BARRIER RISK BASED APPROACH FOLLOWING THE HAVELOCK NORTH OUTBREAK

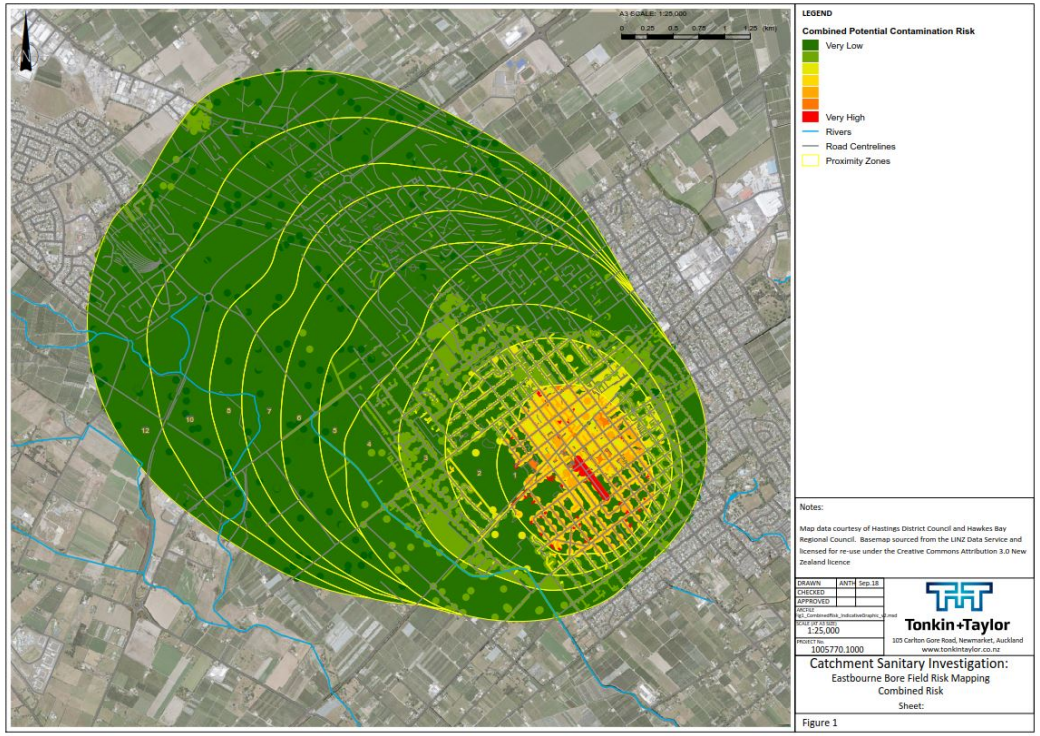
Development of Source Protection Zones for Hastings District Council Drinking-Water Supply

Brett Chapman, Water Services Manager, Hastings District Council

Tony Cussins, Technical Director - Hydrogeology, Tonkin + Taylor

Outline of presentation

- Background - Havelock North *Campylobacter* contamination - Inquiry Stage 2 findings (WSPs and a multi-barrier approach)
- Source protection zone (SPZ) development process
  - Conceptual hydrogeology
  - Contaminant sources and pathways
  - Catchment Sanitary Investigation (CSI)
- Catchment risk matrix/heat map (in ArcGIS)
- Risk mitigation/management, including treatment
- Statutory controls to manage activities within catchments



The Havelock North outbreak

- Havelock North public water supply suffered a significant *Campylobacter* contamination event in August 2016 – followed heavy rainfall

- Source of the contamination was the nearby Brookvale Road bore field - part of the HDC water supply system

- Estimated 5,500 residents became ill with campylobacteriosis - 45 hospitalised, possible contribution to three fatalities

Government Inquiry into Havelock North Drinking-Water - the catalyst for major reforms in the drinking-water sector

Outbreaks due to contaminated water sources

Year	Location	Water Type	Pathogens	Cases Confirmed	Total Cases Estimated	Comments
2000	Walkerton, ON, Canada	Groundwater	*E. coli* O157:H7, *Campylobacter*	163 (E) 105 (C) 12 both	2,300 27 HUS 7 deaths	Cattle manure Rainfall Treatment failure
2000–2001	Asikkala, Finland	Groundwater	*Campylobacter jejuni*	71	1450	Rainfall No treatment
2002	Transtrand, Sweden	Groundwater	Norwalk-like virus	4	~500	Leaking sewer pipe near bore No treatment
2001	North Battleford, SK, Canada	Surface water	*Cryptosporidium parvum* type 1	375	5,800–7,100 50 hospitalised	Sewage discharges upstream drinking water intake
2010	Õstersund, Sweden	Surface water	*Cryptosporidium*	>29	27,000 270 hospitalised	

Inquiry Stage 2 – findings/recommendations

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Key Inquiry findings:

- Systemic failures in the industry at all levels
- ~700,000 New Zealanders potentially exposed to unsafe Drinking Water
- Competency/training/certification is lacking
- Enhanced compliance monitoring to demonstrate compliance with DWSNZ
- Water Safety Plans require significant improvement – risk-based, multiple barrier approach

Recommended that:

- All Drinking Water in NZ should be treated, including a residual disinfectant in the reticulation
- A dedicated, independent and well-resourced drinking water regulator to be established
- Water suppliers should be licensed
- The Ministry of Health to develop a clear enforcement policy for safe drinking water
- The "secure" classification of bores should be abolished;
- DHBs should establish joint working groups responsible for oversight of drinking water safety in their region
- A comprehensive review of design, construction, operation and maintenance of all bores

REPORT OF THE HAVELOCK NORTH DRINKING WATER INQUIRY: STAGE 2

DECEMBER 2017

Purpose of Source Protection zones

- Principle 2 states the “protection of source water is of paramount importance” and is the first, and most significant, barrier against drinking water contamination and illness.
- Technically defensible and robust SPZ development within WSP under DWSNZ (2008)
- Assist with requirements of the *NES – Protection of Sources of Human Drinking Water*
- Manage activities in SPZs to ensure water does not become unsuitable for human consumption & risks are managed
- Prioritise infrastructure works to mitigate risk
- Provide a framework for Drinking-water management within statutory processes, including regional plans and plan changes

Sources – surface water, groundwater

Toxic algae bloom in Lake Taupo could cause breathing difficulties

8 Dec, 2017 1:22pm

4 minutes to read

Havelock North – Brookvale Bore 3 WTP

Timaru District Council water supplies need upgrading

MATTHEW LITTLEWOOD
Last updated 15:34, April 6 2018

Stephen Barker/Stuff

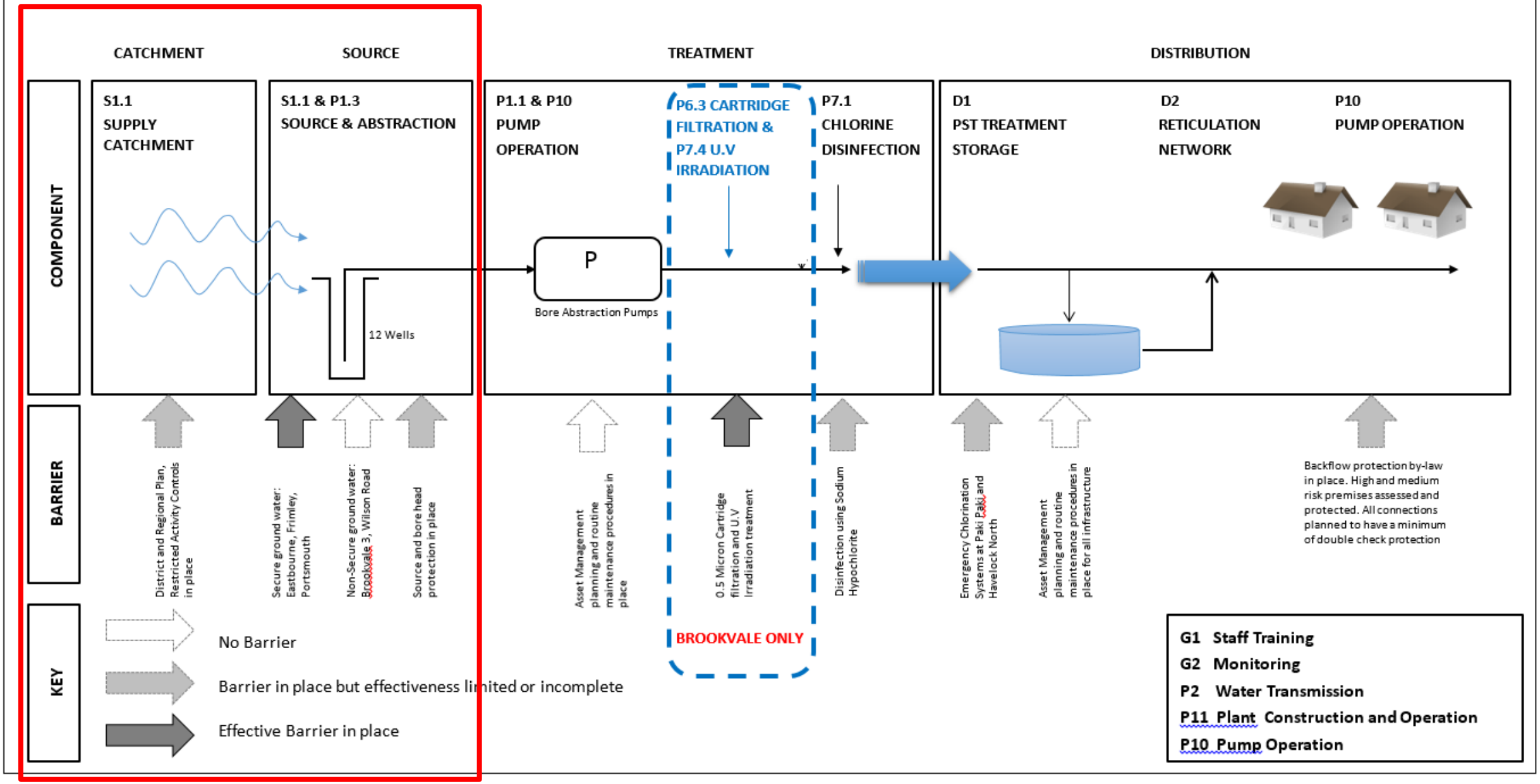
Time is running out for Timaru district residents to have their say on a council proposal to meter water supplies.

Fixing Christchurch City's drinking water comes with multi-million dollar price tag

The multi-million dollar cost of fixing the city's well heads has been revealed.

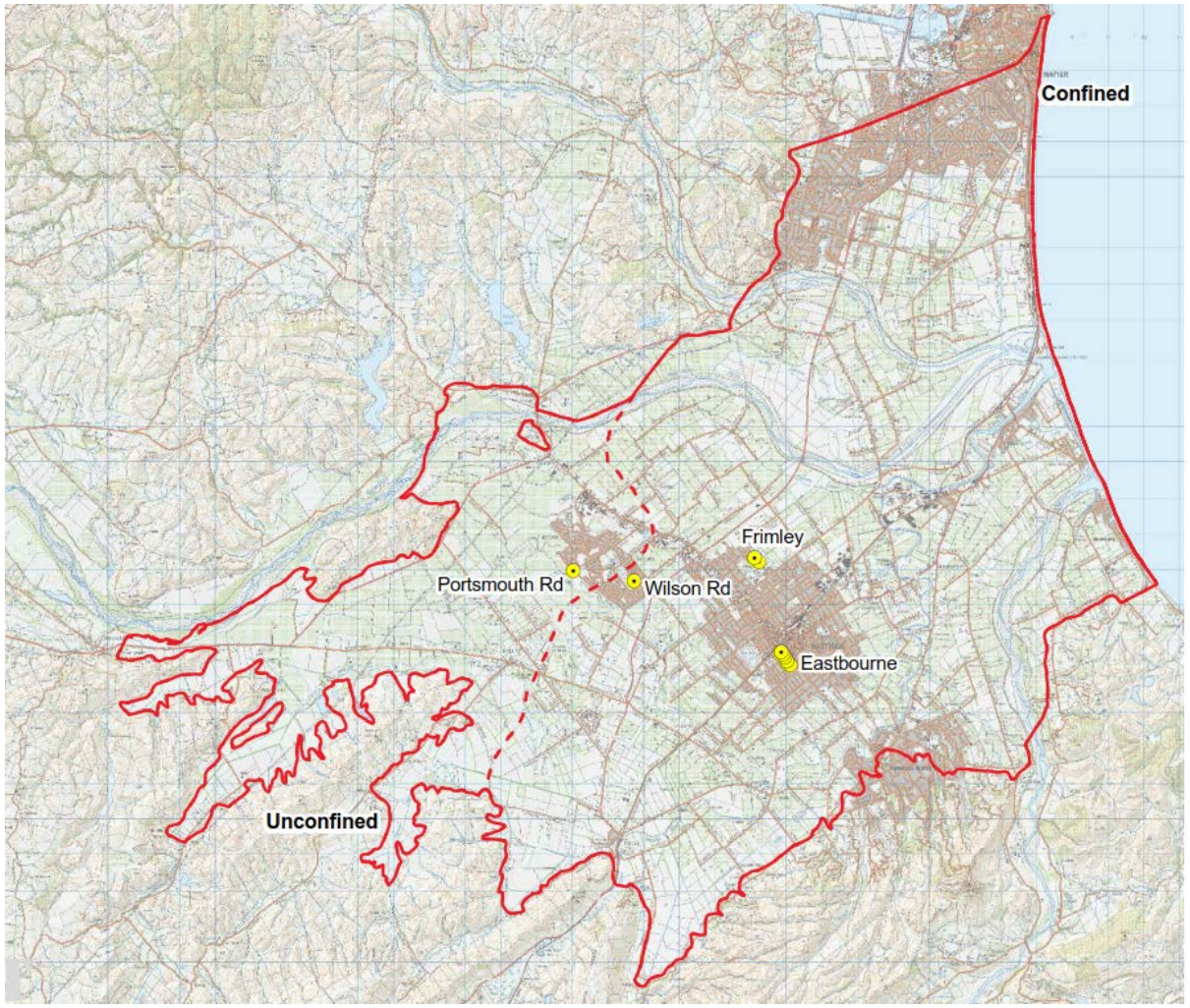
A city council report has shown two options to regain water secure status. The preferred will cost $21.5 million.

Hastings, Havelock North, Flaxmere, Bridge Pa and Paki Paki WSP

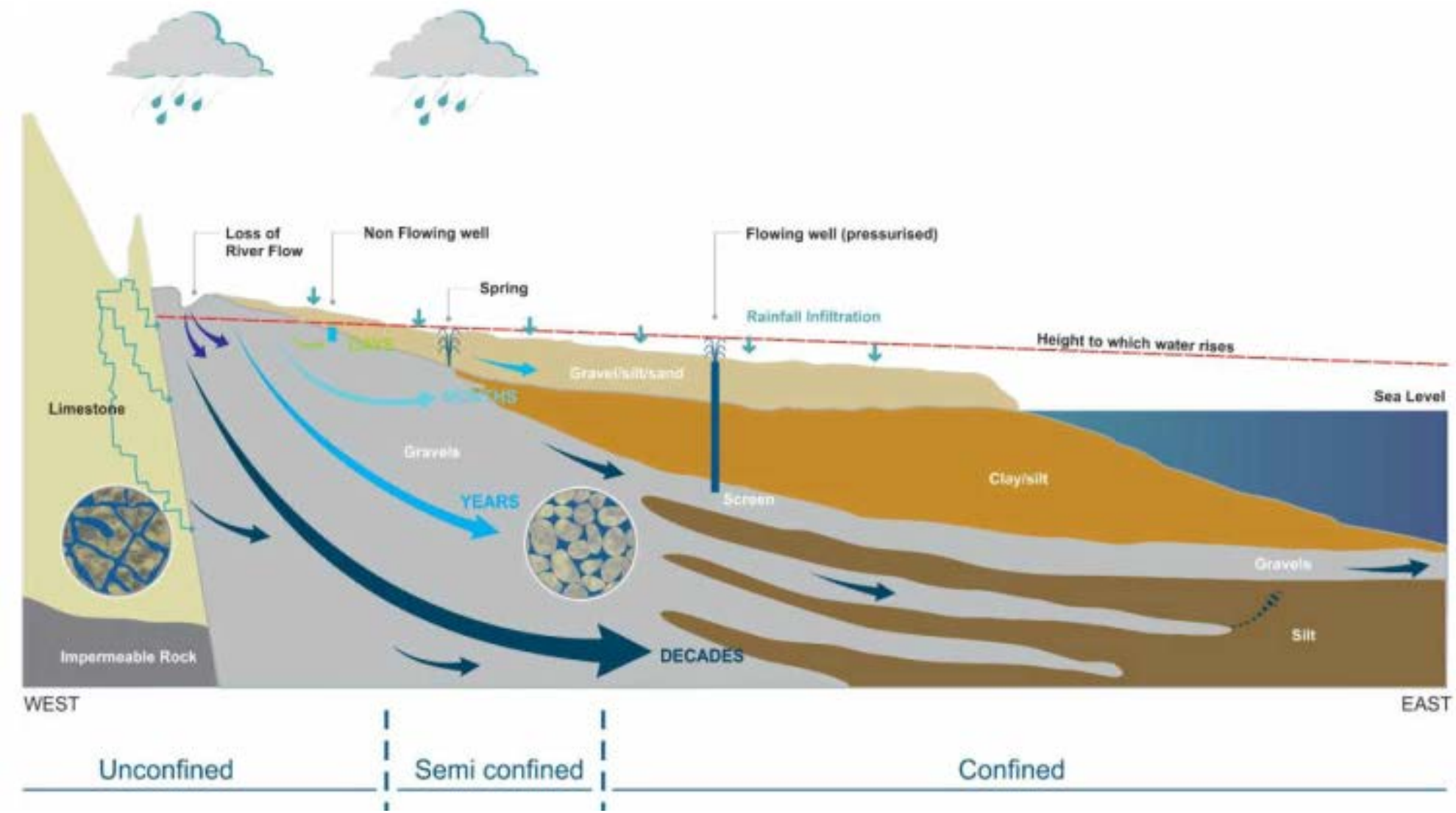


HDC Source protection zones

- SPZs were defined for the four HDC metropolitan water supply bore fields
- Developed using USEPA WhAEM software
- SPZs determine future management areas for each of the bore fields, including:
    - Eastbourne Street
    - Wilson Road
    - Portsmouth Road
    - Frimley Park



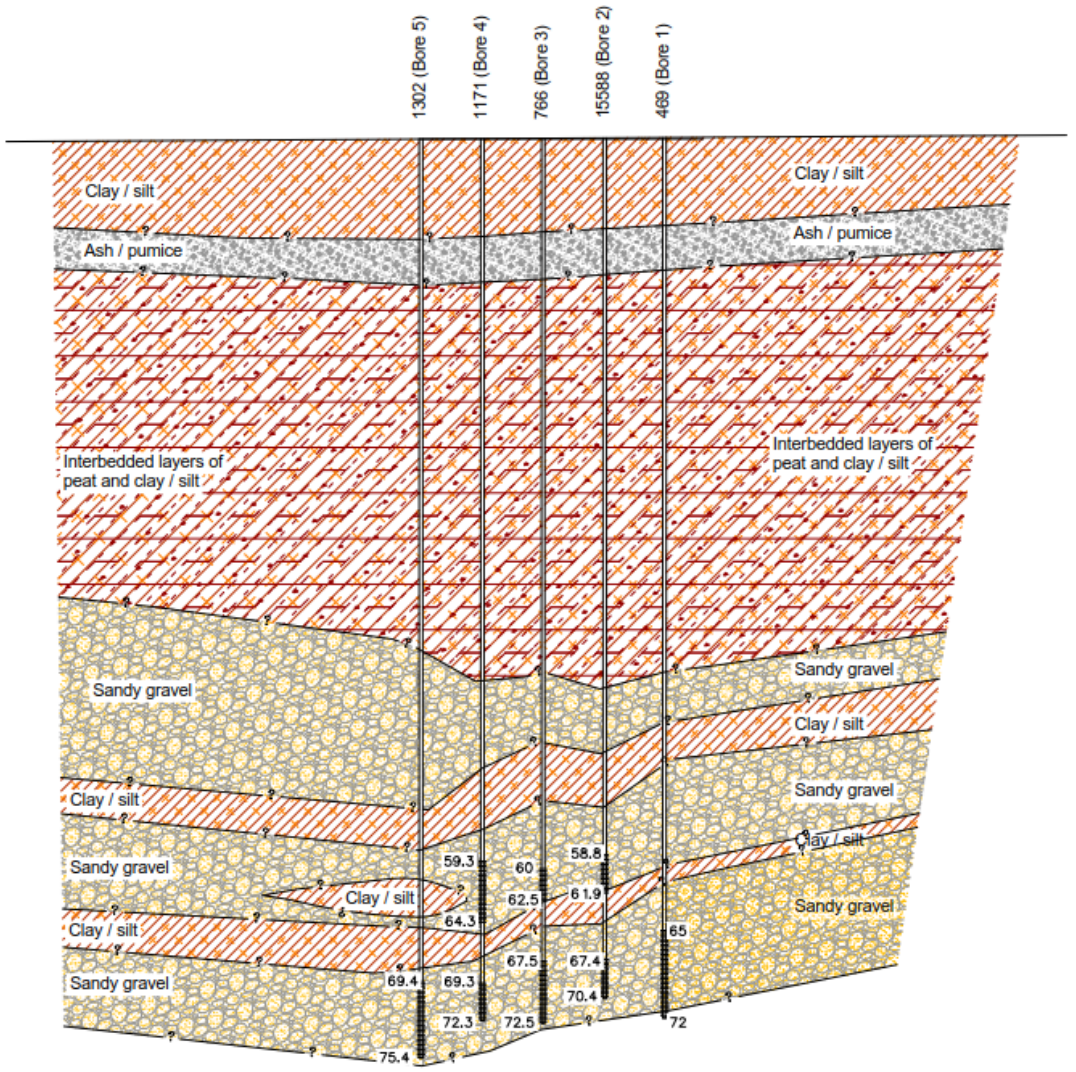
Heretaunga Plains conceptual hydrogeology



HBRC Report No. RM 1619 - 4803 (Groundwater Quality State of Environment; State and Trends; September 2016)

Eastbourne Street bore field

- Aquitards are not continuous
- 3 source aquifers are part of the same hydrogeological unit/aquifer (a leaky system)
- Potential for downward movement of groundwater from surface
- Evidence of influence of rainfall or mixed source water – trend is toward younger water

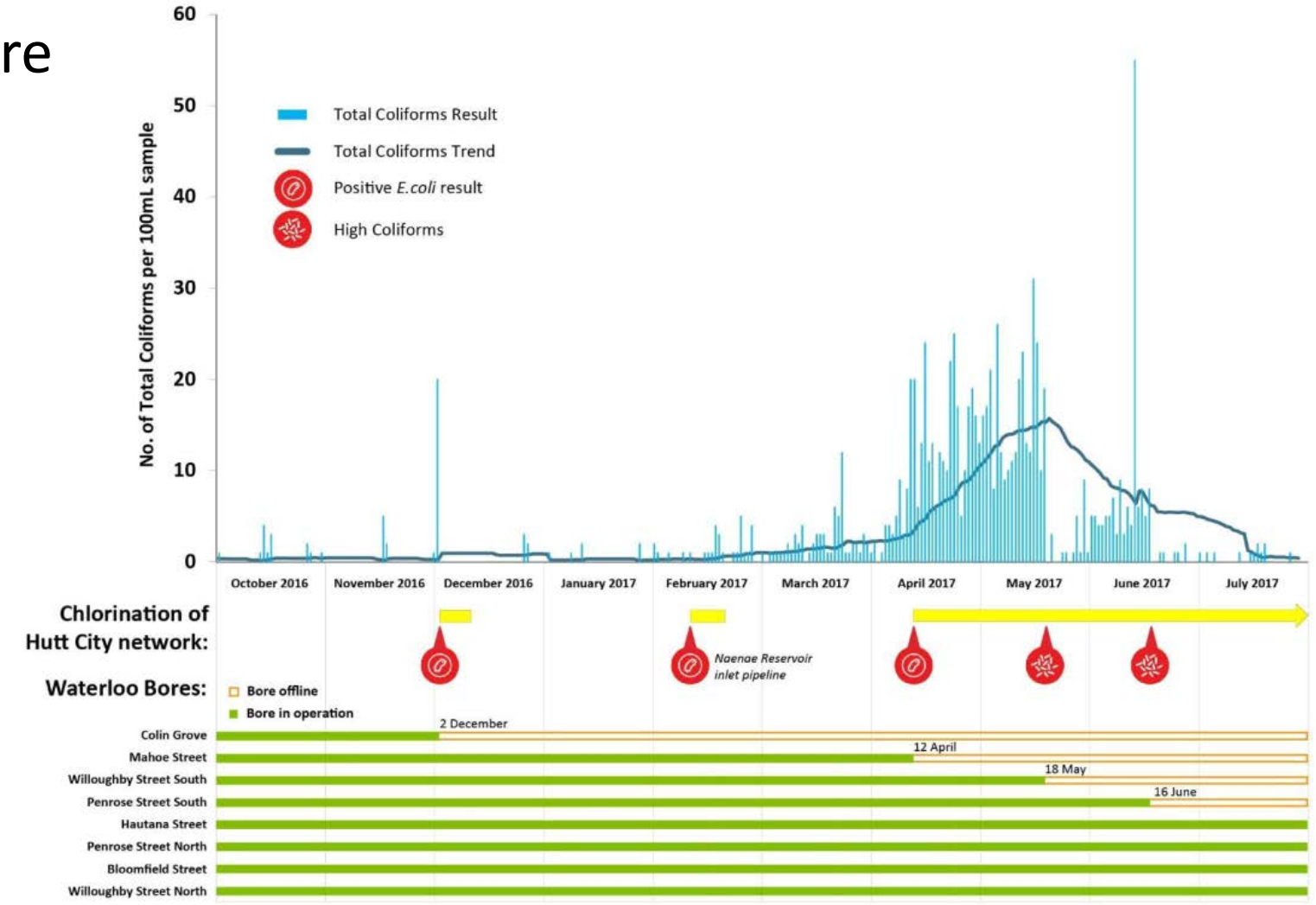


Potential contaminant sources

- Active and abandoned wastewater infrastructure (microbiological)
- Onsite wastewater disposal/treatment (microbiological)
- Former gasworks sites (hydrocarbons/ heavy metals)
- Dry-cleaning (chlorinated solvents)
- Heavy industry (various)
- Bulk storage of chemicals
- Dairy feed lots or intensive calf rearing (protozoa)
- Emerging contaminants of concern (e.g. PFAS, endocrine disruptors)

Precursors to source contamination

- Catchment management failure
- Bore security failure (widespread)
- Rainfall (Havelock North, Watercare and many others)
- Drought
- Major earthworks
- Earthquake (Christchurch, Waiwhetu Aquifer)
- Havelock North outbreak – “Swiss Cheese model”



Age-tracer data (GNS)

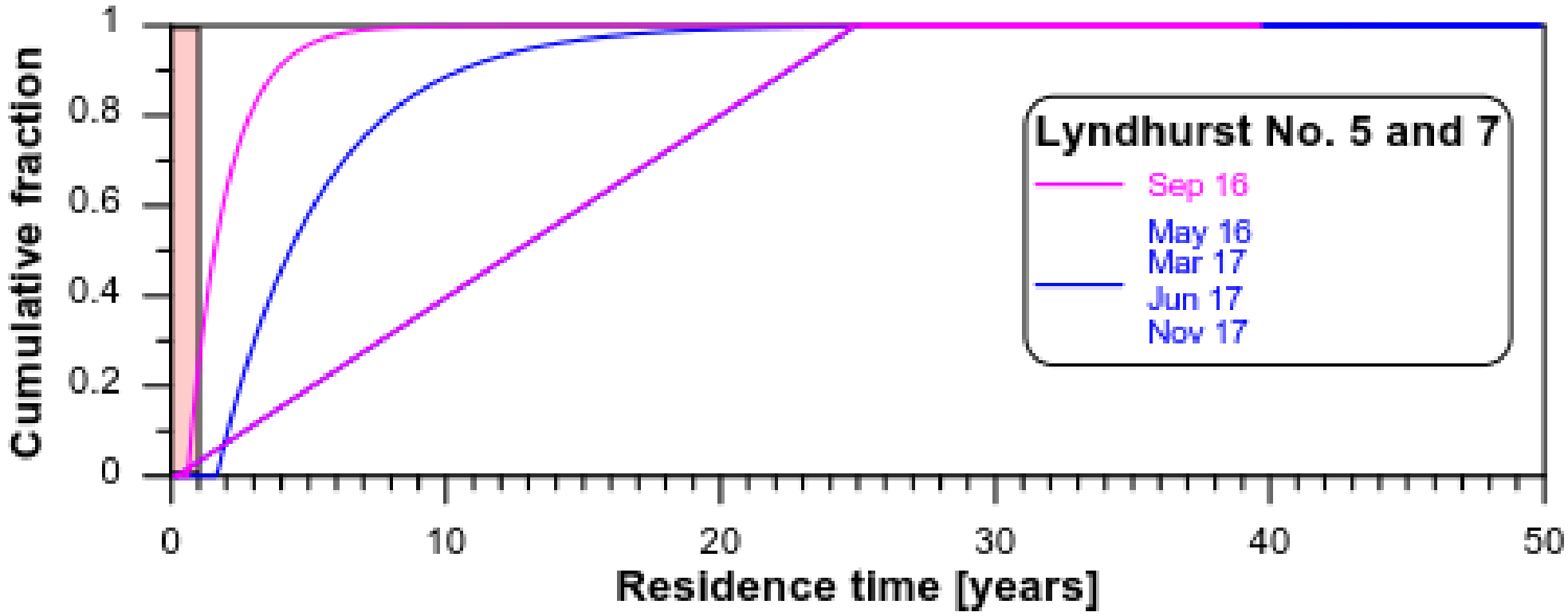


Figure 3.2 Modelled cumulative residence time distribution for the Lyndhurst No.5 and No.7 wells.

Contamination Exposure pathways

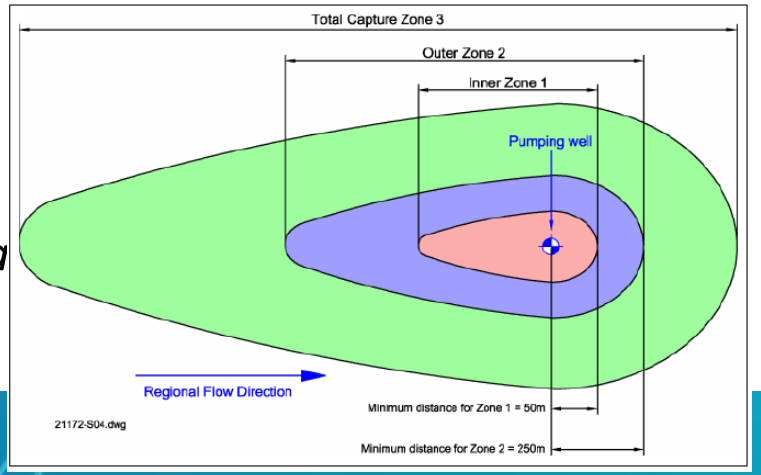
Contamination can enter Heretaunga Plains aquifer systems by:

- Surface contamination leaching into unconfined areas of the aquifer, or in confined areas where the aquitard is thinner or “leaky”
- Operational and decommissioned private bores which intercept the aquifer system - poor bore head security - direct or less restricted pathway into groundwater
- Contamination of springs and spring fed streams for hydraulically connected bore fields
- Stock access to unfenced water ways or run-off during high rainfall events
- Breaches or damage to the aquitard could open pathways for contamination of the aquifer.

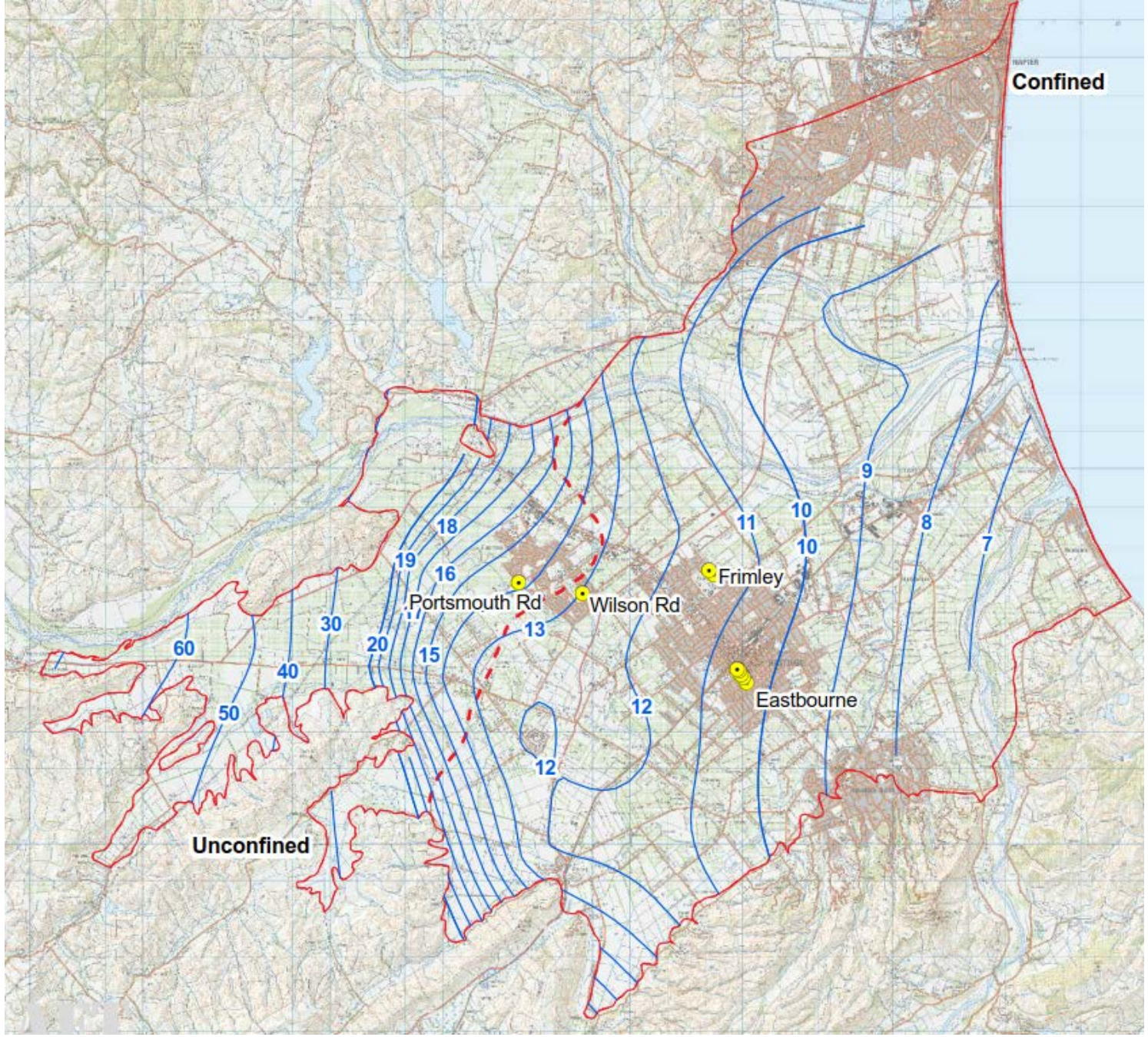
Approach for developing SPZs

T+T adopted the approach published by GNS Science (GNS) to establish the SPZ's, comprising 3 individual zones for each bore field:

- **Immediate protection zone (SPZ1):** a 5m setback zone around each bore head to allow for specific control (by statute, regulation, planning rule) of activities within the immediate vicinity of the bore heads
- **Microbial protection zone (SPZ2):** defined by analytic modelling that represents a 1 year groundwater travel time from source to bore field
- **Capture zone (SPZ3):** the full capture zone, defined by a catchment or hydrogeological boundary, which in this case is based on a 10 year travel time



- Source: *GNS Science, 2014. Envirolink Tools Project – Capture Zone Delinea 2013/57.98p*.



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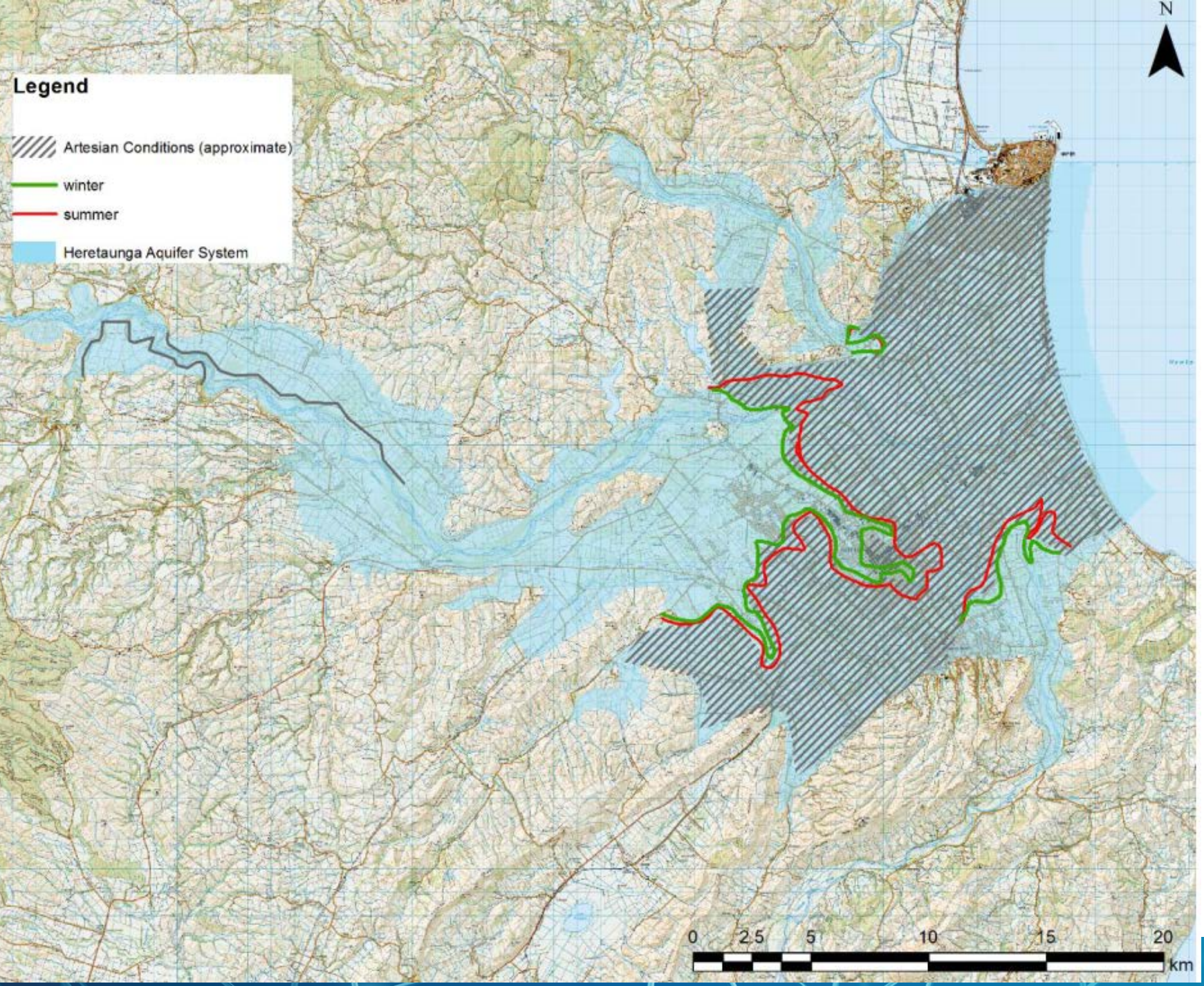
Average summer groundwater level contours (February 2012 - 2015

LEGEND

- Pumping Wells
- Piezometric contours m RL (Feb 2012-15 Avg Data)
- Heretaunga Aquifer System



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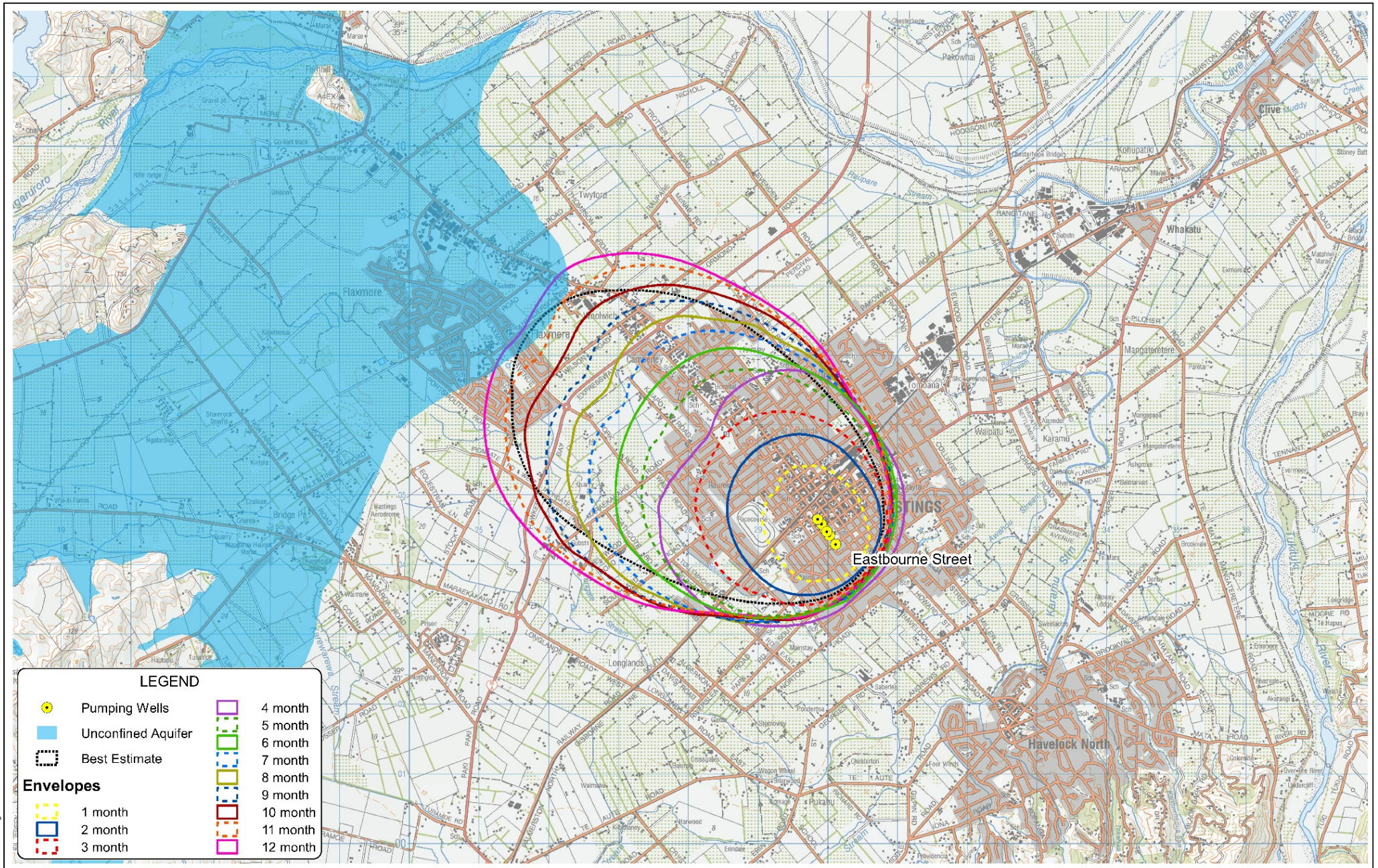
Flowing artesian conditions – winter 1976 and summer 2014

Reference Figure 3-27. Rakowski, P and Knowling M, May 2018. Heretaunga Aquifer Groundwater Model Development Report, HBRC Report No. RM18-14-4997, prepared for Hawkes Bay Regional Council

Calculated time for water to travel from ground surface to the Heretaunga aquifer

Bore field	Aquitard vertical permeability K' (m/day)	Groundwater velocity with n=0.02 (m/day)	Time to travel from ground to aquifer n = 0.02 (days)	Groundwater velocity with n=0.0032 (m/day)	Time to travel from ground to aquifer n = 0.0032 (days)
Wilson Road	0.3	0.6	83	3.75	13
Portsmouth	0.12	0.24	208	1.50	33
Frimley	0.05	0.1	500	0.63	80
Eastbourne	0.05	0.1	500	0.63	80



Notes:

Heretaunga Plains Confined and Unconfined Aquifer Shapefile Source - HBRC GIS

Service Layer Credits: Eagle Technology, HNZ

A3 SCALE 1:50,000

0 0.55 1.1 1.65 2.2 2.75 (km)

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SCALE (At A3 SIZE)	1:50,000	
PROJECT No.		
FIGURE No.	Figure 6	Rev. 1

HASTINGS DISTRICT COUNCIL

SOURCE PROTECTION ZONES FOR PUBLIC SUPPLY BORES HASTINGS URBAN AREA

Eastbourne SPZ2 Development - 1 - 12 Month Travel Times

P:\1005769\1000 HDC Metro SPZ\WorkingMaterial\GIS\MXD\FINAL\1005769-1000-FIG006.mxd Date: 13/09/2018 Time: 2:00:19 PM

Taylor

Non-microbial contaminants

Evaluated whether SPZ suitable for non-microbiological contaminants for each bore field for following sources:

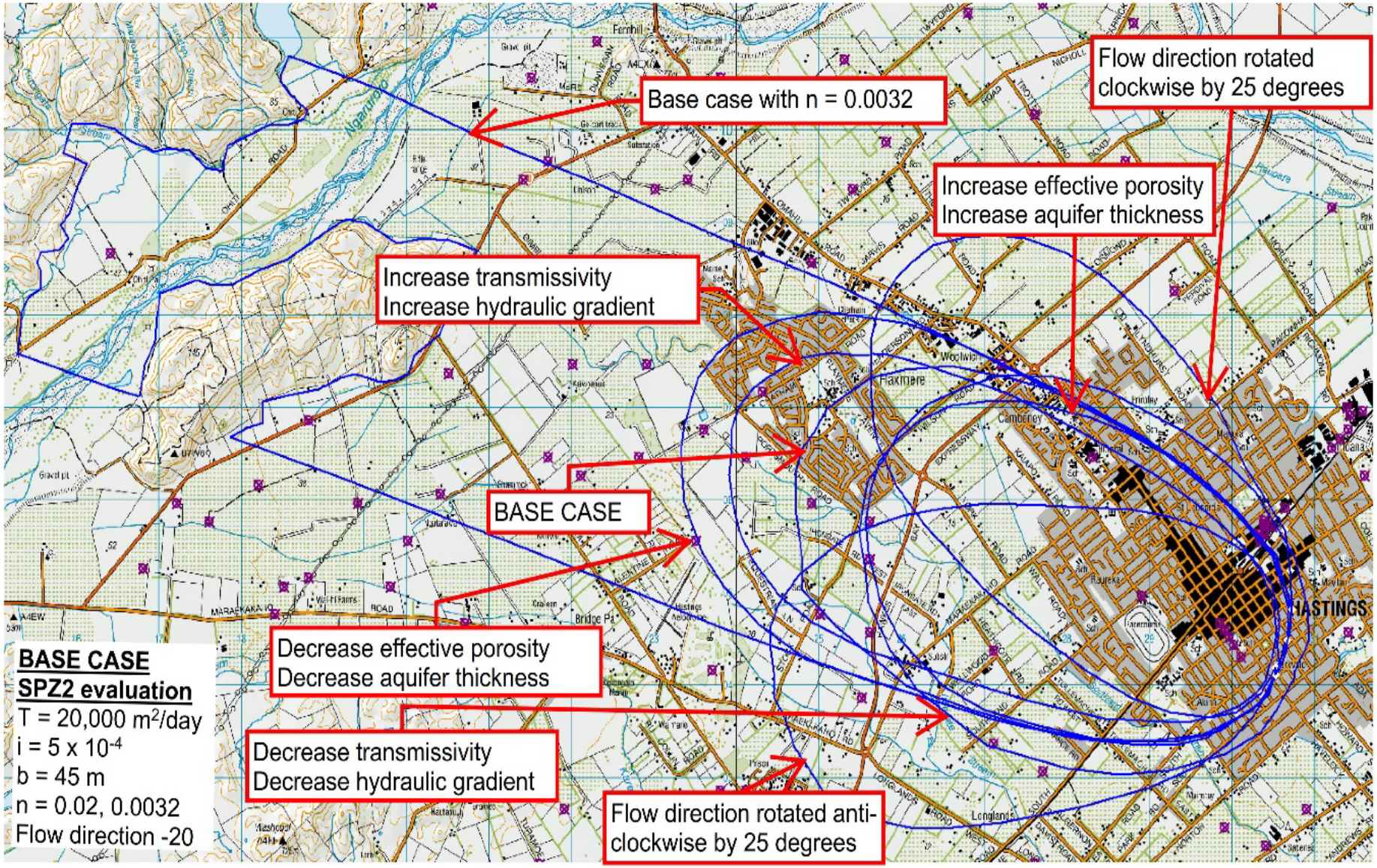
- Arsenic from orchard and timber treatment sites,
- Boron and PCP from timber treatment sites,
- BTEX from petrol stations,
- TCE, PCE from dry cleaners and workshop sites.

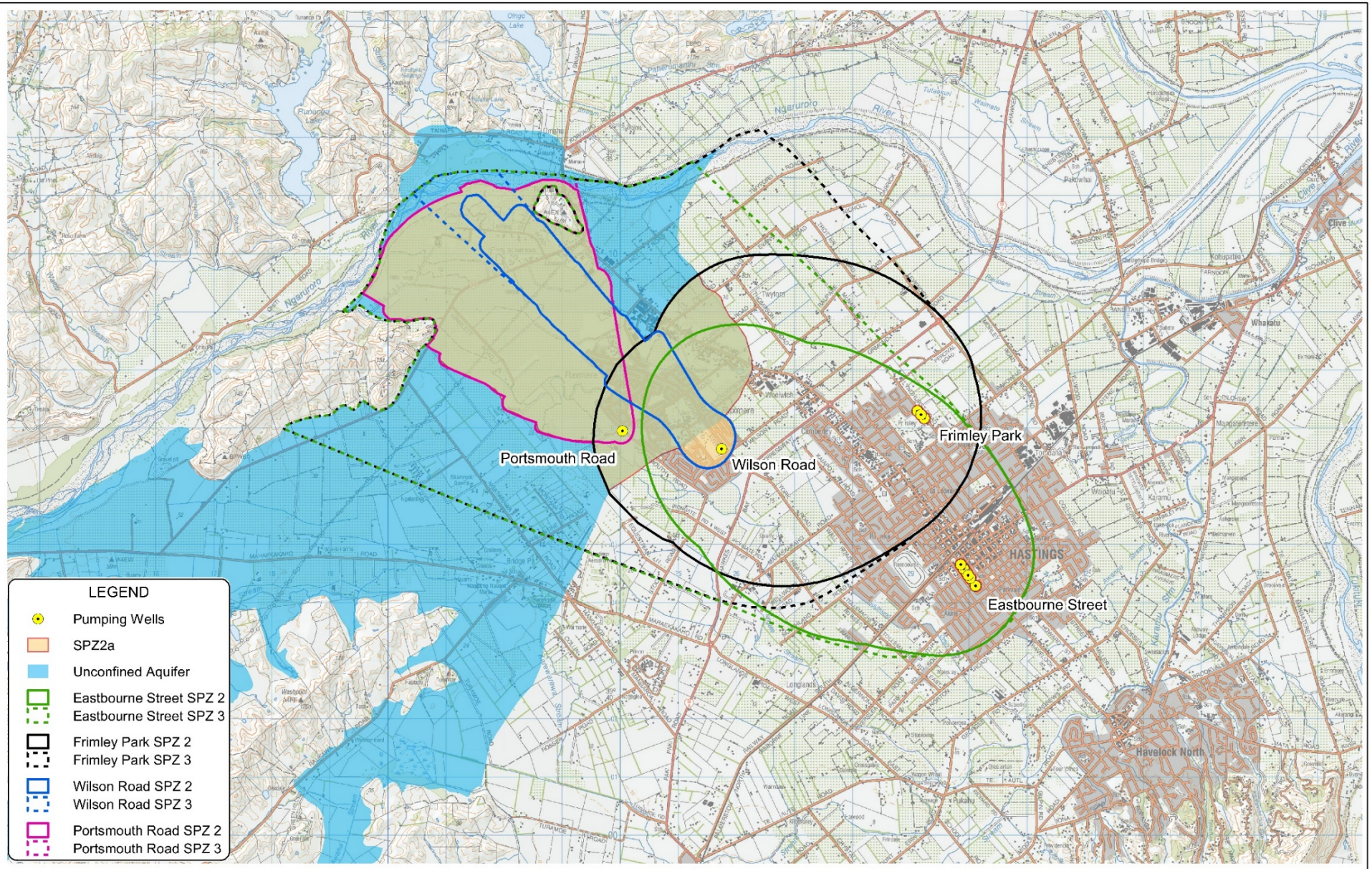
- Organic contaminants: contaminant migration in groundwater, biodegradation and dispersion.
- Levels would be below DWSNZ for plumes originating outside the SPZ, except for TCE (factor of 8 above DWS)
- Suitable for evaluation of emerging contaminants of concern e.g. PFAS

Sensitivity analysis – SPZ2 zones

Parameter	Change	Sensitivity comment
Effective porosity	Increase to 0.025	Reduces size of capture zone to 80% of the base case area
	Decrease to 0.015	Increases the size of the capture zone to 133% of the base case area
	Decrease to 0.0032	Capture zone extends beyond river, and therefore hydrogeological judgement needed to allow for features such as the Ngaruroro River. Capture area increases by over 250%.
Aquifer thickness	Increase by 25%	Reduces size of capture zone to 80% of the base case area
	Decrease by 25%	Increases the size of the capture zone to 133% of the base case area
Hydraulic gradient	Increase by 25%	Increases size of capture zone by approximately 1%. Moves entire zone slightly up-gradient.
	Decrease by 25%	No measurable change in size of capture zone from base case. Moves entire zone slightly down-gradient.
Transmissivity	Increase by 25%	Increases size of base case capture zone by approximately 1% from base case. Moves entire zone slightly up-gradient.
	Decrease by 25%	No measurable change in size of capture zone from base case. Moves entire zone slightly down-gradient.
Flow direction	Rotate clockwise by 25°	No change in size of capture zone from base case. Rotates entire zone to align with groundwater flow from north-westerly direction
	Rotate anti-clockwise by 25°	No change in size of capture zone from base case. Rotates entire zone to align with groundwater flow from east south-easterly direction

Sensitivity analysis #2





Notes:

Heretaunga Plains Confined and Unconfined Aquifer Shapefile Source - HBRC GIS

Service Layer Credits: Eagle Technology, LINZ

A3 SCALE 1:60,000

0 0.65 1.3 1.95 2.6 3.25 (km)

Location Plan

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SOURCE PROTECTION ZONES FOR PUBLIC SUPPLY BORES
HASTINGS URBAN AREA
All SPZ2 and SPZ3 Zones

FIGURE No. Figure 22 Rev. 1

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GNS peer review process

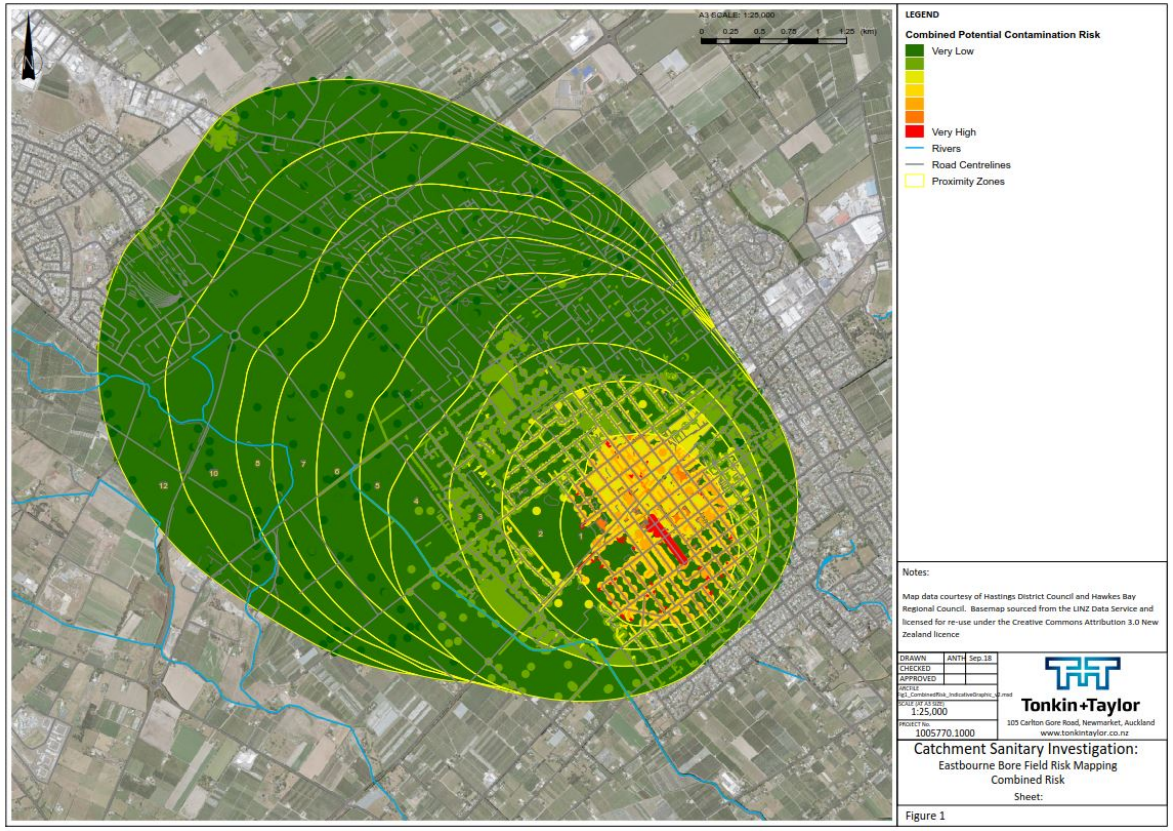
GNS has confirmed that:

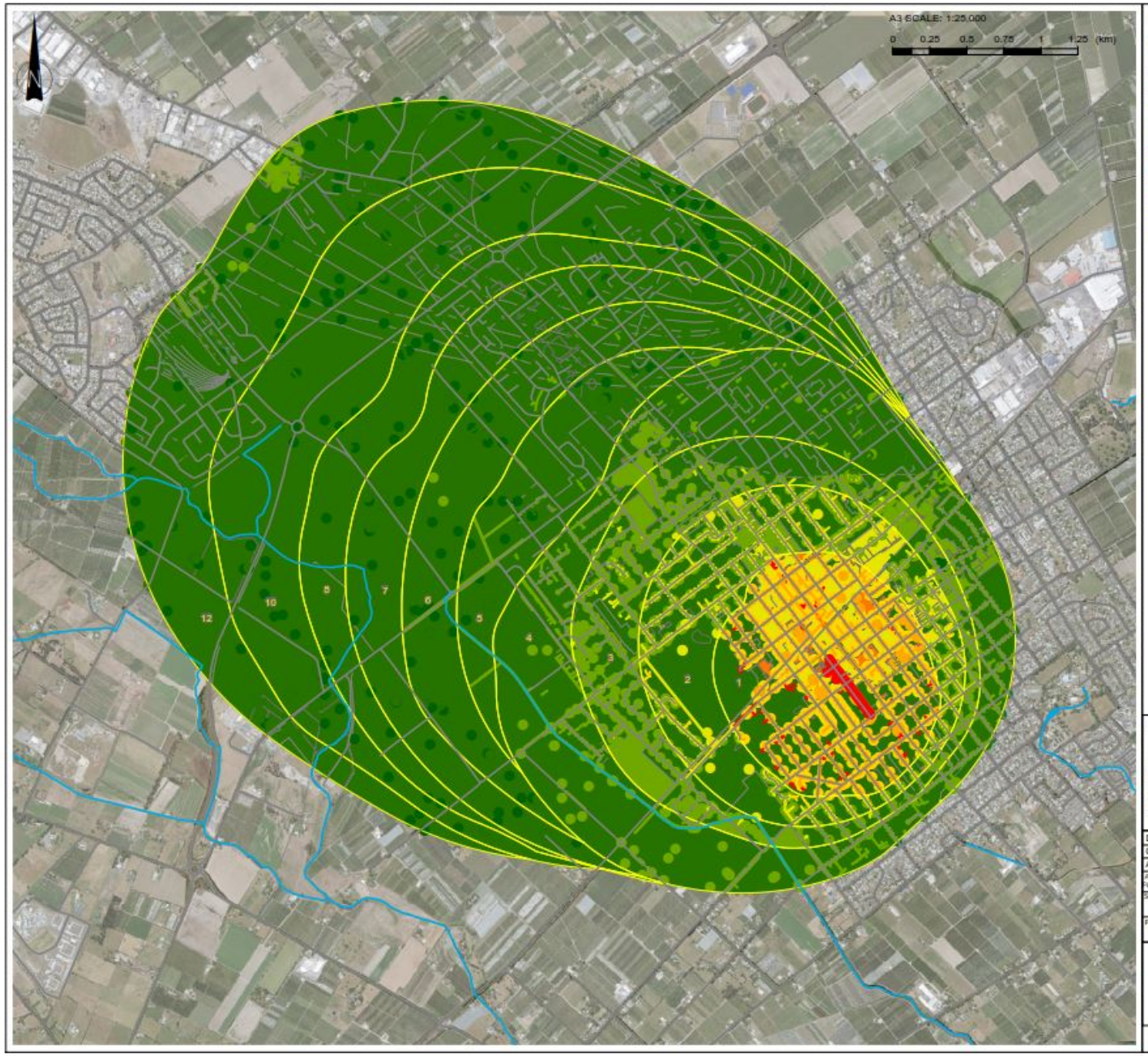
- USEPA WHAEM analytical element model is appropriate for SPZ development
- HBRC regional groundwater model - not suitable for pathogen transport risk assessment
- Sensitivity analysis - Effective porosity, aquifer thickness, hydraulic gradient, transmissivity followed by:
  - Variation of 25 degrees either side of the main flow line
  - Reassessment of SPZ2 zones in the confined aquifer area is justified
- Peer review report

Risk-based Groundwater Source Protection zones

Collaboration between HBRC and HDC for provision/sharing of information, including:

- Catchment Investigations & Source Protection Zones – GIS based
- Resource consents (HBRC & HDC)
- Hazardous Activities and Industries List (HAIL) (HBRC)
- Aquifer vulnerability mapping (HBRC)
- Pollution incidents (HBRC)
- Property files (HDC) ~ 800 commercial properties and 7000-8000 rural and residential properties.
- Services (wastewater, stormwater) (HDC)
- Aerial photography





LEGEND

Combined Potential Contamination Risk

- Very Low
- Very High
- Rivers
- Road Centrelines
- Proximity Zones

Notes:

Map data courtesy of Hastings District Council and Hawkes Bay Regional Council. Basemap sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence

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PROJECT No.: 1005770.1000

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Catchment Sanitary Investigation:
Eastbourne Bore Field Risk Mapping
Combined Risk

Sheet:

Figure 1

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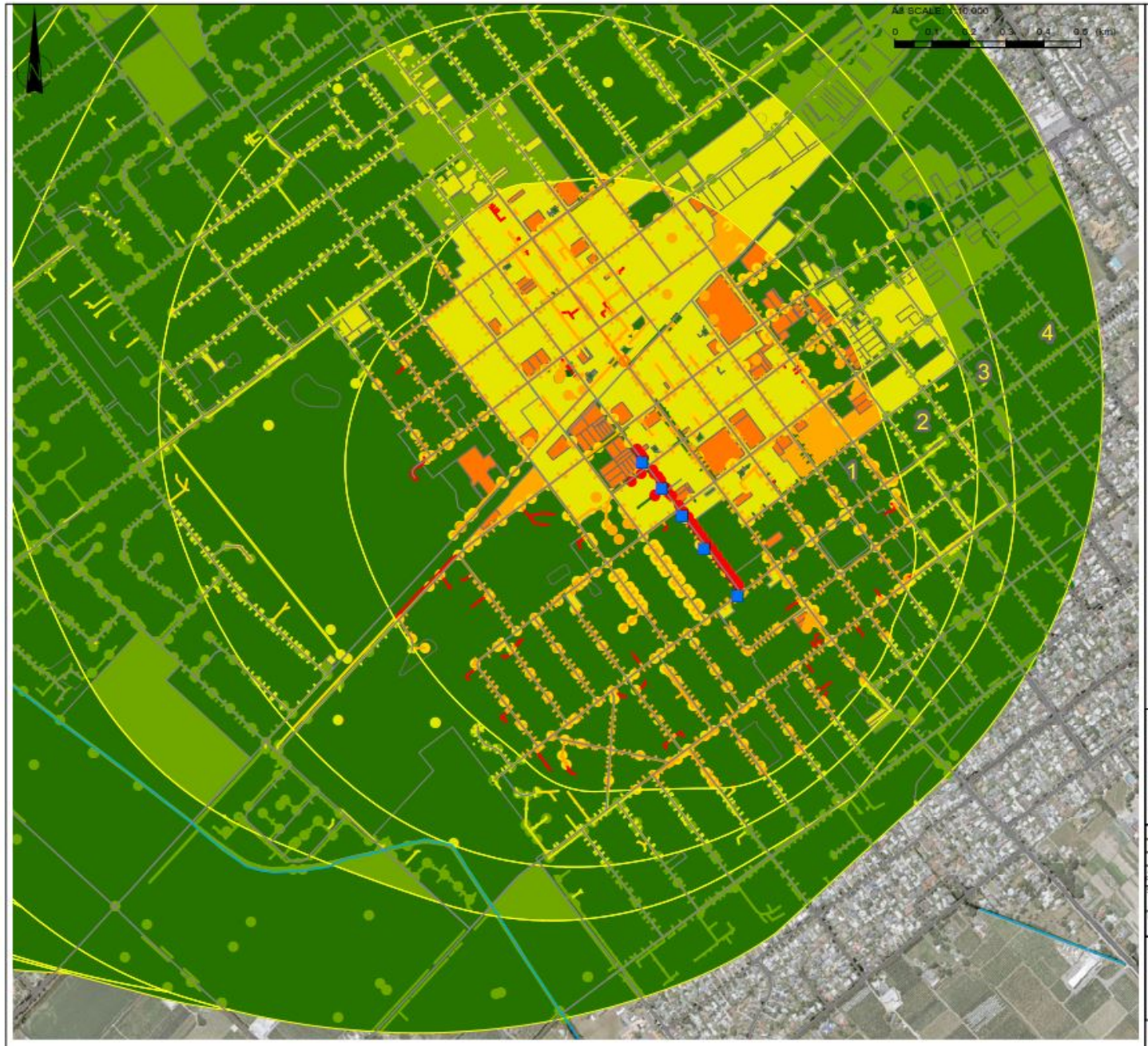

LEGEND

Combined Potential Contamination Risk

- Very Low
- Very High
- Boreholes - Operational
- Rivers
- Road Centrelines
- Proximity Zones

Notes:

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Fig2_CombinedRisk_IndicativeGraphic_Detail_v2

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Catchment Sanitary Investigation:
Eastbourne Bore Field Risk Mapping
Combined Risk

Sheet:

Figure 2

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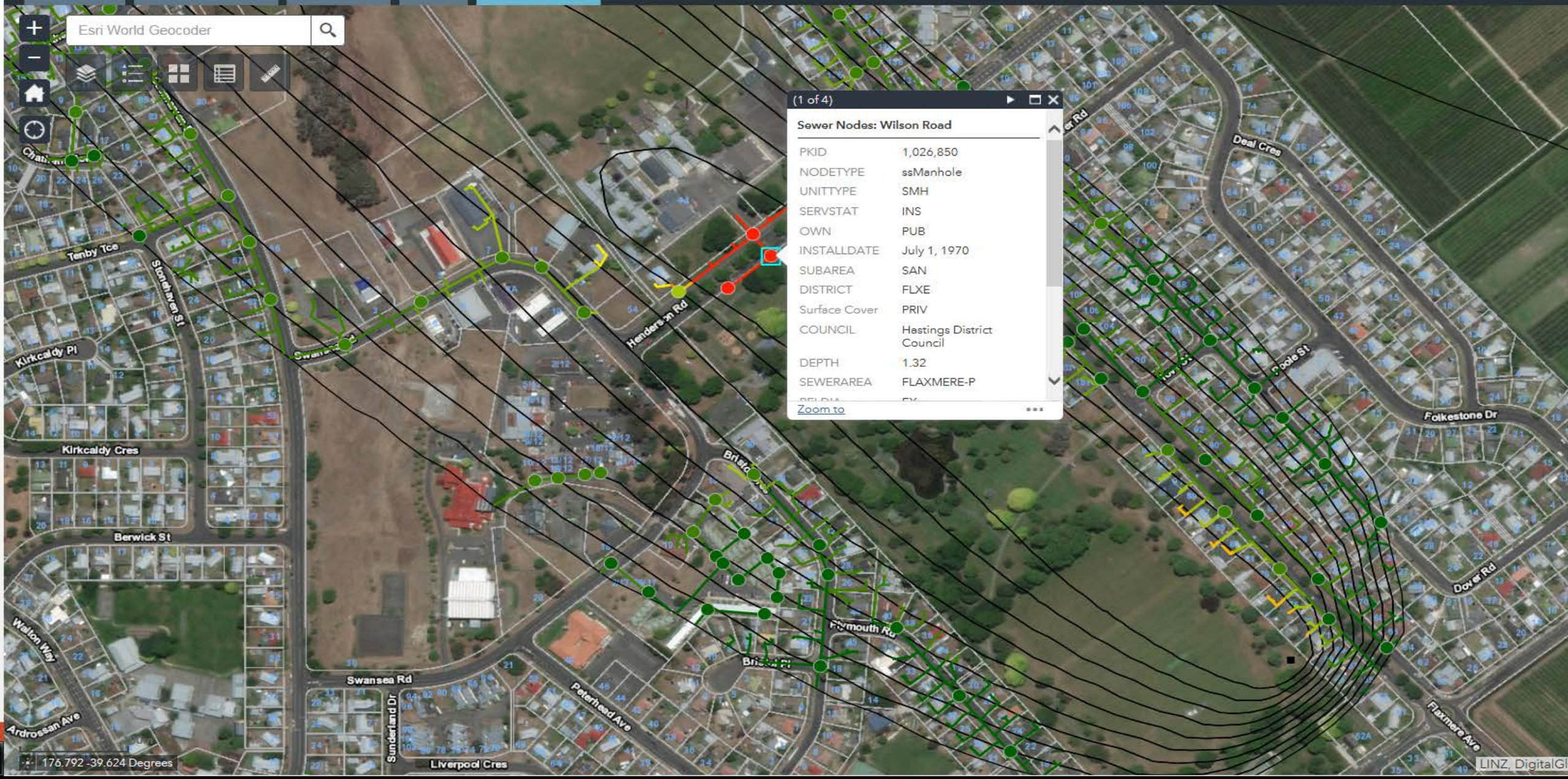
Portsmouth Rd
SH 50
Ngatarawa Rd
Tarbet St
Northlee Pl
Flaxmere Ave
Peary Cres
Kingsley Dr
Lander St
Palgrave Ave
Weddell St
Diaz Dr
Baker St
Scott Dr
Ramsey Cres
Oban St
Bangor St
1
2
3
4
5
6
7
8
9
10
61 -39.607 Degrees


Layer List
Operational Layers
Resource Consents
Well Permits
Boreholes - Operational
Boreholes - Abandoned
Sewer Nodes
Sewer Mains
Sewer Service Lines
Water Mains - Abandoned
Weddell St
Diaz Dr
Baker St
Diaz Pl
Scott Dr
Burton Pl
Burton Cres
Stanley St
Livingstone Rd
Cabot Pl
Walton Pl
Tenby Tce
Stonehaven St
Kirkcaldy Pl
Kirkcaldy Cres
Berwick St
Chatham Rd
Portsmouth Rd
Walton Way
Ardrossan Ave
Swansea Rd
Liverpool Cres
Caernarvon Dr
Peterhead Ave
Birkenhead Cres
Whitby Cres
Henderson Rd
Folkestone Dr
Dover Rd
Wilson Rd
Ayr St
Lorne Cres
Dundee Dr
Crail Ave

HDC Catchment Sanitary Investigations

Eastbourne | Frimley Lyndhurst | Portsmouth | Wilson | All Catchments



Implementation

- Water supplier to fulfil their responsibilities under section 69U of the Health Act, namely to take reasonable steps to contribute to protection of source of drinking water
- Effective monitoring and assessment of overall risks to the water supply
- Statutory framework for incorporation of SPZs into Regional Resource Management Plan (RRMP) and TANK plan change process
- Assist with requirements of the NES – Protection of Sources of Human Drinking Water

Thank you

Questions?