Waikato Regional Council Technical Report 2012/05

Waikato on-site wastewater risk assessment - phase two: factors, weighting and rating calibration study

www.waikatoregion.govt.nz
ISSN 2230-4355 (Print)
ISSN 2230-4363 (Online)

Waikato
REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

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January 2012

Document #: 2122997

Approved for release by:
Ed Brown Date March 2012

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Report

Waikato On-site Wastewater Risk Assessment - Phase Two: Factors, Weighting and Rating Calibration Study

Prepared for Waikato Regional Council (Client)

By Beca Infrastructure Ltd (Beca)

26 January 2012

Revision History

Revision Nº	Prepared By	Description	Date
A	Andy Haigh	Draft for client review	17 Nov 2011
B	Andy Haigh	Final report issued to client	26 Jan 2012

Document Acceptance

Action	Name	Signed	Date
Prepared by	Andy Haigh		26/01/12
Reviewed by	Orlando Kootstra		26/01/12
Approved by	Neil Gunn		26/01/12
on behalf of	Beca Infrastructure Ltd		

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Abbreviations used in this document

EW	Environment Waikato
OWTS	On-site wastewater treatment system
DRASTIC	**D**epth to Water, Net **R**echarge, **A**quifer Media, **S**oil Media, **T**opography, **I**mpact of Vadose Zone media, Hydraulic **C**onductivity of Aquifer
GW	Groundwater
SW	Surface water
GIS	Geographic Information System

Executive Summary

Beca is pleased to present Environment Waikato (EW) with our report summarising the findings of the On-site Wastewater Treatment System (OWTS) Phase Two Calibration Study.

Phase One of the OWTS risk assessment project, undertaken by Beca on behalf of EW in 2010, modelled the risk of OWTS failure at the land parcel level for the Waikato Region using a DRASTIC modelling approach and six contributing factors – System Age, Soil Type, Lot Size, Depth to High Groundwater Table, Aquifer Conductivity and Proximity to Surface Water. Each contributing factor had a rating (0-5) applied to its characteristic and a weighting applied according to overall influence in the potential for OWTS failure. The factors, ratings and weightings were adopted from previous research undertaken by the Canadian Housing and Mortgage Corporation (the CHMC).

This report discusses in detail the investigations undertaken in the OWTS Phase Two Calibration Study, and comments on the findings of the investigations in relation to the calibration of the factors, ratings and weighting used in the Phase One model.

Five separate sources of information were investigated to ascertain potential calibration values. These sources were:

- The EW document *Communities Serviced by On-site Wastewater Systems in the Waikato Region*
- Published community sanitary/wastewater reports or surveys
- Results of field surveys of OWTS in Ngarimu Bay and Hatepe
- Responses to a postal questionnaire regarding OWTS in Ngarimu Bay and Hatepe
- The New Zealand Deprivation Index

For each information source investigated the data obtained was, where possible, loaded into the Geographic Information Systems (GIS) to illustrate the spatial distribution of events (for example, recorded OWTS failure) and for comparison against the Phase One spatial results. Where information sources were not able to be displayed spatially, commentary was made on specific instances or general trends of recorded OWTS failure or potential OWTS failure.

Each of the five sources of information investigated provided different levels of value to the calibration of the Phase One factors, ratings and weighting. While some new factors such as maintenance patterns and deprivation levels were identified as having a part to play when modelling risk of OWTS failure others like occupancy levels (numbers of people) and occupancy patterns (seasonal vs. permanent) were investigated but did not provide any firm correlations to OWTS failure. Additional breakdown of the weightings of Soil Type were identified as an enhancement to that original factor, for example the inclusion of a rating that considers the influence of peat soils and the impact they have on the performance (and increased failure risk) OWTS when saturated.

The Phase Two OWTS Calibration Study has highlighted areas for further investigation and refinement of the OTWS risk assessment model. With further funding these areas could be the focus of more targeted investigation at the community level across a wider cross section of communities in the Region.

1 Document References

The following document should be read in conjunction with this report:

Beca Report (April 2011) *Waikato On-site Wastewater Risk Assessment - Summary of Investigation and Final Model Results.* Beca ref: NZ1-3990866-16[1]

This document collates new study findings with information previously documented in the following reports prepared by Beca for the Waikato Regional Council:

Beca Report (May 2011) *OWTS Phase 2 Proposed Calibration Study Approach*. Beca ref: NZ1-4440464-5[2]

Beca Report (July 2011) *OWTS Phase 2 Calibration Review – EW Communities Memo Review*. Beca ref: NZ1-4665291-2[3]

Beca Report (August 2011) *Report on use of field survey data for the calibration of the Environment Waikato on-site wastewater risk model*. Beca ref: NZ1-4864874-6[4]

[1] As supplied to Environment Waikato 7th April 2011

[2] As supplied to Environment Waikato 23rd May 2011

[3] As supplied to Environment Waikato 14th July 2011

[4] As supplied to Environment Waikato 31st August 2011

2 Objectives of the Calibration Study

Phase One of the project modelled the risk of on-site wastewater using the same factors, ratings and weightings used by the Canadian Mortgage and Housing Corporation (CMHC)[5] whereby the DRASTIC (Aller et al., 1987)[6] style of risk assessment is applied to six key contributing ***factors*** to on-site wastewater risk – age of system, lot size, depth to groundwater, soil type, aquifer conductivity and proximity to surface water. The factors are given a ***rating*** (0 – 5) and a ***weighting*** in the following formula to model overall Risk:

RISK = (R1 x 0.15) + (R2 x 0.15) + (R3 x 0.15) + (R4 x 0.15) + (R5 x 0.05) + (R6 x 0.2)

Where:
R1 = System Age Rating
R2 = Soil Type Rating
R3 = Lot Area Rating
R4 = Depth to Groundwater Rating
R5 = Hydraulic Conductivity Rating
R6 = Proximity to Surface Water Rating

The overall risk is calculated at a land parcel level and the results for land parcels within a community[7] are aggregated to give an overall community Median Quartile Risk Rating.

The objective of the Phase Two Calibration Study is to take the community results from the Phase One modelling and report and compare them to “real world” activities at a selected number of sample communities, with the purpose of highlighting areas where the model calibration could be adjusted to improve its estimation of community risk.

The calibration exercise will look at the **factors** contributing to the risk of OWTS failure, the **ratings** given to different types of factors, and the **weightings** given to each of these factors.

[5] (*CMHC (2006), Validation of an Onsite Wastewater Risk Assessment Model: Technical Series 06-111*)

[6] Aller, L., Bennett, T., Lehr, J.H., Petty, R.J. & Hackett, G. 1987. *DRASTIC: A standardised system for evaluation of ground water pollution potential using hydrogeologic settings.* Environmental Protection Agency, Washington D.C. 130 p.

[7] Extents defined by Environment Waikato.

3 Sources of Information for the Calibration Study

The following sources of information will be used for the calibration study:

1. The memo *Communities Serviced by On-site Wastewater Systems in the Waikato Region* as supplied by EW to Beca on 30th October 2009,
2. On-site wastewater/sanitary surveys or reports supplied by EW,
3. Results of field surveys for two communities (Ngarimu Bay and Hatepe),
4. Responses to household surveys for two communities, and
5. An investigation into the relationship of OWTS with the Deprivation Index.

For each information source the data will be compared to Phase One modelled results focusing on the following three factors;

- Noting influencing factors not modelled as part of Phase One
- Comparison of any noted factors that are modelled in Phase One to review influence (rating and weighting) of the factor
- Comparison of observations in report to the model – noting any inconsistencies and factors that are contributing to these

4 Review of Memo *Communities Serviced by On-site Wastewater Systems in the Waikato Region*

4.1 Overview

The following section summarises findings of the review undertaken on the memo *Communities Serviced by On-site Wastewater Systems in the Waikato Region*[8] (the "Memo") as supplied by EW to Beca on 30th October 2009.

The calibration review looked at three factors in relation to the communities listed in the Memo:

- Factors detailed that are known to contribute to OWTS failure in the community. This includes noting which of the Phase One factors are contributing to failure, as well as noting any other factors not considered in the Phase One model, and if OWTS issues were noted in the community
- Inconsistencies between the observations in the Memo and the Phase One modelled results. Factors that are contributing to these were considered.
- Comparison of the ratings and weighting applied to each Phase One modelled factor with any information included in the Memo in regard to influence of these factors on OWTS failure

4.2 Review results

4.2.1 Review of Phase One influencing factors and any new factors

Each community record in the Memo was reviewed and where a Phase One factor or a new factor was identified as influencing OWTS performance, a note was made against that community in Table 5 (below) as a "Y". In addition, where a community was identified as having issues with OWTS this was noted in the Know Issues column of Table 5.

Two additional contributing factors were identified as factors to check in the Memo – Type of System and Occupation Pattern. As with the Phase One factors, where these were noted by the Memo as influencing factors to OWTS issues they were recorded as "Y".

Overall the review results did not indicate significant trends on their own. The majority of communities listed noted environmental "facts" rather than linking these with OWTS issues. For example, depth to groundwater or proximity to a water course may have been noted, but was not linked to any particular issue with OWTS. A large number of communities did not record any issues with the OWTS. The following table records the number of communities listing each of the factors as an issue (out of total number of 168 communities).

[8] Supplied as *EWDOCS-#1125989-v2-Communities_Serviced_by_Onsite_Wastewater_Systems_in_the_Waikato_Region.DOC*

Table 1 – OWTS Risk Factors and Communities (count) that record factor as issue

Factor	Count
Depth to GW	26
Soil Type	18
Lot Size	4
Aquifer Conductivity	0
Proximity to SW	2
Age of System	4
Known Issues	16
System Type	0
Occupation Pattern	3

Note: the Memo included communities outside of the Waikato Region, but that are within Territorial Authorities that in part overlap the Waikato Region (e.g. the former Franklin District). These were included in our calibration review as they can provide useful information when considering influence of existing modelled and new factors.

4.2.2 Comparison of observations in report to the Phase One model

The Phase One factor results were added to Table 5 in order to compare any recorded factors from the Memo against factors modelled in Phase One.

Note: a number of communities listed in the Memo do not match a community defined in the Phase One modelling exercise. No attempt has been made to match these communities to a Phase One modelled community. As with above, the community list includes communities outside the Waikato Region.

Information from the Memo review and the Phase One modelling can now be directly compared. For example communities identified in the Memo has having soil conditions affecting performance of OWTS can be compared to the modelled soil type rating (R2) from Phase One for these communities.

Table 2 – Comparison of Memo and modelled Phase One Soil Type Rating for communities where soil type was noted as an issue

Community Name	R2: Soil Type	Phase One R2 rating
Glen Afton	Y	5
Glen Massey	Y	0
Gordonton	Y	0
Hahei	Y	0
Ngarimu Bay	Y	5
Ohaupo	Y	0
Pipiroa	Y	5
Renown	Y	5
Rukumoana	Y	5
Rukwhia – Just off SH3	Y	Null
Tahuna	Y	Null
Turua	Y	Null
Waharoa	Y	Null
Waikokowai	Y	0

Waitakaruru	Y	Null
Waitoa	Y	0
Whale Bay	Y	5
Wharekaho/Simpsons Beach	Y	0

In this case the Memo results and the Phase One modelling results are mixed, with the Phase One modelling results detailing a mixture of “5” (clay) and “0” (not clay) for the communities where the Memo has indicated Soil Type is a contributing factor to OWTS issues. A “Null” Phase One R2 Rating occurs for communities noted in the Memo that were not included in the Phase One modelling.

Similarly, with the Depth to Groundwater factor:

Table 3 - Comparison of Memo and modelled Phase One Depth to Groundwater Rating for communities where depth to groundwater was noted as an issue in Memo

Community Name	R4: Depth to GW	Phase One R4 rating
Gordonton	Y	1
Pipiroa	Y	5
Rukumoana	Y	1
Tahuna	Y	Null
Turua	Y	Null
Waharoa	Y	Null
Waitakaruru	Y	Null
Waitoa	Y	3
Awakino	Y	5
Bonshaw Park	Y	5
Hatepe	Y	5
Huntly – Te Ohaaki Road Extension	Y	Null
Karangahake	Y	5
Lake Taupo Christian Camp	Y	Null
Mokau	Y	5
Ohaaki Power Station and Marae	Y	Null
Oruatua	Y	3
Port Waikato	Y	5
Rangiriri	Y	Null
River Road (Broadlands)	Y	5
Tauranga – Taupo	Y	5
Tihai	Y	Null
Waihi Village	Y	5
Wairakei	Y	5
Waitetoko	Y	5
Whatawhata	Y	3

In this case, for the communities where the Memo notes the Depth to Ground water factor as a contributing factor to OWTS issues, the Phase One modelling has also highlighted the depth to ground water risk as, in the majority, a rating of “5”.

It is also worth comparing communities that the Memo notes as having known issues vs. the median overall risk calculated for each of those communities in Phase One:

Table 4 – Comparison of communities with known issues in Memo with Phase One modelled medium OWTS risk for that community

Community Name	Known Issues	Median Total Risk
Gordonton	Y	2.3
Huntly – Te Ohaaki Road Extension	Y	Null
Rangiriri	Y	Null
Whatawhata	Y	3.33
Glen Afton	Y	3.65
Glen Massey	Y	2.9
Hahei	Y	2.18
Renown	Y	3.2
Waikokowai	Y	2.3
Whale Bay	Y	2.93
Wharekaho/Simpsons Beach	Y	1.73
Huntly – Harris Street Extension	Y	Null
Otama	Y	2.93
Taupiri	Y	Null
Tauwhare Pa	Y	2.07
Whakaaratamaiti Marae	Y	Null

In these cases the Phase One modelled median total risk is relatively low when compared to a noted known issue in the community in the Memo. In addition those communities that were modelled in Phase One as having a high OWTS (median quartile) risk (e.g. Waikawau (4.2), Te Anga (4.5) and Marakopa (4.08)) were noted as having a known issue in the Memo. This would indicate a weak correlation between the Memo and the Phase One modelled results, and thus limited confidence in using the Memo to calibrate the Phase One modelled factors, weightings and ratings.

4.2.3 Commentary on the application of the Memo information to the calibration study

The Memo contained little information that could be used to determine a relationship (weighting) between different factors and their contribution to overall OWTS risk.

4.2.4 Memo review results and comparison to Phase One modelled results for each community

Table 5 – All Memo review results and comparison to Phase One modelled results for each community

Memo Review									
Community Name	Depth to GW	Soil Type	Lot Size	Aquifer Conductivity	Proximity to SW	Age of System	Known Issues	System Type	Occupation Pattern
Aka Aka									
Aotea Community									
Araimu									
Athol									
Awakino	Y								
Awhitu									
Big Bay / Orua E									
Bombay									
Bonshaw Park	Y								
Colville									
Coromandel									
Glen Afton		Y	Y				Y		
Glen Massey		Y	Y				Y		
Glen Murray									
Golden Valley									
Gordonton	Y	Y					Y		
Grahams Beach									
Hahei		Y					Y		Y
Hatepe	Y								
Hauturu School									
Hikuai									
Hikutaia & Wharepoa									
Hinua									
Hinuera									
Horsham Downs									
Hot Water Beach									
Hudsons Beach									
Huntly – Harris Street Extension					Y		Y		
Huntly – Te Ohaaki Road Extension	Y						Y		
Kaiaua									
Kaihere									
Karaka									
Karangahake	Y								
Karanui School									
Kariotahi									
Kauaeranga									
Kawhia Community									
Kennedy Bay									
Kihikihi									
Kikowhakarere Bay									
Kinleith									

Phase One Results							
Community Name	Median Total Risk	Median R1	Median R2	Median R3	Median R4	Median R5	Median R6
Aka Aka	3.45	5	0	3	3	1	5
Aotea	2.78	2.1	0	5	5	1	0
Athol	1.95	5	0	1	1	3	0
Awakino	4.65	5	5	5	5	1	5
Bonshaw Park	1.58	2.1	0	1	5	1	0
Colville	3.18	5	0	4	5	1	5
Glen Afton	3.65	5	5	4	5	1	0
Glen Massey	2.9	5	0	4	5	1	0
Glen Murray	2.15	5	0	3	1	1	0
Golden Valley	2.45	5	5	1	5	1	0
Gordonton	2.3	5	0	4	1	1	0
Hahei	2.18	2.1	0	5	5	1	0
Hatepe	4.05	5	0	5	5	1	5
Hikuai	3.45	5	0	1	5	1	5
Hikutaia	3.15	5	0	3	1	1	5
Hinuera	2.45	5	0	3	3	1	0
Horsham Downs	0.98	2.1	0	1	1	1	0
Hot Water Beach	2.45	2.1	0	5	1	1	5
Kaiaua	3.15	5	0	4	5	3	0
Kaihere	1.85	5	0	1	1	1	0
Karangahake	2.75	5	0	4	5	1	0
Kariotahi	2.6	5	5	1	1	1	0
Kauaeranga	2.6	3.55	5	1	1	1	0
Kawhia	3.65	5	5	5	5	1	0
Kennedy Bay	3.33	2.1	0	3	5	1	5
Kikowhakarere Bay	3.2	5	5	5	5	1	0

Memo Review									
Community Name	Depth to GW	Soil Type	Lot Size	Aquifer Conductivity	Proximity to SW	Age of System	Known Issues	System Type	Occupation Pattern
Kio Kio School									
Kohekohe									
Koputauaki									
Korakonui School									
Kuaotunu and Rings Beach									
Lake Taupo Christian Camp	Y								
Lemington – Coinley Drive/Milton Street.									
Lichfield									
Little Bay									
Mackaytown									
Maihihi School									
Maketu marae									
Mamaku Township									
Manaia									
Manawaru									
Mangakaretu									
Mangarata									
Mangatangi									
Mangatawhiri									
Mangateparu									
Matakawau									
Matapoua Bay									
Matatoki									
Mauku									
Maungakawa									
Mercer									
Miranda									
Mokai Kaihinga Marae									
Mokau	Y								
Ngahinapouri									
Ngarimu Bay		Y				Y			
Ngatira Marae									
Ngutunui School									
Northern & Southern Water Area									
Oamaru Bay									
Ohaaki Power Station and Marae	Y								
Ohaupo		Y				Y			
Okapu Marae									
Okoroiri Hotel									
Old County areas of Waihi									
Old Farm Road Waihi									
Omahu									

Phase One Results							
Community Name	Median Total Risk	Median R1	Median R2	Median R3	Median R4	Median R5	Median R6
Koputauaki	3.8	5	5	5	5	1	0
Kuaotunu	2.75	2.1	0	4	5	1	0
Leamington	1.37	2.1	0	3	1	1	0
Lichfield	1.85	5	0	1	1	1	0
Little Bay	2.93	2.1	5	4	5	4	0
Mackaytown	2.63	2.1	0	4	5	1	0
Mamaku	1.85	5	0	1	1	1	0
Manaia	3.05	5	0	2	5	1	2.5
Manawaru	2.8	5	0	3	5	2	0
Mangakaretu	2.15	5	0	2.5	1	1	0
Mangatangi	1.82	2.1	5	1	1	1	0
Mangatawhiri	1.9	5	0	1	1	2	0
Mangateparu	2.6	5	0	4	3	1	0
Matatoki	3.45	5	0	3	5	1	5
Maungakawa	2.12	0.4	5	1	5	1	0
Mercer	3.65	5	5	4	5	1	0
Miranda	2.775	5	2.5	2	5	2	0
Mokau	2.9	5	0	4	5	1	0
Ngahinapouri	1.355	2.1	0	3	1	1	0
Ngarimu Bay	3.8	5	5	5	5	1	0
Oamaru Bay	3.8	5	5	5	5	1	0
Ohaupo	1.85	5	0	4	1	1	0
Old Farm Rd Waihi	1.85	5	0	1	3	1	0
Omahu	2.75	5	0	1	5	1	5

Memo Review									
Community Name	Depth to GW	Soil Type	Lot Size	Aquifer Conductivity	Proximity to SW	Age of System	Known Issues	System Type	Occupation Pattern
Onewhero									
Ongaroto Marae									
Oparau School									
Opito									
Opoutere									
Orua West/Wattle Bay									
Oruatua	Y								
Otama						Y	Y		
Otaua									
Otewa School									
Paerata									
Papa Aroha									
Paparimu									
Pataetonga									
Pipiroa	Y	Y							
Pirongia									
Pokeno									
Pollock									
Port Charles									
Port Waikato	Y		Y						Y
Pukekawa									
Pukemiro									
Puketui									
Pukitu Marae									
Puni									
Pureora Camp									
Puriri					Y				
Ramarama									
Rangiriri	Y						Y		
Renown		Y					Y		
River Road (Broadlands)	Y								
Rotokauri									
Ruamahanga									
Ruapeka Marae									
Rukuhia						Y			
Rukumoana	Y	Y							
Rukwhia – Just off SH3		Y							
Tahuna	Y	Y							
Tapu, Te Mata, Waikawau									
Tatutanui									
Taupiri							Y		
Tauranga – Taupo	Y								
Tauwhare Pa							Y		
Te Akau South									
Te Hihi									
Te Kauri Lodge									
Te Kawa Village									

Phase One Results							
Community Name	Median Total Risk	Median R1	Median R2	Median R3	Median R4	Median R5	Median R6
Onewhero	2.9	5	5	4	1	1	0
Opito Bay	2.93	2.1	5	5	5	1	0
Opoutere	2.6	5	5	4	1	1	0
Oruatua	3.75	5	0	5	3	1	5
Otama	2.93	2.1	5	5	5	1	0
Otaua	3.05	5	0	4	5	1	0
Papa Aroha	3.565	5	5	1	5	1	5
Patetonga	2.025	5	0	3.5	1	1	0
Pipiroa	4.2	5	5	1	5	1	5
Pirongia	2.07	2.1	0	3	5	1	0
Pokeno	2.3	5	0	4	1	2	0
Port Charles	3.65	5	5	5	5	1	0
Port Waikato	3.05	5	0	5	5	1	0
Pukekawa	2.85	5	5	3.5	1	3	0
Pukemiro	2.9	5	0	4	5	1	0
Puketui	2.45	5	0	1	5	1	0
Puriri	3.03	5	0	4	5	1	5
Renown	3.2	5	5	4	3	1	0
River Rd Broadlands	2.15	5	0	1	5	1	0
Rotokauri	2.15	5	0	3	1	1	0
Ruamahanga	2.95	5	0	4	5	2	0
Rukuhia	2.025	5	0	3.5	1	1.5	0
Rukumoana	3.1	5	5	4	1	2	0
Tapu	3.9	5	5	5	5	3	0
Tauranga-Taupo	3.75	5	0	4	5	1	5
Tauwhare	2.07	2.1	0	1	5	1	0
Te Akau Wharf	2.78	2.1	5	4	3	1	0
Te Kawa Village	2.3	5	0	4	1	1	0

Memo Review									
Community Name	Depth to GW	Soil Type	Lot Size	Aquifer Conductivity	Proximity to SW	Age of System	Known Issues	System Type	Occupation Pattern
Te Kohanga									
Te Kouma									
Te Poi									
Te Puru									
Te Rerenga									
Te Toro									
Te Waotu School									
Thornton Bay									
Tihai	Y								
Torehape									
Tuateawa									
Turangi Rural Area									
Turua	Y	Y							
Waharoa	Y	Y							
Waiharakeke									
Waihi Village	Y								
Waikaretu									
Waikino									
Waikokowai		Y					Y		
Waimata									
Waiomu									
Waipipi									
Wairakei	Y								
Waitakaruru	Y	Y							
Waitawheta									
Waitete Bay									
Waitetoko	Y								
Waitoa	Y	Y							
Walton									
Whakaaratamaiti Marae							Y		
Whakatete Bay									
Whakatiwai									
Whale Bay		Y					Y		
Whangapoua									
Wharekaho/Simpsons Beach		Y					Y		Y
Wharekawa									
Whatawhata	Y		Y				Y		
Whenuakite									

Phase One Results							
Community Name	Median Total Risk	Median R1	Median R2	Median R3	Median R4	Median R5	Median R6
Te Kohanga	2.515	3.55	0	1	5	3.5	0
Te Kouma	3.2	5	5	4	5	1	0
Te Poi	2.3	5	0	4	1	1	0
Te Puru	3.93	5	5	5	5	1	5
Te Rerenga	2.6	5	0	1	5	3	0
Thornton Bay	3.5	5	5	5	5	1	0
Torehape	1.85	5	0	1	1	1.5	0
Tuateawa	1.82	2.1	5	3	1	1	0
Turangi Rural Area	2.8	5	0	3	5	2	0
Waiharakeke	3.45	5	0	1	5	1	5
Waihi Village	3.05	5	0	5	5	1	0
Waikaretu	2.3	5	5	1	1	1	0
Waikino	2.58	5	0	4	5	1	0
Waikokowai	2.3	5	0	4	1	1	0
Waimata	2.15	5	0	1	3	1	0
Waiomu	3.8	5	5	5	5	1	0
Wairakei	3.05	5	0	5	5	1	0
Waitawheta	1.85	5	0	1	1	1	0
Waitekauri	2.45	5	0	1	5	1	0
Waitoa	2.6	5	0	4	3	1	0
Walton	2.9	5	0	4	5	1	0
Whakatete Bay	2.9	5	0	4	5	1	0
Whale Bay	2.93	2.1	5	5	5	1	0
Whangapoua	2.18	2.1	0	5	5	1	0
Wharekaho/Simpsons Beach	1.73	2.1	0	5	1	4	0
Whatawhata	3.33	5	5	4	3	1	0
Whenuakite	1.85	5	0	1	1	1	0

5 Review of Onsite Wastewater/Sanitary Survey/Reports

5.1 Overview

A review of available on-site wastewater/sanitary surveys or reports was made to identify any information that could be used to calibrate the OWTS risk model. The review considered information relating to factors that influence the risk of OWTS failure, and the ratings applied to these risks and the weightings (relationship) between these risks contributing to the overall risk.

Three on-site wastewater/sanitary surveys or reports were supplied by EW for review[9]. These were:

- **Whale Bay** Sanitary Survey 2004 (supplied as EWDOCS_n1956490_v1_Whale_Bay_Property_Information.pdf)
- Appendix B of the **Piopio** Onsite Survey [date unknown] (supplied as EWDOCS_n1963075_v1_Piopio_Sewage_Systems_Walkover_Survey_Results.pdf)
- **Tauwhare** Sanitary Works Subsidy Application. Preliminary AEE and Health Impact Assessment (Sep 2004) (supplied as EWDOCS_n1963098_v1_Tauwhare_Pa_Sanitary_Works_Application_including_Septic_Tank_Survey.pdf)

5.2 Review of reports

5.2.1 Whale Bay Sanitary Survey 2004

a. Review of report content

The supplied document is a table listing On-Site System type, Observations and Defects for each property in the Whale Bay community. The Observations and Defects column provides some clues about environmental factors and system factors that might be contributing to system failure and how the type of system impacts the risk.

Some examples of information from the Observation column that provides information when considering risk factors, ratings and weightings are (with comment on potential influencing factors in brackets):

- Row 1 (R1): failure may be related to discontinued maintenance and possible microbiological growth in the irrigation system [potential influencing factors: system maintenance/age]
- R6: No more problems with soakage system since a new “elaborate soakage system” has been installed [potential influencing factors: system type]
- R11: effluent soakage problems in past and new disposal field installed [potential influencing factors: system type; soil type]
- R13: majority of section landscaped with large trees, limiting disposal area. Has had effluent disposal problems [potential influencing factors: lot size; system design]
- R14: stormwater overflow discharges into gully trap and affects disposal system [potential influencing factors: system design]
- R18: old system has failed. Upgraded to resolve [potential influencing factors: system age]

[9] All supplied by Environment Waikato 4th May 2011

- R23: disposal to soak holes. Possible infiltration of nearby tributary [potential influencing factors: proximity to surface water]
- R24: poor soakage in disposal field fixed by extending the disposal field [potential influencing factors: system design]
- R25: limited area for disposal field [potential influencing factors: lot size]
- R26: past soakage issues resolved through landscaping [potential influencing factors: system design]
- R28: grey water and effluent into the septic tank. Disposal area limited and suspected of flowing onto neighbouring property [potential influencing factors: lot size; system type]
- R33: disposal area appears insufficient [potential influencing factors: lot size]
- R37: possible discharge into the soak holes may be into the natural groundwater [potential influencing factors: depth to ground water]
- R43: lush growth indicates that the effluent disposal system may have a limited life [potential influencing factors: age of system]
- R46: level of ground water in the soak hole is approx. 600mm below ground level [potential influencing factors: depth to ground water]
- R48: soak hole contains natural ground water [potential influencing factors: depth to ground water]
- R52: effluent discharge would be into the natural ground water [potential influencing factors: depth to ground water]
- R53: there is a failure in the effluent disposal system [potential influencing factors: age of system; system design]
- R58: discharges into a tributary. Discharge of effluent may be intermittent during heavy usage in summer [potential influencing factors: system design]
- R62: soak holes down to natural ground water. Disposal area not satisfactory [potential influencing factors: depth to ground water; system design]
- R66: soak holes at level of tributary [potential influencing factors: proximity to surface water]
- R73: septic tank appears to be undersized in relation to current standards [potential influencing factors: system type]

b. Commentary with reference to calibration study

From the above review there are a number of Phase One factors that are highlighted as potential contributing influences to OWTS risk including system type, soil type, lot size, depth to groundwater and proximity to surface water.

In addition, a number of other potential further influencing factors are identified that were not included in the Phase One model, including system maintenance pattern/frequency and system design (including disposal field size). System design may be related to system type, lot size and occupancy and use patterns.

The report did not provide enough information to consider the influence of ratings and weightings of different risk factors to overall OWTS risk assessment.

5.2.2 Appendix B of the Piopio Onsite Survey

a. Review of report content

The supplied document is a table of recorded observations from an onsite survey undertaken by EW in Piopio. Each address in Piopio was inspected to identify the presence of an OWTS, the type

of soakage system used, evidence of de-slugging of treatment tank, evidence of seepage on grass, lush vegetation, unsatisfactory soak system, previous failure or if the disposal system could be improved.

There are 202 records from the survey. Of the 202 records the number where the following occurred:

- seepage on grass was recorded = 7
- unusual lush vegetation was recorded = 16
- the soakage system is recorded as unsatisfactory = 14
- indication of previous failure is recorded = 13
- the location of the system is recorded as could be improved = 67

b. Commentary with reference to calibration study

The above figures in themselves do not provide further information to the potential causes of or risk of OWTS failure in this community. They are limited to observations of potential system failure or poor performance (e.g. seepage or lush vegetation). The recording of potential system failure, alone, does not provide information as to why such potential failure was recorded e.g. age of system, system use pattern (seasonal, high resident population, soil type, soakage field area (lot size)) or consequence of system failure (proximity to surface or groundwater).

The numbers of recorded potential failure indicators are low (less than 8%) so it is unreasonable to draw any conclusions from this data as to further factors influencing OWTS risk, or the weighting and ratings applied to these factors.

In addition, the recorded potential indicators do not align (for comparison) with the Phase One modelled factor (Age of System, Soil Type etc.) for consideration of calibration of the Phase One factor weightings and ratings.

5.2.3 Tauwhare Sanitary Works Subsidy Application. Preliminary AEE and Health Impact Assessment (Sep 2004)

a. Review of report content

This report provides some very good information on contributing factors to OWTS risk. Some examples extracted from the report are:

- Pg 3: Soil and Draining Qualities: notes that draining (percolation) in peat layers is slower than the recommended rate for septic tank systems – in Phase One we only distinguished between “Clay” and “not-Clay” in terms of soil type as a contributing factor to system failure. “layers of peat…could cause soakage problems…” Also an important note – in Phase One we only considered dominant soils type, not the layering of soil types.

  It is also noted that peat soils have a high water retention that subsequently raises the water table (depth to groundwater) during rain events.
- Pg 6: Notes “untreated wastewater is currently entering groundwater and stormwater without any treatment due to a combination of high groundwater levels, poor septic tanks and soakage fields”

  Aged or badly constructed on-site disposal systems give poor performance.
- Pg 8: problems occur commonly where maintenance has never been carried out

  Poor soakage can affect performance of even new systems
- Pg 11: undersized tanks, constructed ~ 1920s, contribute to odour problems when under load and ground is already wet

Badly installed systems cause problems

A well-designed septic tank and soakage system should not require cleaning more than every 5-10 years. Any more frequent and they can be concluded as not performing

- Pg 11-12: main causes of septic tank failures in Tauwhare are both inadequate maintenance and changing socio-economic status:
  - Irregular desludging (Pg 14: insufficient desludging of septic tanks throughout the early part of their working life causes many failures. Lack of continuous maintenance causes sludge to build up and eventually blocks the drainage field.
  - Higher household occupancy due to unemployment and retirement; and during specific household events (parties)
- Pg 12: older septic tanks are undersized for the population using them. Many are the older rock type of tank – 2200 litres, although could be 1500 l. EW standard requires 3000 l.

  Existing lots are smaller than that allowed by new subdivision using septic tanks (2500 m^3)

  Many tanks are unserviced.
- Pg 13: Stormwater is discharged directly to ground, and due to flat terrain it is partially absorbed by ground soakage and thus decreasing the effective size of sludged up septic tanks and soakage fields
- Pg 14: Water usage could be a contributing factor especially if community serviced by reticulated potable water
- Pg 15: a lower income community means that residents are not always able to pay for the cost of maintaining a septic tank.

b. Commentary with reference to calibration study

The Tauwhare report highlights a number of risk factors that are contributors to the risk of OTWS failure in this community, namely; the age of systems, the depth to groundwater and system type.

The report also raises a number of new potential influencing factors, including the influence of poorly maintained OWTS, the influence of poorly designed and installed OWTS, household occupancy patterns and influence of reticulated potable water supply.

The report also makes an interesting comment regarding the influence of peat soils to the performance of OWTS and the risk of OWTS failure. In Phase One the ratings for the Soil Type factor are only considered in the context of “Clay” or “Not Clay” where “Clay” is given the highest risk rating and “Not Clay” is given the lowest. The Comments made in the Tauwhare report indicates that there may be value in including peat as a separate Soil Type rating class due to its influence on soakage systems, and its influence on the water table (Depth to Groundwater factor) during high rainfall events.

5.3 Commentary on OWTS surveys and reports

The three supplied documents reinforced the influence of a number of the factors considered in Phase One, namely Age of System, Lot Size, Depth to Groundwater, Proximity to Surface Water and Soil Type.

The three reports raised some new factors that potentially influence OWTS performance and risk of failure, including system maintenance pattern/frequency (which should be considered in conjunction with system type and system age), system design (including disposal field size), the influence of poorly installed OWTS, household occupancy patterns and influence of reticulated potable water supply.

Only one comment within the report related to the rating applied to risk factors, and that was in relation to the influence of peat soils within the Soil Type factor.

Our conclusion from this review was that no connections could be drawn from the reports in respect to the weightings applied to each risk factor in calculating an overall risk profile for OWTS failure.

6 Results of field surveys for two communities

6.1 Overview

The following section summarises findings from the OWTS calibration review undertaken on the field survey data collected for EW for the Ngarimu and Hatepe communities.

The review of the results considers the following factors:

- The survey data collected, it's completeness and application to the GIS OWTS model
- Attributes collected in the field survey that contribute to OWTS performance
- Attributes collected in the field survey that are indicators of OWTS non-performance
- A comparison of the factors collected to the modelled factors from Phase One of the OWTS project in consideration of calibration of the Phase One model factors, weightings and ratings

6.2 Location plan

Field surveys were undertaken in two communities – Ngarimu Bay and Hatepe.

Figure 1 – Location of Ngarimu Bay and Hatepe Communities

6.3 Field survey data

6.3.1 Field Surveys

Field surveys were undertaken in the Ngarimu and Hatepe communities. The field surveys were undertaken by an independent contractor under guidance from EW.

6.3.2 Data supplied

The field survey data was supplied by EW as a single MS Excel spreadsheet[10], with accompanying JPG images and MS Excel spreadsheet tables of the surveyed parcel extents for each community[11].

6.3.3 Processing data for use in GIS

a. Cleaning the survey data for use in GIS

Prior to importing the survey data into the GIS, a number of data cleaning steps were undertaken:

- A number of columns that were not required were removed. These included a number of the OCCUPIER columns
- All question marks were removed from column headings
- A number of values in columns were a mixture of option values (e.g. “Y” or “N” or “Flat”/”Gentle”/”Steep”) and free text values. To increase the value of the dataset (and the ability to analyse the data in the GIS) these differing types of values were separated by creating a <column>_COMMENT attribute column in each case, and separating the different value types
- A number of spelling corrections were made
- A number of consistency corrections were made, for example correcting case
- Trailing spaces were removed from attribute values
- Updated syntax of addresses for a number of records. For example set “32b” to be “32 B”
- Prefixed the Soil attribute values with “S” so that they can be queried as a Text type
- Prefixed the People attribute values with “P” so that they can be queried as a Text type
- A number of records were coloured by the field surveyor. As colours are not able to be transferred through the GIS, a new attribute column COLOUR_FROM_SURVEYOR was added and the colour of any coloured columns was added as an attribute.

The following table details the field survey columns following the data cleaning steps undertaken above:

[10] By email from Trisha Simonson (EW) on 23 June 2011.

[11] By FTP transfer 26 April 2011.

Table 6 – Community survey fields following data cleaning

FIELD	FORMAT	VALUES	VALUE COMMENT	NUM RECORDS WITH INFORMATION
SEPTIC_TANK	Text - Choice	Y, N, Unknown, *NULL*		215
SEPTIC_TANK_COMMENT	Text - Free			
VENTED	Text - Choice	Y, N, *NULL*		206
VENTED_COMMENT	Text - Free			
ODOUR	Text - Choice	Y, N, *NULL*		214
ODOUR_COMMENT	Text - Free			
SOAK_PIT	Text - Choice	Y, N, *NULL*		202
SOAK_PIT_COMMENT	Text - Free			
TRENCHES	Text - Choice	Y, N, *NULL*		102
TRENCHES_COMMENT	Text - Free			
TOPOGRAPHY	Text - Choice	Flat, Flat to Gentle, Gentle, Gentle to Steep, Steep, Terraced, *NULL*		223
TOPOGRAPHY_VALUE	Number	1, 2, 3, 4, 5, 99, *NULL*	1 = Flat to 5 = Steep, 99 = Terraced	223
TOPOGRAPHY_COMMENT	Text - Free			
SOIL	Text - Choice	S1, S2, S2 to 3, S3, S3 to 4, S4, S4 to 5, S5, *NULL*		207
SOIL_COMMENT	Text - Free			
AERATED_SYSTEM	Text - Choice	Y, N, *NULL*		99
AERATED_SYSTEM_COMMENT	Text - Free			
ALARMED	Text - Choice	Y, N, *NULL*		102
IN_ALARM	Text - Choice	Y, N, *NULL*		103
AERATED	Text - Choice	Y, N, *NULL*		101
PACKED_BED_REACTOR	Text - Choice	Y, N, *NULL*		97
BRAND_NAME	Text - Free			
RESERVE	Text - Choice	Y, N, *NULL*		220
RESERVE_COMMENT	Text - Free			
DAMPNESS	Text - Choice	Y, N, *NULL*		219
DAMPNESS_COMMENT	Text - Free			
GULLY_TRAP_OVERFLOW	Text - Choice	Y, N, *NULL*		220

FIELD	FORMAT	VALUES	VALUE COMMENT	NUM RECORDS WITH INFORMATION
GULLY_TRAP_OVERFLOW_COMMENT	Text - Free			
INSECT_NUISANCE	Text - Choice	Y, N, *NULL*		220
GRASS_ABOVE_DISPOSAL_LINES	Text - Choice	Y, N, *NULL*		220
GRASS_ABOVE_DISPOSAL_LINES_COMMENTS	Text - Free			
OVERLAND_FLOW	Text - Choice	Y, N, *NULL*		121
SURFACE_WATER_DIVERSION	Text - Choice	Y, N, *NULL*		120
SLUMPING_TOMO_FORMATION	Text - Choice	Y, N, *NULL*		118
SEPARATION_DISTANCE	Text	*NULL*		
GROUNDWATER_BORES	Text	*NULL*		0
SURFACE_WATER_SEPARATION	Text - Free			
GEOTHERMAL_FEATURE	Text	*NULL*		0
OVERALL_COMMENTS	Text - Free			
PEOPLE	Text - Free	e.g. P?, P1, P1 to 2, P2, P3, P3 to 4, P3 to 4 , P4, P5, P6+, Pupto 6 ACC, *NULL*		58
OCCUPIED	Text - Choice	permanent, seasonal, *NULL*		60
OCCUPIED_COMMENT	Text - Free			
SERVICED	Text - Free			
BEDROOMS	Number			61
TYPE	Text - Free			
WEATHER_INSPECTION_DAY	Text - Choice	Fine, *NULL*		118
WEATHER_PREVIOUS_DAY	Text - Choice	Fine, Showers, *NULL*		118
INSPECTION_DATE	Date			155
MAP_REFERENCE	Text - Free	Generally of the format E2734448 N6456094, although some other free text mixed in.		98

b. Other data observations

During the data cleaning process a number of other observations were made:

- There are a number records missing data, including:
  - No map reference values for any Hatepe records
  - Some records included only the word “Thursday” as a date of inspection attribute – others were a full date
- The Weather column record contained some inconsistent data. For sites in Hatepe inspected on 29/3/11, the weather the previous day is recorded for some as “Showers” and some as “Fine”
- No Weather information is recorded for Ngarimu
- No Type information is recorded for Ngarimu
- For some records there are comments about septic tanks, but no record of Y/N in in the septic tank [present or not] attribute column.

c. Linking survey data back to parcels

In order to illustrate the results of the field survey in GIS, and make comparisons of the field survey data to the Phase One factors and results, it was necessary to link the survey results back to parcels within the EW GIS parcel dataset[12].

Within the EW GIS parcel dataset, the unique identifier for each parcel is the PARCEL_ID attribute. In the field survey spreadsheet the PARCEL_ID had been removed. To reassign this attribute (to enable a match of field survey data to parcel boundaries) a match was made between the field survey data and the EW MS Excel spreadsheet tables of the surveyed parcel extents, based on a match on the LOCATION ADDRESS attribute fields.

The linking process highlighted a number of issues with the field survey data for Ngarimu Bay:

- There are three records for 224 Thames Coast Road. Only one record had survey information recorded so the remaining two were dismissed.
- There are two records for 8 Lockhart Place. Both records have data recorded, each with different number of attribute columns with data recorded. Where columns are complete in both records the data is identical. Merged these records to create one survey record for this parcel.
- There are two records for 13 Patui Avenue. Only one record had survey information recorded so the remaining two were dismissed.
- There are two records for 5 Arthur Road. Only one record had survey information recorded so the remaining two were dismissed.
- There are two records for 31 Patui Avenue. Only one record had survey information recorded so the remaining two were dismissed.
- There are two records for 264 Thames Coast Road. One record has no data, except for the VENTED attribute, which has a value “N”, whereas the other record has the value “Y”. Dismissed the record with only one attribute.
- The record for 22 Springfield Avenue was updated to 22 A Springfield Avenue so that the join to the parcel table matched.

For Hatepe, an issue regarding cross-leases was highlighted. For two parcels two addresses are recorded (one for each house) and two sets of survey results are recorded (one for each septic

[12] As supplied for Phase One of the OWTS project in June 2010.

tank). This occurs for the addresses 123 Arapera Road and 131 Arapera Road (on the same parcel) and for 1 Areta Lane and 15 Areta Lane (on the same parcel).

6.4 Ngarimu results

6.4.1 Overall results

a. Survey coverage

The following map illustrates the Ngarimu survey extent, as supplied by EW to the field survey contractor.

Figure 2 – Proposed survey extent for Ngarimu Bay community

The map below illustrates the number of properties in Ngarimu for which a field survey record result was supplied. The red parcels indicate parcels for which no field survey information was supplied. [It was noted by EW that the parcel extents supplied above may have included unoccupied lots and thus no field survey will have been undertaken for these lots[13]]

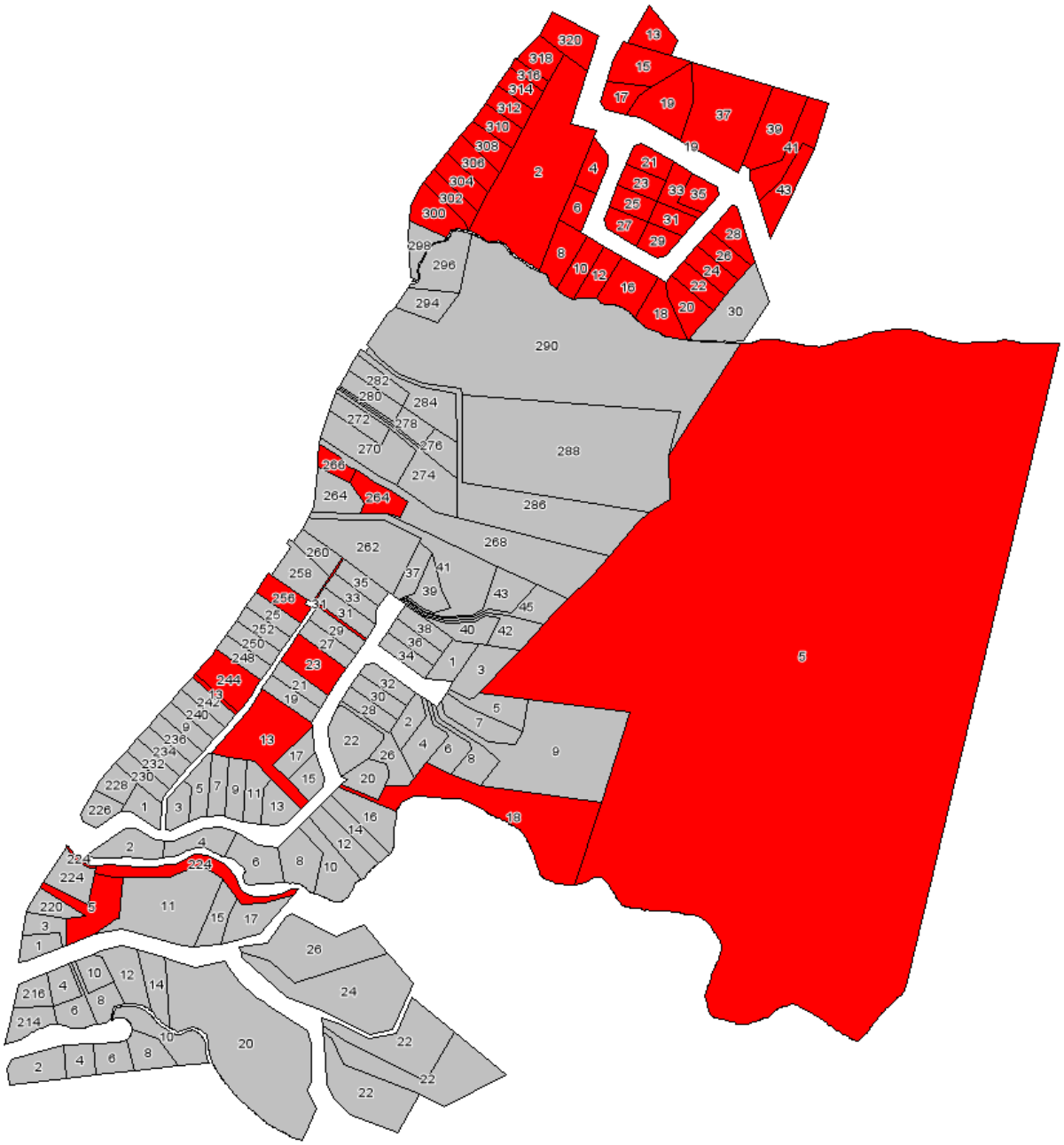


Figure 3 – Actual survey extent for Ngarimu Bay community

[13] In email correspondence between Trisha Simonson (EW) and Andy Haigh (Beca) on 20 July 2011.

b. Presence of septic tank

The following map illustrates those properties where a septic tank was recorded as present by the field survey contractor. The light grey areas are those parcels that did not have any survey results. The dark grey areas are those parcels that do have field survey results, but no specific result for the presence (or not) of a septic tank (i.e. where the attribute field for septic tank is not Y or N).

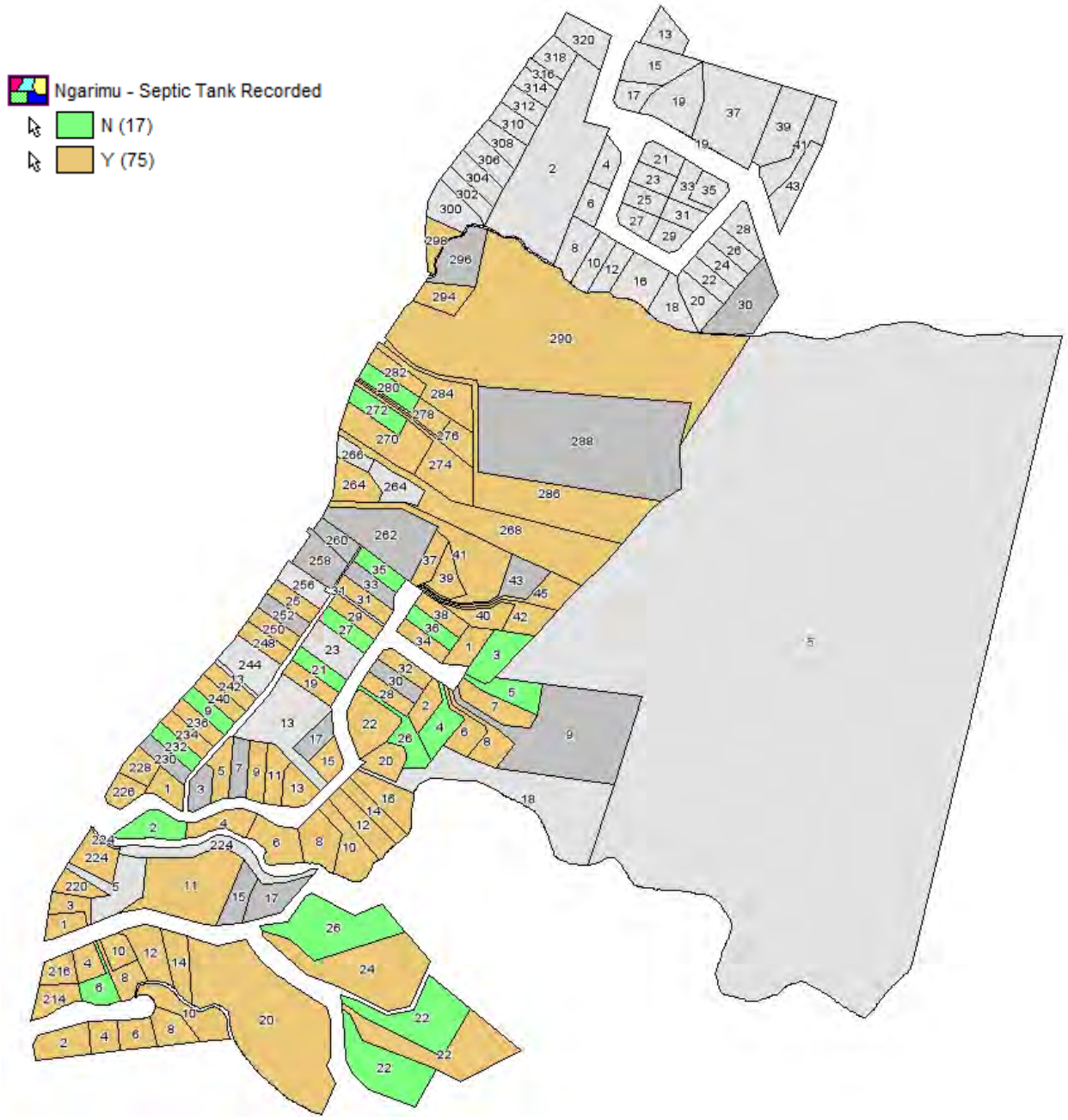


Figure 4 – Field survey recorded presence of septic tank in Ngarimu Bay community

The following map shows the results from Phase One of the OWTS model for Ngarimu, where the likely presence (or not) of a septic tank was assessed based on the EW rating database (where brown indicates a septic tank present and green indicates no septic tank present).

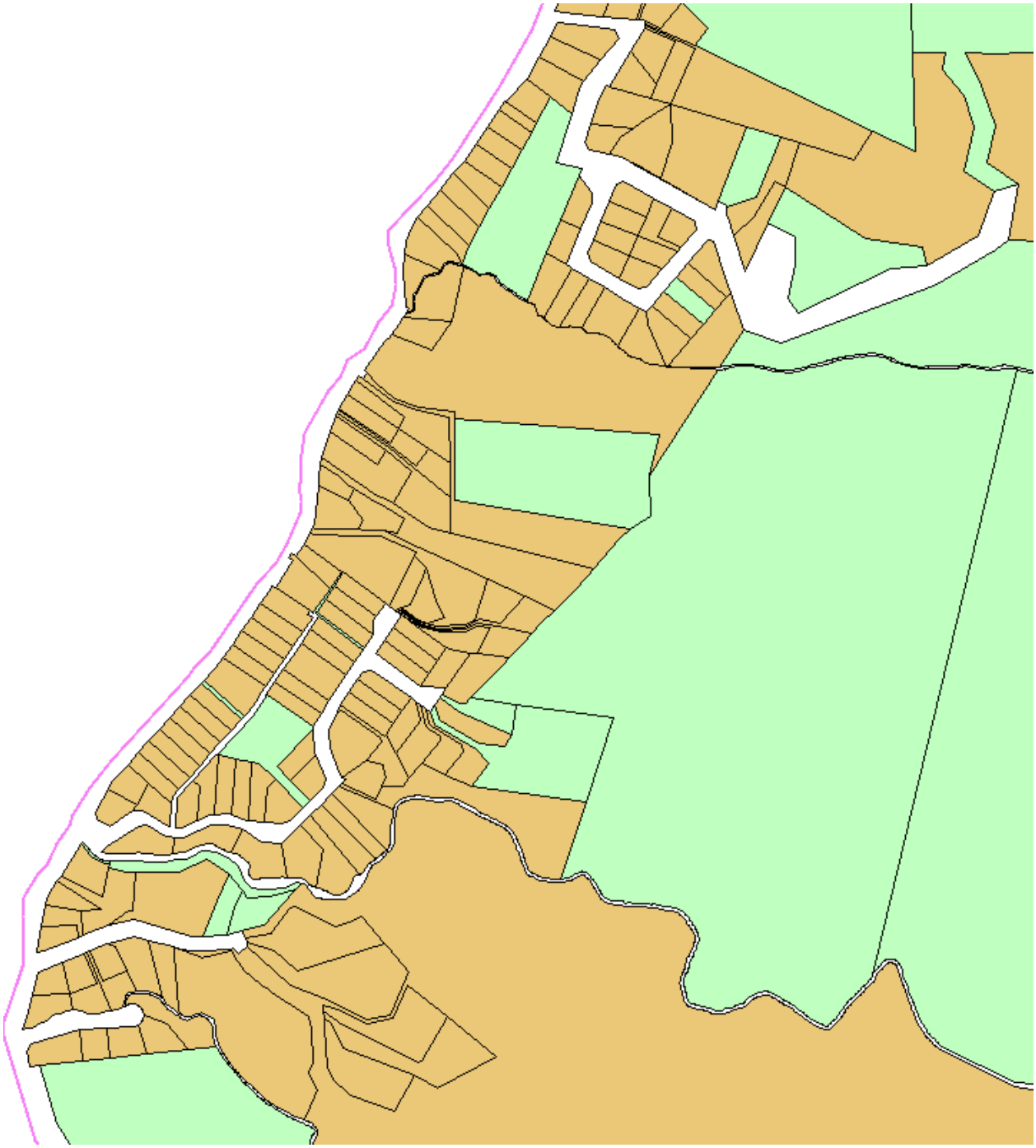


Figure 5 – Phase One modelled presence of septic tank in Ngarimu Bay community

6.4.2 Looking at contributing factors to system performance

a. Soil

The following illustrates the soil results for parcels where a septic tank is recorded as being present (i.e. where the septic tank attribute from the field data is Y). Parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no soil information recorded are shown as dark grey.

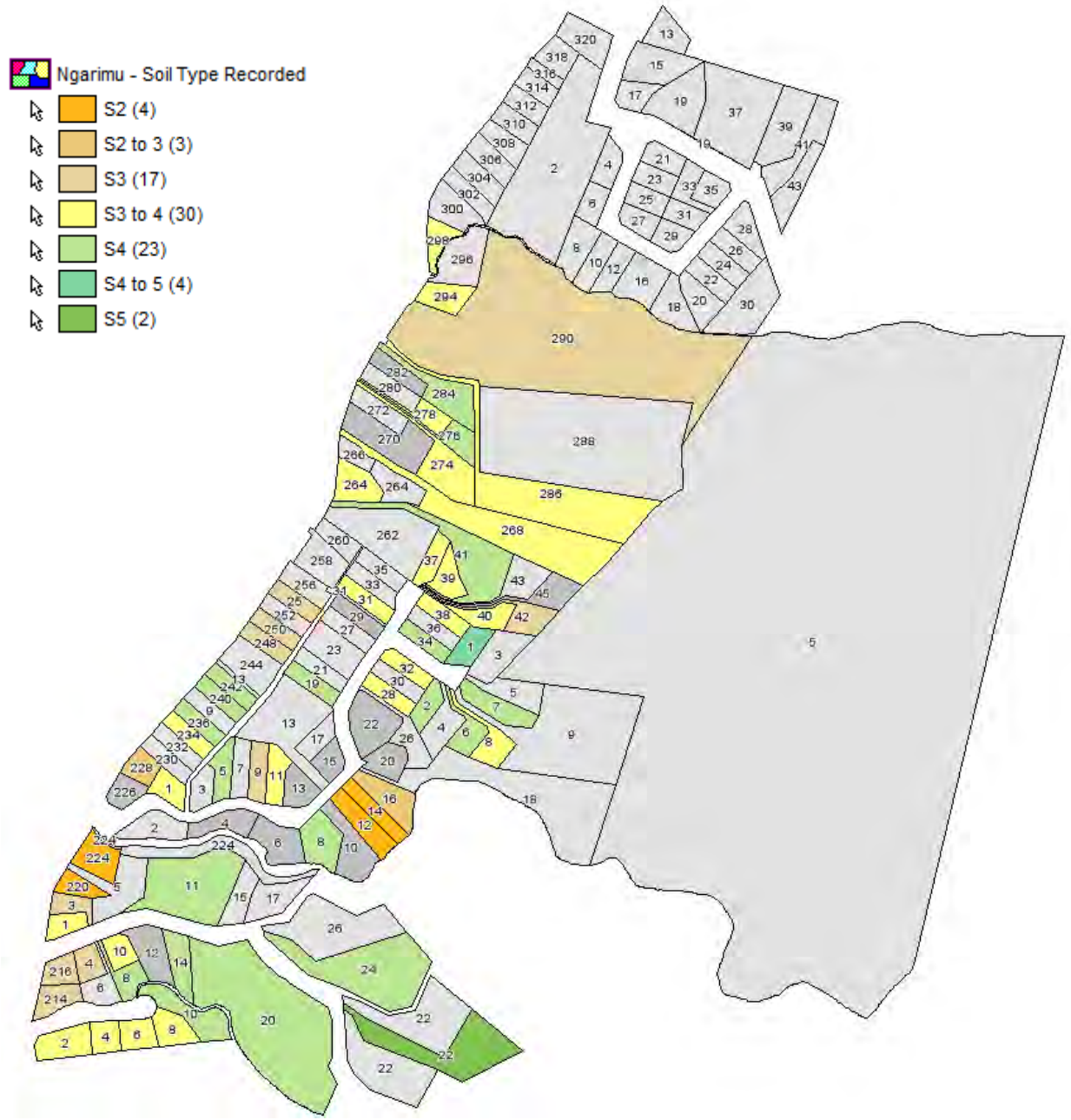


Figure 6 – Field survey recorded soil type in Ngarimu Bay community

As a comparison, the soil values from the Phase One modelling are shown below, where red is defined as Clay, and green is defined as anything else. The grey areas are those parcels indentified as not having a septic tank.

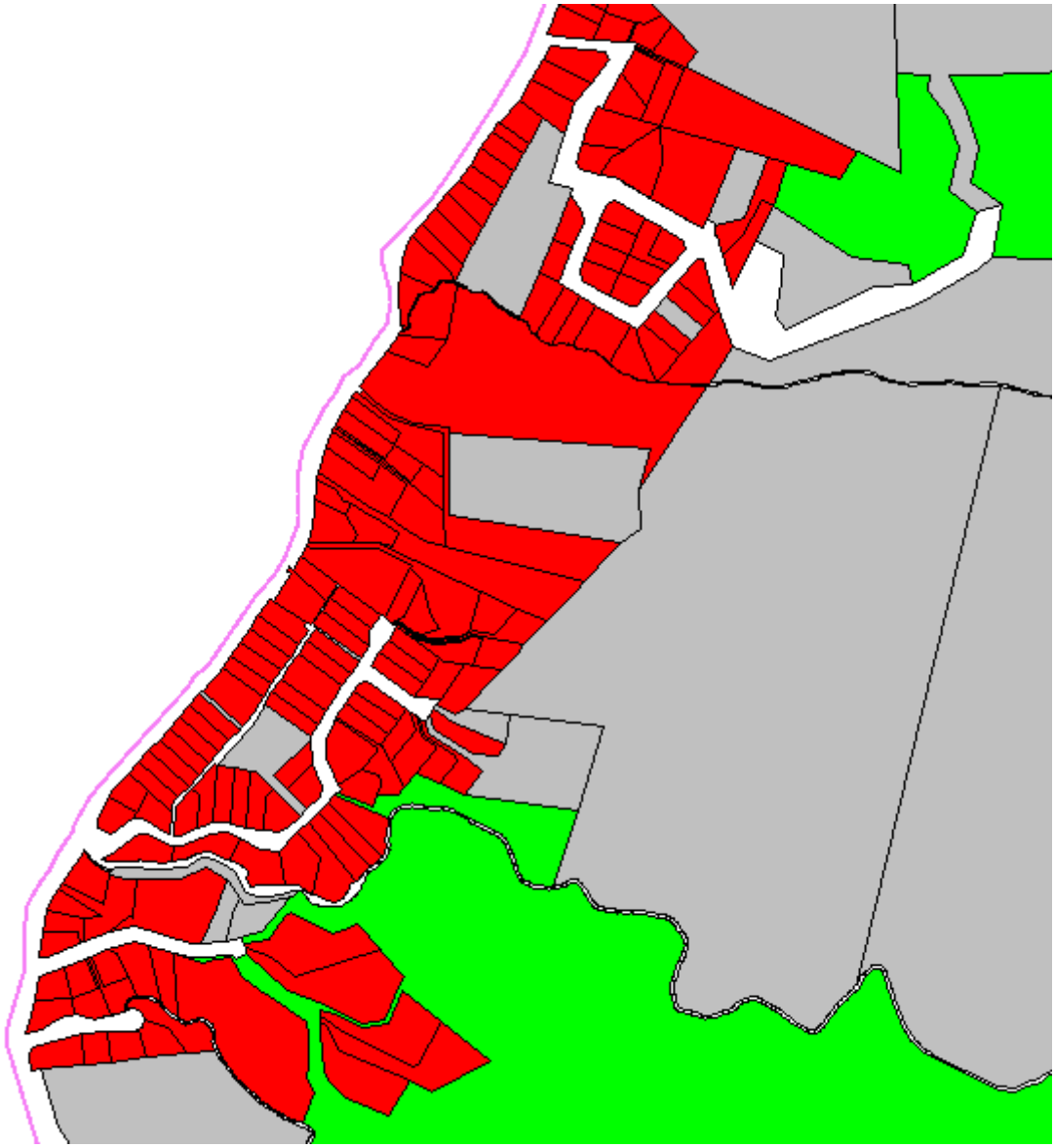


Figure 7 – Phase One modelled soil type in Ngarimu Bay community

b. Topography

The following map illustrates the field survey results for topography for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no topography information recorded are shown as dark grey.

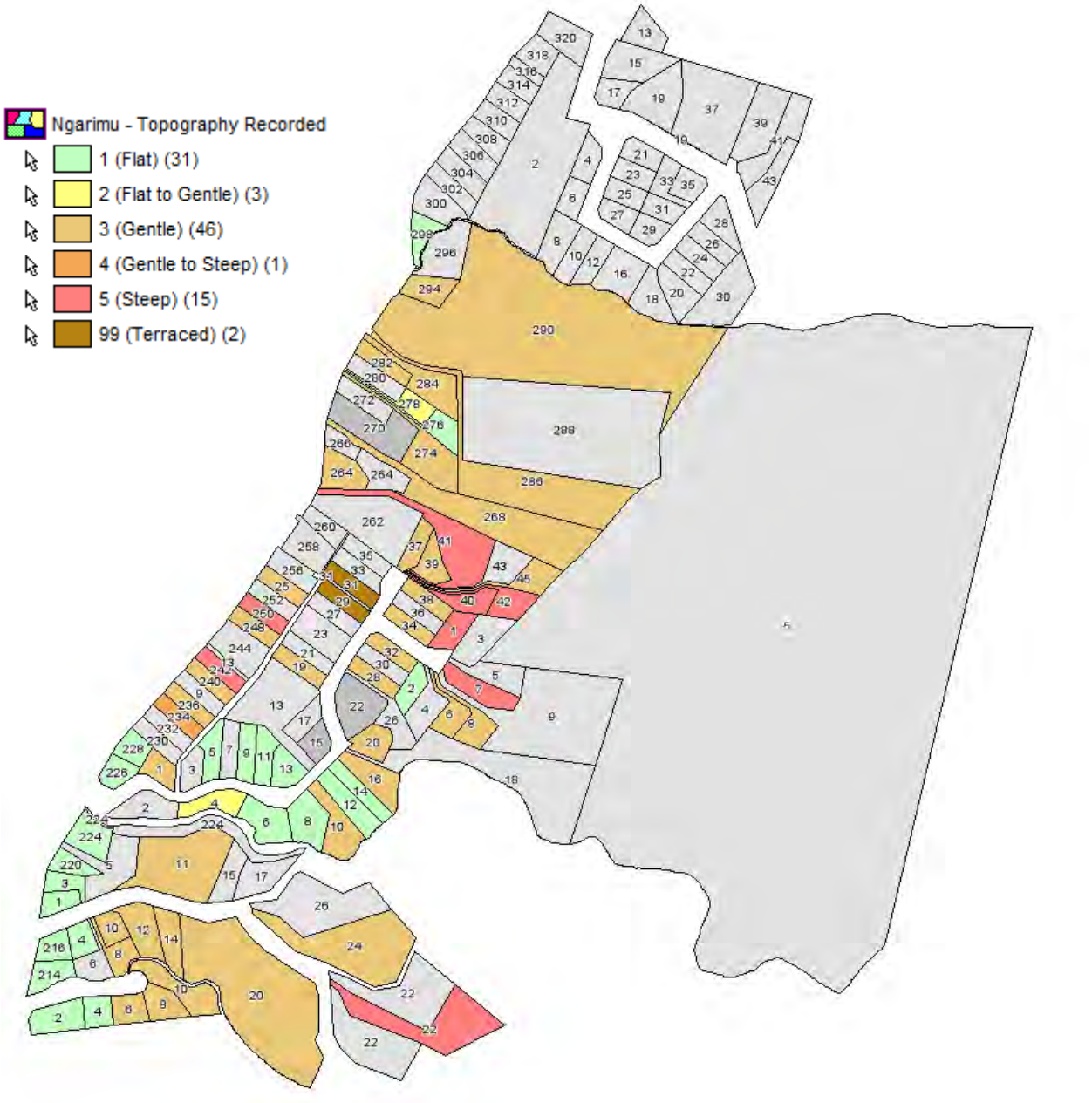


Figure 8 – Field survey recorded topography in Ngarimu Bay community

No specific topography information was modelled in Phase One to compare these results to.

c. Number of people

The following map illustrates the field survey results for the number of people for each property. Again, properties with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no people number information recorded are shown as dark grey.

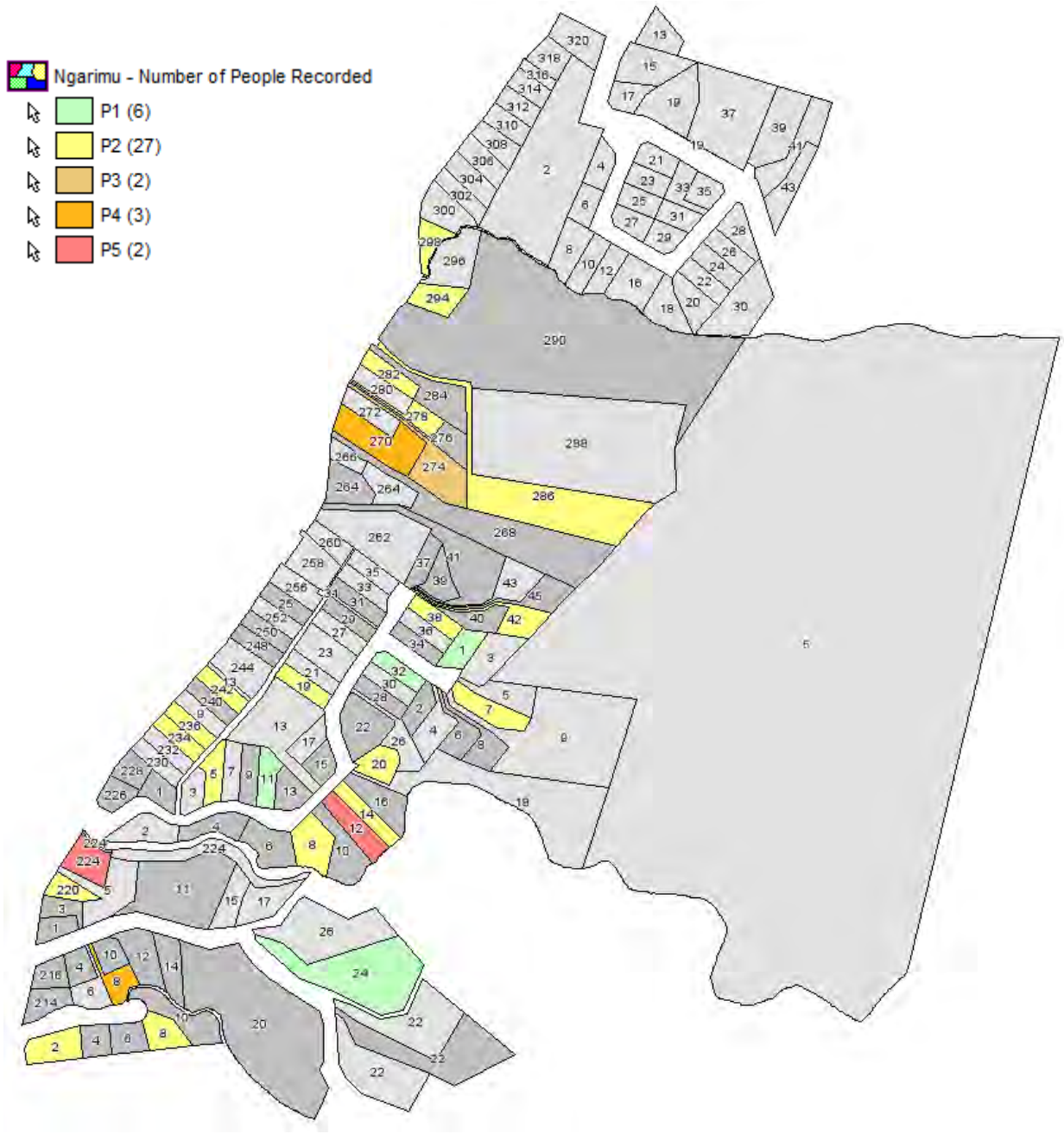


Figure 9 – Field survey recorded number of people per property in Ngarimu Bay community

No specific people number information was modelled in Phase One to compare these results to.

d. Occupancy

The following map illustrates the field survey results for occupancy for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no occupancy information recorded are shown as dark grey.

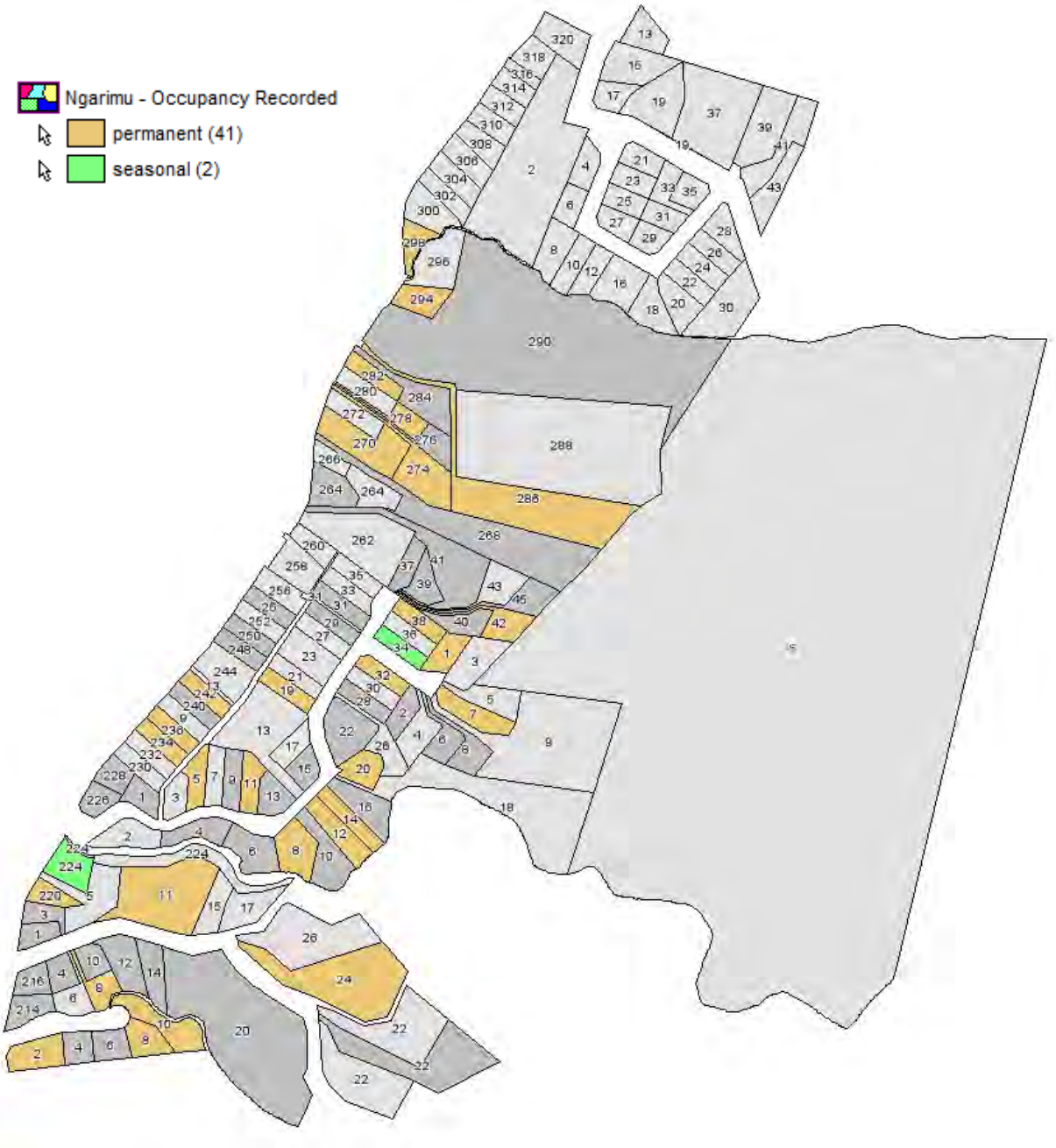


Figure 10 – Field survey recorded occupancy type in Ngarimu Bay community

No specific occupancy information was modelled in Phase One to compare these results to.

6.4.3 Looking at indicators of system non-performance

From the field survey data six attributes that were recorded are identified as potential indicators of system non-performance – Odour, Dampness, Gully trap overflow, Insect nuisance, Grass above disposal lines, and Overland flow. These attributes have been mapped in the following sections.

a. Odour

The following map illustrates the field survey results for odour for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no occupancy information recorded are shown as dark grey.

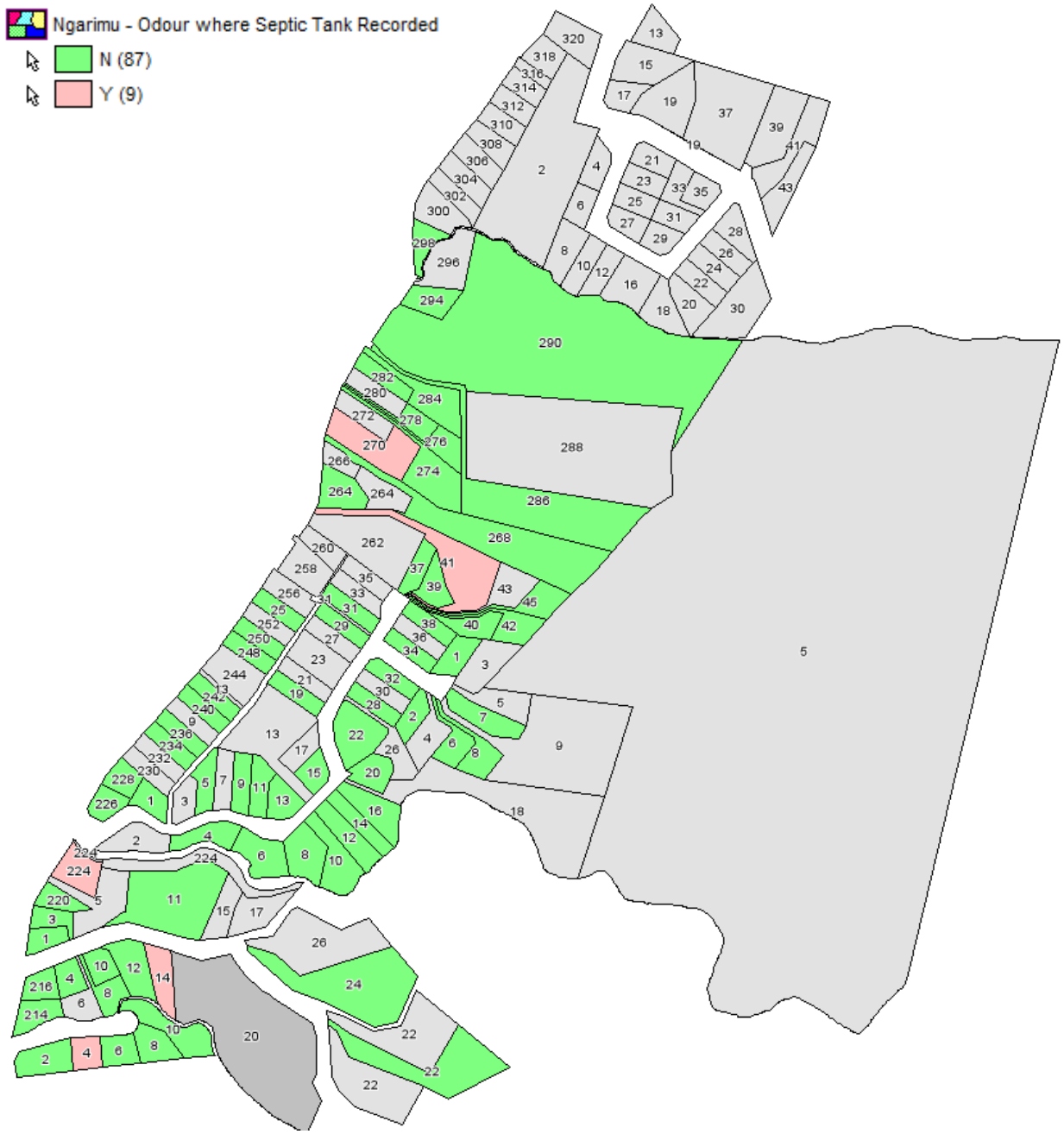


Figure 11 – Field survey recorded odour issue in Ngarimu Bay community

b. Dampness

The following map illustrates the field survey results for dampness for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no occupancy information recorded are shown as dark grey.

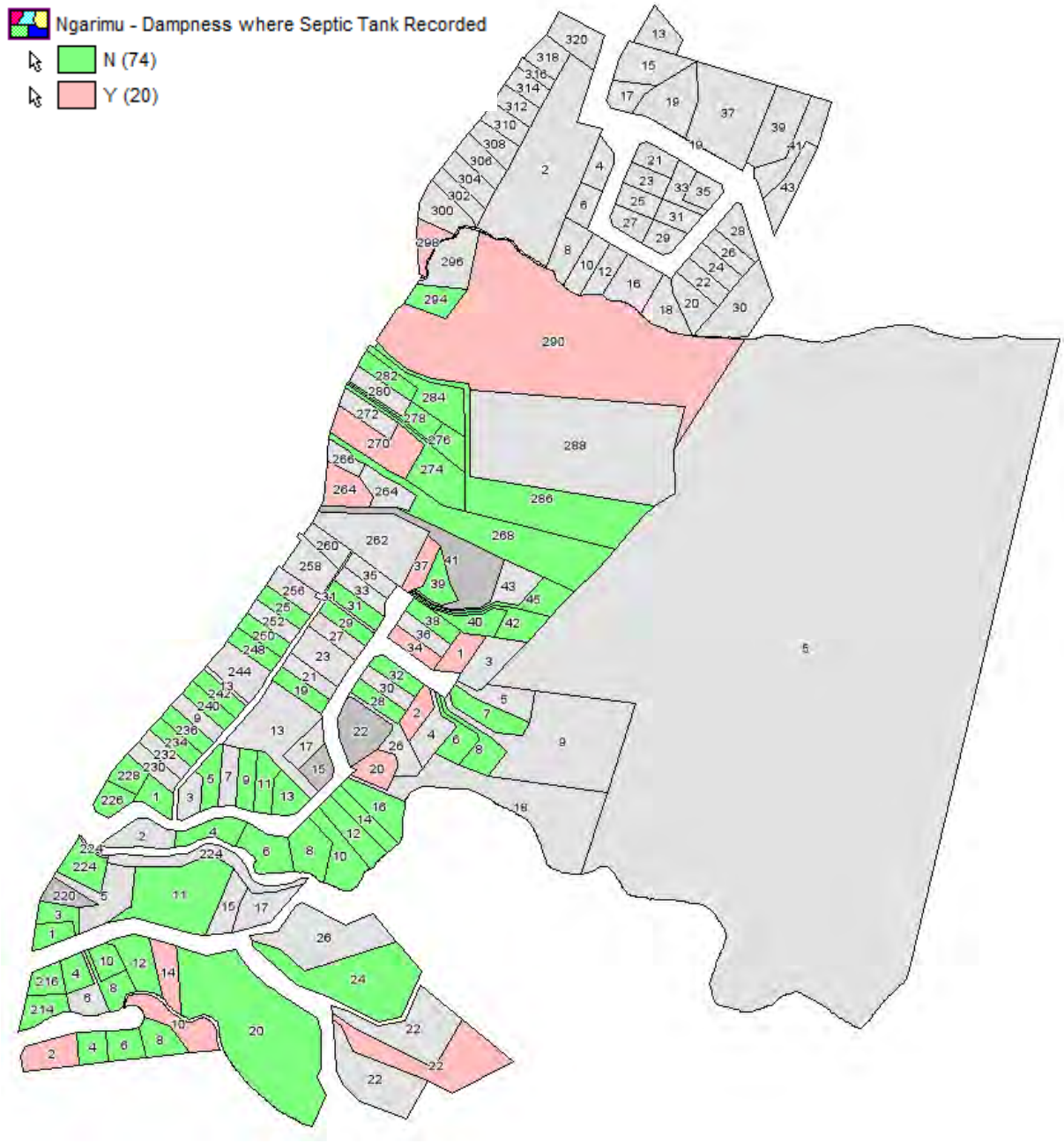


Figure 12 – Field survey recorded dampness issue in Ngarimu Bay community

c. Gully trap overflow

The following map illustrates the field survey results for gully trap overflow for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no occupancy information recorded are shown as dark grey.

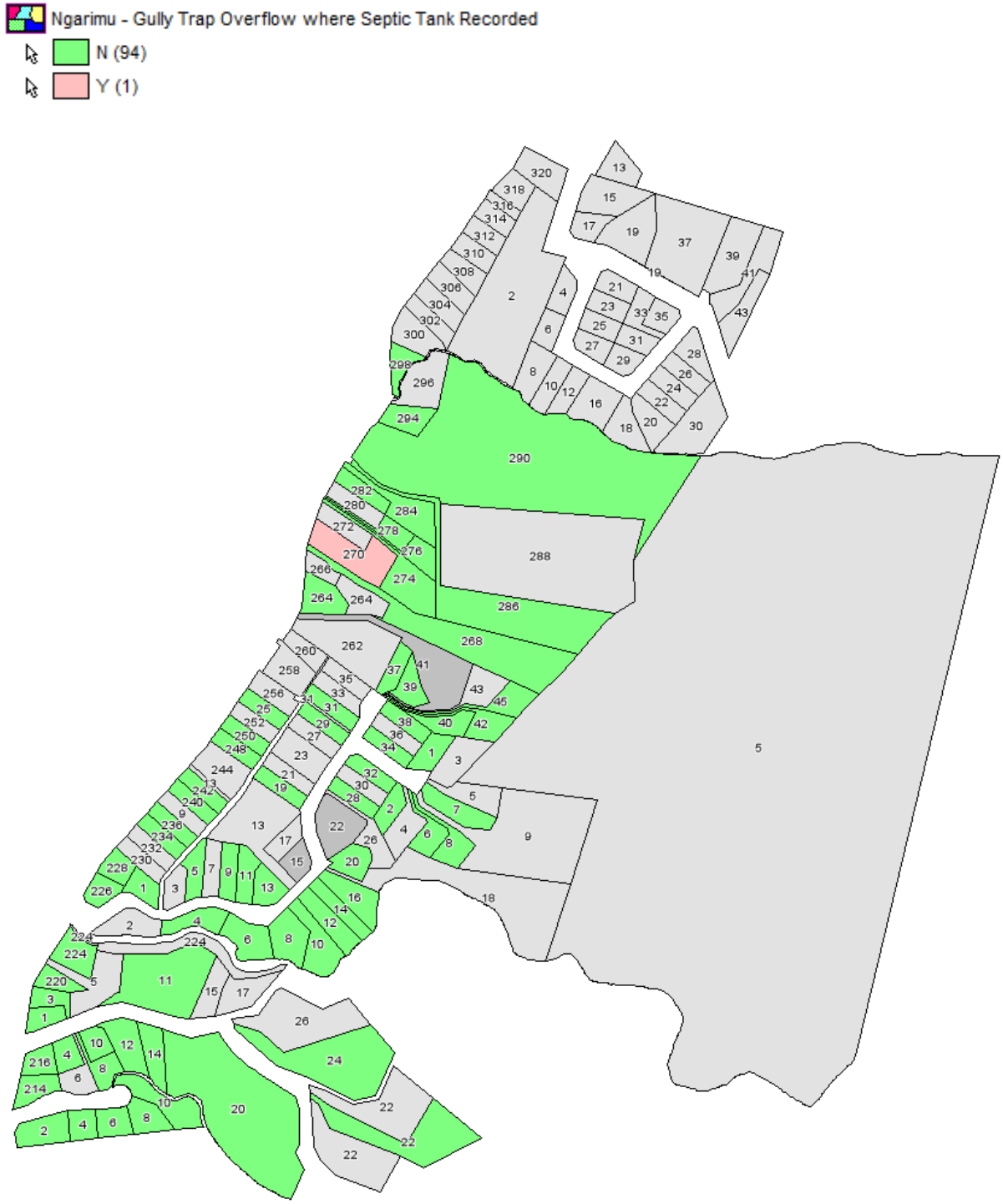


Figure 13 – Field survey recorded gully trap overflow issue in Ngarimu Bay community

d. Insect nuisance

The following map illustrates the field survey results for insect nuisance for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no occupancy information recorded are shown as dark grey.

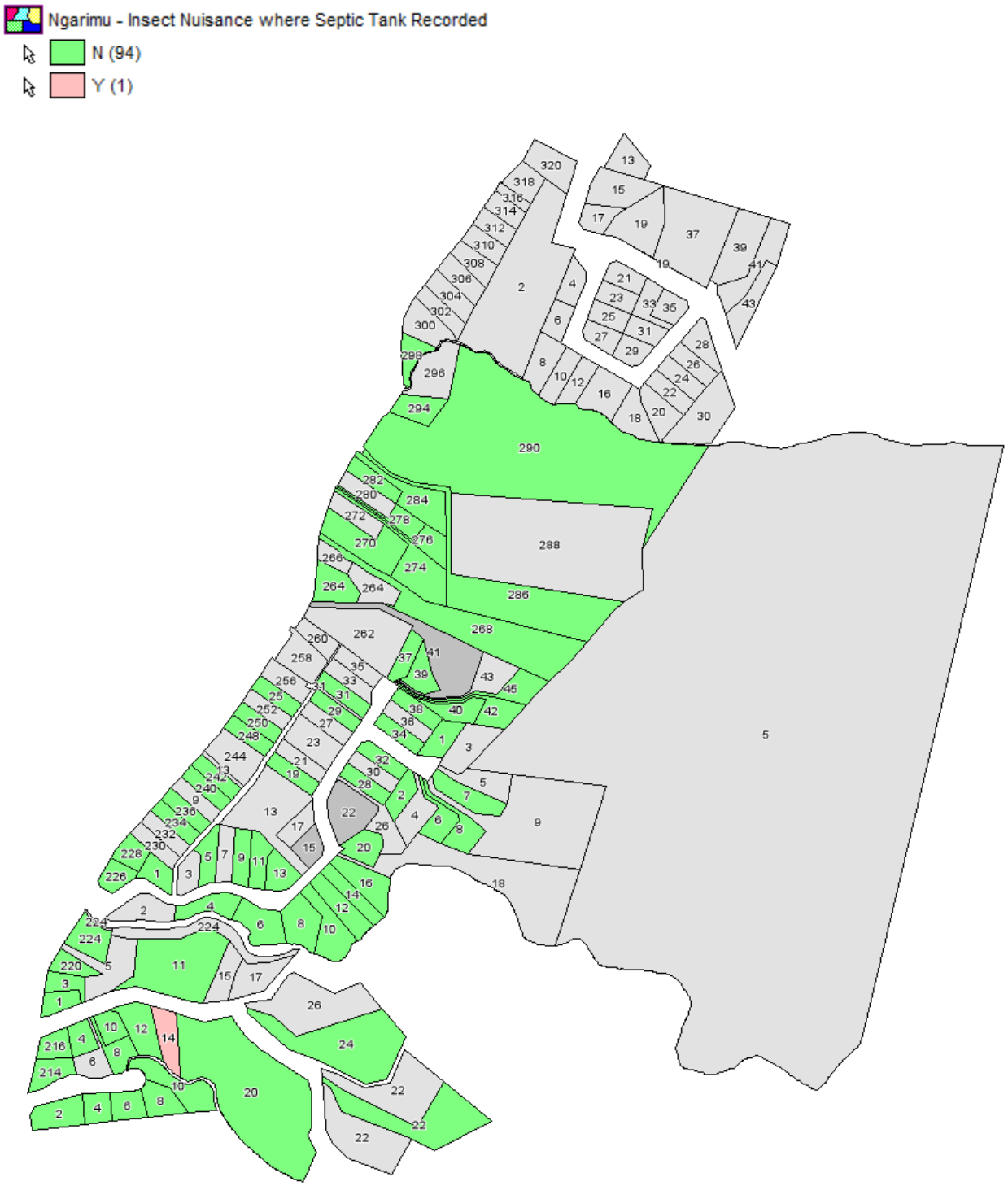


Figure 14 – Field survey recorded insect nuisance issue in Ngarimu Bay community

e. Grass above disposal lines

The following map illustrates the field survey results for grass above disposal lines for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no occupancy information recorded are shown as dark grey.

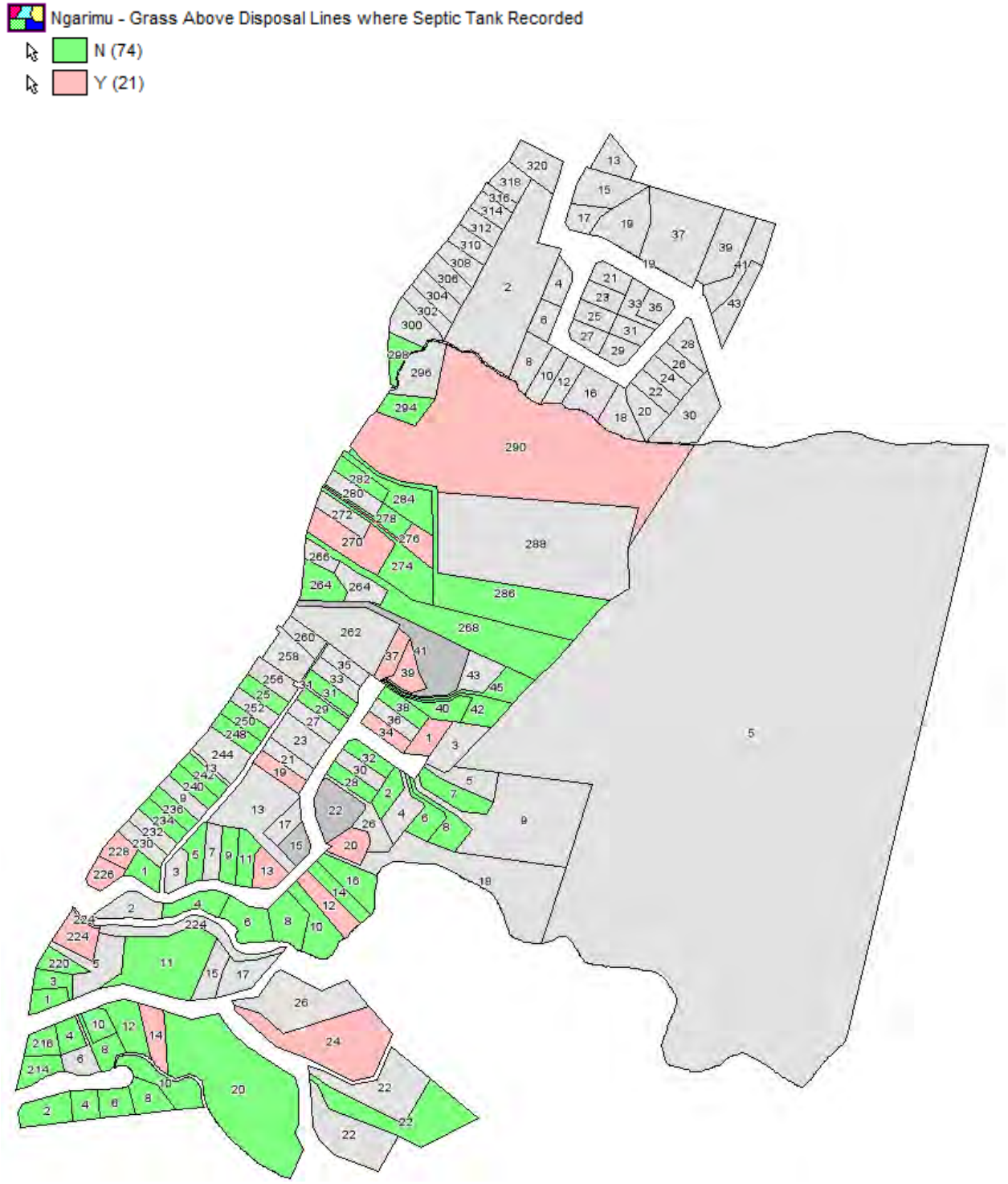


Figure 15 – Field survey recorded grass above disposal lines issue in Ngarimu Bay community

f. Overland flow

The following map illustrates the field survey results for overland flow lines for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no occupancy information recorded are shown as dark grey.

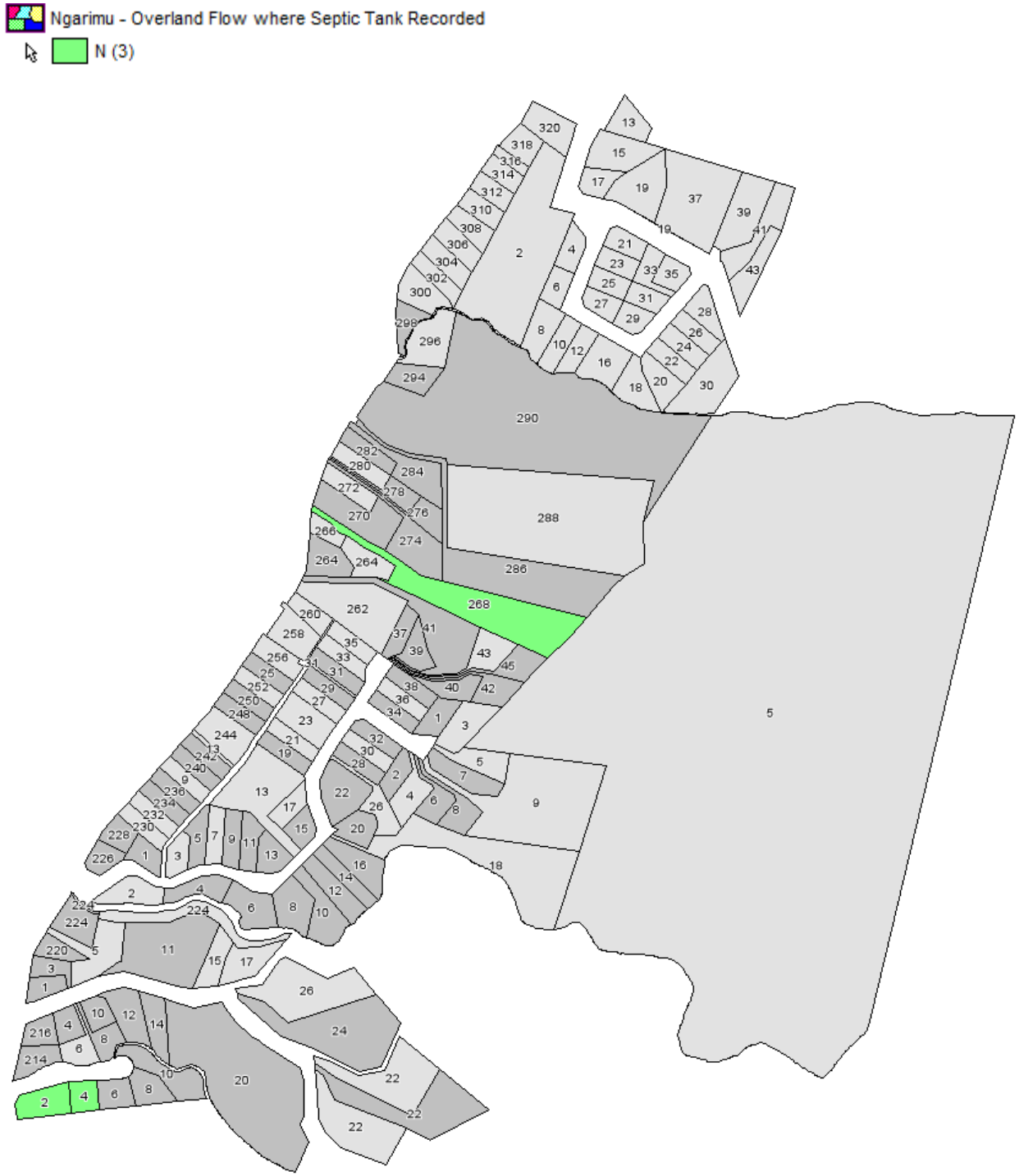
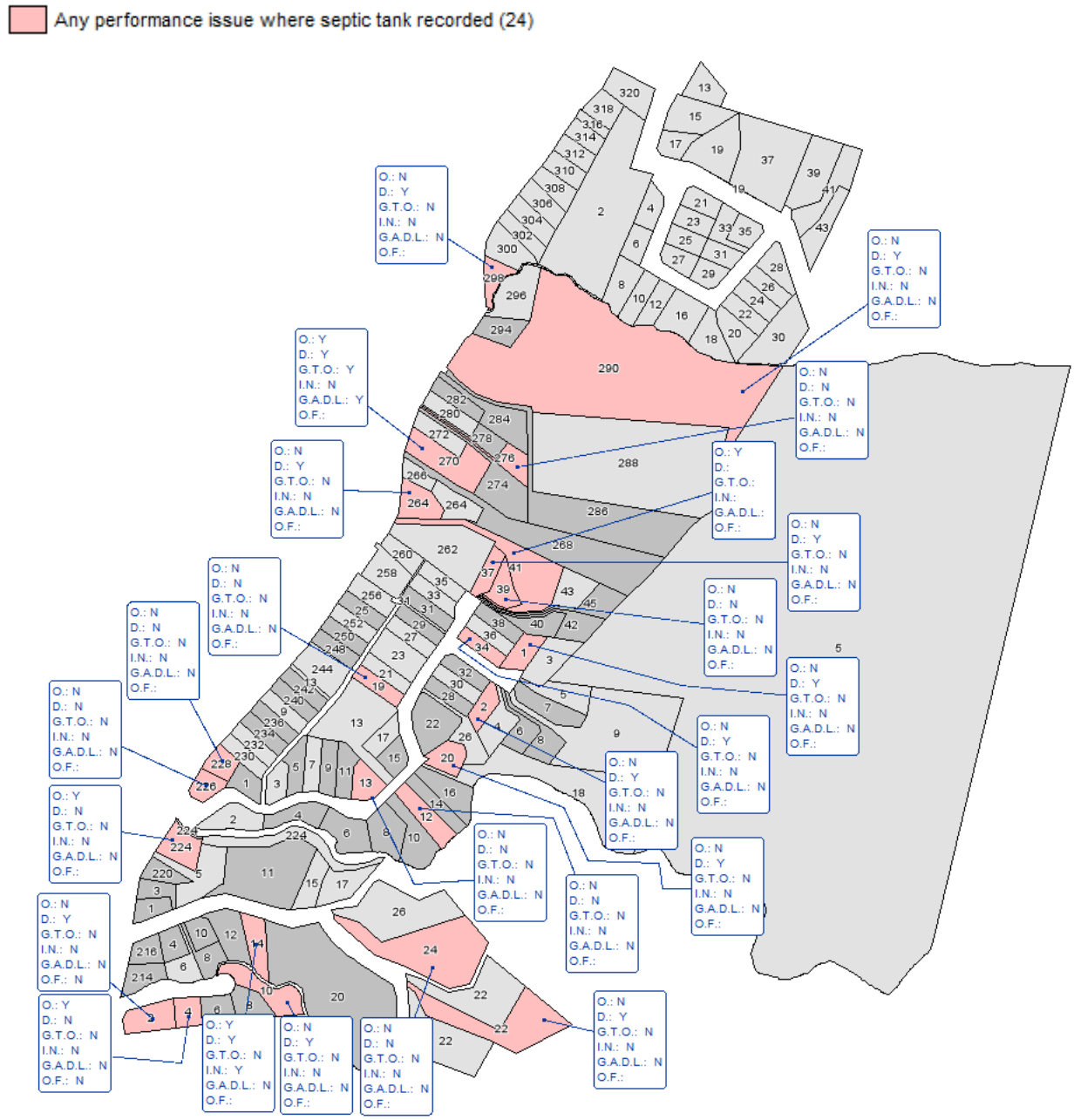


Figure 16 – Field survey recorded overland flow issue in Ngarimu Bay community

g. Where any issue has been recorded

The following map illustrates the field survey results for parcels where any of the above issues has been recorded. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no occupancy information recorded are shown as dark grey.



O = Odour; D = Dampness; G.T.O. = Gully trap overflow; I.N. = Insect nuisnace; G.A.D.L. = Grass above drainge lines; O.F. = Overland flow.

Figure 17 – Field survey recorded any issue in Ngarimu Bay community

6.5 Hatepe results

6.5.1 Overall results

a. Survey coverage

The following map illustrates the Hatepe survey extent, as supplied by EW to the field survey contractor.

Figure 18 – Proposed survey extent for Hatepe community

The map below illustrates the number of properties in Hatepe for which a field survey record result was supplied. The red parcels indicate parcels for which no field survey information was supplied.

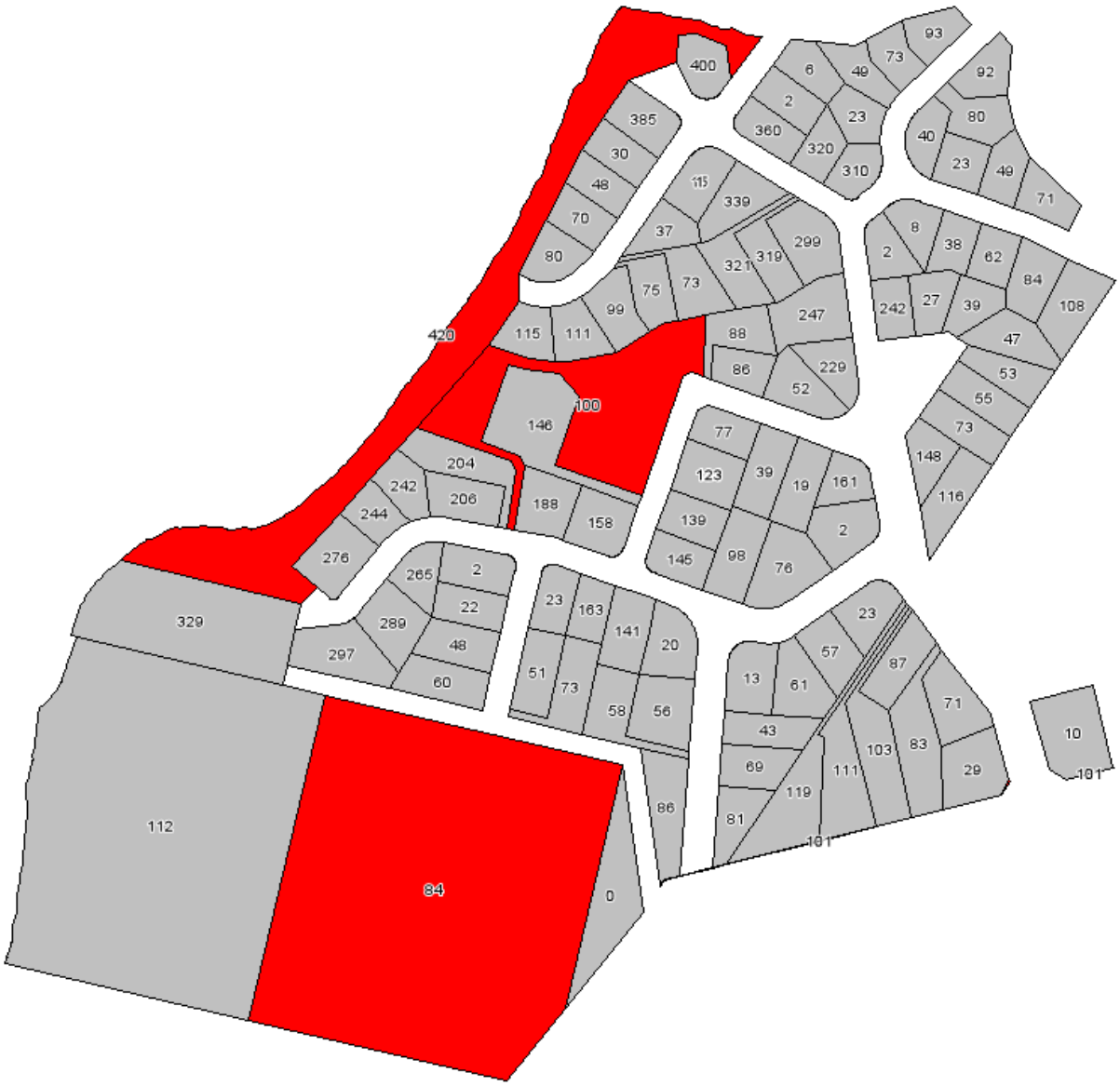


Figure 19 – Actual survey extent for Hatepe community

b. Presence of septic tank

The following map illustrates those properties where a septic tank was recorded as present by the field survey contractor. The light grey areas are those parcels that did not have any survey results. The dark grey areas are those parcels that do have field survey results, but no specific result for the presence (or not) of a septic tank (i.e. where the attribute field for septic tank is Null or N).

Figure 20 – Field survey recorded presence of septic tank in Hatepe community

The following map shows the results from Phase One of the OWTS model for Hatepe, where the likely presence (or not) of a septic tank was assessed based on the EW rating database (where brown indicates a septic tank present and green indicates no septic tank present).

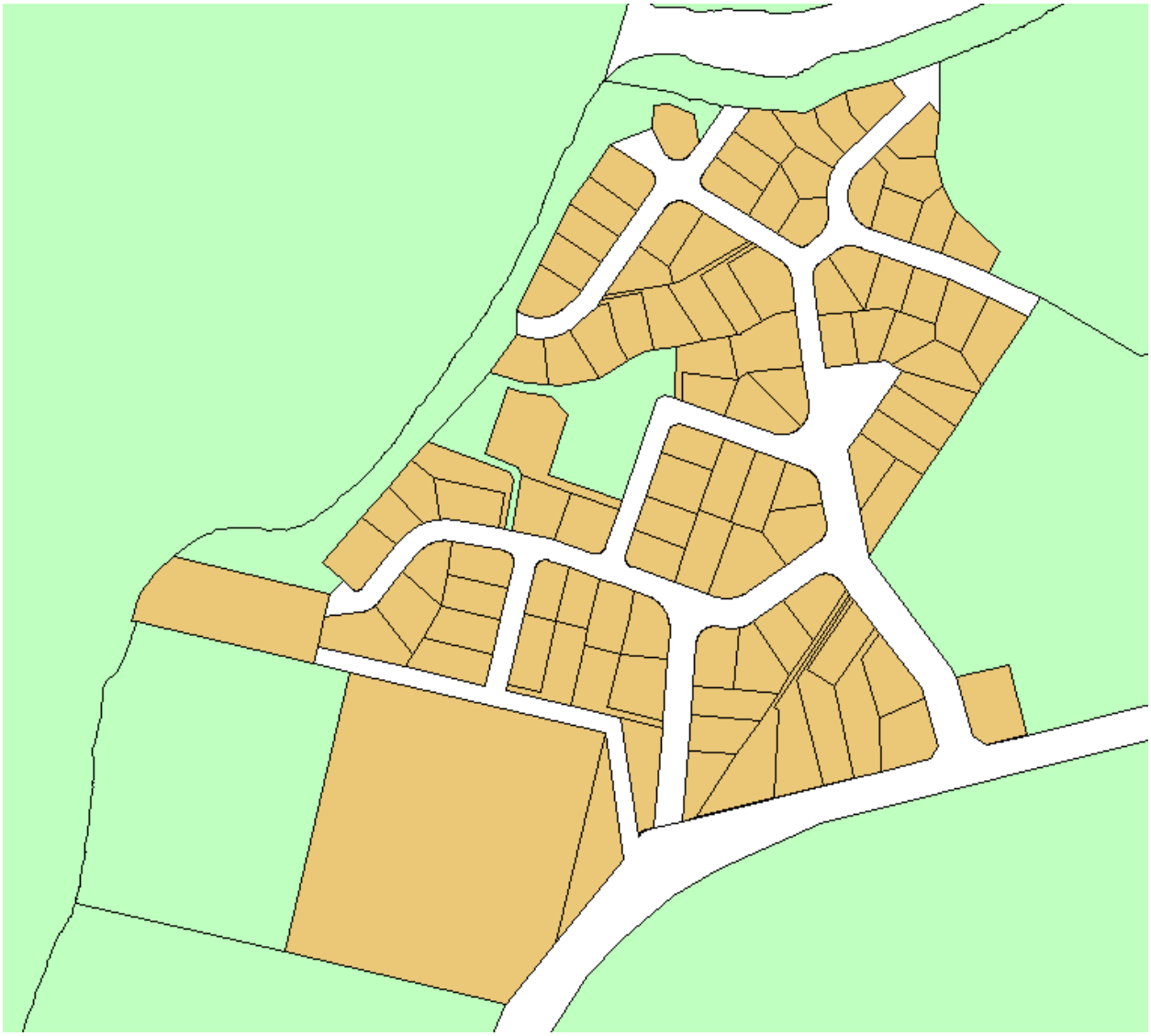


Figure 21 – Phase One modelled presence of septic tank in Hatepe community

6.5.2 Looking at contributing factors to system performance

a. Soil

The following illustrates the soil results for parcels where a septic tank is recorded as being present (i.e. where the septic tank attribute from the field data is Y). Parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey.

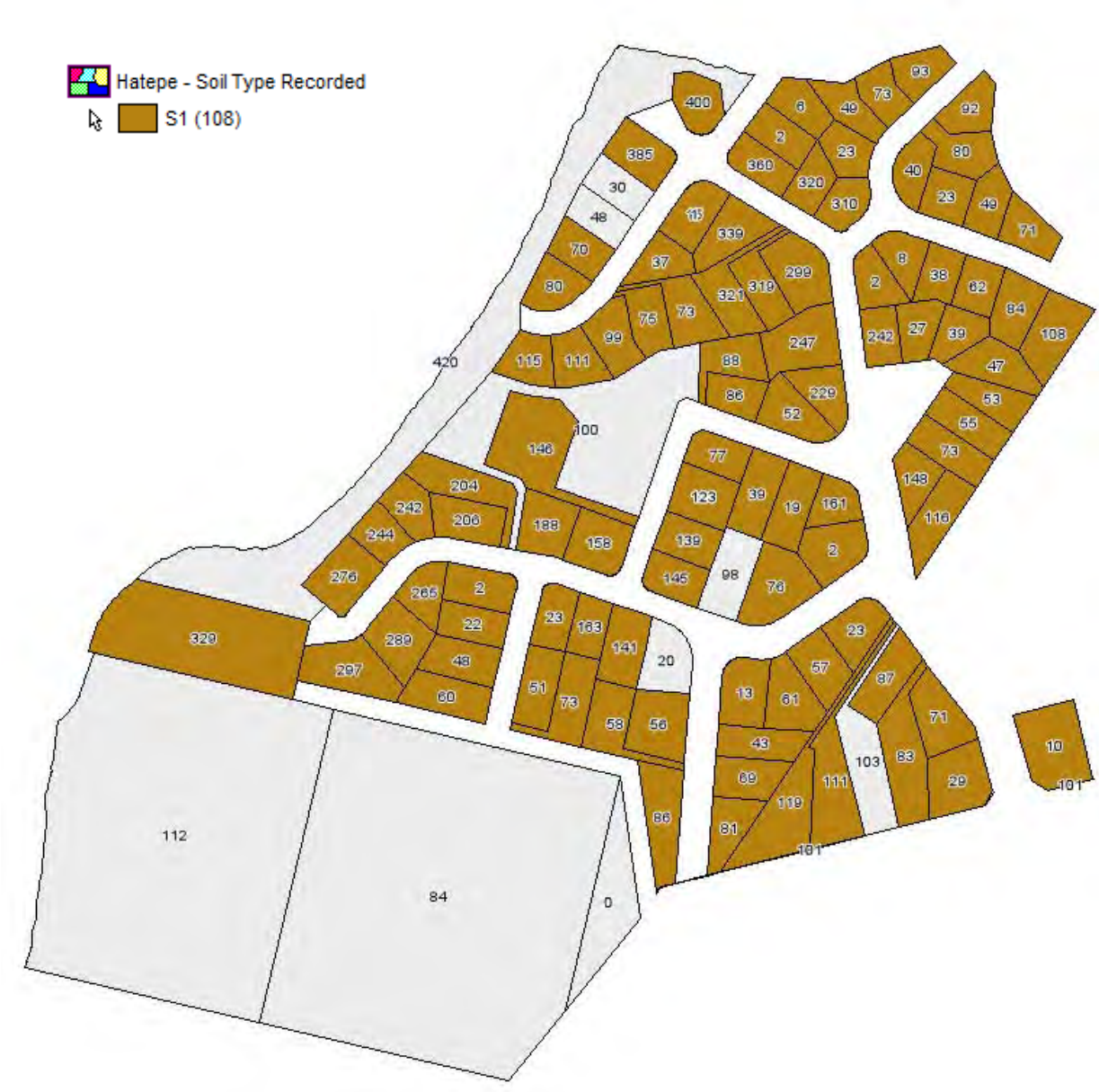


Figure 22 – Field survey recorded soil type in Hatepe community

As a comparison, the soil values from the Phase One modelling are shown below, where green is defined as anything that is not clay. The grey areas are those parcels modelled as not having a septic tank.

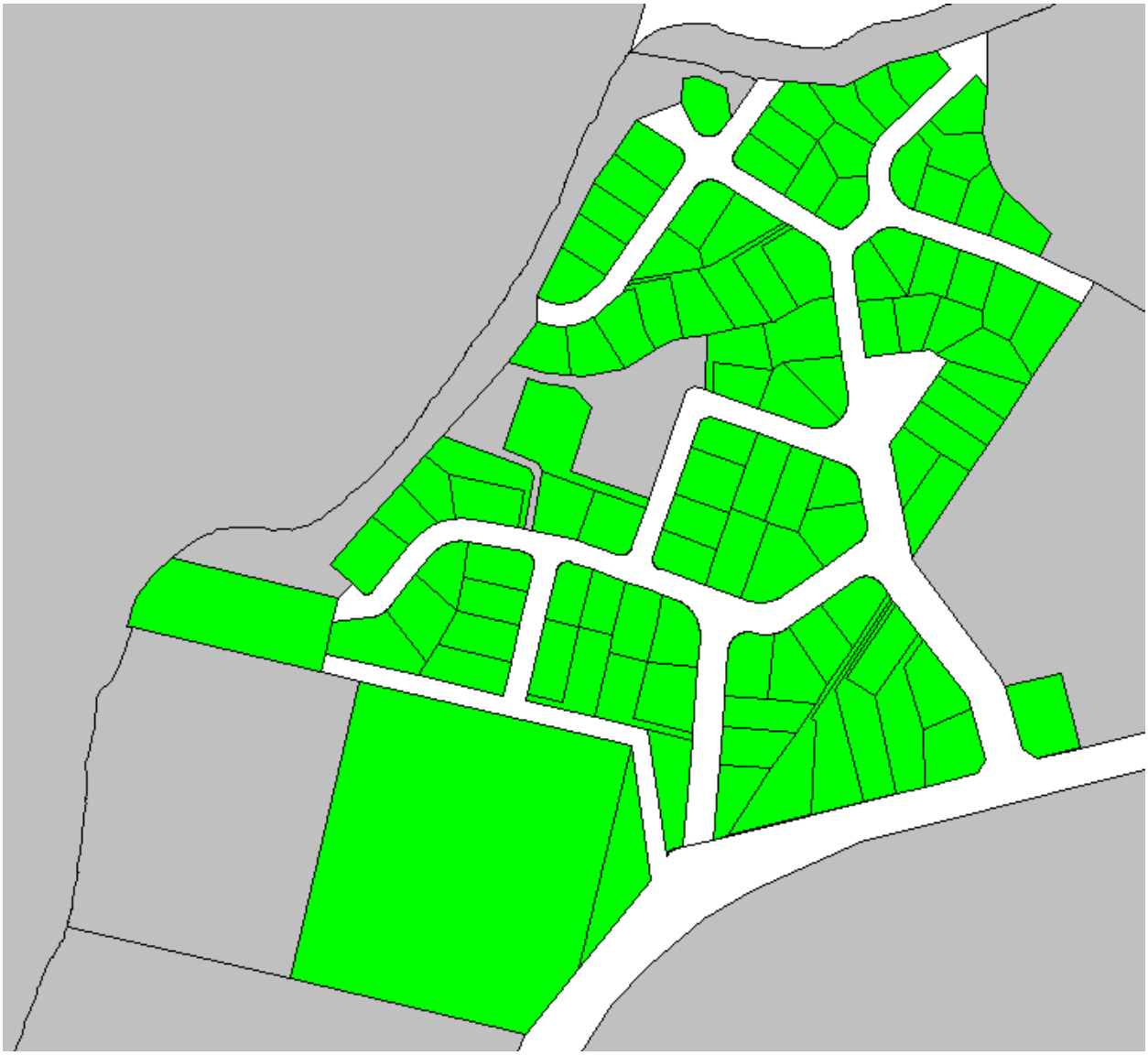


Figure 23 – Phase One modelled soil type in Hatepe community

b. Topography

The following map illustrates the field survey results for topography for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey.

Figure 24 – Field survey recorded topography in Hatepe community

No specific topography information was modelled in Phase One to compare these results to.

c. Number of people

The following map illustrates the field survey results for the number of people for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no people number information recorded are shown as dark grey.

Figure 25 – Field survey recorded number of people per property in Hatepe community

No specific people number information was modelled in Phase One to compare these results to.

d. Occupancy

The following map illustrates the field survey results for occupancy for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no occupancy information recorded are shown as dark grey.

Figure 26 – Field survey recorded occupancy type in Hatepe community

No specific occupancy information was modelled in Phase One to compare these results to.

6.5.3 Looking at indicators of system non-performance

From the field survey data six attributes that were recorded are identified as potential indicators of system non-performance – Odour, Dampness, Gully trap overflow, Insect nuisance, Grass above disposal lines, and Overland flow. These attributes have been mapped in the following sections.

a. Odour

The following map illustrates the field survey results for odour for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey. Parcels with a septic tank recorded but no occupancy information recorded are shown as dark grey.

Figure 27 – Field survey recorded odour issue in Hatepe community

b. Dampness

The following map illustrates the field survey results for dampness for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey.

Figure 28 – Field survey dampness issue in Hatepe community

c. Gully trap overflow

The following map illustrates the field survey results for gully trap overflow for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey.

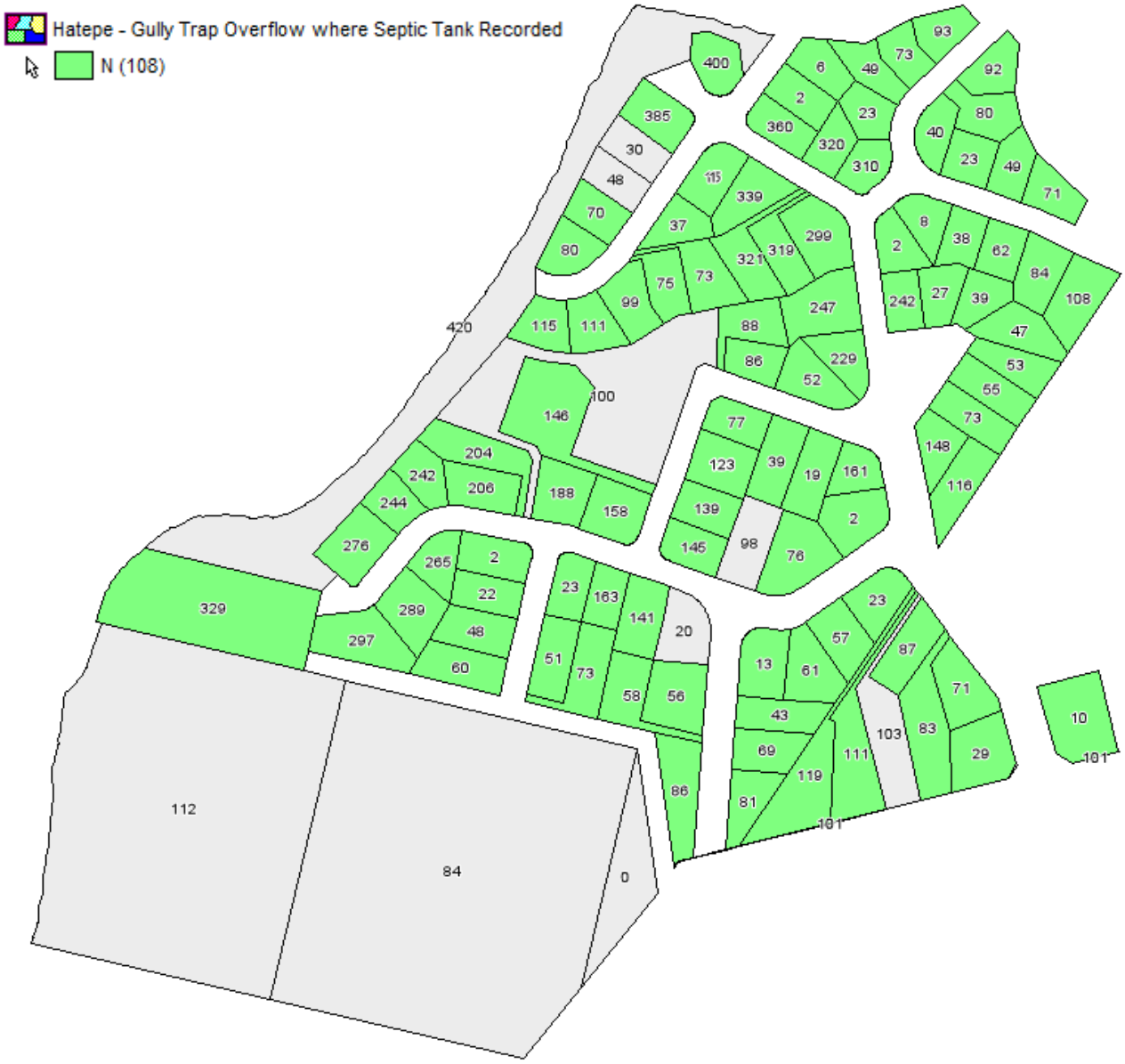


Figure 29 – Field survey gully trap overflow issue in Hatepe community

d. Insect nuisance

The following map illustrates the field survey results for insect nuisance for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey.

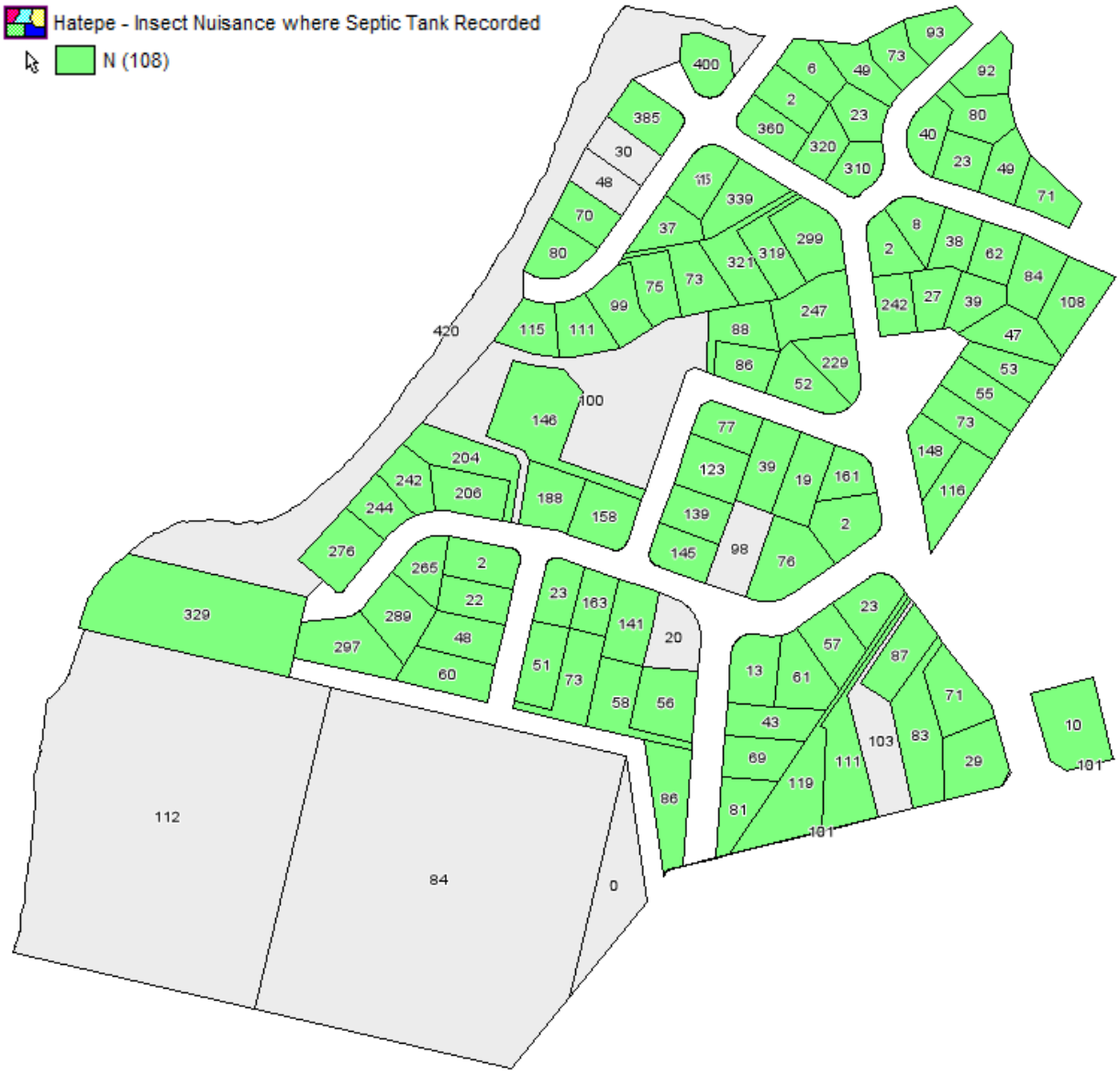


Figure 30 – Field survey insect nuisance issue in Hatepe community

e. Grass above disposal lines

The following map illustrates the field survey results for grass above disposal lines for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey.

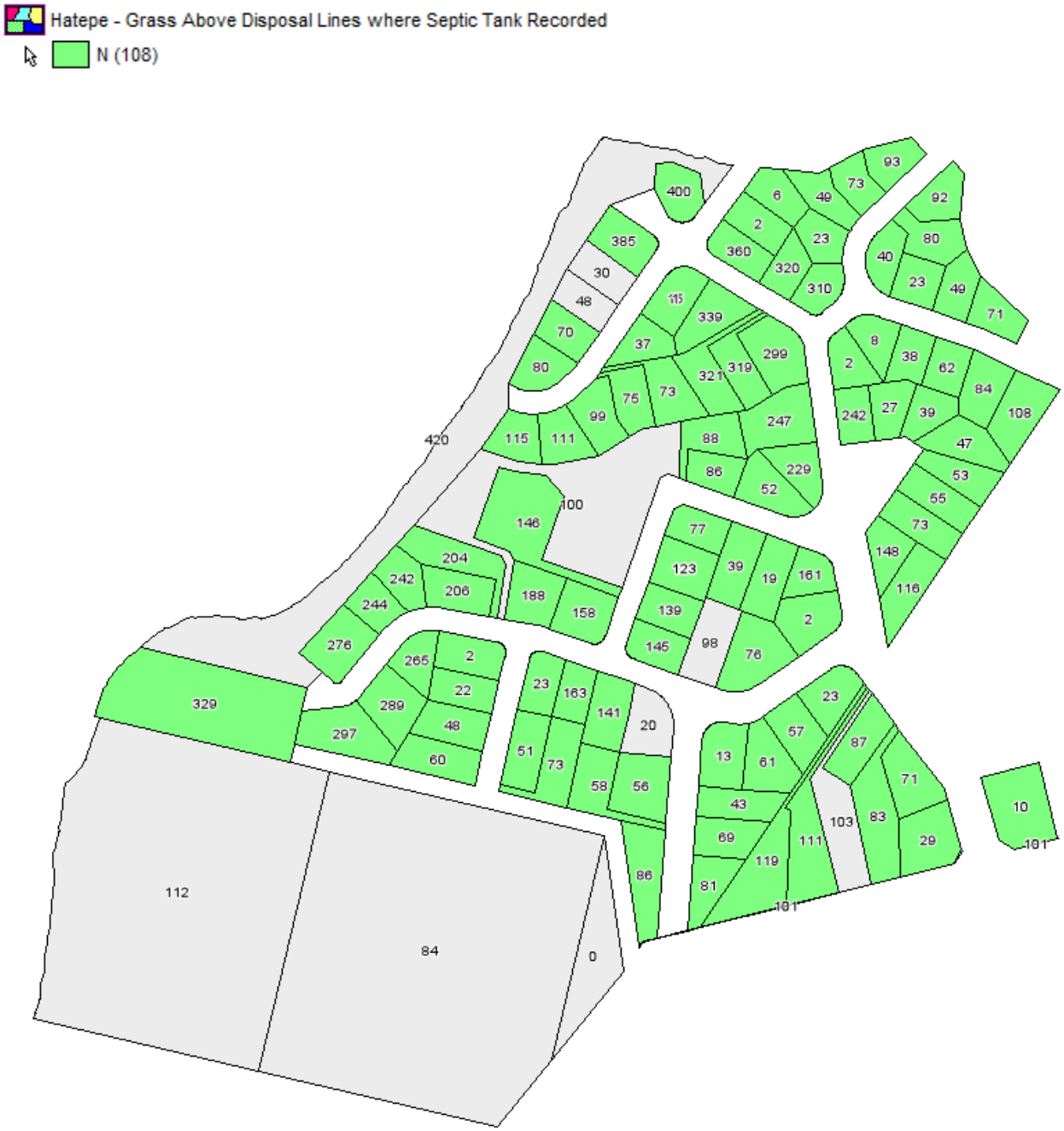


Figure 31 – Field survey grass above disposal lines issue in Hatepe community

f. Overland flow

The following map illustrates the field survey results for overland flow lines for each parcel. Again, parcels with no survey data, no septic tank recorded or no attribute information about septic tank presence, are shown as light grey.

Figure 32 – Field survey overland flow issue in Hatepe community

6.6 Commentary on field survey results in relation to calibration study

Four factors were extracted from the field surveys of the two communities as influencers of potential OWTS failure risk – Soil Type, Topography, Number of People and Occupancy.

Only Soil Type was able to be directly compared to the Phase One OTWS modelling. In the case of Ngarimu Bay the field survey Soil Type showed a range of soils from “S2” to “S5”. The definitions of S2 etc. were not provided by the field survey team, but in comparison the Phase One modelling only indicated one Soil Type for the full extent of Ngarimu Bay – “Clay”. One conclusion that could be drawn from this observation is that the scale (detail) of the Soil Type layers used in Phase One of the modelling is not detailed enough to be applied at the parcel level when assessing the influence of Soil Type on OTWS performance.

Soil Type for Hatepe was only recorded as”S1” for the whole community, which matched the results from the Phase One modelling which recorded the Soil Type as “Not Clay” for the whole community.

The observations on Topography, Number of People and Occupancy for Ngarimu Bay were too incomplete to draw any conclusions as to the impact these factors had on the risk of OWTS failure. The situation was similar for Hatepe where only a very few records (parcels) had any results for Number of People or Occupancy.

Six observations were extracted as potential indicators of OWTS failure – Odour, Dampness, Gully Trap Overflow, Insect Nuisance, Grass Above Disposal Lines and Overland Flow.

No issues were recorded for Hatepe, however the Phase One model identified Hatepe having an overall OWTS median quartile risk rating of 4.05 which is high. This value is driven by the high values for R_1 (System Age), R_3 (Lot Size), R_4 (Depth to Groundwater) and R_6 (Proximity to surface water). It is worth considering why a perceived discrepancy may occur between modelled risk and observed failure. In Hatepe the Lot Size and Age of System have been identified as factors increasing the potential of OWTS failure. However, other factors such as regular maintenance, seasonal (light) occupancy and community wealth may combine to counter the risks incurred through older systems and small lot sizes. The risks due to depth to groundwater and proximity may still be relevant as the field survey did not assess groundwater or surface water contamination.

In Ngarimu Bay sporadic issues were recorded for Odour, Gully Trap Overflow, Insect Nuisance and Overland Flow, and these issues did not follow any specific geographic distribution pattern. As such they may be related to specific property level issues such as poor OTWS design, installation or maintenance. More issues for Dampness and Grass Above Disposal Lines were recorded which may be related to Soil Type (poor soakage) or Depth to Groundwater. However the results again did not follow any specific geographic distribution pattern.

7 Responses to household surveys for two communities

7.1 Overview

The following section summarises responses from a postal questionnaire of residents in Ngarimu Bay and Hatepe communities. The postal questionnaire coincided with the field surveys reported on in Section 6.

The postal questionnaire asked residents to provide information relating to:

- The number of people normally resident in each dwelling
- The number of bedrooms in each dwelling
- The dwelling occupancy type (permanently occupied or during holidays only)
- The type of treatment and disposal system (if known)
- The period of last septic tank or wastewater system service

7.2 Household survey data

7.2.1 Questionnaire

The postal questionnaire sent to each residence in the Ngarimu Bay and Hatepe communities comprised one A4 page with six simple questions with answers to be circled by respondents. The postal questionnaire was distributed by EW, and the responses were collated by EW and scanned for supply and analysis as part of the calibration study[14].

A total of 106 responses were received for Ngarimu Bay and 61 for Hatepe.

The figure on the following page provides an example of a completed postal questionnaire for Hatepe.

7.2.2 Processing data for use

Each of the scanned postal questionnaire responses was entered into a MS Excel spreadsheet to form a single table of responses.

A LOCATION_ADDRESS column was created so that the table of responses could be joined to the property data from EW[15].

The letter “B” was added to the number of bedrooms to set this column as a Text field.

Two minor issues with the response data were identified during the join process:

- Multiple houses at one address e.g. 329 RANIERA ROAD – noted on form that “There are 5 houses on the acre under Kowhai Holdings Ltd. They would all be similar”. But the forms also included a verbal response from 329 RANIERA “GROVE” which described a different house (more bedrooms)

[14] Supplied by Environment Waikato 14 October 2011

[15] The same property data used in the field survey analysis in Section 6

- Survey response has 43 HOETA TE HATA LANE Hatepe changed to 45 from 43 – kept as 43 to match the EW property database.

Address details:

92 KAHIKATOA LANE Hatepe

ENVIRONMENT WAIKATO
Doc no. 1976979
17 MAY 2011
Person resp.
Trisha S

Please circle your answers:

How many people would normally be staying at the dwelling?

1-2 3-4 5-6 6+

How many bedrooms does your property have?

1 2 3 (4) 5+

Is the dwelling occupied permanently or during holiday only?

Permanent (Holiday)

Do you know what kind of treatment and disposal system serves your property?

(Yes) No

If yes, what type of system do you have?

(Septic Tank and Trenches) Septic Tank and Soak Pit

Aerated Wastewater System Sand or Textile Filter

Other System

When was the last time you had the septic tank emptied or wastewater system serviced?

<1 year 1-2 years (2-5 years) 5-10 years 10 years+

Figure 33 – Example completed postal questionnaire form for Hatepe

7.3 Ngarimu results

7.3.1 Questionnaire response spread

The following plan illustrates the distribution of the responses received for the Ngarimu Bay community, where a green property indicates where a response was received and a grey property indicates where no questionnaire response was received.

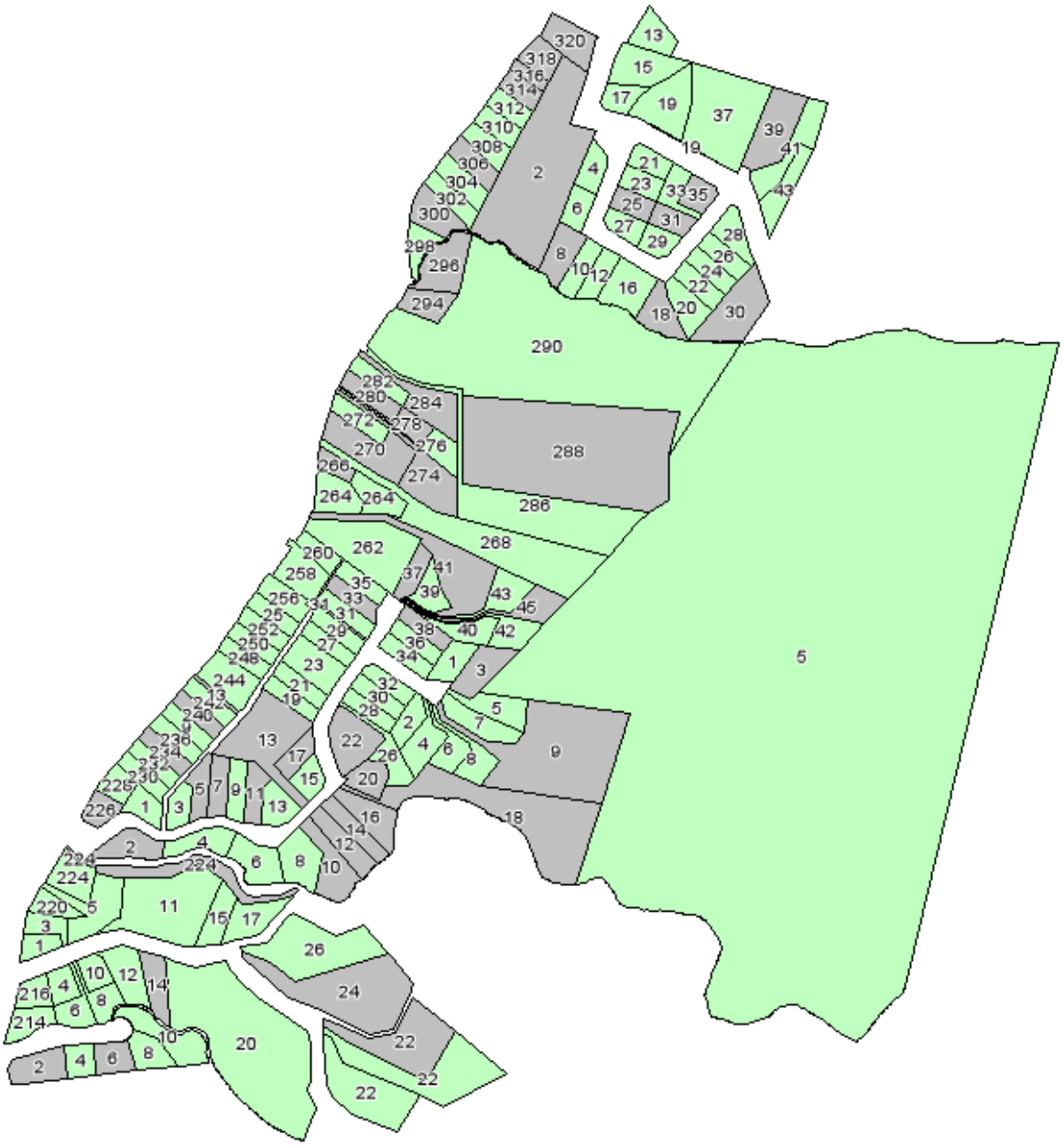


Figure 34 – Household survey responses in Ngarimu Bay community

7.3.2 Response broken down by question

a. Number of people normally resident

This plan illustrates the breakdown of the number of people normally resident for Ngarimu Bay properties where a questionnaire response was received.

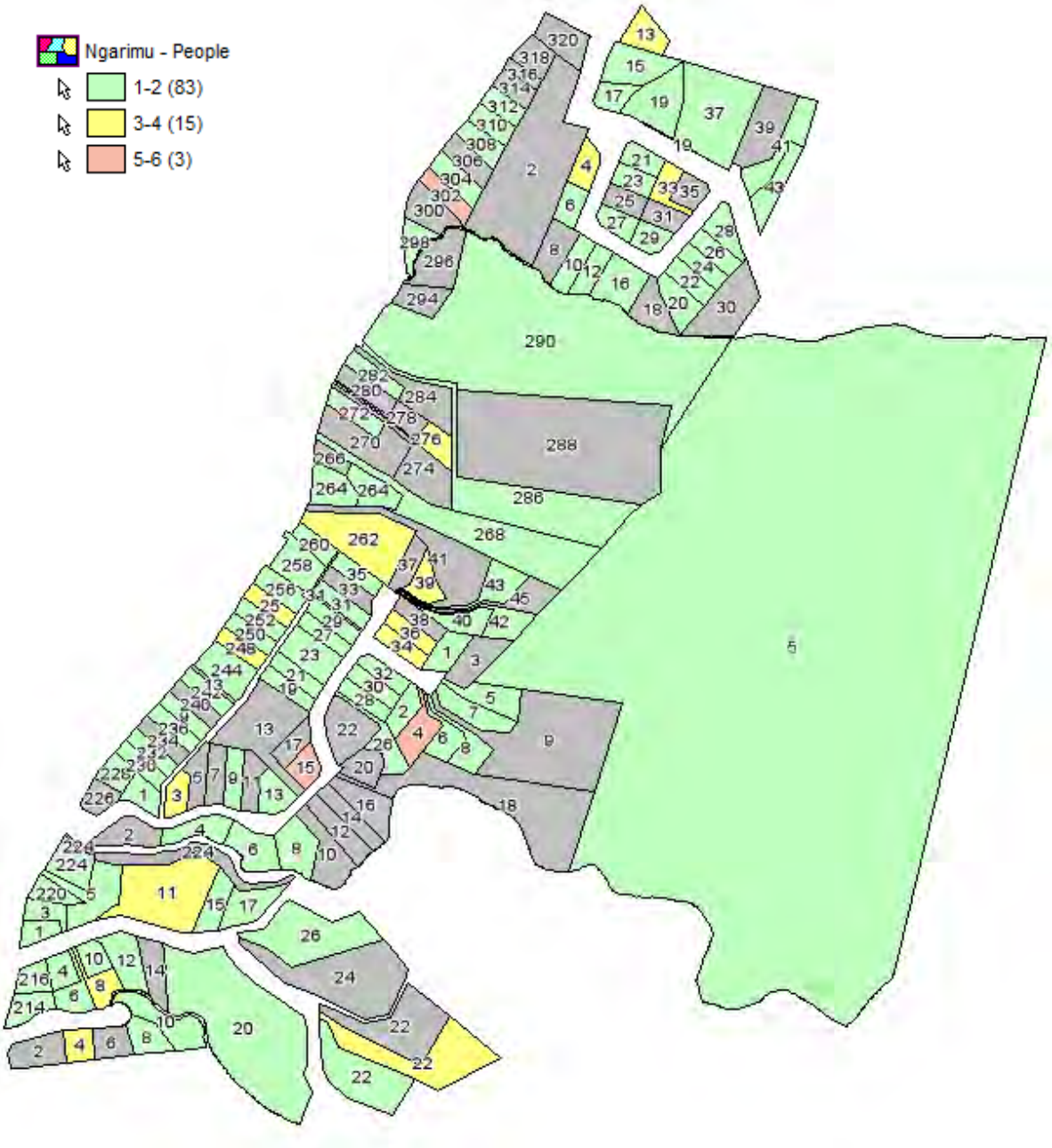


Figure 35 – Household survey number of people per property in Ngarimu Bay community

b. Number of bedrooms in dwelling

This plan illustrates the breakdown of the number of bedrooms in dwelling for Ngarimu Bay properties where a questionnaire response was received.

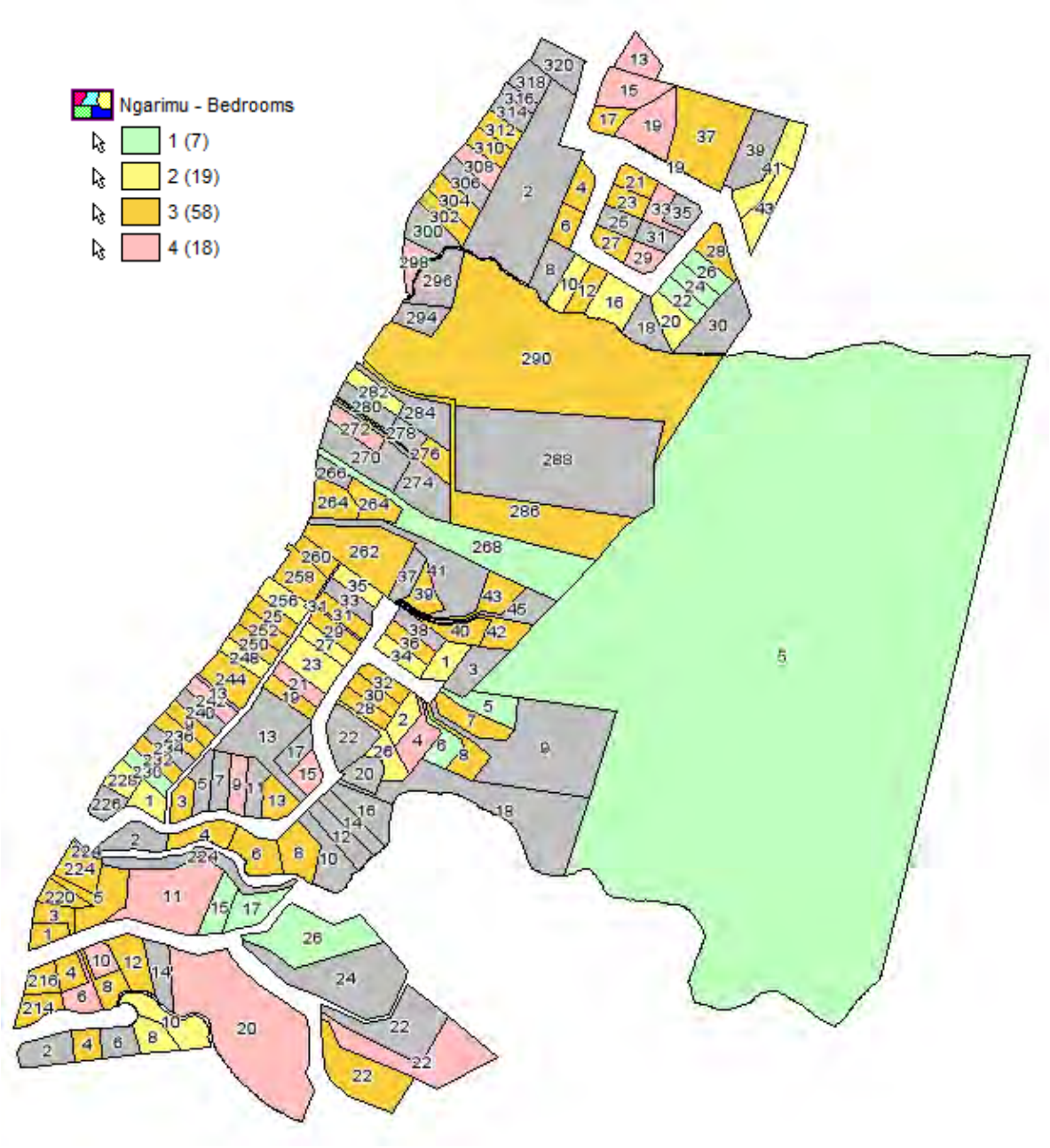


Figure 36 – Household survey number of bedrooms per property in Ngarimu Bay community

c. Dwelling occupancy type – permanently occupied or during holidays only

This plan illustrates the breakdown by dwelling type for Ngarimu Bay properties where a questionnaire response was received.

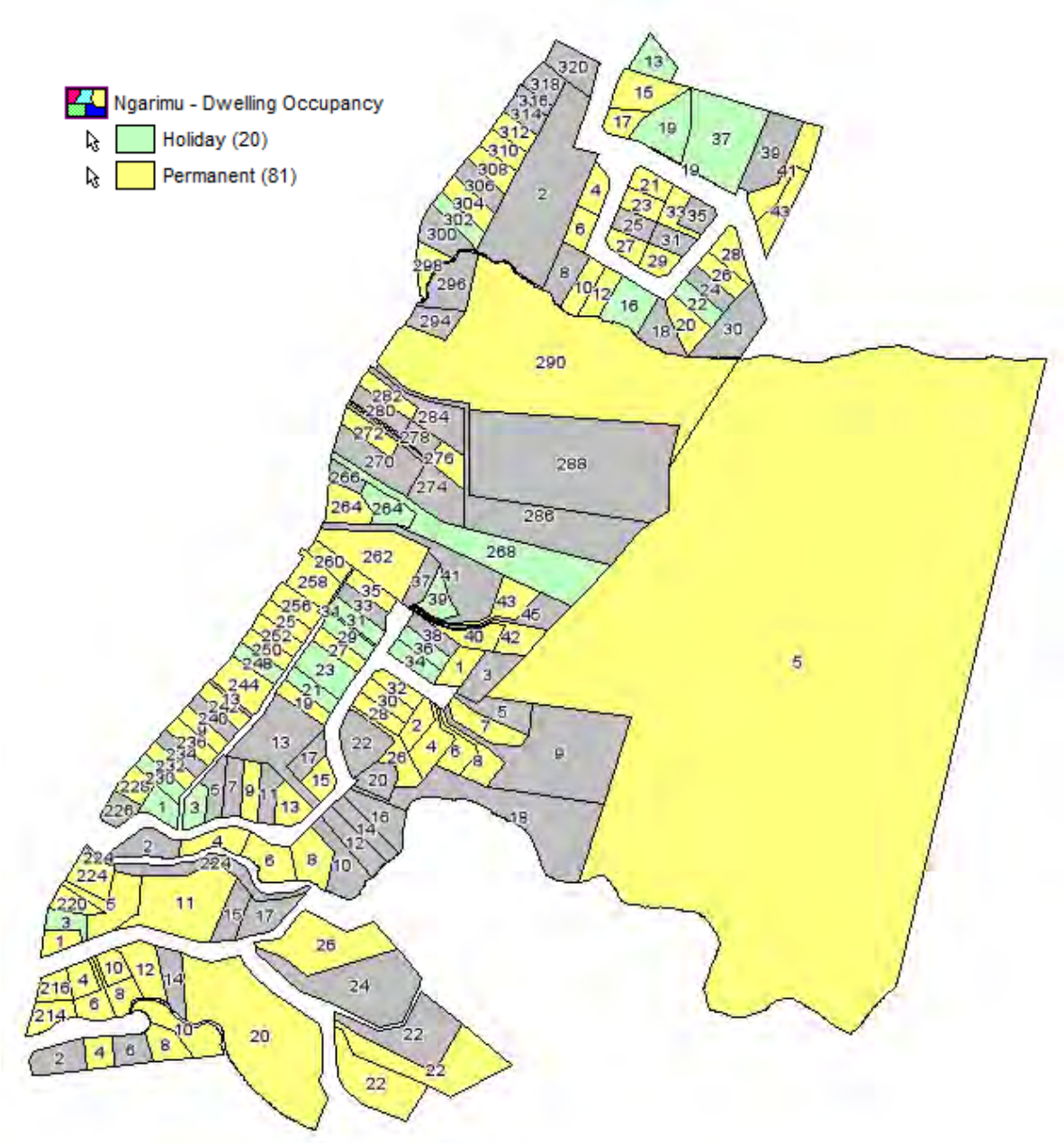


Figure 37 – Household survey occupancy type in Ngarimu Bay community

d. Type of treatment and disposal system (if known)

This plan illustrates the breakdown by type of system (if known) for Ngarimu Bay properties where a questionnaire response was received.

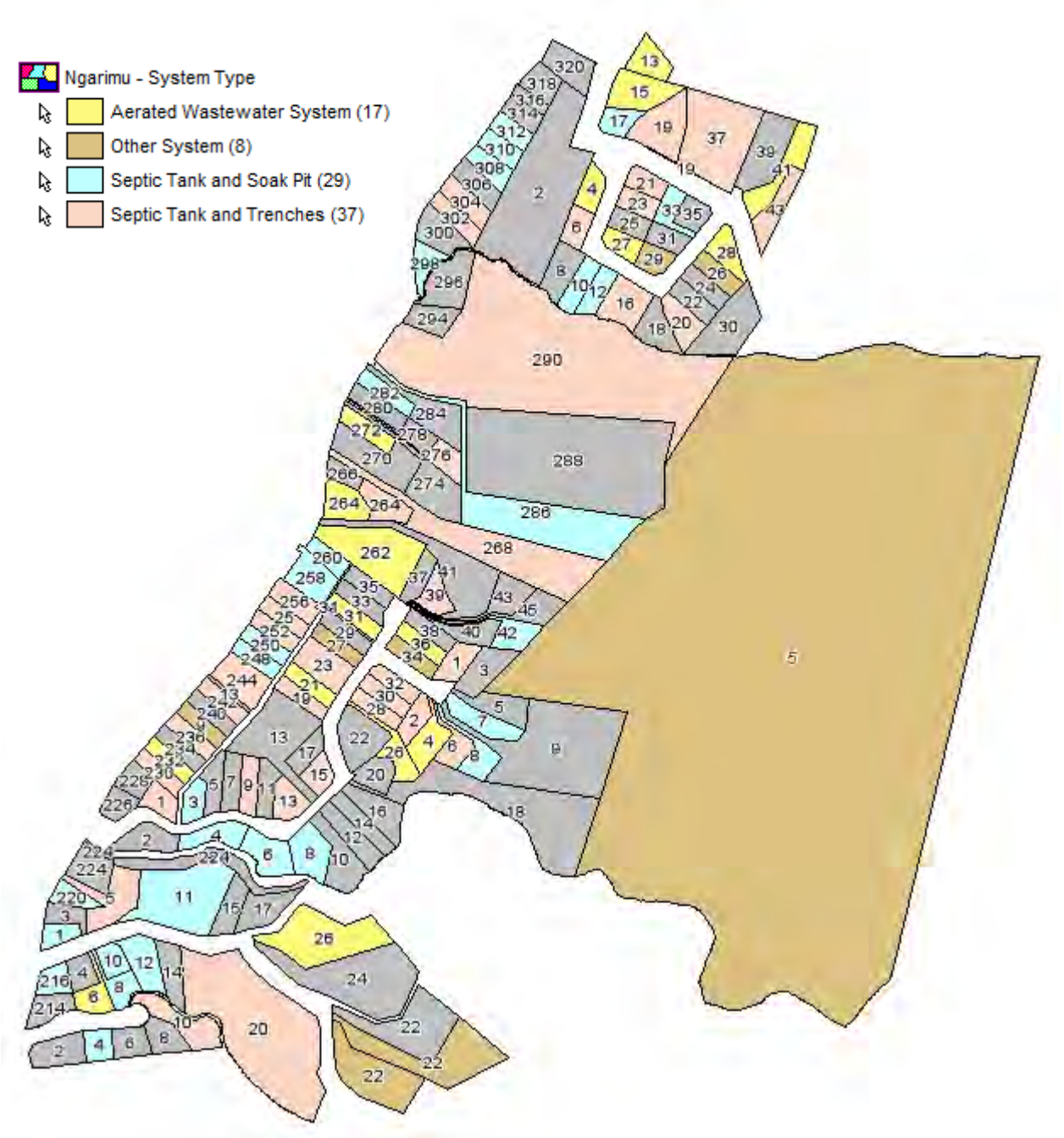


Figure 38 – Household survey system type in Ngarimu Bay community

e. Period of last septic tank or wastewater system service

This plan illustrates the period of last septic tank or wastewater system service for Ngarimu Bay properties where a questionnaire response was received.

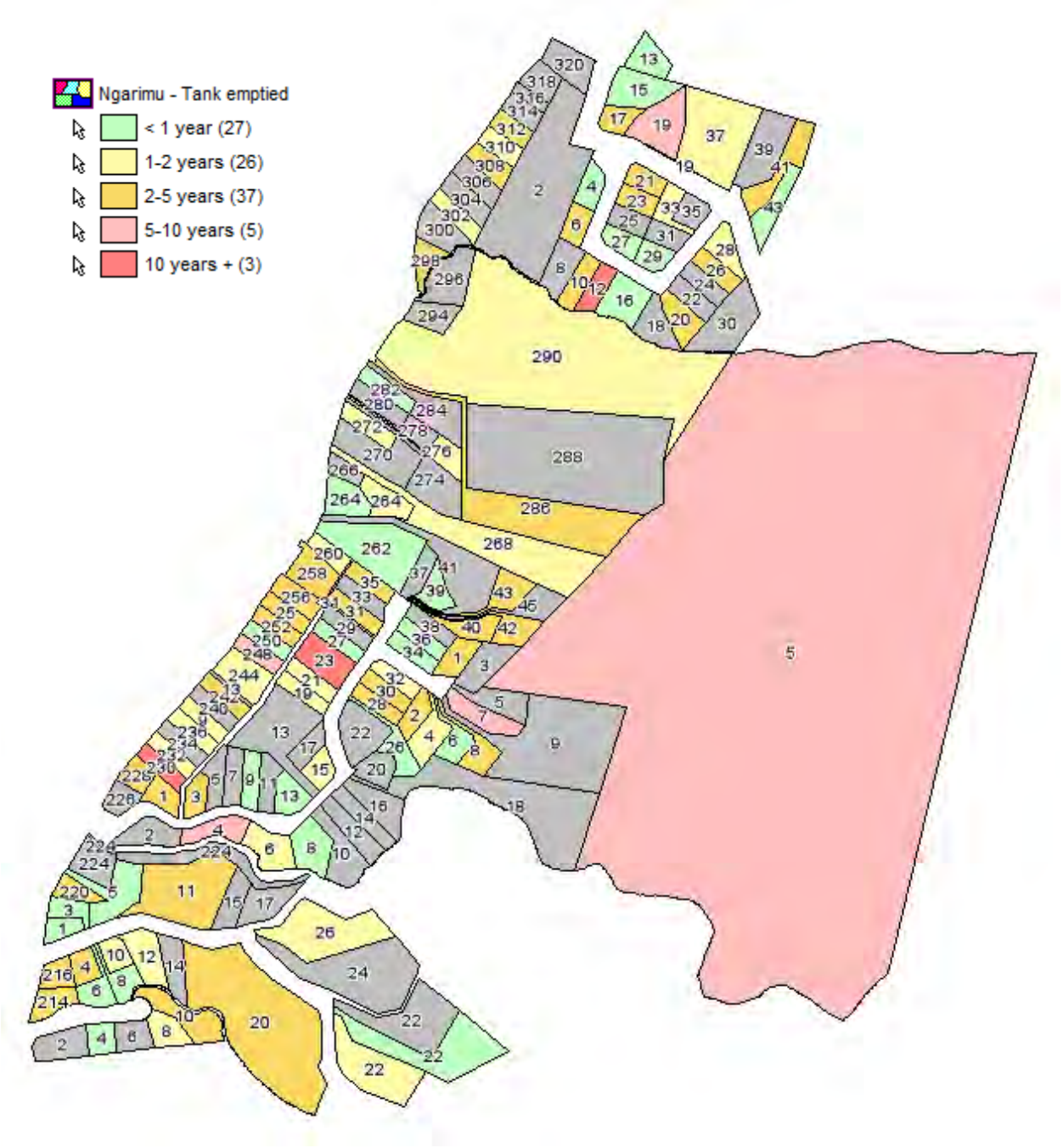


Figure 39 – Household survey tank emptied date in Ngarimu Bay community

7.4 Hatepe results

7.4.1 Questionnaire response spread

The following plan illustrates the distribution of the responses received for the Hatepe community, where a green property indicates where a response was received and a grey property indicates where no questionnaire response was received.

Figure 40 – Household survey responses in Hatepe community

7.4.2 Response broken down by question

a. Number of people normally resident

This plan illustrates the breakdown of the number of people normally resident for Hatepe properties where a questionnaire response was received.

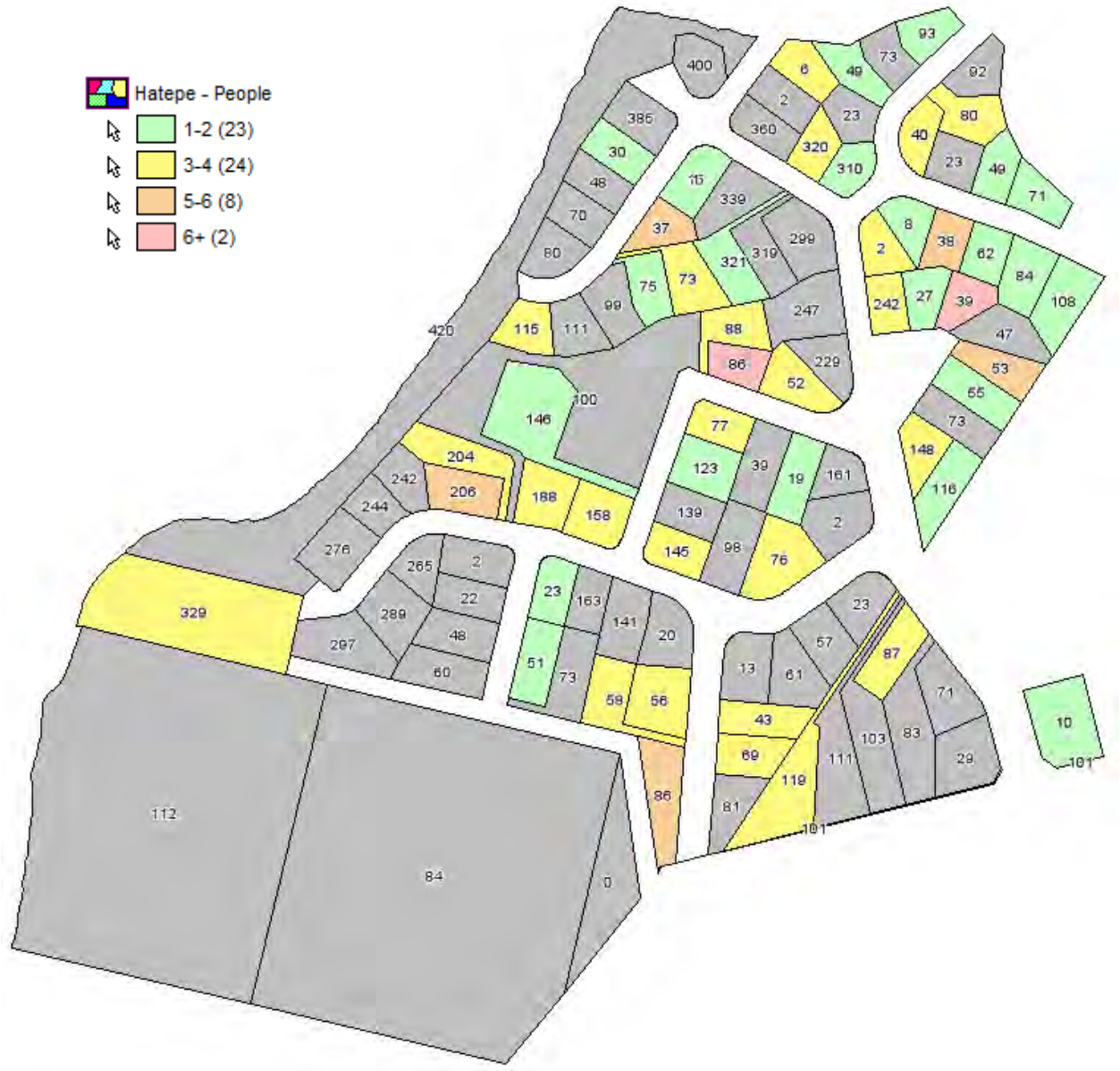


Figure 41 – Household survey number of people per property in Hatepe community

b. Number of bedrooms in dwelling

This plan illustrates the breakdown of the number of bedrooms in dwelling for Ngarimu Bay properties where a questionnaire response was received.

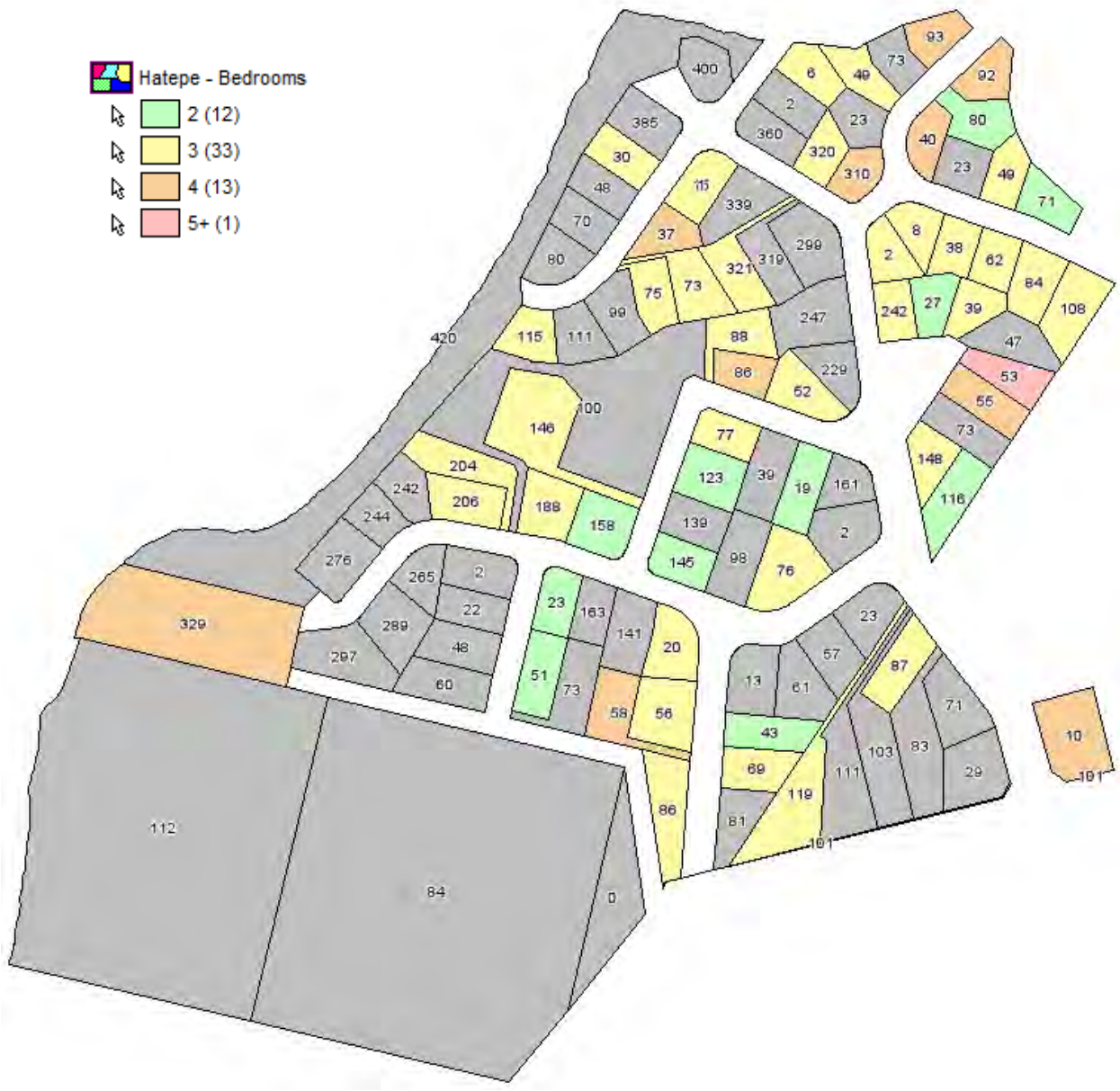


Figure 42 – Household survey number of bedrooms per property in Hatepe community

c. Dwelling occupancy type – permanently occupied or during holidays only

This plan illustrates the breakdown by dwelling type for Hatepe properties where a questionnaire response was received.

Figure 43 – Household survey occupancy type in Hatepe community

d. Type of treatment and disposal system (if known)

This plan illustrates the breakdown by type of system (if known) for Hatepe properties where a questionnaire response was received.

Figure 44 – Household survey system type in Hatepe community

e. Period of last septic tank or wastewater system service

This plan illustrates the period of last septic tank or wastewater system service for Hatepe properties where a questionnaire response was received.

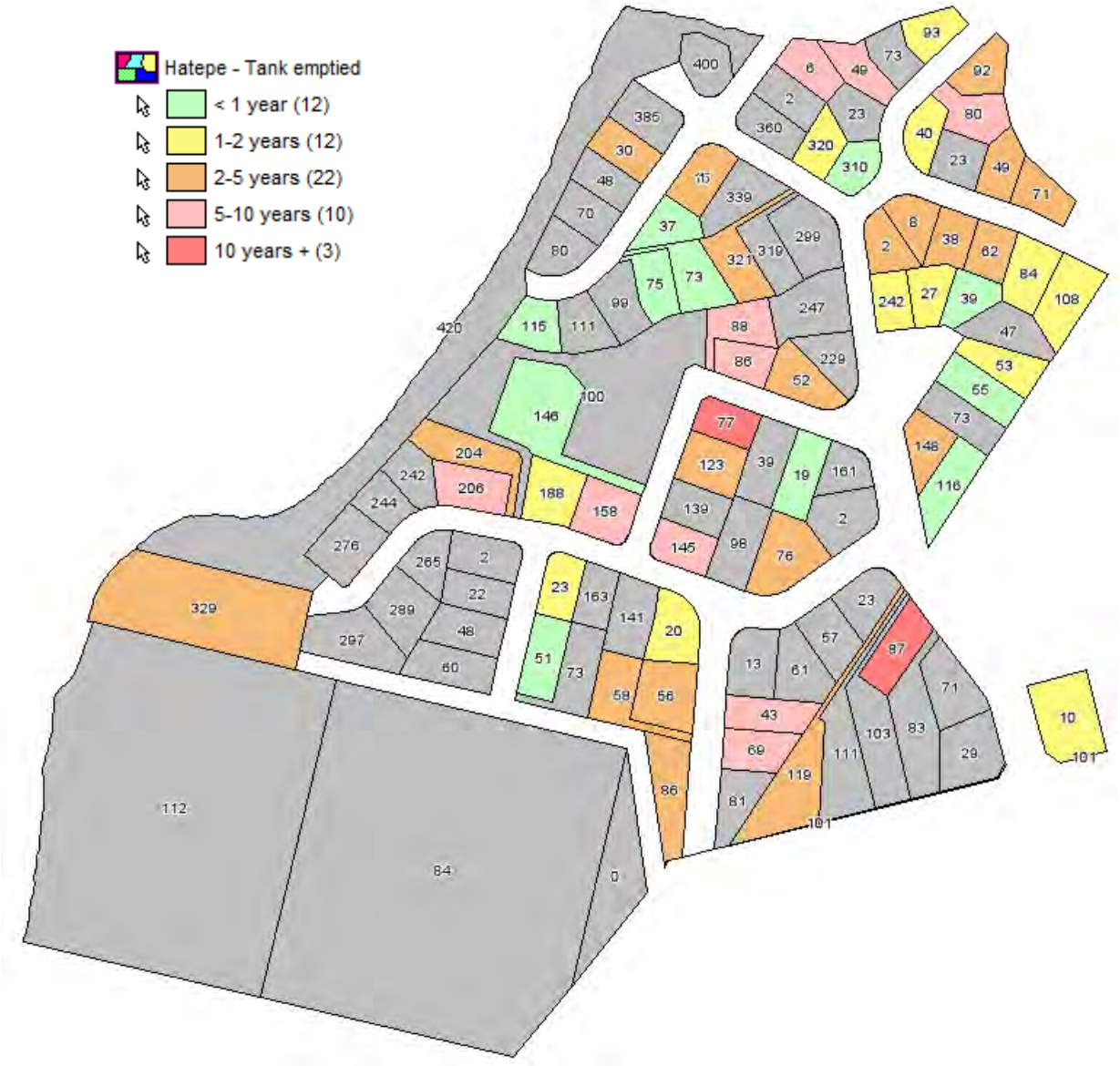


Figure 45 – Household survey tank emptied date in Hatepe community

7.5 Commentary on household survey results in relation to calibration study

The postal questionnaire for the the Hatepe and Ngarimu Bay communities was fairly well responded to by households. The responses recieved were generally well filled out by the respondants and were able to be easily agregated to build a GIS table for illustration and analysis.

In relation to the calibration study, the postal questionnaire provided limited information to inform the consideration of factors, weightings and ratings for the calibration of the Phase One modelling. By themselves the details around the number of people, bedrooms, dwelling occupancy type, type of system and period of last septic tank service cannot be directly related to the potential system failure without observation of system performance. It would be interesting to compare the results from the postal questionnaire against the results from the field survey, for example examine the patterns of occupancy (number of people and type) against OTWS performance issues (odour, dampness, gully trap overflow, insect nuisance, grass above disposal lines and overland flow), however, as discussed in Section 6, the results of the field survey are not comprehensive enough to draw conclusions across the community linking occupancy patterns and potential failure – there is not enough field survey data to draw conclusions.

It is difficult to draw links between the factors such as number of people, system type, occupancy pattern and system maintenance to risk of failure from this information.

8 Investigation into the relationship with the Deprivation Index

8.1 Overview

Section 5 of this report reviewed three community wastewater surveys/reports to draw out further information relating to factors that may influence OWTS performance and potential failure. One of the factors highlighted was the impact that poorly maintenance can have on the performance of OWTSs and thus the increased potential for failure.

This section of the report explores the potential to use the New Zealand Deprivation Index as an indicator of where OWTS may occur.

8.2 The Deprivation Index

The New Zealand Deprivation Index[16] provides an index of socio-economic deprivation across NZ, broken down by Statistics NZ census unit, where 1 is least deprived and 10 is most deprived.

The user guide[17] describes the purpose, application and limitations of the NZ Deprivation Index dataset:

"[The] NZDep2006 combines nine variables from the 2006 census which reflect eight dimensions of deprivation".

These eight variables are (in order of decreasing weight):

- Income: People aged 18-64 receiving a means tested benefit
- Income: People living in equivalised households with income below an income threshold
- Owned home: People not living in own home
- Support:: People aged <65 living in a single parent family
- Employment:: People aged 18-64 unemployed
- Qualifications: People aged 18-64 without any qualifications
- Living space: People living in equivalised households below a bedroom occupancy threshold
- Communication: People with no access to a telephone

Furthermore from the user guide:

"The NZDep2006 index of deprivation has two forms—an ordinal scale and a continuous score. The NZDep2006 index of deprivation ordinal scale ranges from 1 to 10, where 1 represents the areas with the least deprived scores and 10 the areas with the most deprived scores. "

"The NZDep2006 scale of deprivation from 1 to 10 divides New Zealand into tenths of the distribution of the first principal component scores. For example, a value of 10 indicates that the meshblock is in the most deprived 10 percent of areas in New Zealand, according the NZDep2006 scores."

[16] The *NZDep2006 Index of Deprivation* as downloaded from koordinates.com May 2011

[17] Department of Public Health University of Otago (2007), *NZDep2006 Index of Deprivation User's Manual*

"NZDep2006 have been developed with three principal purposes in mind: resource allocation, research, and advocacy.

1. Indexes of deprivation have application in funding formulas [sic]. For example, indexes of deprivation are used in capitation funding formulas for primary health care services, the population-based funding formula for District Health Boards, and in funding formulas [sic] for social services in other sectors.

2. Indexes of deprivation have application in research in a variety of settings such as health and other social services. For example, in the health sector, many researchers use small area indexes to describe the relationship between socioeconomic deprivation and health outcomes; increasing levels of deprivation are associated with higher mortality rates, and higher rates of many diseases.

3. Indexes of deprivation are used by community groups and community-based service providers to describe the populations they serve, and to advocate for extra resources for community based services. "

8.3 Application of the Deprivation Index to the OWTS Phase One model

8.3.1 Consideration of weighted averages

The NZ Deprivation Index is calculated by Statistics NZ meshblock unit. To calculate a weighted average deprivation index value for an area spanning more than one census meshblock we must weight the average by the population of the contributing meshblock populations using the following formula:

$$Weighted\ Average = \frac{\sum(NZDeprivation\_Score\_2006) * (Usually\_Resident\_Population\_2006)}{\sum Usually\_Resident\_Population\_2006}$$

8.3.2 Application of weighted averages to communities

The Maramarua community is a good example of how the weighted average approach should be used to apply a deprivation index value to the community. The following figure illustrates the community extent (as defined by EW in Phase One) as orange, and the individual deprivation index meshblocks as purple (property boundaries are indicated in black).

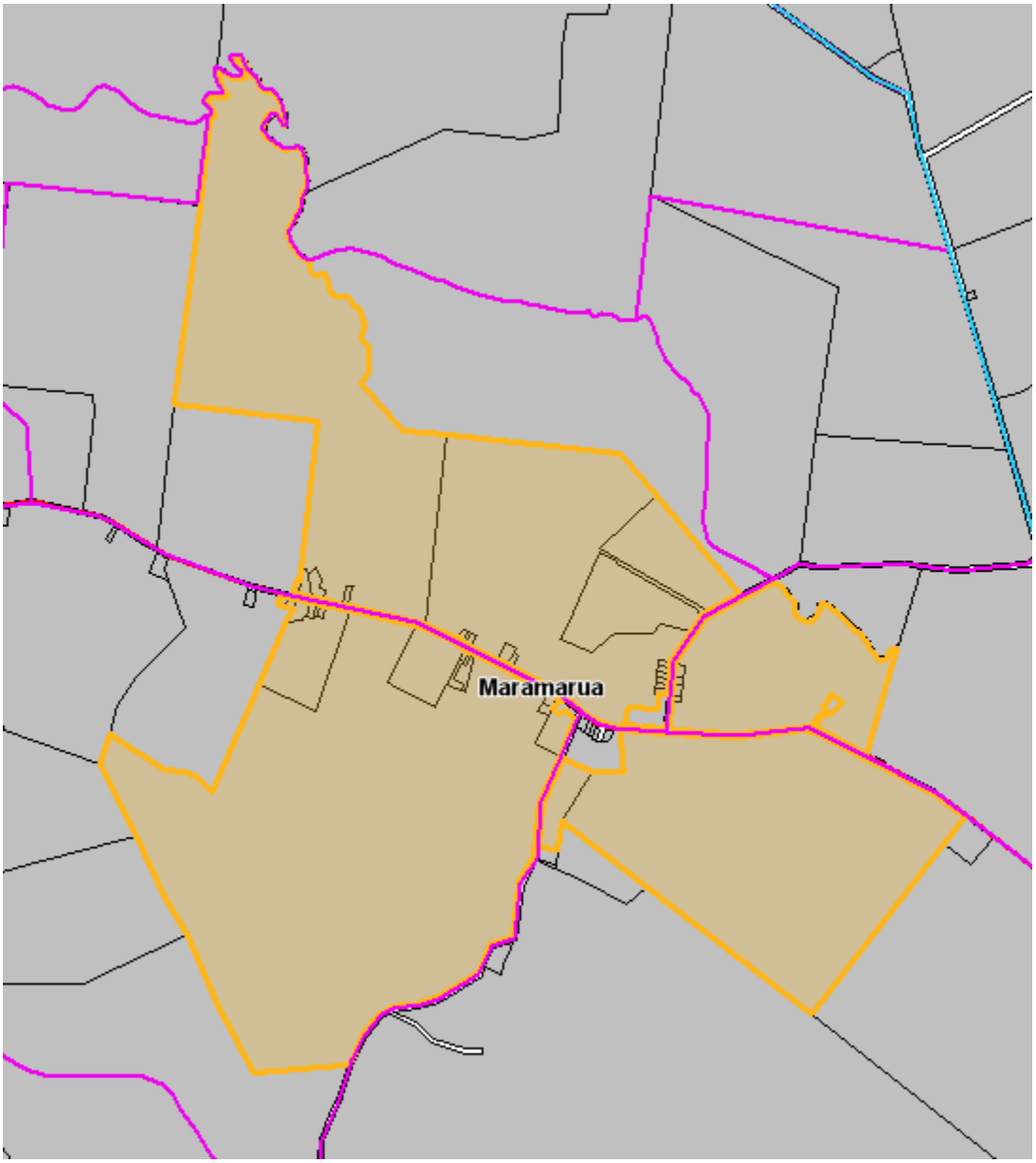


Figure 46 – Maramarua community extent compared to Census meshblock boundaries

The following figure illustrates the application of the weighted average approach to the Maramarua community, where the green areas are the deprivation index meshblocks overlapping the community extent, with their own deprivation values in green text, and the weighted average value in black text:

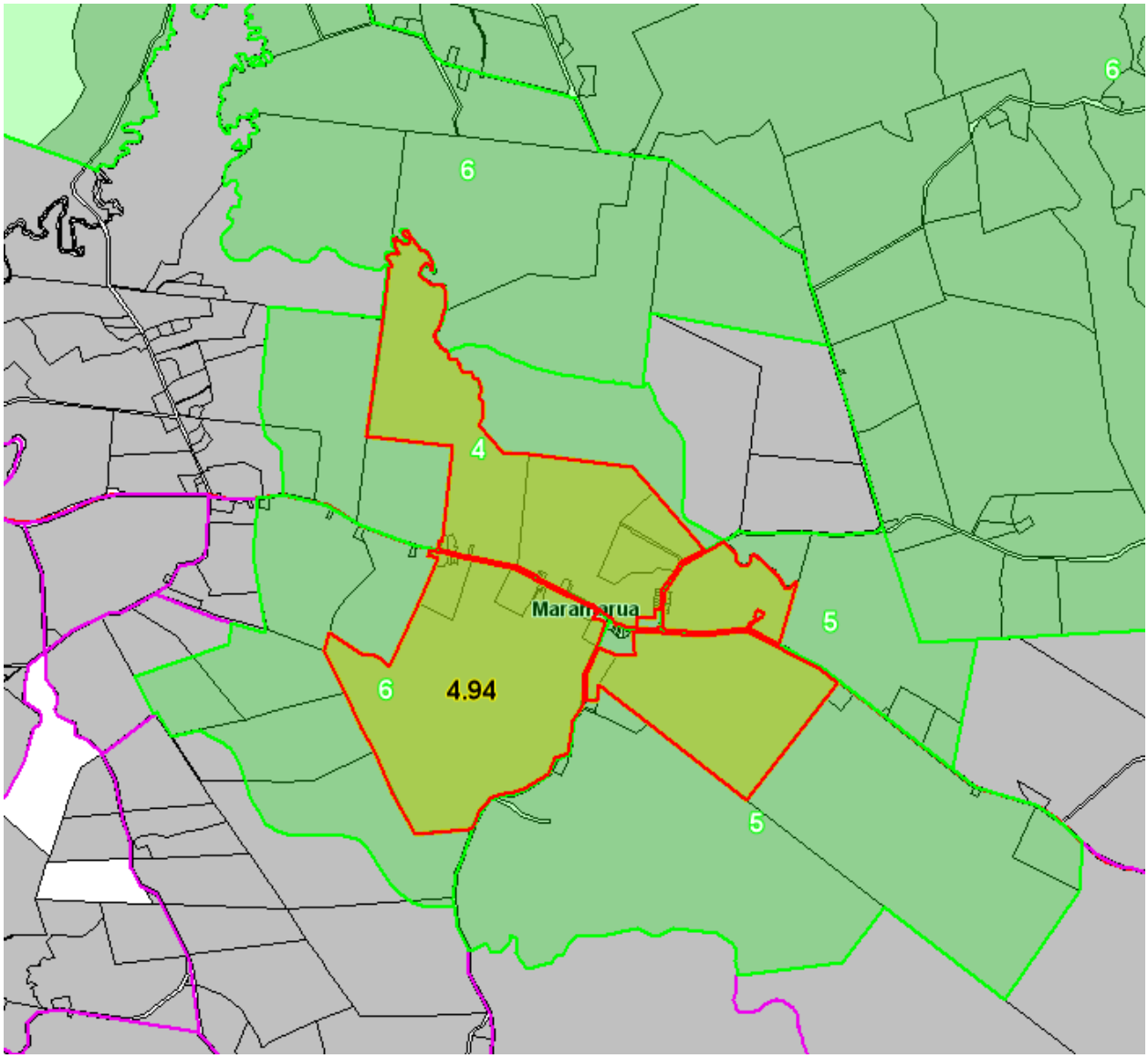


Figure 47 – Maramarua community weighted Deprivation Index

This weighted average methodology for calculating a community deprivation index is weak in that it does not take into account the proportion of the community that may fall into different disparate deprivation Index areas. For example, in Walton, where only a small part of the community falls within the deprivation index “10” area, but the weighted average of 5.37 reflects the influence of the deprivation index “10” areas.

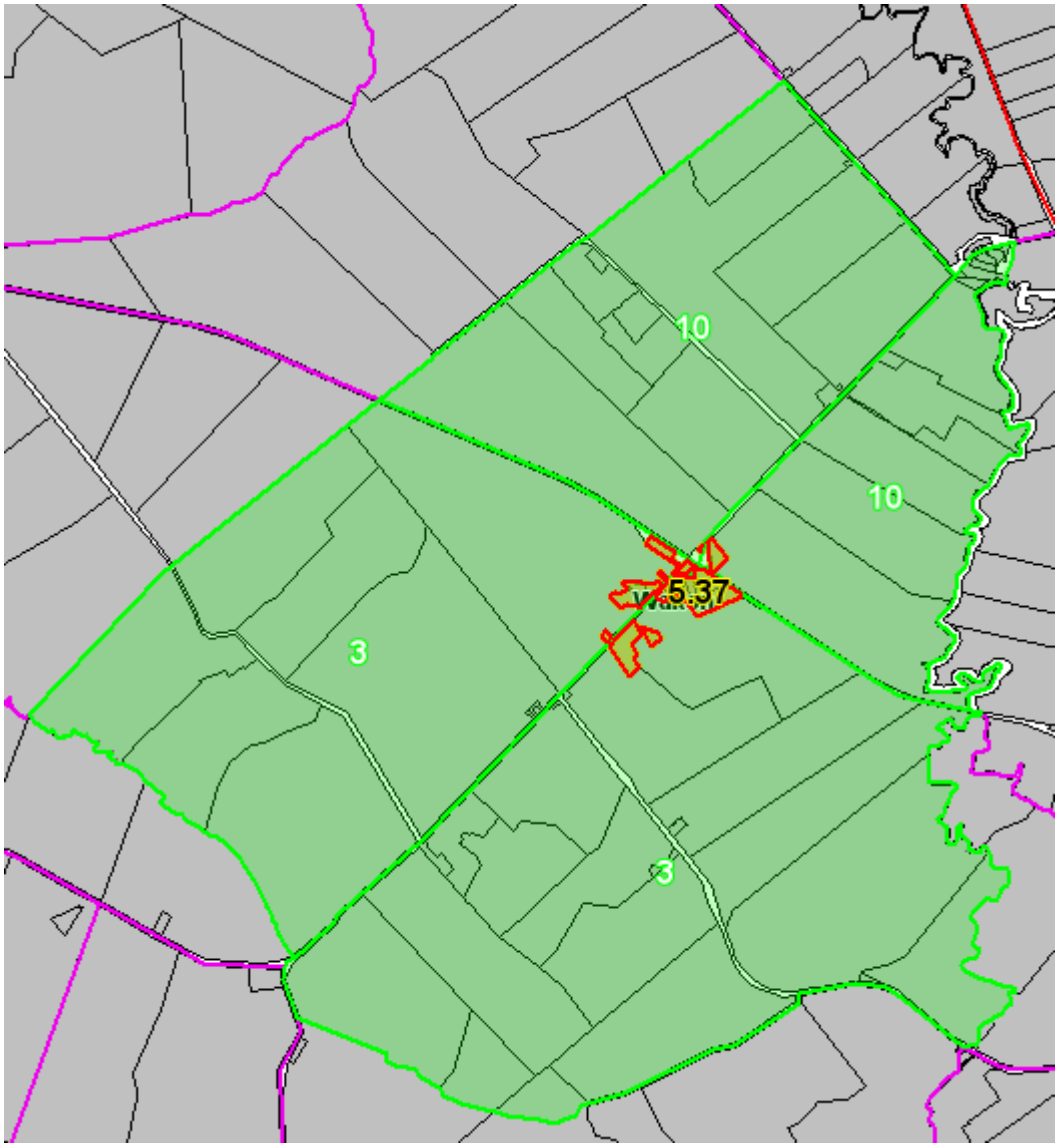


Figure 48 – Walton community weighted Deprivation Index illustrating the influence of neighbouring deprivation index meshblocks on weighted average

Weighted averages using this approach have then been calculated for all the communities from the Phase One model. These are compared against the Phase One Medium Quartile OWTS risk rating in the table below:

Table 7 – Weighted Deprivation Index by Community

Community Name	Median Quartile	Weighted Avg Dep2006	Community Name	Median Quartile	Weighted Avg Dep2006
AKA AKA	3.45	2	OPOUTERE	2.6	6
AOTEA	2.78	9	ORONGO	2.28	5
ARIA	3.125	7.7	ORUATUA	3.75	2
ATHOL	1.95	4.29	OTAMA	2.93	6
ATIAMURI	2.75	8	OTAUA	3.05	3.54
AWAITI	2.6	5.45	PAPA AROHA	3.565	8
AWAKINO	4.65	7	PATETONGA	2.025	4
BONSHAW PARK	1.58	4	PIOPIO	2.75	6.88
COLVILLE	3.18	8	PIPIROA	4.2	4.83
EUREKA	1.77	1.76	PIRONGIA	2.07	2.22
GLEN AFTON	3.65	7.19	POKENO	2.3	4.61
GLEN MASSEY	2.9	6.79	PORT CHARLES	3.65	9
GLEN MURRAY	2.15	5.13	PORT WAIKATO	3.05	8.71
GOLDEN VALLEY	2.45	2.75	PUKEKAWA	2.85	2
GORDONTON	2.3	4.58	PUKEMIRO	2.9	8.78
HAHEI	2.18	3.06	PUKETUI	2.45	4
HANGATIKI	2.85	5.49	PURIRI	3.03	4.83
HATEPE	4.05	6	RANGITOTO	1.85	3.51
HIKUAI	3.45	4	RENOWN	3.2	8
HIKUTAIA	3.15	5.29	RIVER RD BROADLANDS	2.15	3.91
HINUERA	2.45	4.8	ROTOKAURI	2.15	1
HORAHIA	3.15	3	RUAMAHANGA	2.95	6
HORSHAM DOWNS	0.98	1.35	RUKUHIA	2.025	1.73
HOT WATER BEACH	2.45	5	RUKUMOANA	3.1	9

Community Name	Median Quartile	Weighted Avg Dep2006
KAIAUA	3.15	7.35
KAIHERE	1.85	5.26
KARANGAHAKE	2.75	8
KARIOTAHI	2.6	1
KAUAERANGA	2.6	3.35
KAWHIA	3.65	9.59
KENNEDY BAY	3.33	9.79
KIKOWHAKARERE BAY	3.2	8
KINOHAKU	2.95	7
KOMATA	3.85	5.66
KOPUARAHI	4.2	6.33
KOPUTAUAKI	3.8	8
KUAOTUNU	2.75	6.51
KUAOTUNU WEST	2.93	5
LEAMINGTON	1.37	1
LICHFIELD	1.85	4.24
LITTLE BAY	2.93	9
MACKAYTOWN	2.63	6.64
MAHOENUI	3.425	4
MAMAKU	1.85	3
MANAIA	3.05	8.13
MANAWARU	2.8	4.41
MANGAKARETU	2.15	5
MANGATANGI	1.82	5.73

Community Name	Median Quartile	Weighted Avg Dep2006
TAPU	3.9	7.94
TAURANGA-TAUPO	3.75	4.93
TAUWHARE	2.07	3.16
TE AKAU WHARF	2.78	5
TE ANGA	4.5	7
TE KAWA VILLAGE	2.3	5
TE KOHANGA	2.515	5
TE KOUMA	3.2	7
TE KOWHAI	2.58	3.12
TE MATA	3.75	7.94
TE MIRO	1.88	1.6
TE MOANANUI	3.5	7.95
TE PAHU	1.73	2.67
TE POI	2.3	4.78
TE PURU	3.93	6.72
TE RERENGA	2.6	8
THORNTON BAY	3.5	5.83
TIROHIA	2.5	4.9
TOREHAPE	1.85	4
TUATEAWA	1.82	9.63
TURANGI RURAL AREA	2.8	8
UPPER WAINUI ROAD	2.18	4
WAIHARAKEKE	3.45	5.2
WAIHI VILLAGE	3.05	6

Community Name	Median Quartile	Weighted Avg Dep2006
MANGATARATA	1.9	3
MANGATAWHIRI	1.9	4.52
MANGATEPARU	2.6	3
MANU BAY	2.33	7
MAPIU	3	6
MARAMARUA	2.6	4.94
MAROKOPA	4.08	9
MATAPAUA	2.18	6
MATATOKI	3.45	4.46
MAUNGAKAWA	2.12	1
MERCER	3.65	8
MIRANDA	2.775	5.3
MOKAU	2.9	7.6
NETHERTON	2.6	4.49
NGAHINAPOURI	1.355	1
NGARIMU BAY	3.8	5
OAMARU BAY	3.8	8
OHAUPO	1.85	4.56
OLD FARM RD WAIHI	1.85	6
OMAHU	2.75	5.28
ONEWHERO	2.9	3.07
OPARURE	2.35	4.58
OPITO BAY	2.93	6

Community Name	Median Quartile	Weighted Avg Dep2006
WAIKARETU	2.3	6
WAIKAWAU	4.2	7
WAIKINO	2.58	7.11
WAIKOKOWAI	2.3	6.55
WAIMATA	2.15	6
WAIOMU	3.8	8.8
WAIRAKEI	3.05	9.64
WAITAWHETA	1.85	6
WAITEKAURI	2.45	7
WAITETE BAY	2.93	8
WAITETEKO	3.05	8.18
WAITOA	2.6	6.49
WALTON	2.9	7.72
WALTON1	2.9	5.37
WHAKATETE BAY	2.9	5
WHALE BAY	2.93	7
WHANGAPOUA	2.18	8
WHAREKAHO/SIMPSONS BEACH	1.73	5.84
WHAREPOA	3.75	6
WHATAWHATA	3.33	4.71
WHENUAKITE	1.85	6.15
WYUNA BAY	2.965	6.19

8.4 Commentary on the application of the Deprivation Index to the calibration study

The Phase One modelling looks at phyiscal attributes that contribute to OTWS failure risk (soil type, depth to groundwater, aquifer conductivity and proximity to surfacewater) and people-controlled attributes (age of system and lot size).

Drawing a connection between the six Phase One modelled factors and deprivation is difficult. The Phase One DRASTIC measure is an indicator of risk of failure of an OWTS, whereas the Deprivation Index is more an indicator of the potential of systems being upgraded or possibly maintained.

Section 5 of this report highlighted a potential link between the maintenance of OWTS (or lack of) and the increased potential for failure. High deprivation areas in combination with high risk rating areas from the Phase One modelling could be combined to add further weight to the risk of OWTS failure. For example, using the Table 7 data, the Kawhia community has a Phase One risk rating of 3.65 but a weighted deprivation value of 9.59, whereas the Te Puru community has a risk rating of 3.93 but a weighted deprivation value of 6.72. This could highlight that there is increased potential for OWTS failure in Kawhia than Te Puru if it is demonstrated that lack of regular OWTS maintenance is a key contributor to OWTS failure.