Capacity for Growth Study 2013 (Proposed Auckland Unitary Plan): Methodology and Assumptions

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Capacity for Growth Study 2013 (Proposed Auckland Unitary Plan): Methodology and Assumptions

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Disclaimer

While every care has been taken to ensure that the outputs of the Capacity for Growth Study 2013 (Proposed Auckland Unitary Plan) study are accurate within the limitations of the assumptions and limitations outlined elsewhere in this document, Auckland Council disclaims any liability whatsoever in connection with any action taken in reliance of this document or for any error, deficiency, flaw or omission contained in it.

The authors welcome any comment, suggestion or correction.

The purpose of this study is to determine the capability of Auckland to accommodate additional growth, (including dwellings) based on a subset of selected rules from the provisions published in the Proposed Auckland Unitary Plan, as at 30 September 2013.

This study has been undertaken through a computer based geospatial desktop modelling exercise, carried out at parcel or title level. This process necessarily involves the simplification, modification, or omission of some planning provisions that may impact on the real world ability to consent and/or realise capacity identified. It should also be noted that all subdivision is subject to individual consent assessment on a case by case basis on its merits. Accordingly the outputs of this modelling exercise and subsequent reported results of this study in no way imply that subdivision, or the subsequent construction of a dwelling or structure may take place on a parcel or title without fulfilling all of the necessary requirements of the plan applying at the time of application.

The results of this study are designed to be reported at a large-scale level and while the results of the study are presented in parts of this report at the level they were modelled, the use of study outputs at an individual parcel or title scale is not recommended.

As assessments in this study are based on the rules contained within the Proposed Auckland Unitary Plan and cadastral boundaries that were in place at the time the plan was notified, it does not account for the many applications for non-compliant activities that council could receive, nor for future possible changes to planning provisions, which are highly likely to occur though public submissions and Hearings Panel process.

The study does not assess the potential for site amalgamations or multi-parcel applications, all of which would potentially and substantially increase yields indicated.

This study is a measure of 'plan enabled capacity' as facilitated by an interpretation of the rules of the Proposed Auckland Unitary Plan and **is not a prediction of future growth**.

For more information on study outputs, results, possible future updates and improvements, or further advice on how the results can be used or analysed, please contact the Research Investigations and Monitoring Unit at the Auckland Council.

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1.0 Introduction

The Capacity for Growth Study assesses the ability of residential and business land within Auckland to accommodate growth. The capacity assessment undertaken in this study is based on geo-spatial datasets and the provisions set out in the *Proposed Auckland Unitary Plan* (PAUP) (as notified on 30 September 2013) and determines the amount of possible development on every parcel/title in Auckland.

This report summarises the methodology and assumptions used to develop and process the PAUP version of the 'capacity model'. The purpose of this technical publication is two-fold: to summarise the methodologies undertaken to produce the reported capacity yields, and to provide documentation of the assumptions used in the capacity calculation process. This is done so that users of the information contained in the accompanying *Capacity for Growth Study 2013 (Proposed Auckland Unitary Plan): Results* technical report can understand the methodologies and assumptions employed as part of the study.

The Capacity for Growth Study is a quantitative assessment of capacity at a point in time, based on the provisions of the PAUP. It measures whether each site has the potential for more development under a selected set of rules (specifically subdivision, and some bulk and location provisions) – essentially providing a 'census' or a 'stock take' of the land and its potential development capacity, across all of Auckland. The primary objective of this study is to identify capacity for growth, and it is with this base that further assessment on the possibility of uptake of this capacity can be made; such analysis has been undertaken and the results are reported as part of this publication.

The outputs from the Capacity for Growth Study creates a base from which further work can, and will be undertaken to try and help answer many of the pressing questions facing Auckland relating to land supply.

This report has been written with a number of disparate audiences in mind, including but not limited to the general public, planners and policy makers, but also modellers and geospatial analysts who may be tasked with replicating, modifying or maintaining a Capacity for Growth Study type model, or perhaps undertaking a similar exercise in other jurisdictions.

The plan and the model developed to assess it is complex – there is no avoiding this. Accordingly there is an embarrassment of detail included on the mechanics of what has been undertaken and how, including 'code' and logic test statements that may mean little to the lay reader, but are the key to facilitating the effective translation of the plans rules and spatial data into outputs of utility to a wider audience via spatial analysis. We hope that this technical detail does not distract too much from the usefulness of this document to less technically inclined readers, but is a necessary inclusion for the repeatability of this approach into the future.

This report is to be read in conjunction with the *Capacity for Growth Study 2013 (Proposed Auckland Unitary Plan): Results* (TR2014/010) technical report, which presents the results of the study.

2.0 Background

2.1 Why did we undertake the study?

This study measures the potential capacity enabled by provisions published in the PAUP. Some of the reasons why this is study is relevant, required and is useful include:

- To provide a comparison of capacity enabled under the PAUP when compared to Auckland region's legacy district plans. This enables us to compare areas of change in capacity provision (either increased or decreased)
- A test to see whether the PAUP provides the necessary development capacity for the 30 year period outlined in the High-Level Development Strategy of *The Auckland Plan*
- A base on which to make assessments and comparisons during the upcoming panel hearings for the PAUP; enabling the testing of scenarios and possible effects of changes to the levels of development capacity enabled by the proposed plan
- Continuation of longitudinal research exploring the development capacity of Auckland over time
- Informing and supporting ongoing modelling and monitoring (see section 2.2 below).
-

Currently Auckland region's legacy district plans are in effect – they control what can happen today, and will continue to impact on future development potential by facilitating development and cadastral patterns that will persist for many years after they are eventually replaced with the PAUP. The modelling processes undertaken as part of the 2012 study, as well as the results that were produced, has provided both an excellent baseline for comparing change, but also enabled us to build a PAUP based model and generate outputs in a shorter period of time than would have otherwise occurred.

The 2013 study will be the fifth iteration of the Capacity for Growth Study; with previous studies being undertaken in 1996, 2001, 2006 and 2012. Many aspects of the study have been undertaken to preserve characteristics of the series, allowing some longitudinal comparisons to be made[1], but due to continuous improvement in approaches between studies, some care is required in making direct comparisons.

2.2 What will study results be used for?

The study analyses the plan enabled capacity of every parcel and title across the Auckland region. The results of this analysis will be used for:

- Inputting into the Auckland Residential Futures Model (ARFM) (council's growth model) and the Auckland Strategic Planning Model (ASP). The results will act as the baseline land supply for model operations
- Inputting to other assessments including projections of growth, realisable development potential and market assessments, generally as a base set of potentially developable sites for further filtering
- Implementation monitoring of *The Auckland Plan*. The plan requires that land and dwelling supply be monitored: "…ensure that there is at all times 20 years' forward supply of development capacity, and an average of seven years (with a minimum of five and maximum of 10 years) of unconstrained, 'ready to go' land supply" (Auckland Council, 2012a).

[1] Although we have cautioned against making some direct comparisons between different iterations of the Capacity for Growth Study due to both changes in modelling techniques used and the reporting of results, comparisons can be made be made between development capacity yields. For information and advice on this, please contact the authors of this report.

- Monitoring the provisions in the current *Auckland Regional Policy Statement* (RPS) and the provisions enabled through Change 6 (refer Policy 2.6.3 Methods - Urban Containment and Policy 2.6.18 Methods - Rural Areas) (Auckland Regional Council, 1999). The RPS requires that Auckland Council undertakes surveys every five years to determine the provision and uptake of residential and business urban development opportunities, as well as the provision and uptake of countryside living opportunities available in rural areas.
- Monitoring the provisions in the proposed *Regional Policy Statement* section of the PAUP: Part 1 (Introduction and Strategic Direction), Chapter B (Regional Policy Statement), Section 2.3 (Development capacity and supply of land for urban development) outlines 1) objectives, 2) policies and 3) the requirement for monitoring, of "sufficient development capacity in the urban area and sufficient land for new housing and businesses over the next 30 years, to support population and business growth within the Rural Urban Boundary" (Auckland Council, 2013a).
- Research and analysis through the comparison of the development capacity currently enabled through Auckland's operative district plans compared to that potentially enabled through the PAUP.

3.0 Assessing capacity

This section provides an overview of the processes that were undertaken to calculate the capacity presented in the companion results report and expanded on in detail in this report.

As this study is a quantitative assessment of plan enabled capacity, understanding and interpreting the rules and provisions governing subdivision (and some bulk and location requirements) of the PAUP was the first step undertaken. In order to correctly interpret the rules, we engaged with planners that were principally involved with writing the rules and provisions of the PAUP. The approach taken to the interpretation of the plan was a literal one, with the rules utilised as they have been written, rather than an intention based interpretation. This provided a test run of the rules of the plan on every parcel in the region, which in and of itself highlighted a number of minor issues with the plan's text and supporting spatial data which have informed aspects of the council's submission, to align the plan more closely with its intended outcomes.

The study primarily used a software programme called FME[2] to undertake the modelling process required to calculate capacity. For the purposes of calculating capacity, the study was broken down into five components: residential, business, rural residential, business redevelopment and special areas.

Each of these five components utilised different methods (outlined in this report). By constructing a series of geo-spatial queries and assessments (known collectively as a 'model') for each of the components, using the rules outlined in the PAUP we were able to calculate the proposed potential capacity of Auckland to accommodate growth. The 'model' used to calculate capacity is not a truly integrated single model, but rather a set of sub-models; each sub-model undertakes calculations relating to each capacity type. All capacity calculations, (except the business redevelopment capacity assessment and the special areas assessment), were undertaken using FME. The business redevelopment capacity assessment uses results from a newly developed three-dimensional FME spatial assessment as inputs into a one-dimensional model, which was constructed in Microsoft Excel.

Special areas (including some structure plan areas) have not been assessed by our parcel based modelling process, and information provided in this report has for these areas has been primarily drawn from the PAUP, as well as other sources. This is because:

- Modelling is unnecessary as area specific information is often very clear on capacity expectations
- Parcel based modelling will not result in modelling outputs consistent with area specific information based on landscape, archaeological, infrastructure constraints or other matters.

For some special areas specified in the PAUP we have not been able to estimate/calculate or report on the capacity due to:

- A lack of suitable information
- The special area not having any capacity for dwellings or business land
- The capacity of these areas is dependent on the outcome of future planning processes
- Some special areas being undefined, for example Future Urban zoned areas (FUZ) around many rural towns

Locations within the Rural Urban Boundary (RUB) identified as falling within the Future Urban zone (FUZ) have a PAUP enabled capacity of effectively nil. The purpose of the FUZ is as a 'holding zone', to preclude urban development prior to more detailed structure planning. These provisions are what

[2] FME is a an integrated collection of tools for spatial data transformation and data translation produced by Safe Software Inc. of Surrey, British Columbia, Canada. FME is considered to be a GIS (Geographic Information Systems) utility that enables conversion between data formats and processes and is able to manipulate and generate data geometry and attributes. ESRI ArcGIS remains the primary display and map generation tool for the study.

our PAUP sourced assessment indicates. However, information on the expected longer term outcomes in these major urban expansion areas is sourced from existing publicly available information. We expect information on these areas change as more detailed structure planning processes take place, public consultation occurs and eventually development advances over the next 30 years. Where possible, we have reflected some of this information in reported capacity as 'special area (pipeline)' capacity (i.e. capacity that is not currently plan enabled but expected to be at some future date).

While the outputs from many of the modelling processes are at the parcel or title level, some are not. For example the business redevelopment component and the special areas assessments are generated for an entire business area or special area. As such we have chosen to report the results of the study primarily at the regional and local board levels.

For analysis and reporting purposes, this study breaks the region into five distinct location types. These are outlined below in Table 1, which describes the location types, the method used to calculate capacity and the geographic unit of analysis; the geographic extents of these location types are shown in Figure 1.

Important assumptions and limitations relevant to understanding and interpreting both the calculation method and the results of this study are detailed in section 4.0, with further more specific assumptions being found within the relevant sections of this report.

Readers should be aware that the ‘rural’ area extent and ‘business’ area extent may not reflect any existing extent or future definition of these locations, they are primarily modelling constructs; mechanisms for us to load data into the model based on the plan being modelled.

However, the modelled results can be aggregated into different spatial extents, provided those extents are consistent with the smallest geographic unit analysed. That is, areas smaller than this cannot be provided. This is an issue that affects business and special areas in particular as these sometimes large areas share a single capacity figure that cannot be disaggregated further.

Table 1: Geographic location types used in study and their corresponding capacity calculation method

Location type	Description	Assessment method	Smallest geographic unit analysed
Urban area	Large contiguous areas of properties that have a proposed 'urban type' zone (including residential and business zones from the Zone LUT[3]) and are within the 2010 Metropolitan Urban Limits (MUL) (Auckland Regional Council, 1999)[4,5].	Residential: application of district plan subdivision and bulk and location rules via FME spatial model	Parcel (land assessment and maximum theoretical floor space assessment) Business area (all other floor space assessments)
		Business: assessment of vacancy or potential vacancy via FME spatial model	
Rural towns	Clusters of properties that have a proposed 'urban type' zone (including residential and business zones from the Zone LUT) and are outside of the 2010 Metropolitan Urban Limits.	Residential and business, as per urban area	As per urban area

[3] A LUT is a 'look up table' which contains the simplified parameters of the zoning provisions of the PAUP which are used as an input into the modelling process.

[4] The Rural Urban Boundary (RUB), as defined in the Regional Policy Statement (RPS) section of the PAUP is not used as an urban/rural definition as the area inside the proposed RUB includes land that is zoned 'future urban' and has effectively unknown in its planning outcomes at this point in time.

[5] The 2010 MUL used in this study is based on the extents as at 1 November 2010. This MUL extent has been used as it is the basis on which monitoring of both The Auckland Plan and the PAUP will take place, and there is no other consistent and formalised definition of Auckland's urban area.

Location type	Description	Assessment method	Smallest geographic unit analysed
Business areas and centres	The geographic extents of these areas are largely defined by PAUP zoning[6]. The large contiguous areas of business zoning (from Zone LUTs) that have a similar typology and are considered to be significant areas of employment[7], including urban and rural centres. This layer largely forms a naming function for the location and also used to allocate other non-parcel data sources to the business area. These areas are a subset of the urban area and rural towns.	Business redevelopment component – a spreadsheet based model utilising some parcel analysis and assumptions, to identify vacant and potentially vacant land within a business area. Most business areas and centres fall within the urban area or rural towns.	Overall assessment at business area (i.e. multiple parcels analysed as one geography) Note: inputs used in this model can be collected and applied at a smaller level i.e. parcel or mesh block.
Rural area	Properties with a rural zoning (from Zone LUTs) that are outside of the 2010 Metropolitan Urban Area and those properties that are within the Metropolitan Urban Area that are zoned for rural use, excluding areas that have been identified as forming part of a rural town, or zoned Future Urban.	Rural residential component – titles analysed for subdivision potential to derive a net dwelling potential.	Title
Special areas	Areas spread across the locations above that are not suitable for analysis by the other methods. In many cases these are structure plans, where an overall yield figure is provided for the structure plan area based on published information, and no modelling is required or it is not possible. Special areas include locations of particular activities that are not modelled (e.g. hospitals, quarries, ports etc.)	Spreadsheet to aggregate information gathered from published sources and subject-matter experts. Note: no additional analysis has been undertaken in these areas other than calculation of a net yield (i.e. maximum expected total from special areas, less current take up).	Special area extent. (i.e. figure shared by all parcels/titles making up location, e.g. 12 large rural parcels will deliver 1000 new dwellings once rezoned, serviced and developed in accordance with structure plan)

[6] PAUP business zoning is used to define the extent of 'centres' and other business areas in this study. It should be noted that these are not the same as centres or business areas defined for other purposes, e.g. *The Auckland Plan*, *Auckland Economic Development Strategy* etc.

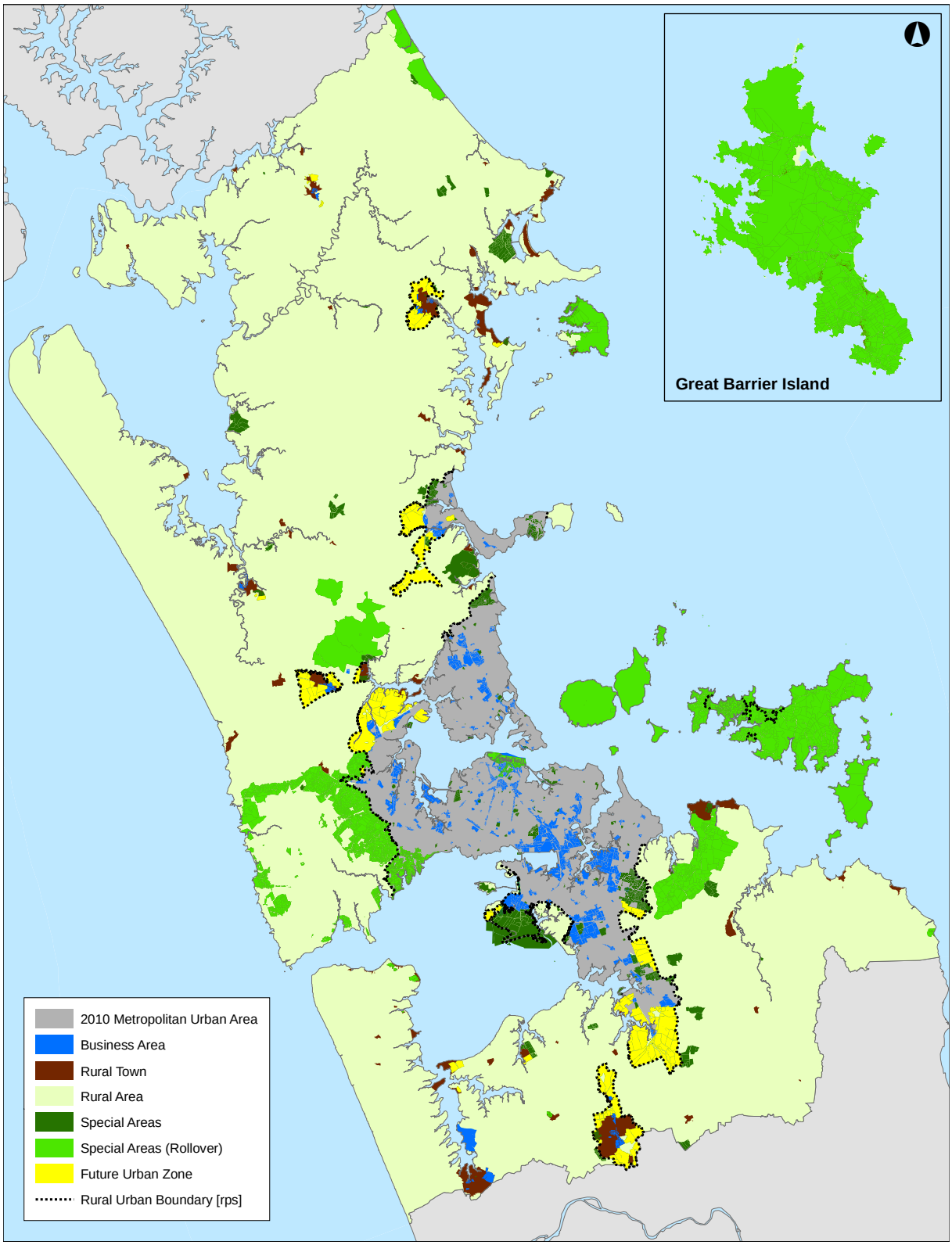
[7] Note that these business areas do not include small areas of business zoning, like those that contain corner dairies, generally in predominantly residential areas.

Location type	Description	Assessment method	Smallest geographic unit analysed
Future urban zoned areas	This extent is based on the zoning layer from the PAUP and is a new zoning encompassing 'unzoned' locations between the MUL and the RUB. Note that the PAUP Future Urban zoning does not permit subdivision (it is prohibited) and otherwise the Rural Production rules apply, effectively to maintain the areas potential for comprehensive redevelopment, accordingly PAUP enabled capacity in these locations is zero. Future plan changes and structure planning is required to be undertaken before the PAUP Future Urban zoning is changed (by plan change/variation) to a yet to be determined zoning pattern that enables development to occur in accordance with any yet to be determined structure plan. Existing high level assumptions about what this future structure planning might enable have been used where known to indicate 'pipeline capacity' for these areas as available at the time of writing.	As per special areas Known assumptions from RUB work available at time of writing collated to specific locations or groups of locations depending on source data. We expect these assumptions to vary considerably as planning progresses in these locations from high level desktop assumptions, to detailed structure planning and design, to plan changes, to build out over the next 30 years and beyond, and figures used in this report should be considered indicative of information available at the time of writing only. Readers interested in the detail of the planning/expected outcomes for these areas should contact the relevant team(s) responsible for the planning and development of these locations for the latest information.	As per special areas

Figure 1 below illustrates the locations of the areas referred to above. Maps showing the extents and locations of rural towns, business areas and centres and special areas are located in appendices A-C of this report.

Note there are a number of overlaps between types (e.g. business zones in rural towns, special areas in FUZ etc.), and the map is therefore indicative of these locations.

Figure 1: Indicative extents of geographic location types used in study



4.0 Study wide assumptions and limitations

Major study wide assumptions are listed below[8]; component specific assumptions can be found in their relevant section or sub-section of this report.

- The provisions outlined in the Proposed Auckland Unitary Plan (PAUP), as notified on 30 September 2013, have formed the basis for this study.
- In this study we have primarily utilised the PAUP rules as they are outlined in the subdivision, residential, business, rural, precincts and relevant overlays sections/parts/chapters of the plan. We have explicitly assumed that these provisions as written 'give effect' Regional Policy Statement (RPS) and Regional Plan aspects of the Unitary Plan and make no differentiation between District Plan (DP) and RPS provisions even where noted in the rule text. Where a conflict exists (if any) between RPS and DP provisions, we have assumed that this will be noted and resolved via the hearings process. In effect, we have taken the plan as it has been written and where some uncertainty exists in interpretation generally taken the most conservative (i.e. precautionary) approach based on the words of the Plan, not the 'intended wording'. Details of the rules interpretation are encapsulated in the code, methods and assumptions used at each component.
- The capacity results are a measure of plan enabled capacity, or 'what does the proposed planning system allow'. Whether this capacity will be realised (or not) has not been a consideration, nor is it implied that because the plan enables a certain kind of development that it will necessarily occur, or because a development has not been identified that it will not. These issues are however better informed by the information contained in this study, as market feasibility is influenced to a greater or lesser degree by planning provisions.
- Capacity is reported in terms of net opportunities for additional dwellings, hectares of land or additional floor space (in square metres), by geographic area and type, depending on the capacity modelled.
- Capacity is calculated under a subset of the PAUP planning provisions, which were discussed, agreed upon and approved by the Auckland Council's Unitary Plan teams. The study utilised the highest activity threshold in cases where the plan provides clear parameters for modelling (i.e. the highest consent category for which modellable parameters are stated). For most bulk and location parameters this is the Permitted Activity standard, (buildings within are permitted, buildings beyond require consent) however subdivision and building development per se is rarely Permitted, and requires resource consent of some sort. No Prohibited or Non-Complying Activity parameters have been used.
- The PAUP study is a 'zero-based' assessment. Zero-based means this study is not limited to assessing those parcels identified in previous studies as having capacity. A zero based approach was taken as the PAUP rules are in many cases different to those that existed for the same locations under the legacy district plans. Subdivision of parcels, demolition and amalgamation can lead to new opportunities being created.
- The 'strike date' for this study is 30 September 2013. PAUP planning rules that were notified at this time are a basis for this study and the data used to undertake the modelling was extracted from council sources. The exceptions to this general principle are:
- Dwelling counts and 'best assessment' dwelling age information used in the study were provided by PropertyIQ Ltd., as at July 2013.
- Title information was sourced from Land Information New Zealand's LandOnline service, as at July 2013.
- Each PAUP zone was classified as either being residential, business, rural, special or other. This classification is an objective assessment based on the modelling approaches used and does not infer any classification for land use planning purposes, though for the most part

[8] Some processes and data manipulation undertaken to generate useable base datasets for modelling have not been included as part of this methodological documentation for brevity.

these categories are interchangeable (special areas can be residential, business, rural or other for example).

- Capacity for residential dwellings and business land in special areas was identified from information on planned outcomes in published material or from precinct plans identified within the PAUP.
- Where capacity has been assessed at the individual parcel/title level no account has been made for the potential of amalgamations of the parcels/titles assessed. Different cadastral arrangements (or 'sites' presented for consent) will produce different outcomes form those modelled. In certain zones (e.g. Mixed Housing zone and Terraced Housing and Apartment Building zone) amalgamation or parcels/titles will significantly increase redevelopment potential.
- Special areas listed in this report are based on the special areas identified (through precincts and otherwise) in the PAUP.
- Where capacity has been assessed at the individual parcel/title level (refer Table 1) no accounting has been made for the potential of amalgamations of the parcels/titles assessed. Different cadastral arrangements (or 'sites' presented for consent) will produce different outcomes form those modelled. In certain zones (e.g. Mixed Housing and THAB) amalgamation or parcels/titles will significantly increase redevelopment potential.
- Designations – parcels or titles identified as having a district plan designation[9] on them that would severely restrict or prevent development of the parcel or title have been excluded from assessment for potential capacity. A map showing the location of district plan designations that were used can be found in Appendix D: Map and list of Proposed Auckland Unitary Plan designations (as used in the modelling process).
- Parcels or titles that fall within identified special area have been excluded from site-by-site assessment, with potential and capacity reported for the entire special area (refer to Appendix O: Special areas with type, location and expected future development yields).
- Dwelling counts used in the study were provided by PropertyIQ Ltd. and are based on the data collected as part of the 2011 property valuations. The dwelling counts were provided per valuation assessment which was then translated to parcel/title level using an allocation method. A schematic of this method can be found in the Capacity for Growth Study 2013 (Proposed Auckland Unitary Plan): Methodology and Assumptions technical report.
- Building footprint capture from the 2010 aerial imagery was completed by Auckland Council's Geospatial Service Delivery teams in October 2012 this and some additional building foot print data has been used as the base data for the modelling process[10].
- Capacity for minor residential units (MRU)[11] was not assessed as part of this study. The residential zoning rules of the PAUP does not include provisions for MRU, but in some cases are allowed in precincts. This is not the same as the conversion of a dwelling into two dwellings provision allowed under the PAUP.
- The PAUP includes provisions for "the conversion of a dwelling into two dwellings" in certain residential zones (Auckland Council, 2013a). We have taken account of this provision in our modelling process and while this capacity has not been reported in the main results section

[9] District plan designations are granted under section 166 of the Resource Management Act 1991. A designation is a provision in a district plan which provides notice to the community that a requiring authority intends to use land in the future for a particular work or project MINISTRY FOR THE ENVIRONMENT. 2008. *Designations and requiring authorities* [Online]. Wellington, New Zealand: Ministry for the Environment. Available: http://www.mfe.govt.nz/rma/central/designations/ [Accessed 8 April 2014]..

[10] Auckland Council's Geospatial team was requested by the Research Investigations and Monitoring Unit to digitise further building footprints for several rural towns that had been omitted in the original data capture process; this was completed 14/08/2013. After running the model for the first time we noted that several of the rural towns assessed as part of the study had produced anomalous results due to the lack of building footprints. This is due to the fact that the town fell outside the area of data capture undertaken by the Geospatial teams. In order to correct this the Research Investigations and Monitoring Unit manually captured the building footprints for these areas - this data while not accurate (due to the resolution of the aerial imagery used to capture the footprints) allows the model to produce more truthful results for these areas.

[11] A 'Minor Residential Unit' (MRU) is a residential unit on a site in addition to another larger residential unit on the same site. Typically a MRU cannot be disposed of separately to the main house (i.e. it cannot be given a separate title) and usually includes a maximum floor space limit. A minor residential unit is sometimes referred to as a "granny flat".

of this report, results on this provisions can be found in section 7.6. Also, "second and third dwellings" (Auckland Council, 2013a) allowed for in certain rural zones are calculated as a separate yield.

- Capacity in the urban area and rural towns (residential and business) has been assessed at the parcel level. Rural residential capacity has been assessed at the title level. A significant amount of data that has been used as part of the modelling process is only available for 'rates assessment areas' (RAA). Other data is only available at larger geographies such as meshblock, local board or region. Accounting for these varying geographies means that care should be taken utilising 'property' level results, and results figures are for this reason generally provided at an aggregated level.
- All reported yields are rounded down to the nearest whole integer, for example if capacity for a parcel or title is calculated at 1.01 or 1.99 dwellings, then both would be reported as a potential yield of one (1). Residential zone decimal yields have been maintained for future analysis (e.g. assessment of potential future 'consentable' developments).
- There are expected to be a number of changes made to the provisions of the PAUP as it moves though the participatory hearings and appeals process, and a number of plan changes (to existing operative plans) and plan variations (to proposed or non-operative plans) would also be expected to occur as part of the continual evolution of the planning systems. As these plan changes were not operative at the time of the study, outcomes from these provisions have not been included.

Note: Comparisons between the reported results of this study and previous iterations of the study should be undertaken carefully as differing geographies, modelling techniques and assumptions employed in each individual study make comparisons problematic. Contact the Research, Investigations and Monitoring Unit for assistance and information on comparing results.

5.0 Capacity types

This study calculates and reports capacity as being in either one of two categories; residential or business. Each of these categories is divided further in order to calculate and report capacity across the Auckland region. Residential capacity measures the number of additional dwelling units that could be built under the rules as published in the PAUP, with business land capacity measured by area of land (in hectares). Floor space and dwellings are also reported in other study components (see below for business redevelopment). A list of these capacity types and a description is found in Table 2.

Table 2: Types of capacity

Capacity type	Definition of capacity type
Residential vacant	Capacity for dwelling units on residential zoned parcels that are currently wholly vacant (no dwellings or buildings), either via further subdivision or construction of a dwelling as of right.
Residential infill	Net capacity for additional dwelling units on residential zoned parcels that are partially vacant and have subdivision potential (based on the modelled consent category from PAUP rules) and are less than 2000 m^2.
Residential vacant potential	Net capacity for additional dwelling units on residential zoned parcels that are partially vacant and have subdivision potential (based on the modelled consent category from PAUP rules) and are equal to or greater than 2000 m^2.
Residential redevelopment	Net capacity for additional dwellings on residential zoned parcels presuming that all dwellings/structures are removed and the sites are redeveloped to yield the maximum number of dwellings permitted (based on the modelled consent category from district planning rules), less the existing number of dwellings, providing a net yield.
Rural residential	Net capacity for additional dwelling units on rural zoned titles, either through titles being currently vacant or through subdivision (based on the modelled consent category from district planning rules). Note that rural capacity now includes the potential for TRSS, significantly increasing the range of potential spatial outcomes possible in rural zones.
Dwellings in business areas and centres (business redevelopment)	Capacity for additional dwellings provided by development and/or redevelopment of parcels in business areas and centres. Capacity in this category is calculated as part of the business redevelopment component (refer section 9.0)
Business vacant land	Capacity (in hectares) of business zoned parcels that are currently wholly vacant (no buildings/structures).
Business vacant potential land	Capacity (in hectares) of the potentially vacant portion of those business zoned parcels that are not wholly vacant.[12]
Business area redevelopment capacity	Net capacity generated from the redevelopment of business land. Sub-types of business redevelopment capacity calculated include: total floor space, business floor space, residential floor space, estimated employees and estimated dwellings.

[12] It should be noted that almost all business zoned sites have a portion of the site which is not covered by building/structure. Our modelling and methodological approach takes this into account and assesses vacant potential capacity based on a site's size and the proportion of site that is vacant (within a population of sites within the district plan area). Refer to the Business Redevelopment section for further details.

Capacity type		Definition of capacity type
Special Areas	Special areas (other)	This category of capacity relates to capacity sourced from non-modelled outputs. The two categories relate to the type of future expected - special areas relate to particular activities, such as hospitals or quarries, and are generally not modelled in any way, and are assumed to provide no additional capacity though are often important features in enabling capacity to be delivered sustainably. Structure plan areas relate to locations where modelling is unnecessary, inappropriate or impossible, and data has been sourced from elsewhere, usually the published structure planning information.
	Special areas (pipeline capacity)	Future capacity that has been identified the longer term strategic planning processes at the time of notification of the PAUP (30 September 2013) but not necessarily zoned in a way that facilitates that capacity to be realised. Examples include capacity in the Future Urban zones and locations identified in other strategic growth management documents. Counted for both residential and business categories. Pipeline capacity is a subset of special areas. All figures represent current publicly available information and are therefore subject to change without notice

Below, Table 3 shows what outputs are generated by each type of capacity assessment.

Table 3: Types of capacity and primary outputs generated

Capacity type	Land (by area)	Dwellings (by count)	Business floor space (by area) for conversion to dwellings and or employment	Employment (by count)
Residential vacant	✓	✓		
Residential infill (incl. vacant potential)	✓	✓		
Residential redevelopment	✓	✓		
Rural residential	✓	✓		
Dwellings in Business Areas and Centres (as a subset of Business Redevelopment Capacity)		✓*		
Business vacant land	✓		See business redevelopment capacity	
Business vacant potential land	✓			
Total business land	✓			
Business redevelopment capacity	✓	✓*	✓	✓**
Special areas	✓		Dependent on information provided in available documentation	

* Dwelling count is a function of floor space allocated to residential in the business redevelopment capacity process.

** Employment is a function of floor space allocated to non-residential use in the business redevelopment capacity process.

The business redevelopment component of this study estimates the likely total floor space area of a business area or centre. Total floor space area is determined and subsequently apportioned to business and residential purposes, from which potential employees and dwellings are calculated. The business redevelopment component capacity types are described in Table 4.

Table 4: Types of business redevelopment capacity

Business redevelopment capacity type	Definition of capacity type
Total floor space	Total amount of floor space (square meters) possible in a business area or centre calculated using three-dimensional modelling techniques
Business (non-residential) floor space	Amount of business (non-residential) floor space (square meters) likely to be yielded from a business area or centre's total floor space.
Residential floor space	Amount of residential floor space (square meters) likely to be yielded from a business area or centre's total floor space.
Estimated employees	Estimated number of employees likely to be accommodated in a centre or business area, based on the amount of business (non-residential) floor space yielded and a floor area per employee ratio.
Estimated dwellings	Estimated number of dwellings likely to be accommodated in a centre or business area, based on the amount of residential floor space yielded and a floor area per dwelling ratio.

6.0 Modelling process

This section of the report outlines the process undertaken to calculate both the residential and business capacity results. The modelling process has been broken down into sub-sections, including an overview of the process, formatting of data and the undertaking of spatial queries. The modelling approach used in this iteration of the study is very similar to that used in the 2012 study, with the basic process being as follows:

- Review rules to be applied
- Review data available
- Create process to model rules against relevant properties using available data
- Run model, revise/refine model, repeat
- Calculate, confirm and report results
- Post study work

Decisions made in the conversion of the plan's text to a computer algorithm, including which aspects of the rules will be included or excluded, and the quality and availability of data to represent factors mentioned (or implied) in the rules, are key aspects which will influence the resulting capacity. In many cases there are multiple ways in which capacity can be calculated, additional factors which can be considered or excluded, and new data that becomes available that was not at the time. For these reasons and others we have been as clear as possible with the approach we have used, so that users of the results are aware of these conversions and the limitations they introduce and future modellers can make improvements or corrections as required.

The following section looks at how the modelling process has evolved since the 2012 study, specifically looking at changes and improvements that were made in the process.

6.1 The Proposed Auckland Unitary Plan (PAUP)

The PAUP is different in many ways from the legacy plans it replaces. This has meant we have had to generate new ways of importing data, interpreting the rules, and creating new ways of calculating capacity. However, many of the methods and processes developed through the 2012 study have been able to be utilised in this new set of modelling, with minor tweaks required to reflect new rule parameters. Key areas of change include the new Terrace Housing and Apartment Buildings (THAB) zone, the Mixed Housing Urban (MHU) zone, and the Mixed Housing Suburban (MHS) zone (urban residential capacity calculations), and the consideration of Transferable Rural Site Subdivision (TRSS) (rural residential capacity calculations). Each of these provisions is a significant departure from approaches used in the region previously. In addition, we expect them to evolve further through the Unitary Plan hearings process.

The creation of the new, single, Unitary Plan for Auckland has for the first time bought a consistency to the zoning provisions across the region. In tandem with this has been the improvement of the quality of the spatial data supporting the plan, which has enabled us to be innovative in the calculation and methodology. Examples of this include the ability to now model three-dimensionally business areas. Undertaking such modelling under the variable approaches provided across the region's legacy district plans, while possible, was so time consuming that it was impractical.

During the first half of 2013, a bespoke model was created to calculate the capacity enabled under the provisions of the Draft Auckland Unitary Plan (DAUP) (as published in March 2013). The creation of this model allowed us to develop a model and processes to calculate and test many of the concepts that are now contained in the PAUP, prior to its notification. Despite this 'practice run', the large number of changes between the DAUP and the PAUP has meant that while we were able to have a head start (particularly with the data conversion process), many of the provisions had been changed significantly enough that a complete redevelopment of the model components was required to enable

calculation of capacity that best reflected the updated PAUP provisions. The modelling of the PAUP could not be commenced until *after* both the rules had been finally determined (the part of the plan that tells us 'what is allowed to happen'), and accurate spatial data developed to support them (the part of the plan that tells us 'where it is allowed to happen'.

This section expands significantly on the information presented in the equivalent section of the methodology and assumptions report of the 2012 study. Significant discussion on the data conversion process has been included to allow better understanding by users of the results on how they were derived. A significant amount of detail on the model's coding has also been included. It is hoped that this will assist readers to understand the key variables or parameters that influence the outcomes of the modelling, and in turn this will improve the utility of the model, including undertaking future investigations and improvements.

6.2 Conversion of the PAUP zones, precincts and overlays to 'CfGS zones'

The PAUP proposes a wholly new approach to 'zoning' in Auckland when compared to the nine legacy district plans it largely replaces and/or updates[13]. A small number of base zones (47) in the PAUP is complemented with a larger number of precincts (379), and an even larger number of overlays (in excess of 100,000 features), all of which can vary the provisions of the base zones on an exceptions basis[14] A significant number of 'map diagrams' (more than 400) are also included in the text of the PAUP sometimes illustrating site specific details and exceptions.

In this study we have primarily utilised the PAUP rules as they are outlined in the subdivision, residential, business, rural, precincts and relevant overlays sections/parts/chapters of the plan. We have explicitly assumed that these provisions as written 'give effect' to the RPS and Regional Plan aspects of the Unitary Plan and make no differentiations between district plan (DP) and higher-level provisions. Where a conflict exists (if any) between RPS and DP provisions, we have assumed that this will be noted and resolved via the hearings process. We have taken the plan as written.

As noted above the PAUP proposes a very limited number of ‘base zones’ in order to reduce the complexity of the region's planning system. While this is true, the potential numerical combinations of these base zones with a larger number of precincts and overlays means that the actual set of potential iterations of rules that apply to any given parcel is far greater than the small number of base zones suggests[15]. This in turn has complicated the modelling process. A number of ‘diagrams’ and additional policy and detail maps (generally included as small inset maps in the planning text itself but not the maps volumes) not available to us as spatial data sets add further site specific detail and nuance to the planning provisions, which for practical considerations have had to be disregarded.

To deal with the complexity of the plan and to be able to instruct the model what to do with each parcel based on its location, we have 'boiled down' the various overlapping aspects of the PAUP into a single layer called 'CFGS_zoning'[16]. The particular rules and combinations of the plan need to be applied to any given parcel, but also as a matter of practical modelling requirements (essentially to avoid double counting), each given parcel can be in only one zone; this is entirely dependent on where the parcel is in relation to the base zone, precinct and overlays.

The following section outlines this PAUP zones, precincts and overlays to 'CfGS_zone' conversion process.

[13] A significant portion of the precincts section is a PAUP look-and-feel 'translation' of legacy zoning provisions)

[14] Base zone rules apply unless varied by the precinct or overlay - the amount of variation from base zone provisions varies between minor to significant.

[15] The actual number of potential iterations is $(z + p)^o$, where z = number of zones, p = number of precincts and o = number of overlays (this is a very large number). Thankfully the actual iterations (ignoring overlays that are not zones) is much less than this and is $Z+P+ \text{'zonelike'}\ O$. These can be further iterated by the remaining overlays but for the purposes of calculating 'raw' capacity these remaining overlays have been largely ignored.

[16] 'CFGS_zoning' and 'CFGS_zone' refers to zoning data created as inputs into the capacity model from the raw Proposed Auckland Unitary Plan data

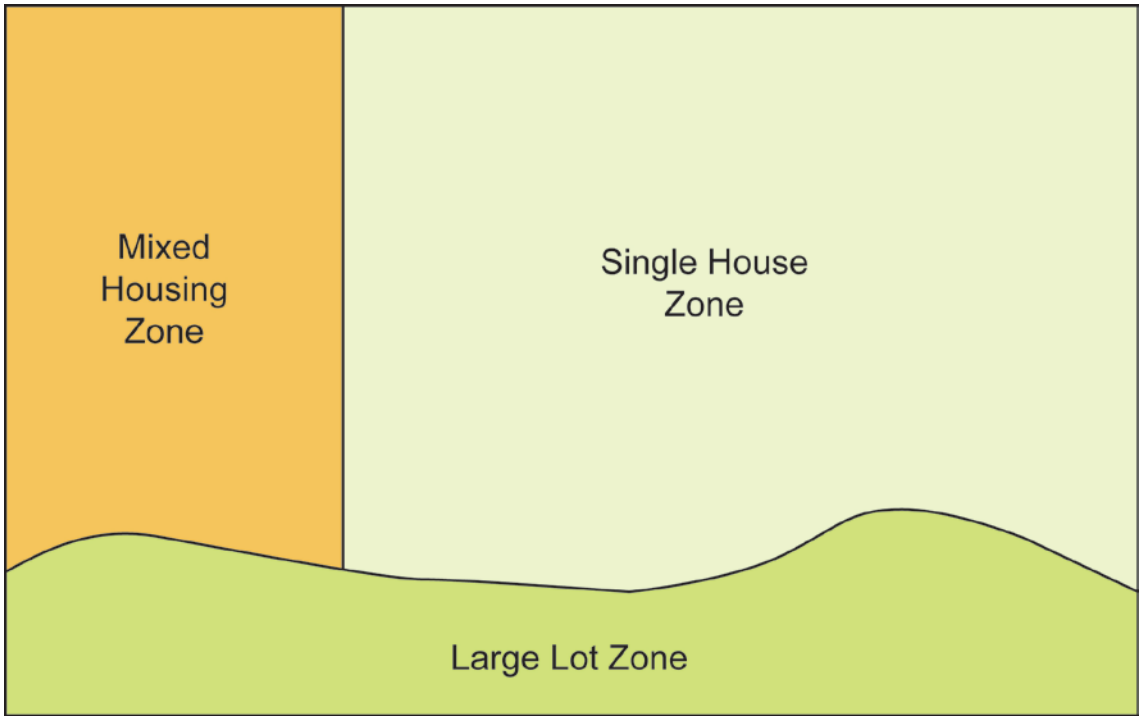
6.2.1 Conversion of PAUP zones, precincts and overlays to CfGS_zones

As noted above, the PAUP has a small number of base zones. However these can be varied by the presence of precincts (which act effectively as zones) overlays (which identify various spatial features, usually non-parcel linked, but some of which also act in effect as zones) and map diagrams (inset maps which provide explanatory detail in the text).

These four separate layers (zones, precincts, overlays and diagrams) each needs to be taken into account when assessing capacity potential of the PAUP. This potentially results in an n^4 scalar problem, which extends beyond the scope of our modelling process. This we believe, is also well beyond the intention of the plan to provide this much scope for variation (or is unnecessary for us to dig that deep for the purposes of this study) so we were able to make some decisions to keep the plan's potential iterations for modelling purposes within a reasonable framework.

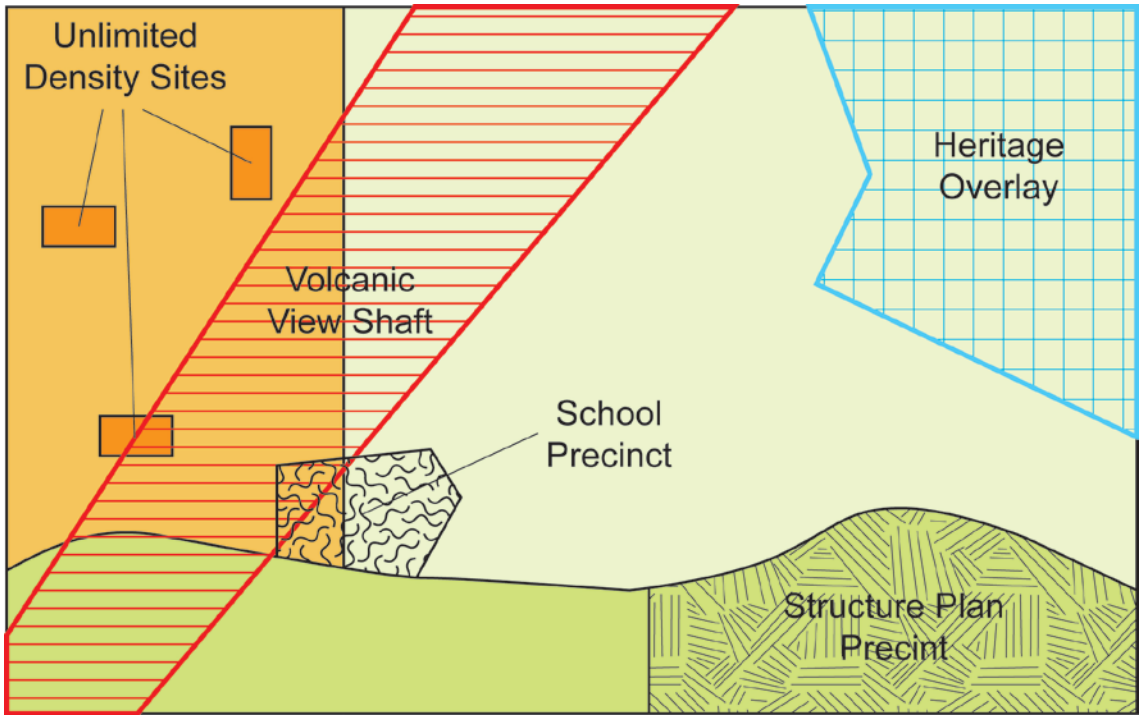
Zones and precincts are largely parcel based (except where a parcel is split by a zone) and overlays are largely non-parcel based, reflecting such non-cadastral features as historic heritage features, significant environmental areas, and volcanic view shafts. There are also a small number of overlays, which effectively act as zones. The following series of diagrams (Figure 2 to Figure 5) illustrate the concept of the conversion of zones, precincts and overlays into a single, flattened Capacity for Growth Study zoning base, which we have called 'CfGS_ zones'. Note that 'diagrams' included in the PAUP are not considered at all in this conversion process.

Figure 2: Base zone layers



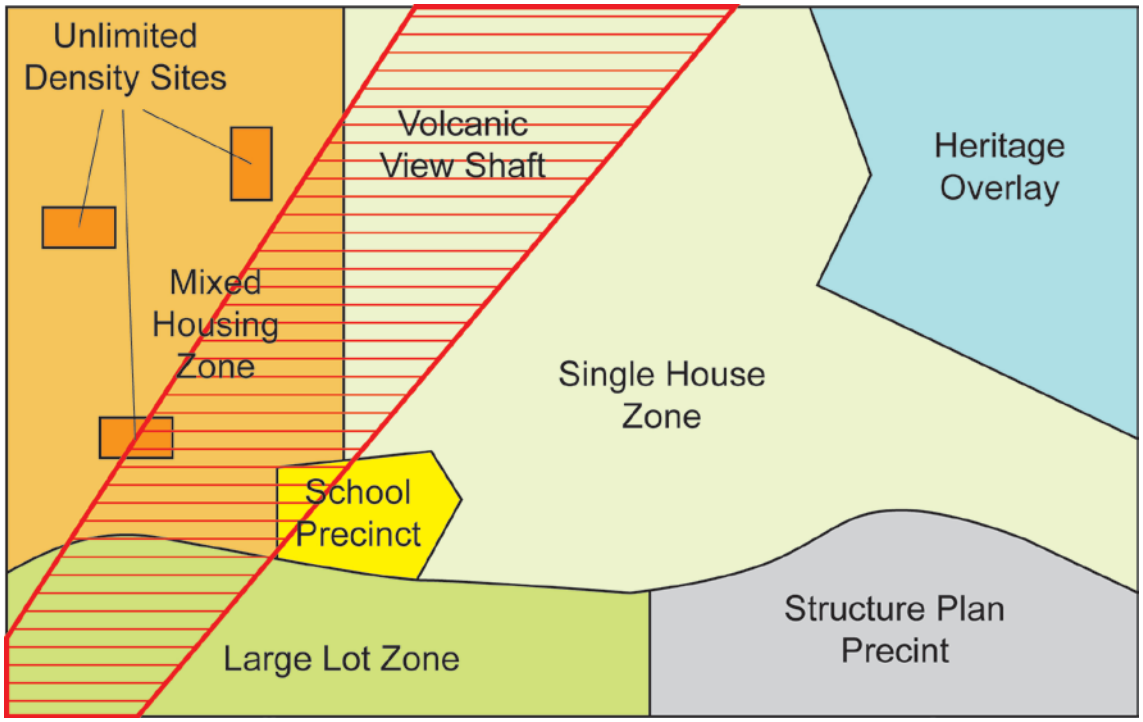
Existing base zone layers from the Proposed Auckland Unitary Plan. (UP_BASEZONE)

Figure 3: Base zone layers with precincts and overlays added



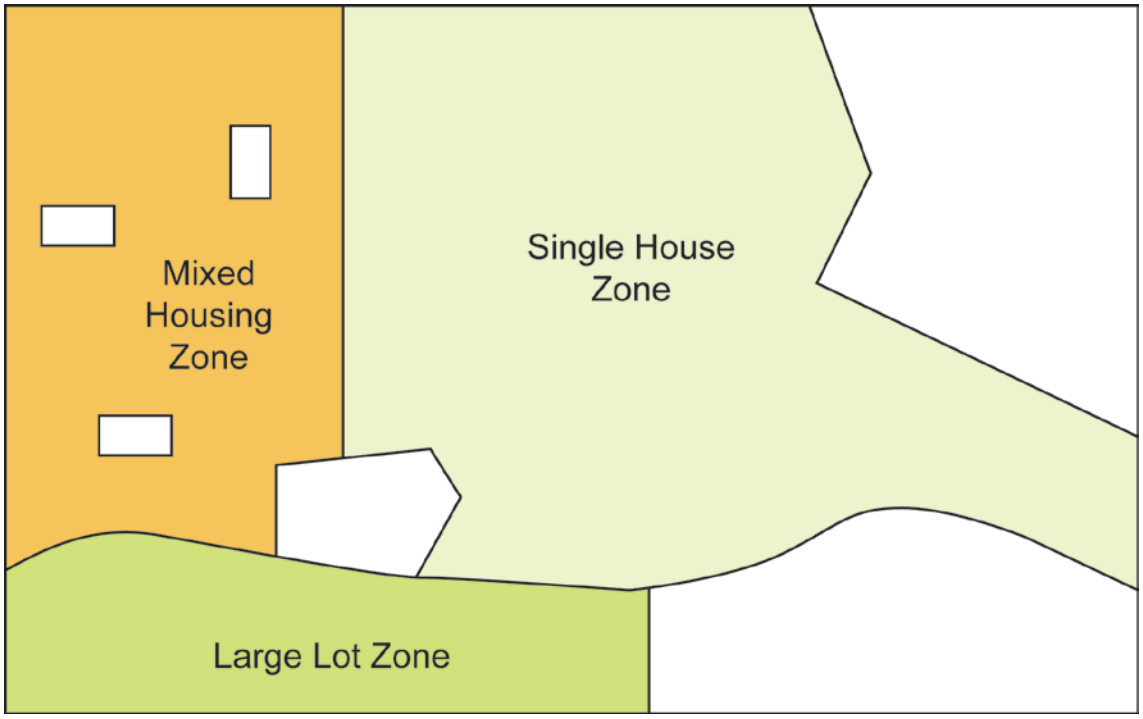
Zones with precincts and overlays added (which act to vary or replace the base zoning provisions)

Figure 4: Zones, precincts and overlays resolved to their functional land uses (CFGS_zones)



Zones, precincts and overlays resolved to functional land use classes (only the Volcanic View Shaft remains as an 'overlay'), all the others become 'CfGS_zones'.

Figure 5: Post-processing example of where original or underlying base zone provisions remain unmodified by precincts and overlays (for initial capacity modelling purposes only)



Locations where standard 'base zone' rules apply without modification.
Note that the Volcanic View Shaft overlay may impact on building height, bulk, location or design within the 'CFGS_zone'.

Effectively, all PAUP base zones are 'zones', all precincts are 'zones', and some overlays are 'zones' (the remaining overlays remain as overlays). Using the concept outlined in the figures above, a single CFGS_zone layer was created using the following order of priority rules (effectively the reverse of the way the plan is written), such that the detailed overlays end up on the top, with base zones at the 'base':

- Overlays that act as zones (zone-like)
- Precincts
- Base zones

Based on this, zone-like overlay features clip precincts features, and precinct features clip PAUP base zone features, as shown in below in Table 5.

Table 5: Conversion of PAUP features to Capacity for Growth Study features

PAUP feature type	Converted to Capacity for Growth Study feature type(s)
Zone (ZO)	Zone (ZO)
Precinct (PR)	Zone (ZO)
Overlay (OV)	Zone-like are zone (ZO) Rest are overlay (OV) Some are not used
Diagram	Not used

So instead of the (mathematically possible, but overstated in this case) scenario of:

$$n^{rules} = (Base\ zones \times precincts \times overlays)$$
$$= (47 \times 369 \times 105{,}542)$$
$$= 1{,}830{,}414{,}906\ Rules\ to\ model$$

We instead have a much more manageable data set:

$$n^{rules} = (Base\ zones + precincts + zone\text{-}like\ overlays) \times selected\ other\ overlays$$
$$= (47 + 369 + 55)\ x\ selected\ other\ overlays)$$
$$= (471)\ Rules\ to\ model\ \text{x}\ selected\ other\ overlays$$

This approach requires the review and consideration of the text relating to all the zones, precincts and overlays prior to determining which overlays are zone-like, which remain to be used in the modelling, and which will be overlooked. Only base zone areas without a precinct or zone-like overlay remain to be modelled as per the base rules of the base zone. For residential areas this is approximately 80 per cent of the total area, with the Single House zone being the base zone most 'modified' (by area) by precincts and overlays.

Overlays that are not considered zone-like, are put aside from initial capacity modelling, except where they are specifically mentioned in zone rules or where they are grouped together to represent a building platform requirement (which is used in testing for residential and business infill calculations and rural subdivision).

Most overlays are constraints to development rather than yes/no exclusions. These features are often combined into aggregate features for processing (i.e. 'hazards' or 'heritage features' made up of numerous overlays and additional corporate spatial data) rather than treated separately, and some are not used at all, especially those that were initially assessed as not materially impacting on capacity, such as 'retail frontage requirements' or 'aquifer loading areas'. This is not to say that these are not important for other reasons (such as the use the ground floor might be put, or the impact on aquifer recharge rates), just that in terms of the built environment anticipated by the plan, they are considered to make little or no material or practical difference.

Designations are treated as a special overlay group. They are first filtered so only those assessed as having 'significantly precluding zoned capacity realisation' are considered (e.g. airspace restrictions, road widening and pipelines removed, schools, motorway and rail designations retained) and all parcels are assessed, but tagged with a 'designation count' (number of 'significant' designations the parcel intersects) and designation schedule (PAUP reference number) of those designations. All reported capacity is based on results from parcels where a filter of "count of designation is equal to zero" has been applied.

A summary of PAUP input and processed features are contained in Table 6. It should be noted that in some instances, some precincts have a 'base zone' assessment type, where the precinct requirements were determined to be not relevant for capacity assessment as the precinct varied the base zones insufficiently in terms of the built environment anticipated by the base zone, they are considered to make little or no material difference and that it was more efficient to process them as the base zone rather than create an additional modelling process.

Table 6: PAUP to Capacity for Growth Study data conversion schematic

<table>
<tr><th>PAUP data type</th><th>UP_ZONECLASS</th><th>CFGS_ZONECLASS</th><th>MODEL_TYPE</th><th>ASSESSMENT_TYPE</th><th>ASSESSMENT_SUBTYPE</th></tr>
<tr><td>Base zones (47)</td><td>ZO (47)</td><td rowspan="6">ZO (471)
All zones (47)
All precincts, (369)
Some zone-like overlays (55)</td><td>Residential (76)</td><td>Infill
Frontage
Sub-precinct*
Special</td><td></td></tr>
<tr><td rowspan="4">Precincts (369)</td><td rowspan="4">PR (369)</td><td>Business (45)</td><td>Commercial
Industrial</td><td>City centre
Metropolitan centre
Town centre
Local centre
Neighbourhood centre
Mixed use
Business park
General business
Light industry
Heavy industry</td></tr>
<tr><td>Rural (35)</td><td>Custom
CSL
Minimum site area</td><td>Note: TRSS and subdivision calculated separately.</td></tr>
<tr><td>Special (176)</td><td>Special activity
Structure plan
Rollover (<TA_Code>)**</td><td>* Special areas that are also business areas have been assessed for vacant and vacant potential land.</td></tr>
<tr><td>Base zone (81)</td><td colspan="2">Base zone features are precincts where insufficient variance exists to require separate modelling and are assessed against the underlying base zone rules as if the precinct does not apply. In effect the precinct or overlay is ignored.</td></tr>
<tr><td rowspan="3">Unique overlay features (105,542)</td><td rowspan="3">OV (5,352)
Unique overlay groups</td><td>Other (69)</td><td colspan="2">'Other' zones are not modelled (roads, sea, public open space etc.)</td></tr>
<tr><td>OV (4,580)</td><td>Overlays</td><td colspan="2">Overlays are used in model where appropriate, also post processing. CFGS_GROUPCODE (8) used to classify into capacity impacts. Also grouped for various processes (e.g. rural and urban building platforms, and post- filtering)
Designations are a special overlay group and tagged against each parcel.</td></tr>
<tr><td colspan="4">Unused overlays (717) (diagrams, various non-capacity related spatial datasets, and non-polygon features)</td></tr>
</table>

* Where Assessment_Type = Sub-precinct the requisite spatial data required for modelling does not exist in the zone, precinct or overlay feature, and needs to be manually created from diagrams

**Where Assessment_Type = Rollover locations are where the provisions are exactly as per legacy rules and CfGS_2012 results and/or modelling will be reused. <TA_Code> contains the legacy TA from which the rules and results (CfGS 2012) have been rolled over from.

6.2.2 Modelling of CFGS_zones

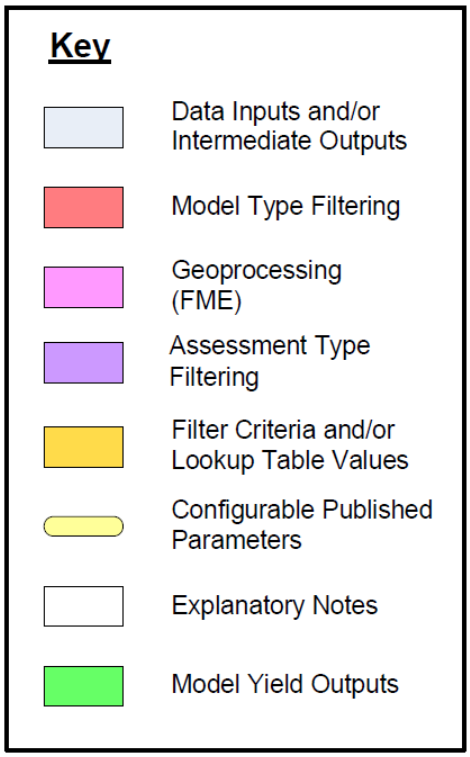
The process for calculating the capacity for each parcel, title or area within a particular study component is conceptually the same irrespective of the component; calculate the net potential for additional development under the relevant rules applying. What differs between each zones assessment is the assumptions that are used.

The CFGS_Zone process above, is simply the process by which it is determined what rules will be applied to each assessment area (be that parcel, title or area). This section describes how those rules are 'converted' into model inputs, tested against assessment areas and output as capacity information.

Figure 6 below provides a legend to Figure 7 (and subsequent process diagrams). Figure 7 illustrates, at a high conceptual level, the modelling process for the entire Capacity for Growth Study with each of the study components highlighted.

Capacity calculation methods for each of the components are outlined in the following sections of this report, with each containing a process diagram that illustrates the procedure taken to calculate capacity. Further component specific assumptions are also outlined.

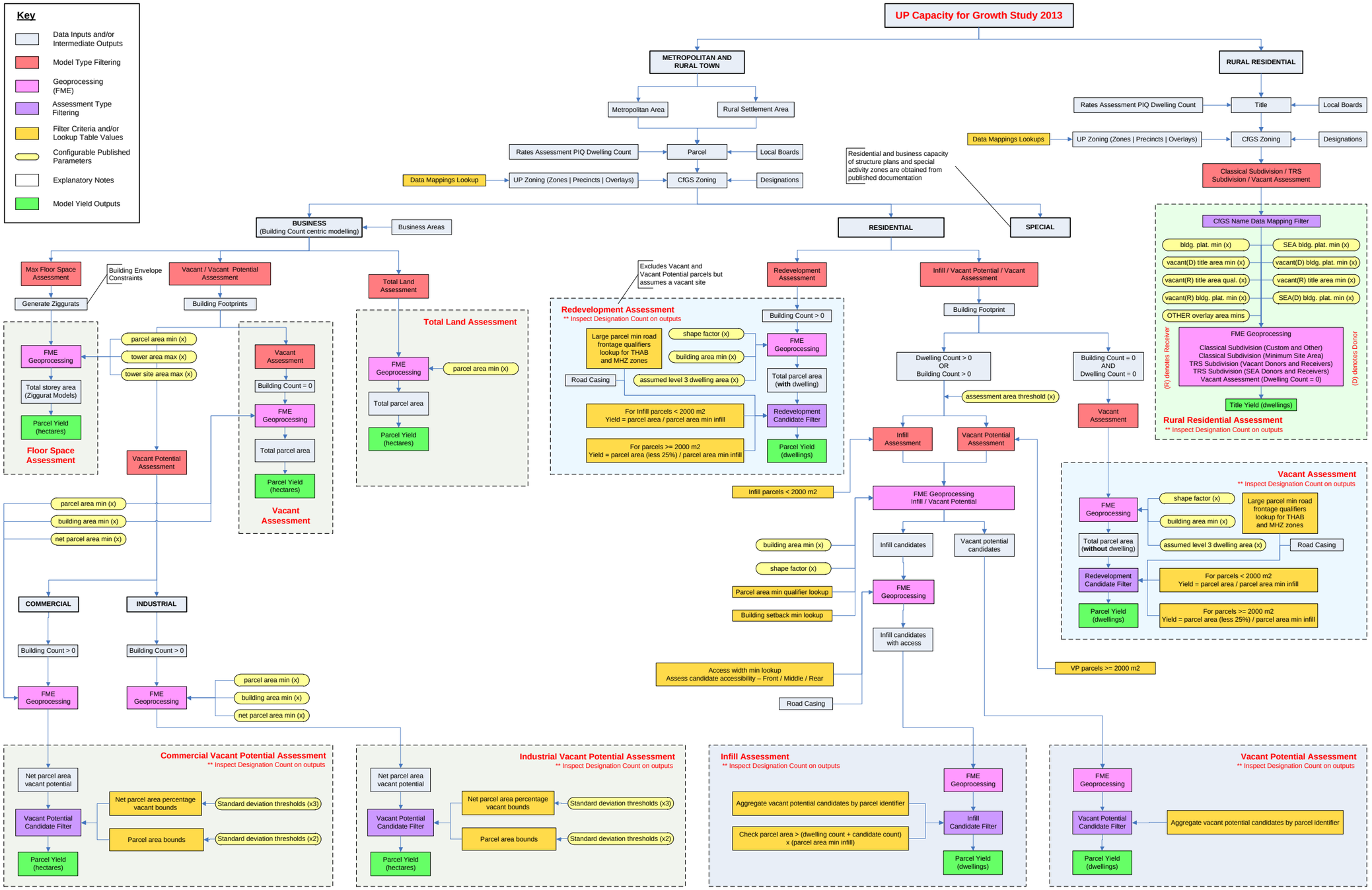
Figure 6: Modelling process diagrams legend



Each component's process diagram is an illustrative representation of the actual modelling process undertaken in FME. Full and detailed examples of the modelling schematics can be found in Appendix H: FME workbench schematics.

Data sets sourced to undertake the capacity modelling can be found listed in Appendix F: Data and sources utilised in study, with description and source.

Figure 7: Overview of Capacity for Growth modelling process (geo-processing modelling schematic)



Unitary Plan Capacity for Growth Study 2013 : Geoprocessing Modelling Schematic

U:\CPO\ASR\Research Investigations and Monitoring\Land Use Research\Capacity for Growth UP 2013\FME_Documentation\CfGS_UP_2013_Process_Diagram_v1.1.vsd

Mike Oberdries | 29 July 2013

7.0 Residential capacity (urban and rural towns) methodology

Residential capacity is the measure of the net number of additional dwelling units that could be built under PAUP provisions, as modelled (i.e. based mainly on total land area and land shape factors). Results for residential capacity results can be found in the *Capacity for Growth Study 2013 (Proposed Auckland Unitary Plan): Results* technical report.

Capacity is calculated under four typologies, which represent different levels of change to the existing situation, these are:

- Residential vacant - being the development of sites without current dwellings or buildings
- Residential infill - being the development of land on sites smaller than 2000 square metres, with dwellings or buildings without removing those existing dwellings or buildings
- Residential vacant potential - being the development of land on sites larger than 2000 square metres, with dwellings or buildings without removing those existing dwellings or buildings
- Residential redevelopment - being the (re)development of land on sites with dwellings or buildings after removing those existing dwellings or buildings.

An overview of the methods used to calculate these capacity types are outlined in the sections below.

Note that residential capacity in business areas (including centres) is calculated as part of the business redevelopment component, the methodology for which is reported in section 9.0.

7.1 Residential capacity assessment – global assumptions

This section details assumptions that apply to all parcels that were assessed as part of residential modelling. These assumptions are listed in Table 7. Other assumptions that are specific to a single capacity calculation type are included in the relevant sub-section of this report. Zone specific assumptions, such as minimum lot sizes can be found in Appendix I: Proposed Auckland Unitary Plan residential zones (CfGS zones) and assumptions, that contains the look-up tables (LUTs) directly utilised by the model.

Table 7: Residential capacity global modelling assumptions

Assumption name	Assumption Value	Description	Components assumption used in
Minimum valid parcel size	100 m²	There are many small parcels across the region; these can include the likes of small parcels adjoining larger ones, vehicle access ways, pedestrian accesses etc. Such parcels are considered too small to realise any form of capacity as such parcels that are smaller than 100 m^2 were excluded from the modelling process. A further 'shape test' and some parcel attribute queries are also undertaken to remove access lots and the like with an area greater than the minimum valid parcel size.	All residential components

Assumption name	Assumption Value	Description	Components assumption used in
Infill and vacant potential demarcation threshold	2000 m²	A threshold of 2,000 m^2 was used as a demarcation point between infill and vacant potential. This allowed for the application of different densities on larger parcels. The 2000 m² demarcation threshold is consistent with previous studies.	Infill Vacant potential Redevelopment
Minimum building footprint area	50 m²	Buildings that are small, and therefore easily moved or removed should not be considered as a constraint to realising capacity; as such buildings that had a foot print that were smaller than 50 m^2 were excluded from the modelling process.	All residential components
Minimum dimension for a building/dwelling platform	11 m x 11 m (120 m²)	The plan specifies that each new vacant site be capable of containing a rectangle of eight metres by 15 metres (total of 120 m²). Note: Due to the practicality of geospatial modelling, we use a representation of a regular polygon (a square) of the same area (roughly 11 metres by 11 metres). This may result in some candidate areas with 'narrow' platforms failing to qualify that may otherwise pass a manual assessment, potentially balanced by 'squat' dwelling platforms that do pass that shouldn't have.	Infill
Parcel area minimum qualifier	Varies, refer LUT	Minimum size of the residential parcel to be assessed for infill type capacity. This is calculated as parcel area minimum plus the balance area minimum. However, under the PAUP this is always twice the minimum infill area, as both the infill candidate and the balance must meet the minimum parcel area requirements.	All residential components, but assumptions are zone specific. Refer LUT.
Parcel area minimum	Varies, refer LUT	Minimum size of the resultant residential parcel infill candidates	Infill, but assumptions are zone specific, Refer LUT
Parcel vehicle access width minimum	Varies, refer LUT, never less than minimum 2.5 m formed carriageway.	Minimum width between any existing building footprints (larger than the minimum building footprint area) and the parcel boundary, which would allow a vehicle to pass from the road to a non-frontage infill candidate.	Infill, but assumptions are zone specific, Refer LUT
Parcel building setback minimum	Refer LUT	Minimum (average) distance from any existing building footprint (larger than the minimum building footprint area) that infill development candidate areas can occur. This effectively operates as a yard from existing building footprints to ensure the new boundary is set back an appropriate distance (obviously impacting on the area that is available). Where no yards are required this can be set to zero. Where yards vary by boundary, an 'average' is created.	Infill, but assumptions are zone specific, Refer LUT.

7.1.1 Net and gross parcel area minimums

The residential and residential subdivision rules refer to "net site area" for the application of the relevant density rules.

Net site area (and other related terms) is defined in the PAUP (refer to Part 4: Definitions in the PAUP; note that underlined words are also defined terms in the plan) as:

- Net site area: The total area of a site, excluding any area owned in common, any area subject to a road widening designation, any part of an entrance strip and any private ways.
- Entrance strip: The narrower part of a rear site extending back from a road to provide access to the principal part of the site.
- Rear site: A site with frontage of less than 10 metres to a legal road, except that a site served by a service lane is not a rear site.

The application or consideration of this rule set in every situation in the modelling process is very difficult as we do not actually create a model scheme plan from which future areas "*owned in common* or *private ways"* can be netted from the site area.

For consideration of entrance strips, the definition is too subjective to apply in a computer model, as it does not define what is 'narrower', or the 'principal part', and while it may be discerned what is intended, for sites that might be irregular in shape, and for those sites that will become rear sites after development (almost all of them, given minimum driveway widths are less than 10 metres), application of the 'assumed intent' of the rule 'accurately' in an automated process is not possible.

In addition, we have assumed that modelled development will be arranged to maximise returns, such that sites may be ultimately arranged to minimise vehicle access requirement net area losses. Accordingly, where the minimum net site area has been applied, this represents a maximum possible yield within the rule parameters, but actual layout and future development may not meet these assumptions.

For infill and vacant potential assessments, net site area requirements are however implicitly provisioned for within the method, though the spatial candidate finding process (which ignores narrow areas between existing development and the site boundaries) and in vacant potential sites (greater than 2000 square metres) where multiple dwelling developments will be more common), an additional 25 per cent reduction in candidate area is allowed for, including for access/net site areas.

Vacant site and redevelopment calculations (on sites less than 2000 square metres) do not allow for this spatial reduction, but it could be assumed that such sites are more likely to maximise dwelling yield given the greater freedom to arrange layout without constraint from existing buildings. For those larger than 2000 square metres the 25 per cent site area (versus candidate area) reduction also applies. In the more intensive development typologies (THAB and MHU; 'unlimited density' in particular) the use of worked examples to derive density implicitly considers the requirements for net access and common areas. Therefore, while net site area rules are not directly applied, the methodology makes sufficient provision for this requirement, that at the global level, any difference will likely be self-compensating. At progressively smaller scales, especially individual parcels, some care should however be used.

7.1.2 A note on the variability of input parameters and scenario testing

The ability to vary the parameter values contained within the LUTs (and indeed some of the global parameters) has been a key model development consideration. We are aware that the PAUP is likely to change through the Unitary Plan hearings process, and ongoing plan variations and changes after the plan is operative are a normal function of planning in a rapidly evolving city. The ability to accurately investigate the effects of these potential changes is a powerful addition to the evidentiary basis of the planning system. As such we have developed the model as a mechanism by which different scenarios can be tested, such as the variation of minimum infill site sizes or yard setbacks (or whatever parameters are in the relevant LUT) by variation of those LUT values and rerunning the model.

The other mechanism of testing changes, though considerably more involved, is via the variation of spatial inputs, such as the extent of zones, or various other spatial inputs as used in the workbench(s). There are also a limited number of more general, global settings that can be changed (known in the model as 'published parameters'). These values are outlined in Table 7, and are built into the FME

workbenches. These global settings and the more specific values in the LUT can both be varied in order to undertake scenario testing.

Potential changes to provisions of the plan that require considerations outside of this in-built variability are considered to be an 'architecture' change. These changes are considerably more complex (depending on the scale of change from the PAUP) essentially requiring the development or amendment of the way the model operates.

7.2 Residential vacant

Residential vacant capacity is the number of dwellings that can be yielded from residential zoned parcels that are currently 'vacant'. Vacant residential parcels occur across the region; not just in areas that have been newly developed, but also in existing suburbs.

Conceptually, there are four main types of residential vacant parcels in Auckland, these are detailed below (and illustrated in Figure 8). These categories have been used for descriptive rather than analytical purposes, and require an aspect of subjective judgement on a per parcel basis. Therefore vacant land in this study has not been classified into these categories, however they may be useful framework for future investigations and classifications as the likelihood of development and the tools to unlock this latent potential may vary accordingly.

A number of critiques have also raised issues in that sites in some of these categories are not actually 'vacant' and may never be developed. While this may be at least partially correct (in that not all development potential is likely to be realised) the latent potential of these sites for development is not extinguished by present use, the length of time a parcel has been vacant, or the parcels size.

This debate conflates the separate but interrelated issues of zoned '*potential for development*' and the '*likelihood of that development occurring*'.

This study is primarily concerned with the accurate measurement of plan enabled potential, such that more subjective debates about likelihood (including consideration of 'market potential') are able to be much better informed.

- **Small scale subdivision:** New parcels that have been created through a small scale subdivision, and have yet to have a dwelling constructed on them (they just happened to be 'caught' by our study between title being granted and the immanent construction of a dwelling - these type of parcels are being created and consumed around the region more or less constantly).
- **Long term vacant:** Parcels that have been vacant for a long period of time – their owner(s) has chosen not to construct a dwelling on them to date for a range of reasons, not all of which are immediately obvious or discernable[17].
- **Other use:** Parcels that are used for other purposes, such as amenity value (a larger back yard or garden), recreation (have a swimming pool or tennis court), parking for adjoining parcels etc. These can readily be converted from their existing use should the owner desire and such 'other uses' are considered 'temporary' with temporary meaning they will be 'one day' be replaced with zoned development. These other uses can and do pose an impediment to development largely related to the owners appreciation/enjoyment of them relative to some other, potentially more productive use, and as such can generally change at a moment's notice.
- **Large scale subdivision:** Parcels that have been created through large scale subdivision (greenfield developments, often via a structure plan) and have yet to have a dwelling constructed on them. Note that most of these vacant parcels have *not* been measured

[17] Forthcoming work from RIMU *Long term vacant residential land in Auckland* on long term vacant sites based on qualitative analysis including discussions with land owners of long term vacant parcels should shed more light on the ownership of these parcels and their reasons for long term vacancy. Initial findings suggest that all owners interviewed anticipate the sites will eventually be developed 'one day', but not necessarily by them.

through the residential vacant component of the study due to these parcels falling within structure plan and special areas. Capacity in structure plan and special areas are reported separately (refer Table 2).

Despite some of the issues raised above, vacant residential land provides a good indication of how much land is potentially readily available for development. As vacant residential land is zoned, and almost all of it is already serviced or within serviced areas, this land provides opportunities for dwellings that are "ready to go" (or classified as "unconstrained" in *The Auckland Plan Addendum* (Auckland Council, 2012b)). Note that this definition does not account for factors other than zoning and the availability of services.

Figure 8: Examples of vacant residential parcels



Vacant means a parcel has neither (known) dwelling(s) (from parcel dwelling count information) nor (known) buildings (from building footprints, less those smaller than the minimum building area) located on it. Vacant residential parcels must meet all of the following tests:

$$Zone\ type = residential\ AND\ dwelling\ count = 0\ AND\ count\ of\ buildings = 0$$

All valid vacant parcels (i.e. those passing all tests above) are then run though the model (as per section 7.2.1: Calculating residential vacant capacity below) and assessed against the relevant rules

applying to find the maximum number of dwellings the rules enable the site to contain. The key difference from other assessments is the treatment of parcels that are smaller than the zones minimum lot size requirements but larger than the minimum valid parcel size, in that the minimum yield is set to one, rather than zero. All valid vacant parcels therefore are assumed to have the potential capacity for at least one dwelling irrespective of possible subdivision potential or planning rules applying - one residential title equals one dwelling. This is because such parcels are assumed to have an underlying property right for 'reasonable use'. For residentially zoned parcels this means residential occupation which reasonably necessitates a dwelling.

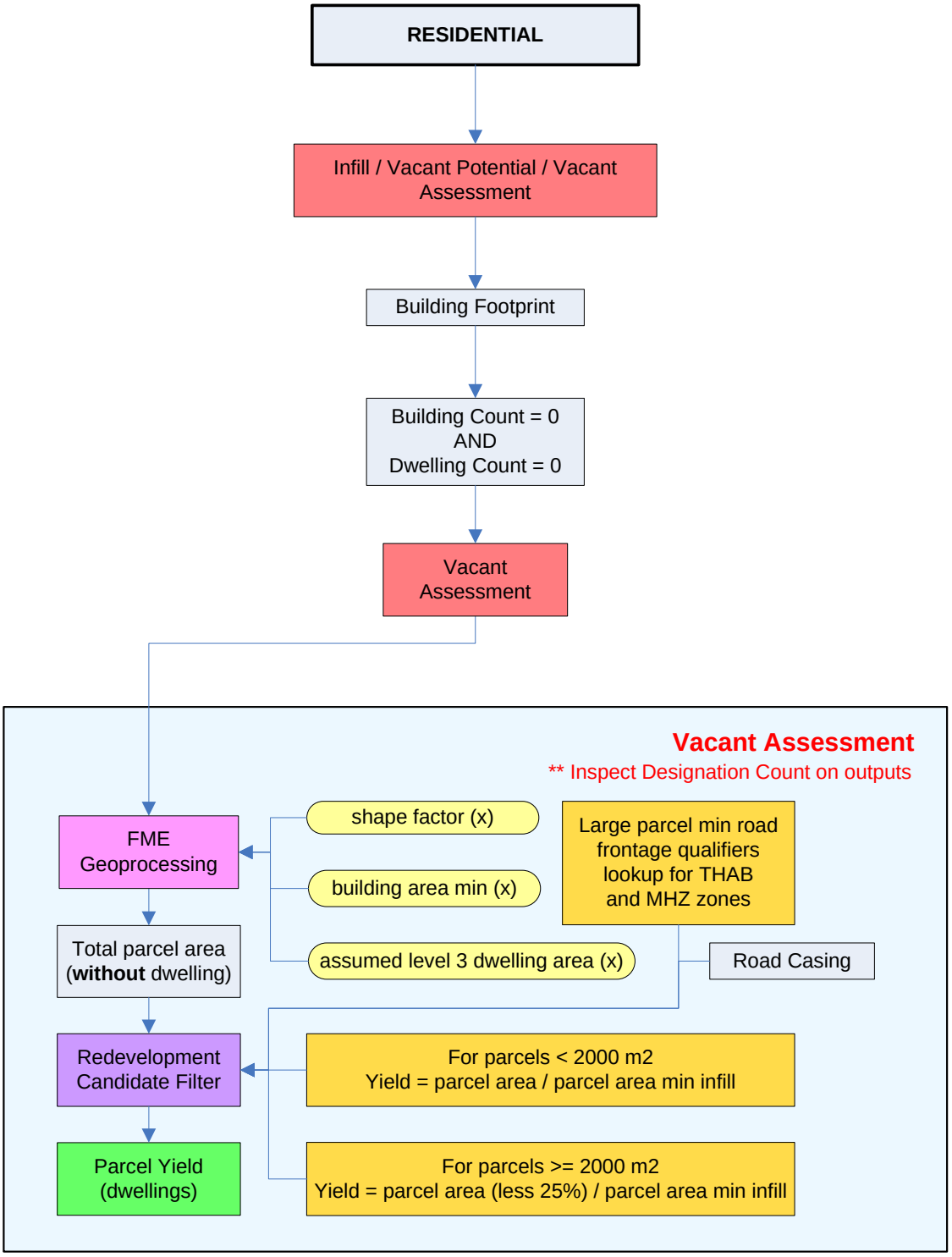
The consent category for obtaining consent for dwellings on vacant residential sites is not assessed or noted, and would note that while the plan may modify the design, style, size, shape or consent category (and potentially the likelihood of a dwelling being constructed) it does not extinguish this underlying ‘right’. Many of these smaller vacant parcels are in fact ‘small scale’ subdivision sites that were granted resource consent to go below the minimum tested for by the model (or smaller)

Note that the approach to vacant parcels taken in rural areas is slightly modified (by the addition of an extra assessment type) to account for *specific rural zone rules* modifying the consent category for dwellings on certain parcel types and in certain zones.

7.2.1 Calculating residential vacant capacity

Vacant residential capacity is calculated through a modelling process, which can be seen in Figure 9.

Figure 9: Diagram of residential vacant capacity calculation



Residential parcels identified by the model as being vacant are selected, and the capacity for these parcels is calculated in one of two methods depending on the parcels size. For parcels that are less than 2000 square metres; the district plan zoning density was applied:

$$yield = ROUNDDOWN\left(\frac{parcel\ area}{minimum\ lot\ size}\right)$$

For parcels that are equal to, or are larger than 2000 square meters 25 per cent of the parcel area was removed from the calculation to allow for reserve contribution, access lots/vested roads etc.; for the remaining area, the district plan zoning density (as for smaller parcels) was applied:

$$yield = ROUNDDOWN\left(\frac{parcel\ area\ \times 0.75}{minimum\ lot\ size}\right)$$

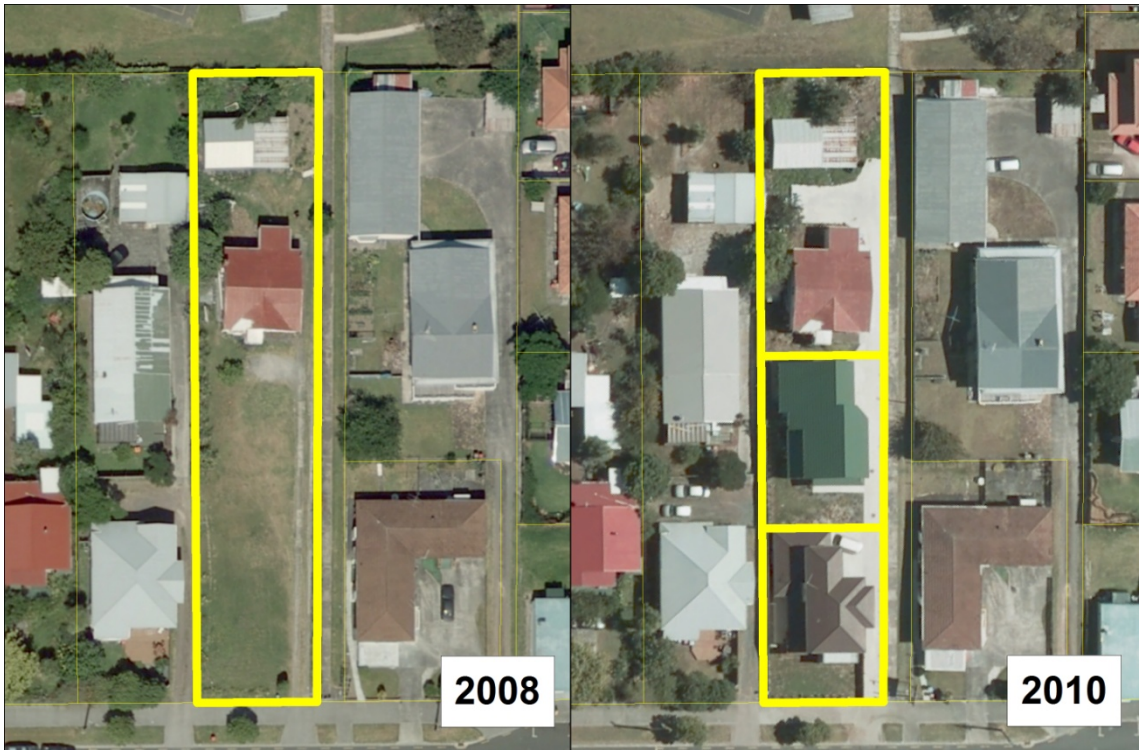
A detailed diagram of each of the spatial modelling and yield calculation processes (undertaken in our modelling software, FME) can be found in Appendix H: FME workbench schematics.

7.3 Residential infill (including vacant potential)

Residential infill capacity (including vacant potential capacity) is the number of additional dwellings that can be yielded from residential zoned parcels that are partially vacant and have subdivision potential (based on the highest consent category from the relevant PAUP rules that contains modellable parameters), presuming that any existing dwellings or structures greater than the minimum valid building area (50 square metres) stay in place.

Below Figure 10 shows an example of where infill type development has previously taken place. The existing dwelling on the parcel has remained in place and in this case, the property has been subdivided allowing for two new parcels each with a new dwelling.

Figure 10: Example of infill on a residential parcel



While the residential infill and residential vacant potential capacity is very similar in typology (i.e. they are both calculated on parcels that currently have a building and/or a dwelling located on them), calculations to determine each parcel's capacity is modelled using differing calculation methods. Parcels considered for *infill* are less than 2000 square metres, while parcels that are measured for *vacant potential* are equal to or larger than 2000 square meters. The reason we make this distinction is to enable us to use and apply slightly different assumptions to the larger sites (vacant potential); this distinction is primarily for modelling purposes, and exists to account for the slightly different development process typically undertaken. While the 2000 square metres area threshold is relatively arbitrary, it is consistent with prior studies and real world examples and can be varied if required in further modelling runs.

The different approaches for calculating yields are listed below (Table 8). The process for calculating yields from both of these capacity types can be seen in Figure 11 below. The application of the yield calculations shown are detailed in section Appendix I: Proposed Auckland Unitary Plan residential zones (CfGS zones) and assumptions.

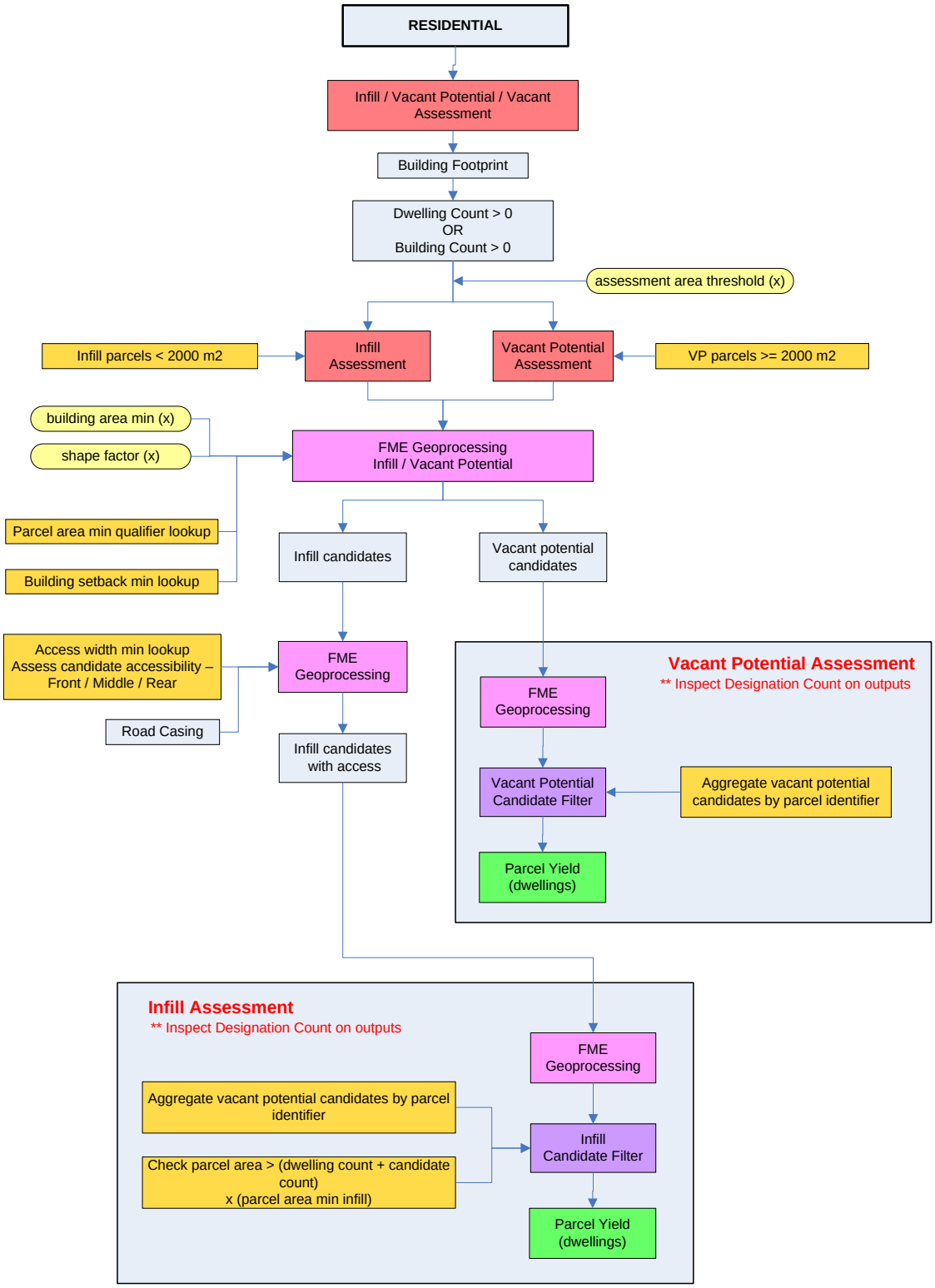
Table 8: Residential parcel size subdivision assumptions

Subdivision type	Parcel size threshold	Description
Small (infill)	Less than 2,000 m^2	Standard infill approach from relevant PAUP district plan rules
Large (vacant potential)	Greater than 2,000 m^2	As per the small subdivision, but the candidate site area is reduced by 25 per cent to allow for reserve contribution, vested roads etc. before the yield calculation is undertaken. No access test is applied (this is assumed to be met through the use of the 25 per cent deducted)

As part of this process, a spatial model was constructed to enable us to determine the part(s) of residential parcels that would be suitable to accommodate additional dwelling(s) in accordance with the PAUP district planning rules. This model used the digital cadastral database (property boundaries) and building footprint outlines in order to make the assessment.

The following section briefly outlines this modelling process.

Figure 11: Diagram of residential infill (incl. vacant potential) capacity calculation



7.3.1 Overview of infill and vacant potential modelling process

Residential parcels that are assessed for infill and vacant potential must first meet the various global residential parameters outlined in section 7.1 (Residential capacity assessment – global assumptions). The next test is a minimum qualifying parcel area test (see formula below), requiring parcels, typically, to be twice the minimum lot size for the zone in which it is located

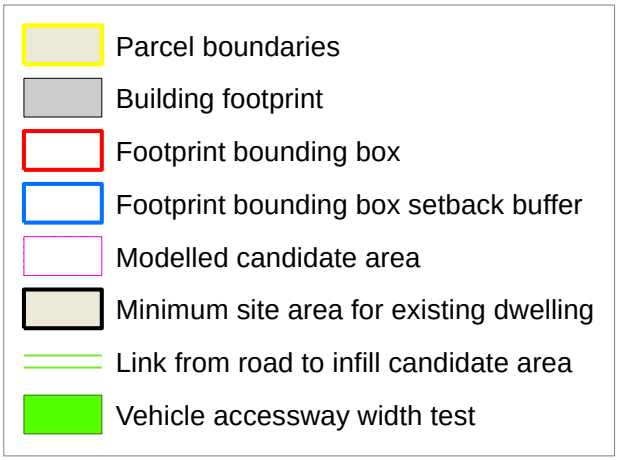
$$Parcel\ area\ \geq\ parcel\ minimum\ area\ qualifier$$

For example if the minimum lot size is 400 square meters the minimum parcel size for assessment would need to be at least 800 square meters (as the new parcel and the existing parcel would both need to meet the minimum lot size requirements of the rules, in most situations[18]).

The next steps are a series of complex spatial and mathematical calculations to calculate infill potential accounting for the spatial arrangement of existing buildings and development on the existing parcel. This infill process varies from the simple mathematical potential (albeit supported by spatial tests) undertaken on vacant parcels (or in redevelopment scenarios) where existing parcel development does not need to be built around. The following sub-sections (7.3.1.1 to 7.3.1.7) outline the infill and vacant potential modelling steps and have been illustrated with figures.

A key to these figures is shown below in Figure 12.

Figure 12: Key to modelling process figures (Figure 13 to Figure 18)



7.3.1.1 Selection of parcel for infill testing

Below Figure 13 shows an example residential parcel that meets the minimum lot size test for the zone.

[18] Two variables are given in the LUT which allow for variation from this simple/common approach - _PARCEL_AREA_MIN_QUALIFIER and _PARCEL_AREA_MIN_INFILL. _QUALIFIER is the minimum lot size to be considered for subdivision, and _INFILL is the lot size used to calculate capacity. In the PAUP these values are exactly double, but variation can allow allowance for net site areas, existing dwellings to be on smaller (or larger) lots and so on.

Figure 13: Selection of parcel for infill testing



7.3.1.2 Application of building bounding box

Once the parcel has been selected, a bounding box is generated on any buildings (as represented by polygons in the building footprint layer, which have been digitised from the aerial photography) that are greater in area than the pre-set building size minimum. This test is intended to filter out garages and other smaller buildings[19] that would not reasonably foreclose infill development. This is shown below in Figure 14.

Figure 14: Application of building bounding box



[19] It is considered that small buildings such as garages and sheds would be of low cost and low effort to move or remove from a parcel.

7.3.1.3 Application of building setbacks

The bounding box is generated to allow us to create a rectangular buffer around the building in order for us illustrate the minimum building setbacks required under the planning rules; this is demonstrated in Figure 15 below. The width of this setback is controlled by 'parcel building minimum setback' variable in the LUT. The setbacks are usually a function of the yard rules, but in this case are only applied to the existing buildings, to ensure the new boundary is set back the appropriate distance to comply.

Figure 15: Application of building setbacks



7.3.1.4 Generation of infill candidate area on candidate parcel

Once the setback from existing buildings has been confirmed the spatial model then generates the potential infill area of a parcel. Below Figure 16 shows an infill candidate area that the modelling has generated on the example parcel. Further detail on the spatial infill candidate creation process is included in section 7.3.2.

Figure 16: Generation of infill candidate area on candidate parcel



It should be noted that at this point, the hatched infill candidate area illustrated in 7.3.2.

Figure 16 is the modelled vacant area of the parcel where additional dwellings could be located. It does not indicate the extent of a potential new lot to contain the building, which would be net of the required area for any existing dwelling(s). Further discussion of the actual process used to find and define the infill candidate area from the candidate area and parcel area is given below in relation to Figure 17, and is discussed in some technical detail in section 7.3.2.

7.3.1.5 Check of remaining infill candidate area on candidate parcel accounting for existing dwelling(s)

A check of the remaining infill candidate area on a candidate parcel to account for a minimum site area required for the existing dwellings is now undertaken. This is done mathematically, but is illustrated visually in Figure 17 where a portion of the candidate is removed as it is required for the existing dwelling. If the remaining unallocated area is still larger than the 'area parcel minimum' variable then the candidate moves onto the next step.

Figure 17: Check of remaining infill candidate area on candidate parcel accounting for existing dwelling(s)



This is the final candidate area available for new dwellings and must be larger than the zone minimum ('area parcel minimum' variable)

7.3.1.6 Test for minimum access width on infill model candidates

Once suitable candidates for compliant infill have been determined a final test is undertaken to check whether there is sufficient room for vehicle access from the road to the infill candidate area of the parcel. This is displayed in Figure 18.

Figure 18: Test for minimum access width on infill model candidates



This example shows that the vehicle access minimum width requirement is met between the existing dwelling and the boundary of the parcel. If this test fails, the parcel is considered unsuitable for infill development ('access test failed').

Note that vacant potential parcels are not subjected to the access test as:

- The access width is generally specified to be wider than the minimum used in the LUT for the higher number of dwellings that would be expected on larger parcels, but also
- Because this latent potential is expected to be sufficient motivation to overcome such 'minor' constraints.

The parcels that fail the access test are saved as a unique dataset for future analysis, as there is a lot of 'land' that is locked up but could be used if access rules were relaxed, buildings were moved, or neighbours get together to undertaken more innovative approaches or sites amalgamated. Examples of where candidates have passed and failed the access test are shown in Figure 19, illustrating the impact of vehicular access on development potential, and the capacity that could be unlocked. This also highlights the degree to which future outcomes of rules based planning are highly interdependent on and with the outcomes of previous rule based planning, which is reflected in the existing built form and cadastral pattern of an area.

7.3.1.7 Calculation of potential capacity yields

Once all of these tests have taken place to filter suitable residential parcels, the infill and vacant potential capacity yields are calculated.

Parcels that are less than 2000 square meters are classified as 'infill capacity', while those equal to and larger than this size are classed as vacant potential capacity. Like residential vacant, parcels smaller than 2000 square metres (refer section 7.2) have their yield calculations generated by using the minimum lot size;

$$parcel\ infill\ yield = \left(\frac{final\ candidate\ area}{minimum\ lot\ size}\right)$$

Yield calculation for residential vacant potential is the same as used for residential vacant parcels greater than 2000 square meters, and uses the same demarcation between parcel sizes to make the calculation. For candidate areas that are equal to, or are larger than 2000 square meters, 25 per cent

of the candidate area was removed from the parcel area calculation to allow for reserve contributions, vested roads etc. and for the remaining area (75 per cent) the district plan zoning density was applied:

$$vacant\ potential\ yield = \left(\frac{final\ candidate\ area\ \times 0.75}{minimum\ lot\ size}\right)$$

It should be noted that the testing for infill and vacant potential is the same, except the access test is not run on final candidate areas on vacant potential parcels (i.e. parcels over 2000 square metres), and 25 per cent of the site is excluded from the developable area before calculating the dwelling capacity for the site.

A detailed diagram of each of the spatial modelling and yield calculation processes (undertaken in our modelling software, FME) can be found Appendix H: FME workbench schematics.

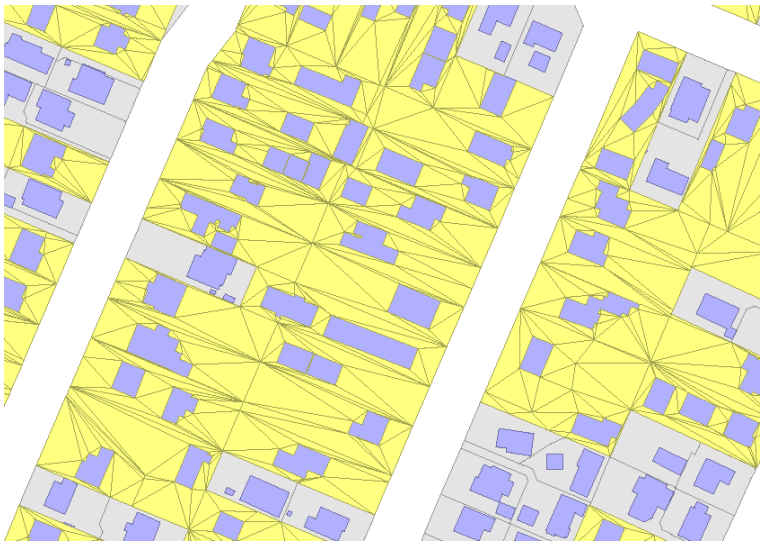
Figure 19: Residential infill candidates that have passed and failed the access test

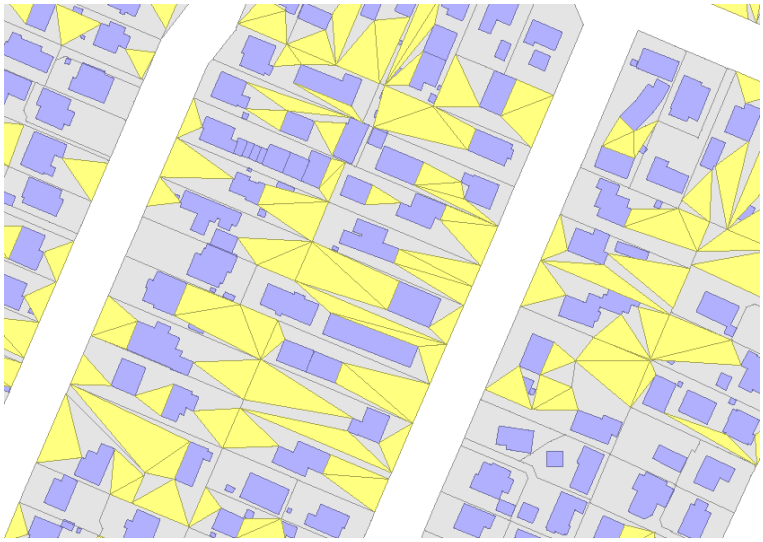
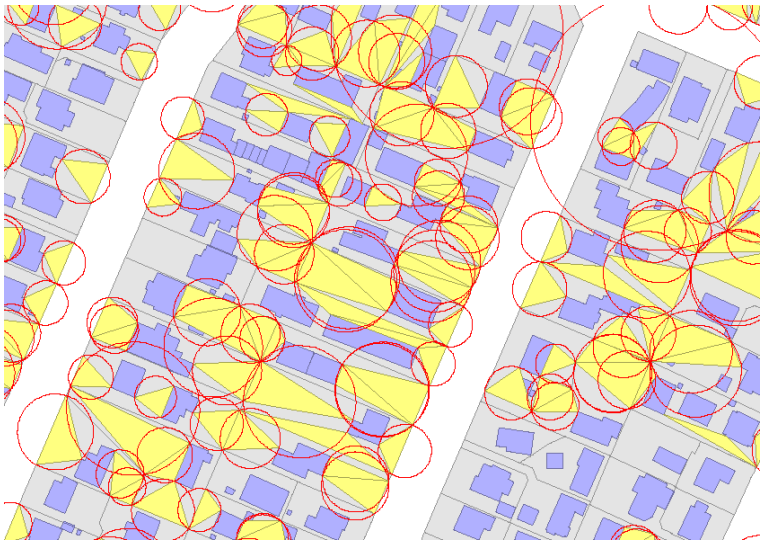
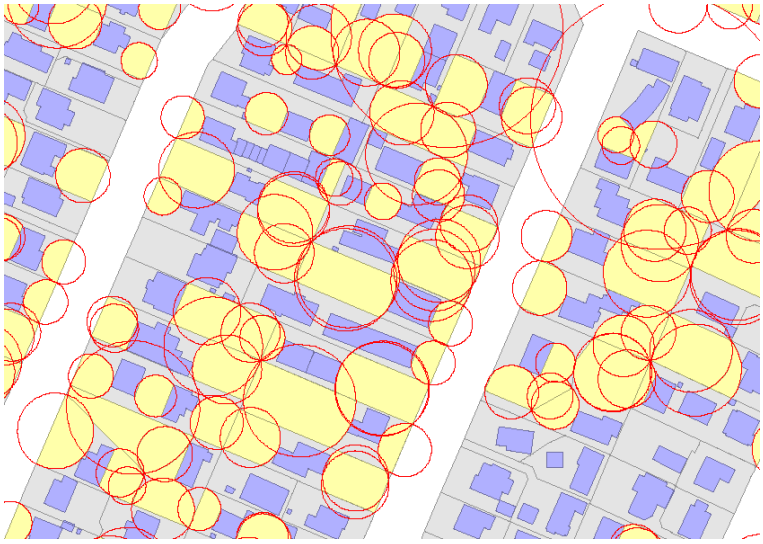


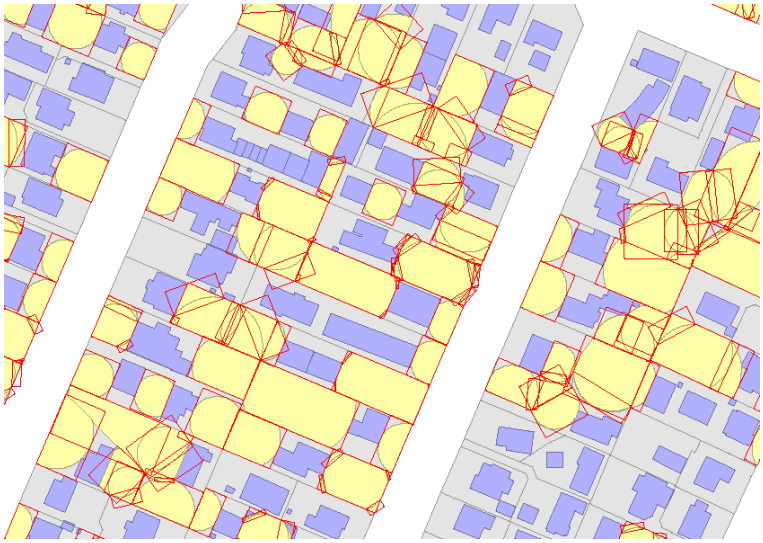
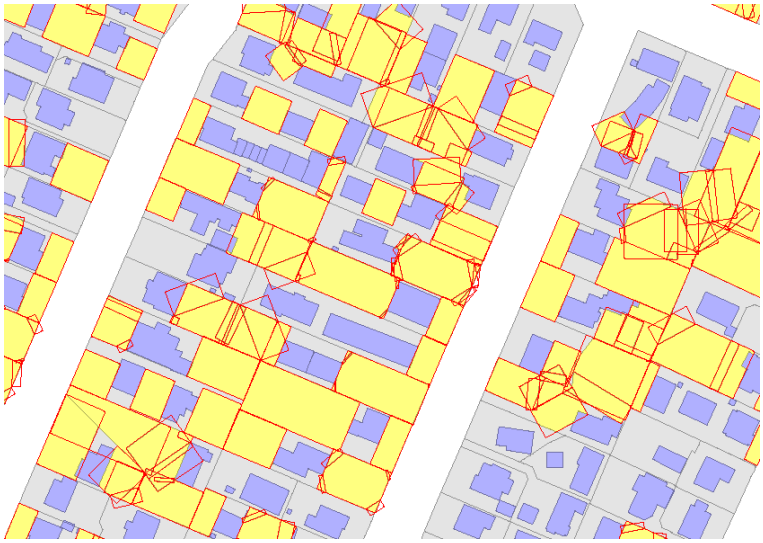
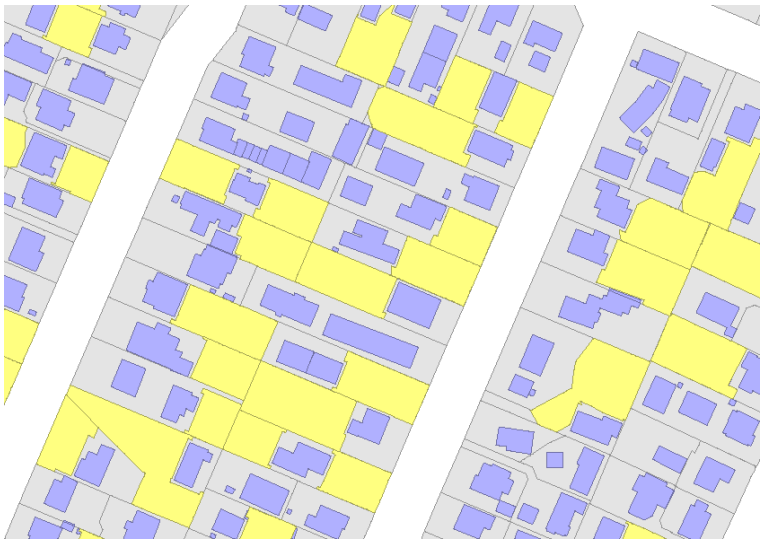
7.3.2 Calculating a parcel's infill candidate area: spatial generation process

This section outlines in some detail the spatial processing undertaken to find the infill candidate areas on parcels also taking account of existing buildings, as described conceptually in the preceding section particularly 7.3.1.4 above. This section is included as to allow the reader to understand the spatial analysis involved in generating the outputs for this capacity type. We believe this is a significant advance on previous approaches undertaken to assess the area of a parcel available for possible infill development, and an improvement on previous capacity studies. While the diagrams below in Table 9 show the outcomes of the spatial processing and conceptual basis, the undertaking of the modelling behind these diagrams is considerably more intricate.

Table 9: Conceptual visualisation of outcomes of spatial processing for infill candidate area assessment

Step	Image
Step 1: 'Real world' represented by cadastral property boundaries aerial photography and building footprints.	
Step 2: Triangulate the vacant space (between building platforms and parcel boundaries) Note that not all parcels get triangulated – they are too small to subdivide according to the minimum parcel area rules applying to them (i.e. *parcel area calculated < parcel area minimum)* and are excluded to reduce the significant geo-processing overhead inherent in this intensive spatial assessment.	

Step	Image
Step 3: Triangles are filtered by area and shape, leaving only the larger, and 'less pointy' ones (select top three ranked triangles on each parcel using area and circularity test). Note also that the triangulation process ignores buildings less than a certain size (i.e. *building footprint area calculated > building footprint min (50* m^2*)*) – which is also configurable.	
Step 4: Expand the three top ranked triangles to gain more coverage using circles (a circle can be defined by any three points on its circumference).	
Step 5: Clip the circles to the parcel their instantiating triangle relates to.	

Step	Image
Step 6a: Replace clipped circles with a geometry orientated bounding box to further extend candidate coverage.	
Step 6b: Clip the bounding boxes to the parcel their instantiating triangle/circle relates to.	
Step 6c: Buffer buildings *(> building footprint min (50 m2))* by the required setbacks (*building_setback_min)* to ensure compliant separation of the candidate area from the existing building(s) **Step 7:** Filter out the candidate areas that are not large enough to contain a new site *(> parcel area min*) after also allowing for the existing dwelling count to occupy any required area of the parcel (as both existing AND new lots must meet the minimum site area tests)	

Step	Image
Step 8: Then test that those with sufficient remaining candidate area can also contain a building platform (in this case a 120 m² square (converted from 8 x 15 m rectangle referred to in rules for processing requirements)), and the remaining ones are then passed on to the next step. **Step 9:** Access tester for width *(> access width min*) by creating a shortest path between the candidate parcel and the road parcel casing, while avoiding any buildings in the way, and use of buffering Parcels in yellow have passed all tests; parcels in pink have passed all tests except 'access'.	
Step 10: Back to the 'real world' showing passed candidate areas on parcel geography. In reporting we show the whole parcel as having capacity rather than the modelled candidate area for both visibility on the large scale maps we produce, and also to avoid 'over-analysis' of the candidate areas/shapes rather than a focus on the message that it is the *whole site* that carries the potential as the development does not necessarily need to be located within the candidate area. The candidate area testing is a means to determine site potential, not (necessarily) a guide to determine the future development form on that parcel.	

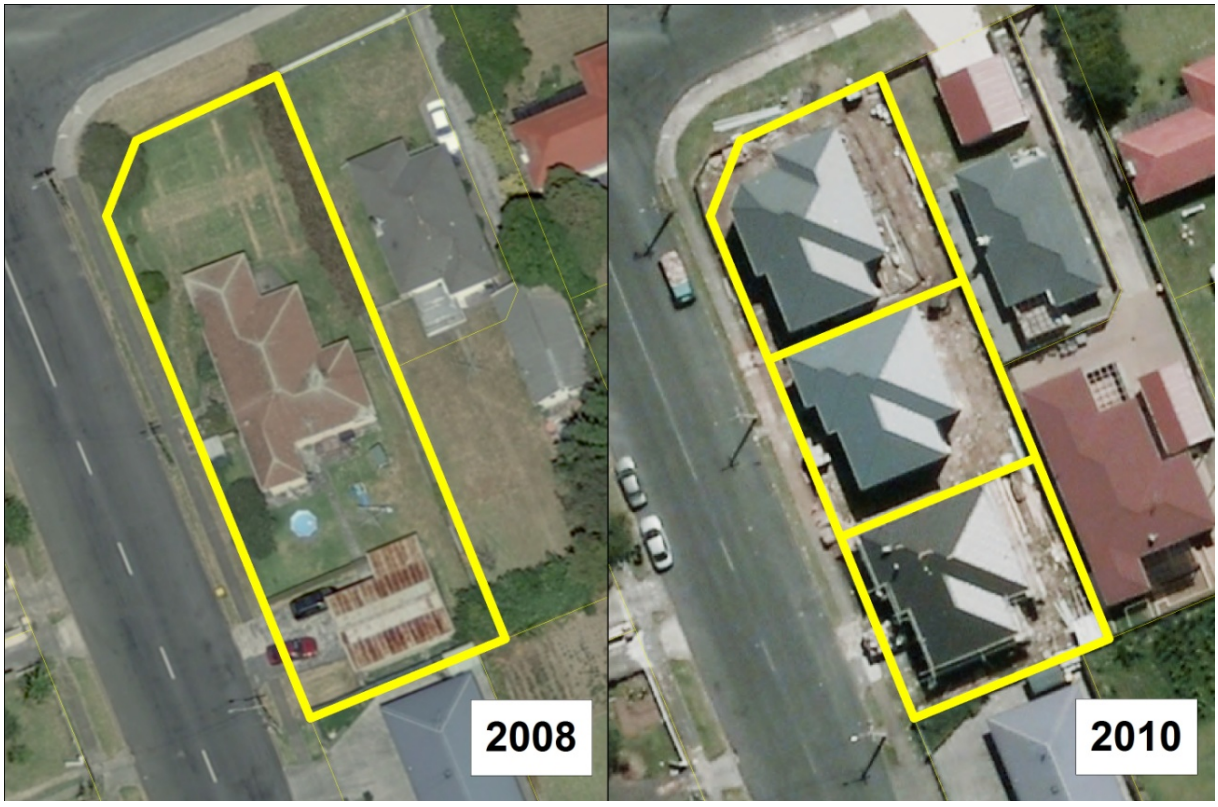
7.4 Residential redevelopment

Residential redevelopment capacity is the number of additional dwellings that can be yielded from residential zoned parcels, presuming that all existing dwellings/structures are removed and the parcels are redeveloped to yield the maximum number of dwellings permitted (based on the modelled consent category from PAUP district planning rules). Examples of this kind of development are shown in Figure 20 and Figure 21 below. In both these examples, the site area is sufficient for additional dwellings under the applicable rules, but the locations of the existing buildings preclude (compliant) infill development. That is, these parcels would fail the infill modelling assessment as described in the previous section.

We note that two types of redevelopment are most prevalent; redevelopment through the removal of the existing dwellings or buildings and building to a higher density or, redevelopment through the relocation of an existing dwelling on a parcel to allow for additional dwellings (examples of which are shown in Figure 20 and Figure 21). Both of these potential development approaches are valid outcomes under the method used to calculate capacity, which calculates a net increase in dwellings irrespective of the actual mechanism used when they are developed, two examples using these figures are:

- Using Figure 20
  - Three new dwellings less one existing dwelling (in this instance removed offsite)
  - Results in a net increase of two additional dwellings.
- Using Figure 21
  - Two 'new' dwellings less one existing dwelling (in this instance relocated onsite)
  - Results in a net increase of one additional dwelling.

Figure 20: Example of redevelopment through the removal of an existing dwelling*



* Also note infill on adjacent parcel

Figure 21: Example of redevelopment through the relocation of an existing dwelling



Redevelopment is an important measure of the theoretical capacity of the PAUP. It is critical that we understand the maximum number of dwellings that the plan has enabled in various areas, because although it is highly unlikely that *all* of these opportunities will be taken up, it is probable that *at least some* could be. It is important to be able to accurately capture the degree of maximum theoretical change the plan enables as a best (or worst) case scenario to determine what the maximum level of change that the plan allows is, based on the existing level of development, current cadastre and generally compliant future development.

Like the other forms of residential capacity, residential redevelopment capacity is calculated through a spatial modelling process, which is outlined in Figure 22 below. The gross area of each residential parcel is calculated as part of the model, after which the redevelopment capacity yield is calculated. Like the process for calculating yield in the residential vacant and residential infill components, the calculation varies based on the size of the gross parcel area, and whether it is smaller than, or greater than or equal to the infill/vacant potential demarcation threshold - in this case 2000 square metres. As each parcel is 'assumed to be vacant' or effectively cleared of development before redevelopment occurs, no spatial candidate area or access test is undertaken. The existing legal parcel is assumed to have existing road access, and is a suitable shape to accommodate residential development. For residential redevelopment, calculations are almost entirely mathematical.

Yield net calculations are undertaken to only report the net increase in dwellings (that is we report the potential for *growth*, rather than change in itself), and the existing dwelling count is removed from the gross parcel yield (all negatives are reset to zero), and reported as parcel yield. Thus only parcels with plan facilitated redevelopment potential for additional dwellings under the rules being assessed are captured in the output dataset. Alternatively, parcels with a number of existing dwellings greater than the tested rules allow are not assumed to be 'redeveloped' to this new lower density – while certainly possible, we consider this scenario to be highly unlikely.

For parcels that are less than 2000 square metres; the district plan zoning density was applied:

$$yield\ on\ parcels < 2{,}000\ \mathrm{m}^2 = \left(\frac{parcel\ area}{minimum\ lot\ size}\right) - existing\ dwelling\ count$$

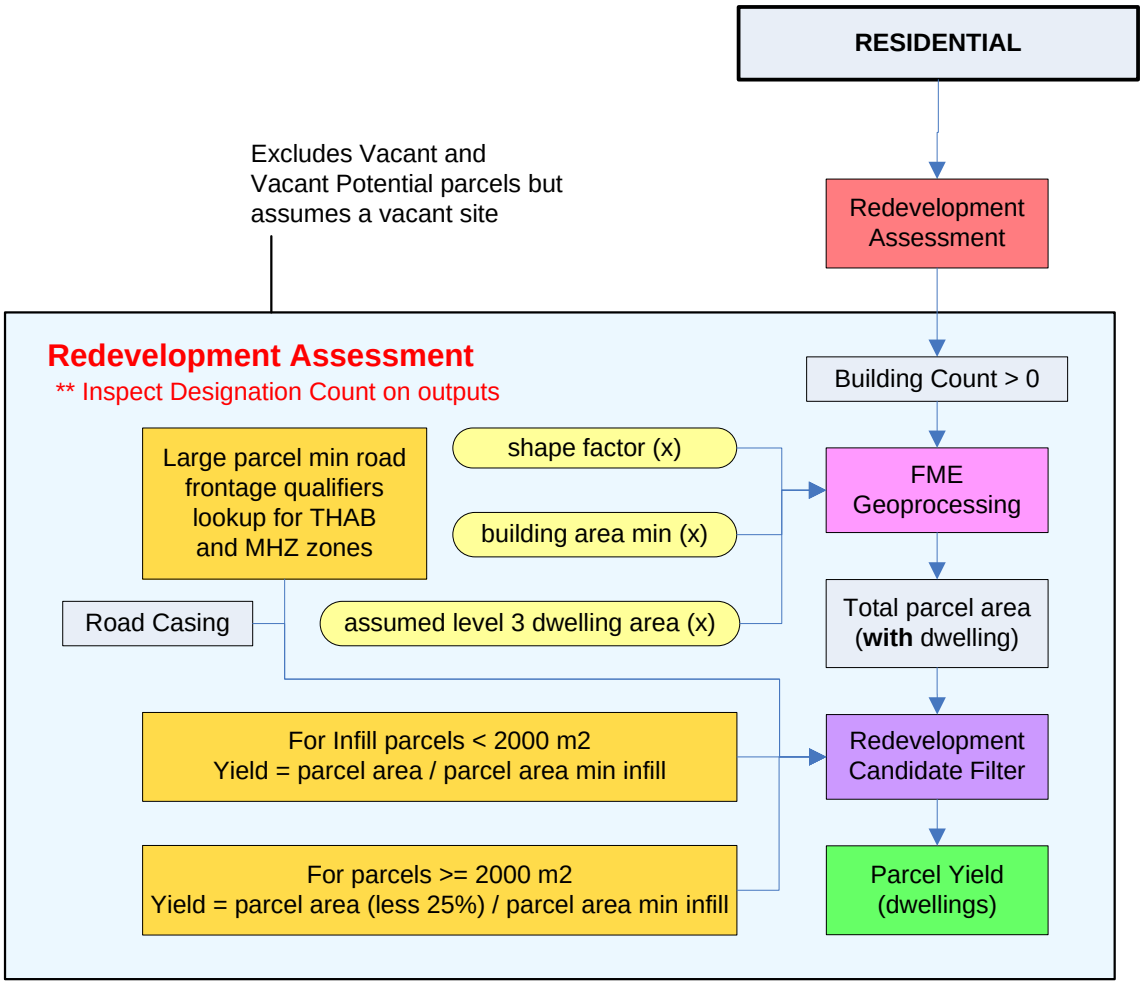
For parcels that are equal to, or are larger than 2000 square meters square meters; 25 per cent of the parcel area was removed from the calculation to allow for reserve contribution, vested roads etc. and for the remaining area the unitary plan zoning density was applied:

$$yield\ on\ parcels \geq 2000\ \mathrm{m}^2 = \left(\frac{parcel\ area\ \times 0.75}{minimum\ lot\ size}\right) - existing\ dwelling\ count$$

A detailed diagram of each of the spatial modelling and yield calculation processes (undertaken in FME) can be found in Appendix H: FME workbench schematics.

Results for residential redevelopment capacity can be found in the *Capacity for Growth Study 2013 (Proposed Auckland Unitary Plan): Results* technical report.

Figure 22: Diagram of residential redevelopment capacity



Under residential redevelopment modelling, if the assessed capacity is greater than what is currently on site, then the parcel is reported as residential redevelopment candidate.

Further work is recommended to better understand the relationships between the plan enabled potential for redevelopment identified using the simple spatial factors utilised in this study, and the

many other factors that influence redevelopment activities. The results of this study (being a reflection of what the plan allows to happen) are only one aspect of the likelihood of development occurring equation.

Residential redevelopment capacity is not calculated on parcels that are 'vacant', or have been identified as having 'vacant potential', as the development potential of these parcels is already captured using a similar assessment methodology; this is outlined in Table 10.

Table 10: Redevelopment and relationship to other capacity assessments

Capacity assessment type	Also assessed for redevelopment capacity	Notes
Vacant	No	Site is already 'redeveloped'
Infill	Yes	Removal of existing dwelling and redevelopment to maximum permitted density may result in higher yield than infill method due to location of buildings etc.
Vacant potential (infill on sites larger than 2,000 m^2)	No	'Redevelopment style' modelling approach already taken via vacant potential assessment. Location of existing development is not explicitly considered in vacant potential modelling (e.g. access test, building buffer etc. accounted for by 25% net site area reduction), net yield results of both calculations will be the same.
All other parcels without yield under other capacity assessment	Yes	Removal of existing buildings and redevelopment to maximum permitted density may result in a yield not identified by other approaches due to location of buildings etc.

A clarification also needs to be made between the assessment of redevelopment capacity on a parcel level and the reported capacity using redevelopment. The two are used as upper and lower ranges for capacity reporting and are based on different combinations of capacity types as indicated in Table 11 below.

Table 11: Constituents of residential capacity totals

Capacity type	Capacity utilising infill	Capacity utilising redevelopment
Vacant	✓	✓
Infill	✓	✓
Vacant potential (infill on sites larger than 2,000 m^2)	✓	✓
Redevelopment	(THAB and MHZ intensive development parcels only)	✓

Accordingly, the reported 'capacity using infill' calculation is:

$$Capacity\ utilising\ INFILL = (vacant + infill + vacant\ potential)$$

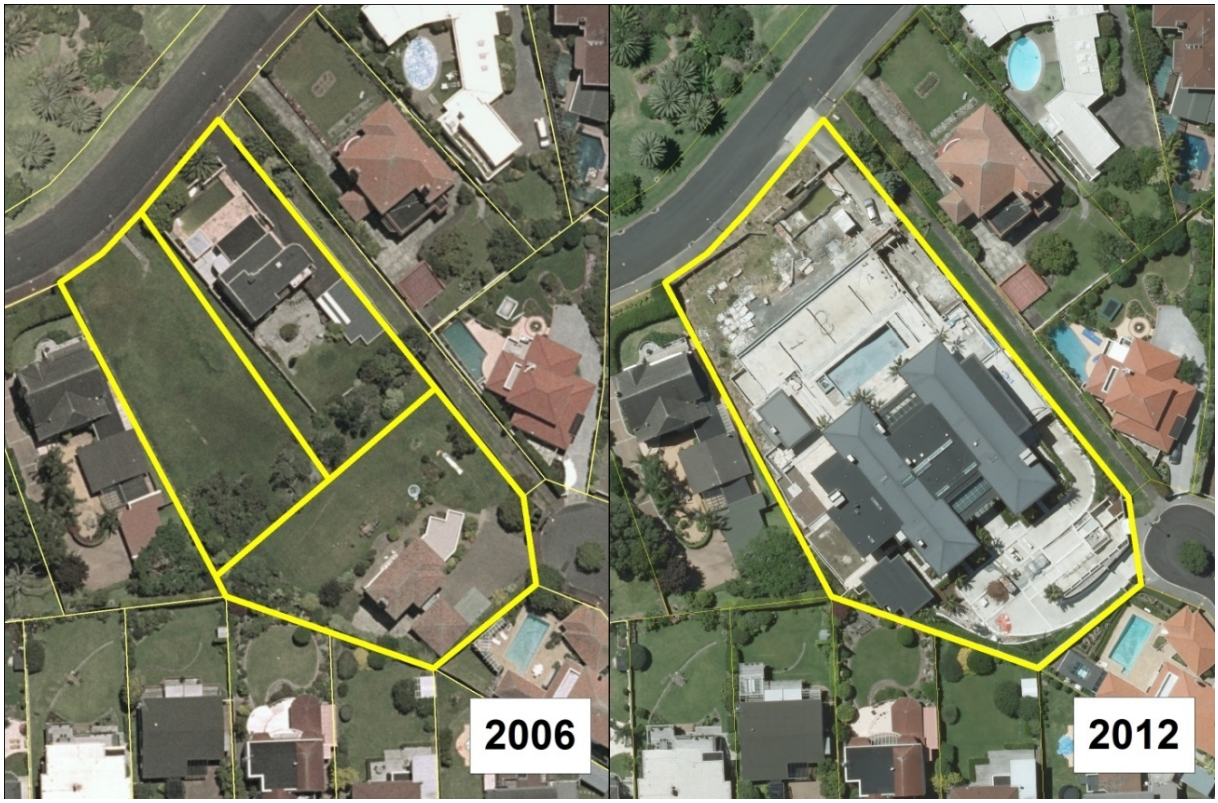
Whereas the reported 'capacity using redevelopment' calculation is:

$$Capacity\ utilising\ REDEVELOPMENT = (vacant + vacant\ potential + redevelopment)$$

Our primary interest in this study is not to measure or forecast 'all new development' or ‘change’ but to find the plan enabled potential for development that could increase the net total stock of dwellings in plan compliant way.

The capacity calculations should not be used as a forecast of total dwelling construction activity, because they will be somewhat higher than net increase in dwellings (capacity) as existing dwellings must be at least numerically replaced before additional stock is created, and upgrade and/or replacement of existing stock without increasing the total number of dwellings is also very common. It should be noted that there are cases where redevelopment of a site does not yield additional dwellings and in fact reduces the overall number of dwellings. Often this reduction in the number of dwellings also occurs through the amalgamation of parcels, as demonstrated in Figure 23.

Figure 23: Example of redevelopment yielding fewer dwellings



The example seen in Figure 23 shows three parcels that have been amalgamated into one parcel in order to build a large residence on the parcel, thus reducing capacity potential.

The Capacity for Growth Study 2006 recorded a capacity potential of three additional dwellings across the parcels (a possibility for two dwellings on the then vacant parcel and one dwelling on one of the then occupied parcels). With the amalgamation, site clearance and subsequent new dwelling construction the *infill* potential of the parcel has been reduced to zero, both in an infill modelling sense and in a practical one - who would demolish such recent high value improvements to replace them in the short term? This type of 'redevelopment' has not been assessed as part of the study, as it is relatively rare, and effectively impossible to forecast.

Potential for the single large dwelling already existing on a site to be (internally) converted into a number of smaller ones however does exist; both in a planning rules sense and a practical one, and this would still be captured by the redevelopment calculation which works on the land area / minimum dwelling area less existing dwellings. Because the number of existing dwellings is one, but the parcel is large enough to contain many more under the minimum site areas applying in the zone, this parcel will still have a calculated redevelopment yield. Again it is the net potential for additional plan compliant 'dwellings' we are trying to capture, not just 'new build houses'. Filtering work post study can be used to exclude examples of this type from the overall figures, using such metrics as estimated age

of dwelling (it's too new to be economically converted or demolished), or improvement value to capital value ratios (it's too valuable to be converted or demolished), should these examples be required to be excluded.

As the study's results are expected to be used for a very wide range of uses, some of which are unknown, we have captured everything, for filtering later, that filtering depending on the end use.

7.5 Intensive development in residential zones: capacity calculation methodology

The PAUP proposes a number of zones (Mixed Housing Suburban (MHS), Mixed Housing Urban (MHU) and Terraced Housing and Apartment Buildings (THAB)) where more intensive, generally attached[20] styles of residential development is enabled, but only on sites that meet a certain criteria. In the two Mixed Housing zones, detached development is enabled on sites not meeting these criteria; in the THAB zone only sites meeting the criteria are developable. For these more intensive development opportunity sites, the 'traditional' infill approach as outlined above is not the best method to identify potential capacity under these new planning provisions; it being more suited to detached style dwelling assessment. This is because not only are the site and space criteria for multiple dwellings often quite different from those for single detached ones, but also the role of volume (i.e. width, depth and height) starts to play a role, rather than just land area (width and depth).

Development of a number of new approaches to calculate potential for residential development have been created incorporating key rule/zone parameters and enabling them to be varied if required. This section outlines approaches taken to calculating capacity in these zones, from most to least intensive.

Illustrated in Table 12 below are the categories of assessment that these intensive residential zones fall into. Note in particular that the THAB and 'large parcel' mixed housing options are undertaken as redevelopment and vacant site assessments only. This is for two main reasons:

- **Modelling process constraints and practicality:** The nature of the infill candidate shapes created are such that they will never pass the road frontage test even if otherwise their shape and area is sufficient - the shapes have non-linear (or jagged) edges (from the iterative expansion and clipping process used to generate them), so their road frontage (if any - most will be to the rear of existing buildings) will be small at the GIS measurable scale even if to the eye they look to be likely candidates.
- **Rule intentions:** THAB and mixed housing large parcel developments are intended as a comprehensive full site redevelopment type approach in most cases. It is not intended that existing standalone dwellings should remain on the site to be 'built around' potentially compromising design outcomes - thus our capacity assessment is undertaken only on vacant parcels or as a full site redevelopment option, not as infill[21].

Care therefore needs to be made in comparing 'capacity utilising infill' and 'capacity utilising redevelopment' in these zones and between these zones and other zones.

'Standard' and 'intensive' development type in the table below refers to relative intensity of development enabled on those parcels by the respective zoning rules interfacing with their site area and frontage. Refer to respective parcel area/frontage diagrams in the following sections.

[20] Attached dwellings are houses that share at least one common wall; these include townhouses, apartments and 'sausage' flats/units.

[21] Reiterating that 'non-large parcel' MHZ developments (for developments of less than four dwellings on sites not meeting the unlimited density criteria) are assessed in the infill/vacant potential category

Table 12: Assessment categories for development in intensive residential zones

PAUP Zone	Development type	Area/ frontage diagram colour	Vacant assessment	Infill/vacant potential assessment	Redevelopment assessment
Mixed House Suburban	'Standard' development candidate parcels	All excl. green	✓	✓	✓
	MHS 'Intensive' development candidate parcels	Green	✓	N/A	✓
Mixed House Urban	'Standard' development candidate parcels	All excl. green	✓	✓	✓
	MHU 'Intensive' development candidate parcels	Green	✓	N/A	✓
Terraced House and Apartment Buildings	THAB single dwelling candidate parcels	White section only	✓	N/A	N/A
	THAB 'Intensive' development candidate parcels	All parcels excepting white	✓	N/A	✓

7.5.1 Terraced Housing and Apartment Buildings (THAB) zone

The Terraced Housing and Apartment Buildings (THAB) zone provides for attached residential dwelling developments that can be constructed on parcels that meet certain size and shape rules, up to a certain number of levels (as determined by the base zone rules and overlays, if present). The rules relating to the THAB zone do not state nor directly control dwelling density within the building. A number of bulk and location requirements also apply which are allowed for in the modelling (site coverage in particular, but also various setbacks). Other, more subjective urban design criteria also apply; it is assumed all modelled developments will conform to these criteria[22].

In effect the THAB zone rules control the bulk, location and form of *buildings*, and the sites on which they can be constructed, within the confines of which, *residential dwellings* may exist. Lower density developments are not encouraged, though there is a provision allowing single dwellings (one dwelling is permitted, developments of two to four dwellings are discretionary, and developments of five or more are a restricted discretionary activity).

We have interpreted this new 'single dwelling' provision (after discussion with the Unitary Plan residential team) to mean that a single dwelling is enabled as a permitted activity only where one does not currently exist, rather than an open ended provision allowing iterative additions of infinitely more dwellings, so long as they are added one at a time. (Both of these approaches are arguable interpretations of the rules as written). If this is not the case (and single dwellings are permitted to be added iteratively as permitted activities, without limit), then the potential for dwellings in the THAB zone could be considerably higher than we have calculated.

This 'single dwelling' provision, as we have interpreted it, and the Unitary Plan team advise they believe it is intended it to be read, also has the potential to *decrease* potential redevelopment uptake in the THAB zone by allowing potentially very low density developments on currently vacant (or occupied by non-residential activity) parcels, potentially precluding THAB style redevelopment in the short to

[22] As we are modelling potential based on building bulk alone, we assume that detail of the design, layout and etc is of relatively minor effect on overall yield in aggregate, though there will obviously be instances on a site specific basis where such matters could result in large variation from modelled outcomes, but such issues apply to a greater of lesser degree to all modelling.

medium term and/or reducing potential scope for future parcel amalgamation necessary to create the site requirements for THAB development by increasing the improvement value on the site.

This is because while the THAB zone allows significantly more intensive development than is current in most locations where this zone applies; it is heavily reliant in change (via site amalgamation) to the existing cadastral pattern to create the site characteristics required to trigger the application of the rules. Amalgamation is rare in Auckland context historically, but anecdotal discussions suggest that it is most likely to occur where improvement value is low and land values are high. Any interim low density improvements therefore reduce the stock of potential amalgamation candidates and foreclose more intensive development intended by the THAB zone provisions (see also section 7.7: Amalgamation of residential parcels).

Like all the other zones, parcels are assessed for capacity as they exist at the time of the study. The THAB zone requires that sites have a minimum road frontage length and that length be present for 80 per cent of the site depth. In relation to the modelling, only the first requirement is tested (road frontage length), meaning that a large number of parcels meeting this test are corner sites. This means that if a corner site's two road frontages together exceed the minimum length development could be 'consentable', subject to specific design/context considerations, despite not strictly meet the "frontage is 80 per cent of depth" requirement[23].

Modelled development potential in the THAB zones has been limited to those sites that currently have sufficient frontage. This is a small proportion of the total number THAB sites, as well as a small proportion of the THAB zoned area. The THAB zone rules are implicitly encouraging of, and reliant on the amalgamation of parcels within the zone in order for more comprehensive redevelopment opportunities to be realised. The potential for the THAB zone to deliver significantly more capacity for additional dwellings exists if parcel amalgamation is undertaken.

The calculation of capacity for additional dwellings on parcels within the THAB zone is split into two main steps, these are:

- Site selection criteria: selection of sites on which THAB development can occur
- Development criteria: development criteria to apply to sites that pass the site selection criteria.

These steps are explained and expanded upon in the following sections.

7.5.1.1 THAB site selection criteria

There is no size constraint on the site selection for the THAB zone, only a requirement for a minimum length of road frontage. The road frontage needs to be greater than 25 metres, or greater than 30 metres if bonus floor levels (plus any additional height overlay) are to be used. Note that volcanic viewshaft constraints may apply where these are less than the available height limits.

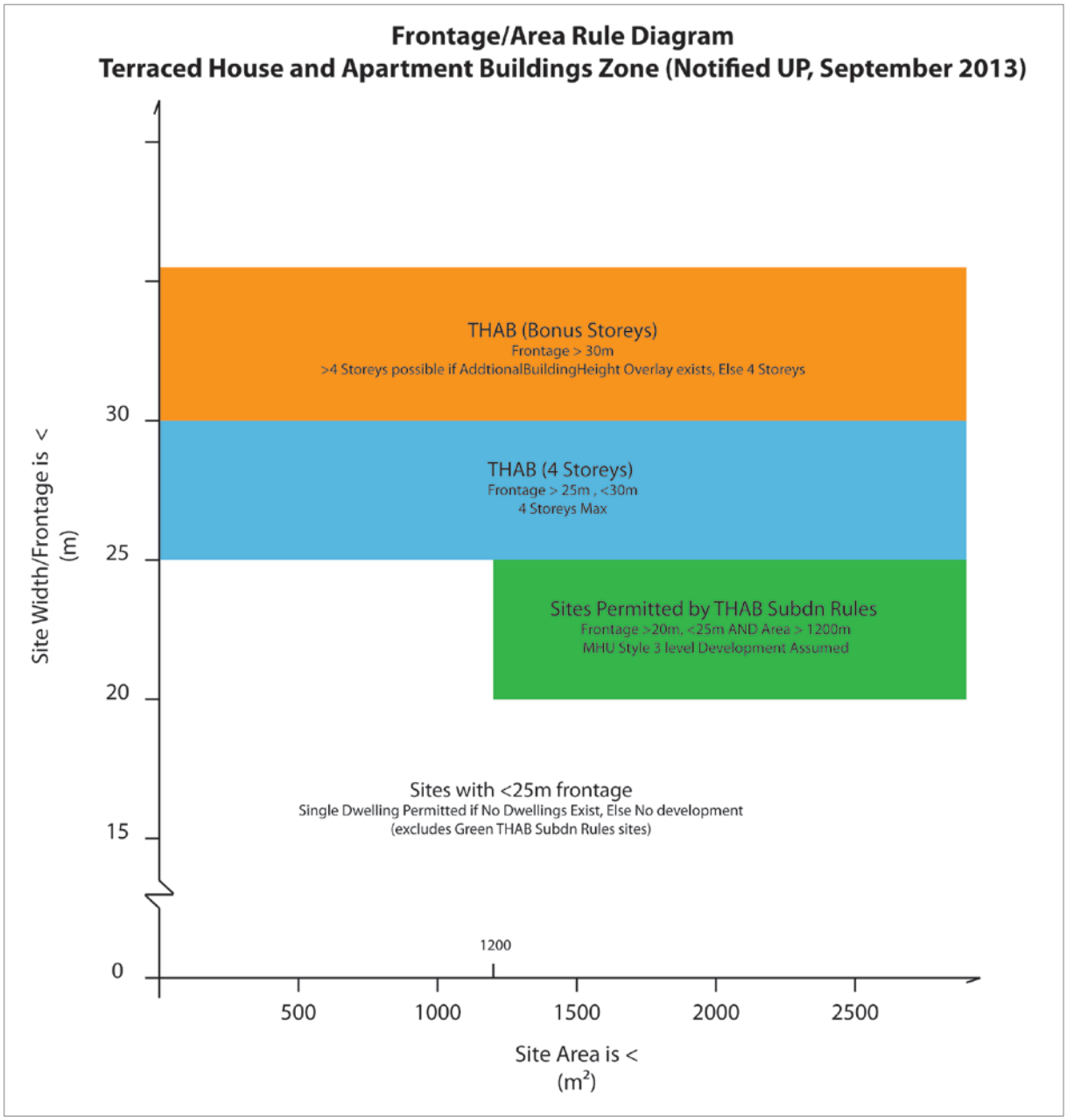
Sites that are larger in size than 1200 square metres and have more than 20 metres, but less than 25 metres of road frontage are not specifically mentioned in the THAB residential rules, but are outlined in the subdivision section of the plan. Therefore minimum vacant site parameters are able to be created. Discussions with the Unitary Plan team suggests that given that the subdivision rules allow the creation of sites that cannot be developed in strict accordance with the zone rules, that an assumed 'consentable' development opportunity would be best modelled. We have therefore added a category of development where sites meeting the subdivision criteria (parcels greater than 1200 square metres, with a frontage between 20 metres and 25 metres would be modelled as a three level Mixed House

[23] The rules are not clear on this point, and informal discussions with the Built Environment Unit of Auckland Council suggest such corner sites would likely have the higher-density development consented due to the ability for development to front the street and be setback from adjoining properties. Stricter interpretation of this rule (one frontage only) would reduce valid THAB candidates to near zero also reducing reported capacity further. Addtionally on corner sites the depth to frontage requirement applies either as the whole frontage (to which no part of a standard parel would be equal to or greater in width) or a diagonal accrss the parel, and only the diagonal section will meet the width to depth ratio, either way in each approach the portion of the site equal to or greater than the frontage is near 0, certainly nowhere near the required 80%.

Urban (MHU) style, rather than assuming no development (or a single dwelling). Single dwellings are allowed for if a site currently has no dwelling(s)[24].

Considering the above, we have developed frontage/area rule diagram, as shown in Figure 24. Arranging the site selection data in this way (representing the rules through the coloured 'boxes') has allowed us to create a modelling process with parameters that could be adjusted or amended if necessary. This is also useful for manually testing an individual parcel's capacity results by being able to quickly see what potential a site might have when looking at its frontage and site size on the graph.

Figure 24: Terraced Housing and Apartment Building zone frontage/area rule diagram



[24] Note this is different from vacant assessment, which requires there to be no dwellings and no buildings larger than 50 square metres. This is because while all dwellings are buildings, not all buildings are dwellings.