

Measuring Auckland's Urban Extents: Background and Methodology

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1.0 Overview

1.1 Background

Urban extents provide a snapshot of the size and shape of the portion of the Auckland region that is urbanised (focused primarily on the main urban/built up area). These snapshots are based either on historical information, or aerial ortho-imagery (aerial photographs) from which digital spatial datasets have been created. These datasets are stored as polygons in Auckland Council's corporate spatial data (GIS) repository (known as SDE). The measuring of the location of the extent of Auckland's urban area is currently undertaken by council's Land Use and Built Environment Research team, part of the Research Investigations and Monitoring Unit.

Auckland Council currently stores 15 urban extent snapshots, the earliest being 1842 and the latest dataset being 2014. Table 1 below details the years for which a snapshot exist and lists the source of this data set. More information about the datasets, their sources and how they were captured can be found in section 1.3 (Urban Extent Data Sources). A map illustrating the urban extents listed in Table 1 can be found below in Figure 1.

Table 1: Auckland Council urban extent datasets and sources

Year	Source
1842	Bloomfield (1967)
1871	
1915	
1940	Unknown
1945	Bloomfield (1967)
1959	Auckland Council
1964	Bloomfield (1967)
1975	Auckland Regional Council (1)
1987	
1996	Auckland Regional Council (2)
2001	
2006	
2008	
2010/2011	Auckland Council
2013	Auckland Council
2014	Auckland Council

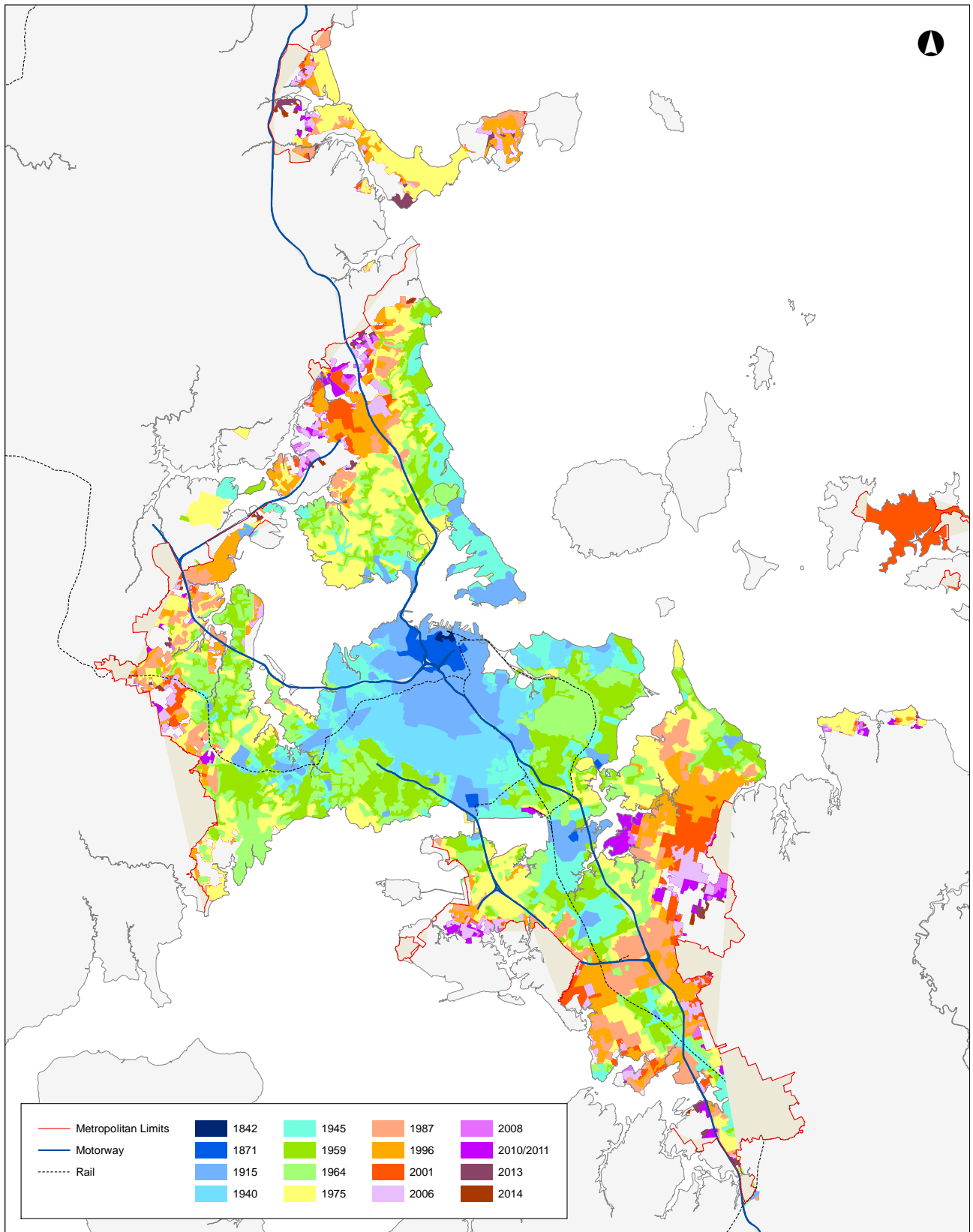


Figure 1: Historic Urbanisation in the Auckland Region: 1842 - 2013

1.2 Data use

The principle use of the urban extent data is to measure the expansion of the urban area over time. Examples of use of the urban extent datasets include:

- Measurement of the size of the urbanised area, for use in population density calculations
- Calculation of the rate of urbanisation of peri-urban areas¹
- Visualisation of the development age of urban areas²
- Measurement of the loss of rural land and high-class³ land to urbanisation

1.3 Urban Extent Data Sources

1.3.1 Urban extents for 1842, 1871, 1915, 1945, and 1964

We are very fortunate to have urban extent information for Auckland dating back to 1842. This data is sourced from an article by Bloomfield (1967) called 'The Growth of Auckland 1840-1966', which included maps detailing the extent of Auckland's urbanised area, and how it was growing over time. Figure 2 (see below) shows a copy of one of these maps, this particular example showing how the urban area of Auckland grew between 1916 and 1945.

The urban extent data shown on the maps in Bloomfield (1967), was captured through the manual digitisation at an unknown time (prior to 2006) by staff of the Auckland Regional Council (Tony Batistich, personal communication, 2007). This data was then stored as a GIS dataset in the Auckland Regional Council's spatial data repository.

¹ Areas that are in some form of transition from strictly rural to urban. These areas often form the immediate interface between rural and urban areas. They may eventually evolve into urban areas, or they may stay somewhere in between. The majority are on the fringe of established urban areas but they may also be clusters of rural-residential developments within rural landscapes. (Parliamentary Commissioner for the Environment, 2001).

² Land included within the urban zones of metropolitan urban area, satellite towns, rural and coastal towns, serviced and unserviced villages (Auckland Council, 2013).

³ High class land is defined as Land Use Capability (LUC) Classes 1-3. According to the draft Unitary Plan (2013) (Regional Policy Statement section); elite land is defined as LUC class 1 and prime land as LUC classes 2 and 3.

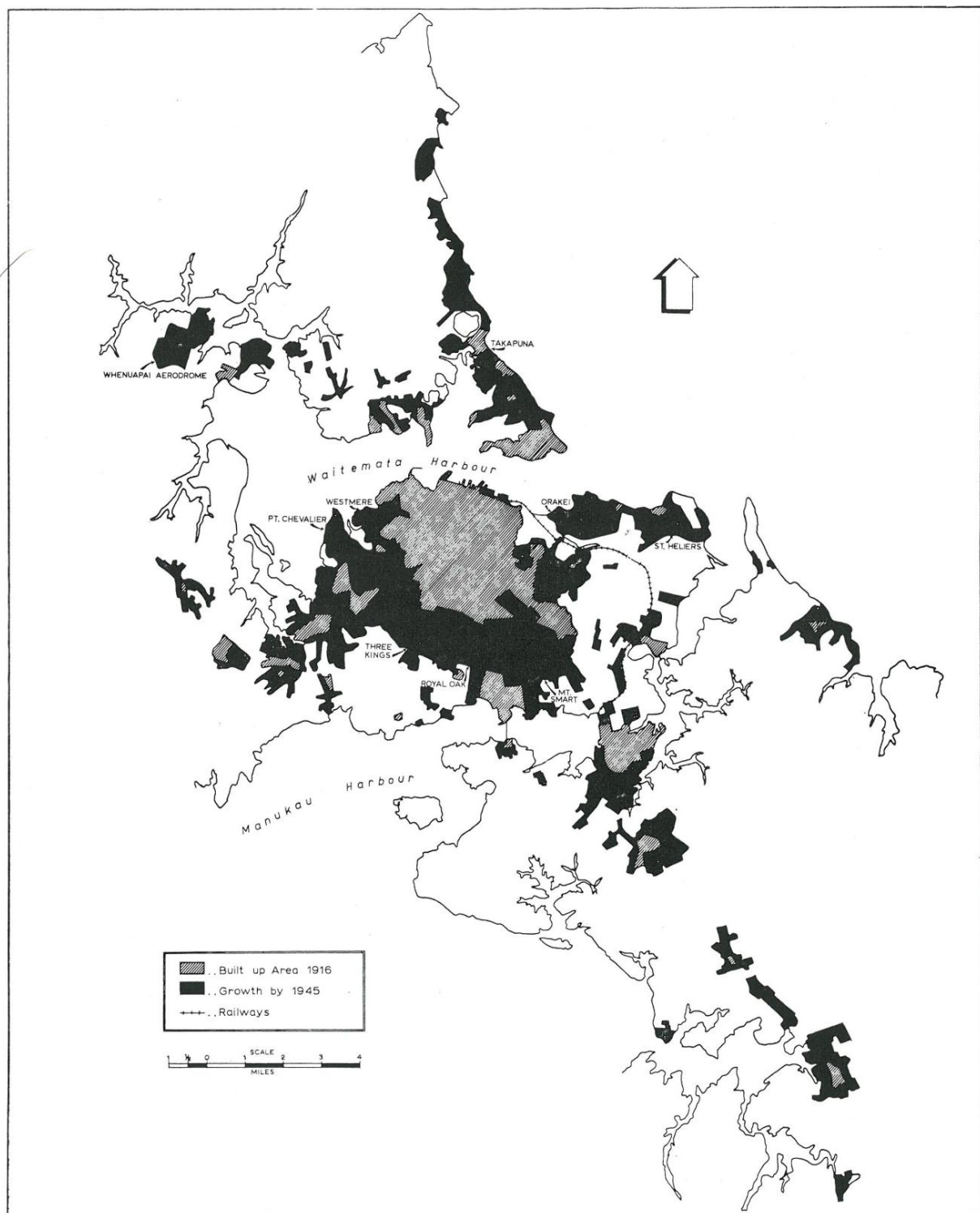


Fig. 6. The Growth of Auckland, 1916-1945.

Figure 2: Example of an illustration plate from 'The Growth of Auckland 1840-1966' adapted from Bloomfield (1967)

1.3.2 Urban extent for 1959

At the time of the writing of this report, no urban extent has been captured for the urban area of Auckland in 1959. Aerial photography for nearly all of the Auckland urban area at this time has now been made available, and as such it is expected that this data will be digitally captured in due course, and stored with the other urban extent datasets in council's geospatial repository.

1.3.3 Urban extents 1975 and 1987

The urban extents for Auckland for years 1975 and 1987 were captured at an unknown time prior to 2006 by staff at the Auckland Regional Council, through the reviewing of from large format, hard-copy aerial imagery prints. From these aerial photographs a GIS layer was created that best reflected the urban area (Tony Batistich, personal communication, 2007).

Very little information about the capture of this data is available as no documentation about the process was undertaken at the time.

Reserves (primarily esplanades), schools and other large open spaces associated with urban development at the edge of the urban 1975 and 1987 urban extents were not always captured as part of the urban area. This oversight has needed to be rectified, with some of the errors identified in the 1975 and 1987 data sets being manually corrected as they were found. Those errors that were not corrected, where later identified, have been incorporated as corrections in the data capture of extents of subsequent years.

1.3.4 Urban extent 1996

The urban extents for 1996 were captured retrospectively in 2009 by the Auckland Regional Council (ARC). After the organisation obtained digital copies of the 1996 aerial imagery to load into its geospatial data repository, each of the images was manually georeferenced⁴, and then collectively built into a tiled catalogue.

After the completion of the process above, the urban extent of Auckland as at 1996 was captured using the same method as had been done for 2001 onwards (see below). The methodology used for this data capture is included in section 2.0 (Methodology for Urban Extent Capture (1959, 1996, 2001, 2006, 2008 and 2010/2011)) of this report.

Due to the inexact nature of the manual georeferencing process, in places there is a mismatch between the aerial imagery and the location of features on the ground; for this reason caution must be used when using this data set. The urban extent data, while captured at a small scale, is designed to be used at a macro-level (regional and sub-regional levels) and at this scale these errors have a minor effect on the use of the data.

⁴ Georeferencing is the alignment geographic of data to a known coordinate system so it can be viewed, queried, and analysed with other geographic data. Georeferencing may involve shifting, rotating, scaling, skewing, and in some cases warping, rubber sheeting, or orthorectifying the data (ESRI, 2013) Note that georeferencing is different from georectification.

1.3.5 Urban extents 1959, 2001, 2006, 2008 and 2010/2011

Urban extent data for the years 2001 and 2006 was captured by the Auckland Regional Council in 2008, with the urban extent for 2008 being captured in 2009. The urban extent for 2010/2011 was captured by the Research Investigations and Monitoring Unit (RIMU) of Auckland Council in January of 2012 and the 1959 extent captured in the second half of 2013

The data capture for these extents was undertaken from the manual digitisation of the urbanised area from digital aerial photography. Documentation of this process is outlined in section 2.0 (Methodology for Urban Extent Capture (1959, 1996, 2001, 2006, 2008 and 2010/2011)) of this report.

1.3.6 Urban extent 2013

Urban extent data for 2013 was captured by the Land Use Research team of RIMU in the second quarter of 2014. It was determined by RIMU that a 2013 extent should be captured in order to concord with the population and dwelling data captured as part of the New Zealand Census of Population and Dwellings undertaken by Statistics New Zealand on the 5th of March, 2013. This, among other things, will enable for more accurate estimations of population in the region's built-up area.

Aerial photography for Auckland's urban area has not been captured since the previous photos were taken in 2010/2011. In addition council's Geospatial Unit has indicated that in the future there will not be a aerial image capture of the entire urban area in a single year (council's Geospatial Unit is moving towards procuring a partial capture of the city's urban area each year, with the entire urban area re-captured every two or three years) (Leonardo and Roberts, 2014). As such a new methodology has been developed for data capture of the urban extents for 2013. It is envisaged that this methodology will be used going forward and will allow the possible annual capture of extents. Documentation of this process is outlined in section 3.0 (Methodology for Urban Extent Capture (2013)) of this report.

1.3.7 Urban extent 2014

As part of the Research Investigation and Monitoring Unit's ongoing land use monitoring and with the development of a new method for capturing the urban extents, a data capture for 2014 was undertaken in August of 2014. This capture, and future data captures will use the method developed for the 2013 extent and is outlined in section 3.0.

1.4 Validation of Historical Data

We have been able to compare some the historical urban extent data from Bloomfield (1967) with other sources (Department of Statistics, 1956, Auckland Regional Planning Authority, 1963) enabling us to provide some sort of verification of the validity of the datasets for 1945, 1956 and 1964.

We have also been able to validate the urban extent datasets that were captured by the Auckland Regional Council for 1975 and 1987, by comparing the datasets to maps produced by the then Department of Statistics (1971a, 1971b, 1971c, 1971d, 1981d, 1981c, 1981b, 1981a)

1.5 Limitations of Urban Extent Data

Below are some of the limitations of the urban extent data, which should be taken into account when using the data for mapping or analysis:

- While the more recent urban extent data is captured close to a parcel level, due to its inexact nature, it should only be used at a regional or sub-regional scale. While data capture for post-1996 datasets have been generated at a low scale, it is not parcel accurate.
- Due to the nature of data capture for the urban extents from 1842 to 1964 (due to the inexact nature of the digitisation of illustrations from a published book), care should be taken when using this data.
- The source of the 1940 urban extent is unknown.
- Reserves (primarily esplanades), schools and other large open spaces associated with urban development at the edge of the 1975 and 1987 urban extents were not always captured as part of the urban area. This oversight required rectification in later urban extents where possible,.
- Data capture for the urban extents has concentrated on the urban core, but more recent updates have included some large rural towns, namely Beachlands-Maraetai and Pukekohe.
- Despite most of the urbanised area on Waiheke Island lying within the Metropolitan Urban Limits (MUL)⁵, there has been no data capture prior to 2001 for this area due to the unavailability of aerial photography).

⁵ The Metropolitan Urban Limits (MUL) are the extent to which the urbanised area of Auckland can develop up to. The MUL acts as a dividing line between urban and rural. The MUL was defined and maintained through the Regional Policy Statement (RPS) (up to 2013).

2.0 Methodology for Urban Extent Capture (1959, 1996, 2001, 2006, 2008 and 2010/2011)

Capturing of the urban extents using aerial imagery does not follow a strict set of rules, but more a set of guidelines. Because the urban extent data is designed to be an approximation of the size, shape and location of the urban area rather than an exact representation, data collection does not need to be exactly parcel/property boundary accurate.

Data capture and editing is done in ESRI's ArcGIS software, ArcMap. The process of data capture is started by making a copy of the previous urban extent spatial data. This copy is taken from the Auckland Council GIS data repository (SDE) as either a shapefile or a geo-database file. In recent years, the urban extent information has been made by extending the previous version of the extents by adding to it in areas where the city's urban area has expanded. Figure 3 below illustrates how this was done in a sample area between the years 2001 and 2006.



Figure 3: Example of urban extent expansion between 2001 and 2006

For ease of data capture, newly urbanised areas that are contiguous with current urban area, is done by creating new polygons that overlap the existing urban extents. These new polygons are digitised from the aerial photographs, following the new limits of the urban area, where possible, following parcel (property) boundaries and ensuring that vertices of any new polygons created are 'snapped' to those of the underlying parcel data. Once a new polygon has been created for a newly urbanised area, it is merged with the polygon covering the previous urban area. This is repeated for all areas that have seen a change to the extent of the urbanised area.

It should be noted that some of the newly urbanised areas may not be contiguous with the old area. In these cases a polygon is still created and merged with the original polygon - making a multi-part polygon, an example of a non-contiguous area can be seen in Figure 4 below.



Figure 4: Example of non-contiguous urbanised area

Areas that are captured include locales that contain completed dwellings and buildings, or dwellings and buildings which are under construction and clearly visible at the time that the aerial photography was captured. Areas that have had roads laid and lots/sections created, but no houses or buildings constructed are not included in the urban area extents; this is illustrated in Figure 5 below. The reason that only areas that have buildings constructed, or under construction on them are captured is that they are the clearest way to visually determine whether an area has been developed or not. Often in areas where only roads have been constructed (in some cases this is done ahead of any subdivision of land) it is not entirely clear as to what should demarcate the urbanised area and non-urbanised area.. It is for this reason that buildings are used as an indicator of urbanisation.

As noted earlier, because the urban area extent is only designed to be an approximation, not every parcel that has had a building constructed on it is captured. Figure 5 also illustrates how the discretion of the person capturing the data has been used - you can see that there are clearly a few houses that are apart from a cluster that have not been included.

At times the newly urbanised areas straddle roads, reserves and even railway corridors. In these cases the urban extent polygon line is drawn to include the opposite side of any vested road or vested reserve. Figure 6 below illustrates an example of this. While this is a guideline, it should be noted that it has not been strictly adhered to over the recently captured data sets.

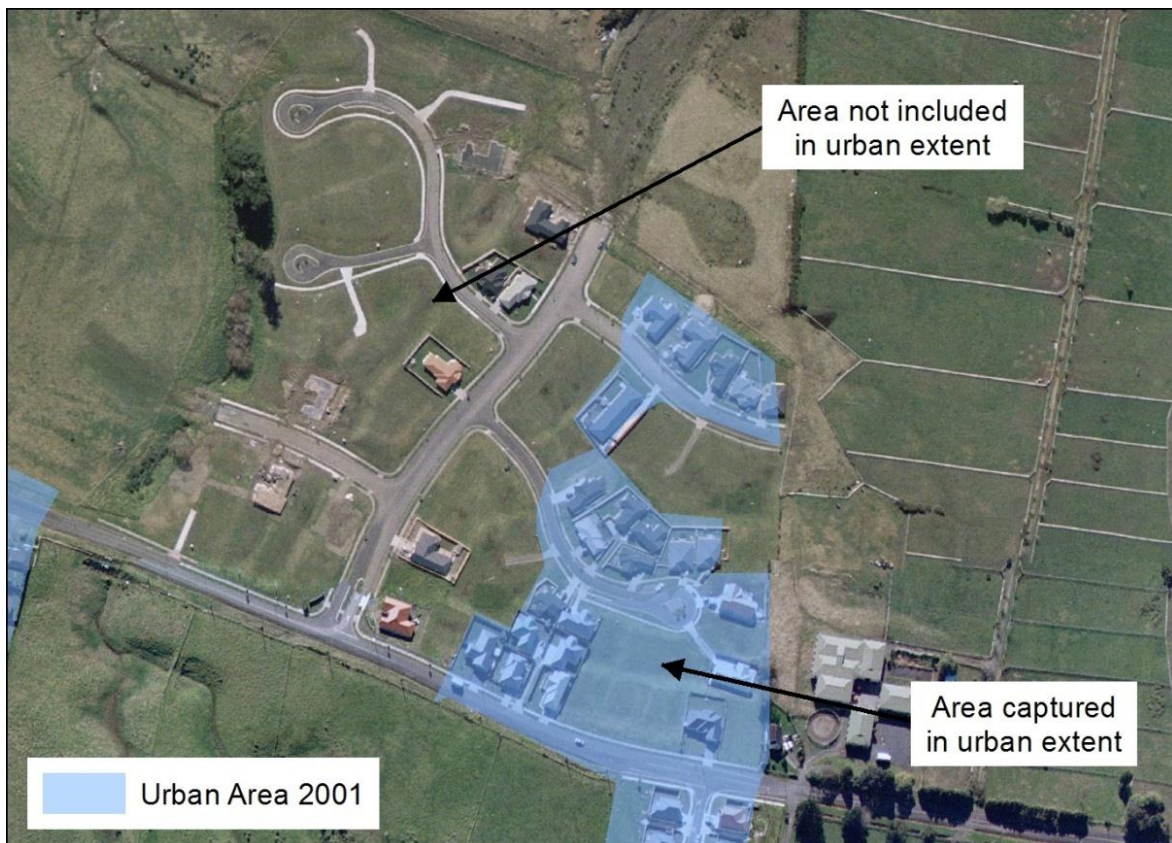


Figure 5: Example of urbanised area captured from 2001 aerial imagery



Figure 6: Example of data capture relating to roads and reserves

In conclusion, there are several pointers that should be considered when capturing the data:

- There is no right answer - it's a judgement call by the person undertaking the data capture.
- Base future data capture on what has done before by looking at areas around the current area you are capturing, or areas you have captured previously
- If it appears that an area should have been captured previously, capture it.

3.0 Methodology for Urban Extent Capture (2013)

3.1 Background and the need for methodological change

With changes to the way Auckland Council procures urban aerial imagery, it was identified by RIMU that a new way of estimating the urban extents would need to be developed. From 2014 the entire urban area will not be captured in a single year, with the new process capturing only parts of the urban area, concentrated on areas of change (Leonardo and Roberts, 2014). A need to establish an urban extent for 2013 to align with population and dwelling data captured as part of the census was also identified, allowing RIMU to better estimate the population and dwelling density of the urban area.

With the development of this new methodology, based on and cross-checked with aerial imagery it means that annual urban extents will be able to be captured, allowing RIMU to better track urban expansion and change of the urban over time.

There are several reasons why this new method is now possible, where it wasn't before. Primarily we now have access to download new property titles spatially, including their issue date, regularly. This means that we can easily identify when a new title is issued (down to the day), thus using a selection criteria based on the title date allows us to identify areas of change. This data is used in conjunction with a building consent dataset that RIMU own and manage which identifies the approximate location of p consents have been issued. Together these datasets are used to identify areas of development, and therefore urban expansion.

More information on the data sources used in this new method can be found in section 0 below.

It is envisioned that when new aerial imagery is available for parts of, or the entire urban area, they can be used to cross check areas that have been captured using this new method.

The 1st of July 2013 has been used as the 'strike date' for this urban area capture. This date was chosen as it is in the middle of the year, offering an 'estimate' of the urban extent for the year. As such titles that were issued between the previous data capture and the 1st of July, and building consents issued up to the 1st of July are used as a guide to judge the extents.

3.2 Data used in urban extent capture (2013)

Below in Table 2 is a list of the datasets that have been used to estimate the urban extents as part of the urban extent data capture for 2013.

Table 2: Data used in urban area data capture

Data	Notes and use	Source
Urban aerial photography	Orthoimagery of Auckland's urban area. Used as a reference to land use at the time photo was taken. The previous set of images is from 2010/2011. Used as a check to see whether the area is likely to have gone under some sort of development, for example preparatory earthworks for a residential subdivision.	Auckland Council
Previous urban area extent	The urban area extent, as captured in the previous iteration of this project. For the 2013 data capture, this was the 2010 urban area extent. This is used as base on which to 'build'. Areas of urban expansion identified are added to this base in order to create the new urban extent.	Auckland Council
Title boundaries	The spatial representation of the boundaries of the land contained on a Certificate of Title (COT), includes the date of COT issue. Used to identify property boundaries (and therefore the urban extent) in conjunction with the title boundaries.	Land Information New Zealand
Parcel boundaries	A cadastral polygon with a legal description. Generally matches title boundaries. Used to identify property boundaries (and therefore the urban extent) in conjunction with the title boundaries.	Land Information New Zealand, via Auckland Council
Building consents	Approximate location of building consents (residential and non-residential) issued in the Auckland area. Used to indicate whether development has or is taking place in a location.	Auckland Council

3.3 Methodology of urban extent capture (2013)

The method for capturing the 2013 urban extent is based on the previous method of data capture outlined in section 2.0, as such many of the pointers outlined in that section (such as capture of public open space and roads) have been used in the 2013 data capture.

Rather than just basing the new urban extent on identifying areas of development in the aerial photography, we now incorporate multiple datasets to make the assessment. The following three figures (7, 8 and 9) illustrate progressively how the data is added, and then used to create a new urban extent boundary.

The aerial imagery from 2010/2011, parcel boundaries and the urban extent that was captured in 2010 can be seen in Figure 7 below. Parcels are often created through subdivisions long before they are developed, as such they often appear on maps before there is anything there on the land. This can also be seen in Figure 7, but it should be noted that these parcel boundaries are at April 2014, whereas the aerial imagery is from 2010/2011.

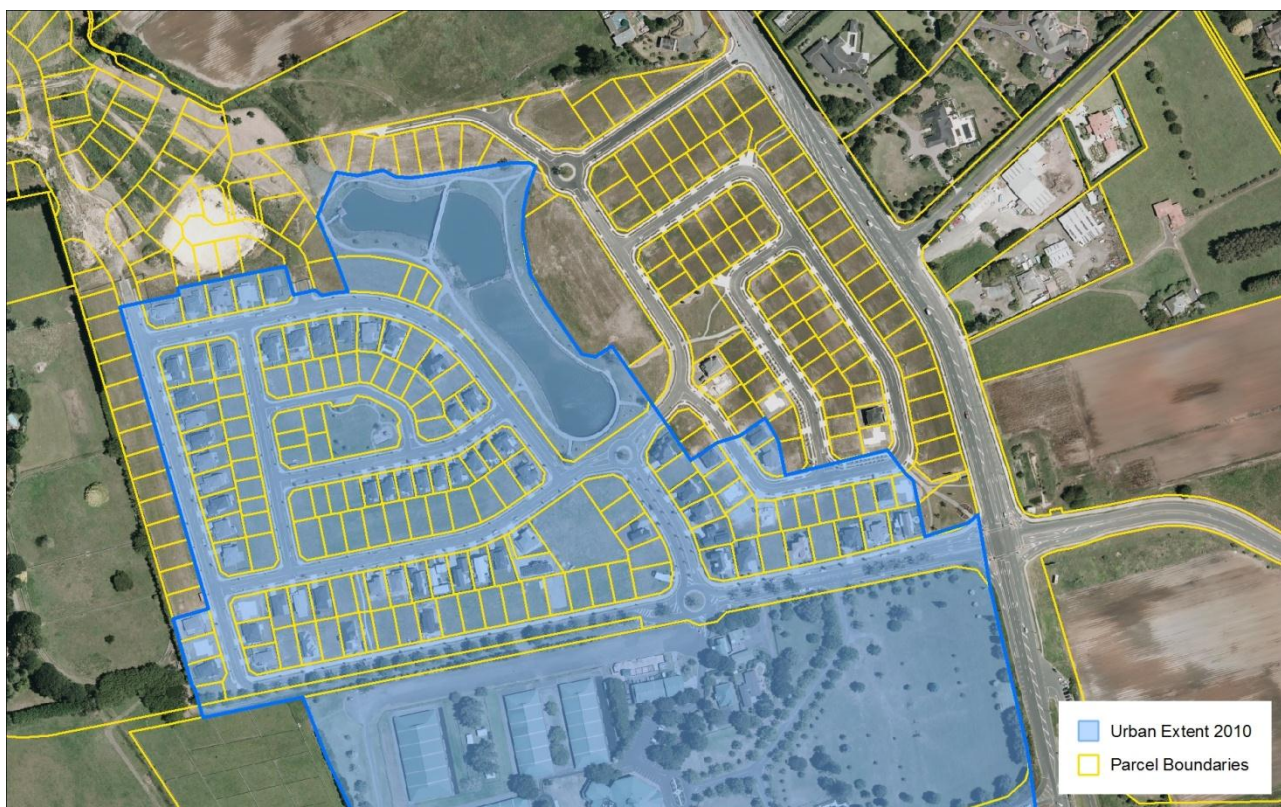


Figure 7: 2010 urban extent and parcel boundaries

The inclusion of additional data to the map (new titles and building consents) can be seen in Figure 8. Here we can see clearly areas where new titles have been issued (green shaded). On top of this you can also see the location of new building consents, with consents issued prior to, and after January 2011⁶ shown. Combined, we can estimate the areas in which the urban extent has expanded, using these two datasets as a proxy for development. From this those parcels that have been 'developed' are captured as part of the new urban extent (as per the methodology and standards raised in section 2.0. Finally, Figure 9 illustrates the new urban extent, as captured based on the title and building consent data.

As raised in section 2.0 and further illustrated in Figure 6, you can see that areas of open space, including stormwater retention ponds and newly vested roads have been included in the updated extent.

⁶ For the purposes of the urban area data capture, it was presumed that the 2010/2011 extent was at 31 December 2010.



Figure 8: 2010 urban extent and parcel boundaries with newly created titles and building consents

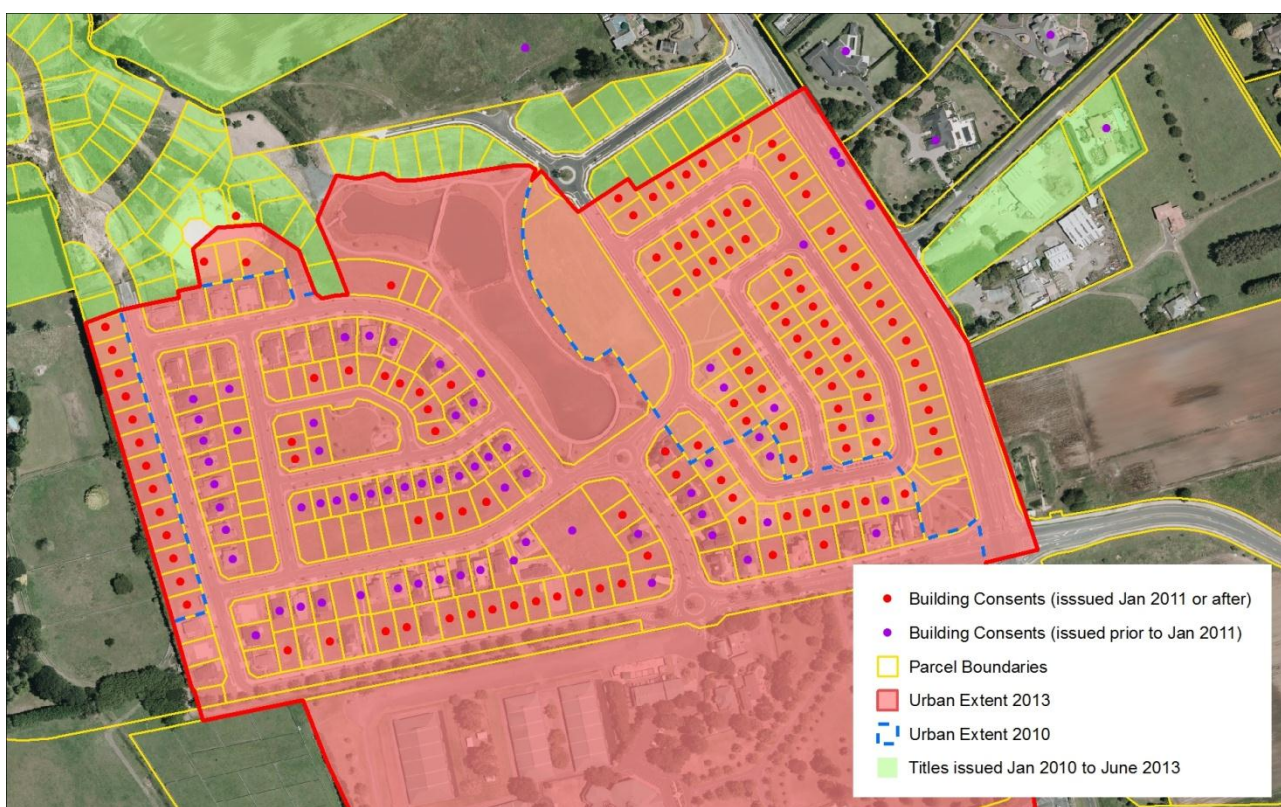


Figure 9: New urban extent (2013) with 2010 urban extent, parcel boundaries, newly created titles and building consents

4.0 Other Data Sources of Interest and Further Reading

4.1 Historic aerial photography

Auckland Council has digital aerial imagery that covers part, or all, of the region for a number of years, dating back to 1940 (primarily the Auckland Isthmus). Some of these can be accessed via Auckland Council's GIS viewer online.

<http://maps.aucklandcouncil.govt.nz/aucklandcouncilviewer/>

4.2 Central Business District coastline

As an interest project, the coastline of Auckland's Central Business District (CBD) was captured for a number of years: 1841, 1908, 1940, 1959, 1966 and 2010. The coastline for these years was captured from numerous sources including survey plans, maps and more recently, aerial orthoimagery. Figure 10 below illustrates an example of this data mapped, when overlayed with the latest aerial photography for the CBD. A copy of the map for the full CBD is available on request from the RMIU team.



Figure 10: Example of Changes to the Coastline in Auckland's Central Business District

4.3 Further Reading

For further information on Auckland and its urbanisation, refer to the following publications:

- Auckland Regional Council, 2010, *A brief history of Auckland's urban form*, Auckland Regional Council, Auckland, New Zealand.
- Bush, G., 1981, *Decently and in order: the Government of the City of Auckland 1840-1981*, Auckland City Council, Auckland, New Zealand.
- Bush, G., 1991, *Advance in order: the Auckland City Council from Centenary to Reorganisation 1981-1989*, Auckland City Council, Auckland, New Zealand.
- Bassett, M., 2013, *City of Sails: the history of Auckland City Council 1989-2010*, Auckland City Council, Auckland, New Zealand.
- Whitelaw, J.S. (ed), 1967, *Auckland in Ferment*, New Zealand Geographic Society, Wellington, New Zealand.

5.0 Glossary

Georeferencing

Aligning geographic data to a known coordinate system so it can be viewed, queried, and analysed with other geographic data. Georeferencing may involve shifting, rotating, scaling, skewing, and in some cases warping, rubber sheeting, or ortho-rectifying the data (ESRI, 2013).

Georectification

The digital alignment of a satellite or aerial image with a map of the same area. In georectification, a number of corresponding control points, such as street intersections, are marked on both the image and the map. These locations become reference points in the subsequent processing of the image (ESRI, 2013)

GIS

Geospatial Information Systems. Used as an abbreviation to refer to the capture, analysis and storage of geographical data as spatial datasets.

Peri-urban

Areas that are in some form of transition from strictly rural to urban. These areas often form the immediate interface between rural and urban areas. They may eventually evolve into urban areas, or they may stay somewhere in between. The majority are on the fringe of established urban areas but they may also be clusters of rural-residential developments within rural landscapes. (Parliamentary Commissioner for the Environment, 2001).

Urban

Land included within the urban zones of metropolitan urban area, satellite towns, rural and coastal towns, serviced and unserved villages (Auckland Council, 2013).

High class land

High class land is defined as Land Use Capability (LUC) Classes 1-3. According to the draft Unitary Plan (2013) (Regional Policy Statement section); elite land is defined as LUC class 1 and prime land as LUC classes 2 and 3.

MUL

The Metropolitan Urban Limits (MUL) are the extent to which the urbanised area of Auckland can develop up to. The MUL acts as a dividing line between urban and rural. The MUL was defined and maintained through the Regional Policy Statement (RPS) (up to 2013). After the adoption of the Unitary Plan the MUL will no longer be in effect and will be replaced by a new urban containment device called the Rural Urban Boundary (RUB).

Parcel

A cadastral polygon with a legal description (can also be known as a property, section or lot).

6.0 References

- AUCKLAND COUNCIL 2013. *Proposed Auckland Unitary Plan*, Auckland, New Zealand, Auckland Council.
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