Socio-economic mapping of sub-catchment communities in the Heathcote catchment, Christchurch

Nicholas Ensor

WCFM Report 2019-006

New Zealand's specialist land-based university

REPORT:	WCFM Report 2019-006
TITLE:	**Socio-economic mapping of sub-catchment communities in the Heathcote catchment, Christchurch**
PREPARED FOR:	**Christchurch City Council (CCC)**
PREPARED BY:	**Nicholas Ensor** – BSc
REVIEWED BY:	Ed Challies, Crile Doscher, Clive Appleton
AFFILIATION:	Waterways Centre for Freshwater Management University of Canterbury & Lincoln University Private Bag 4800 Christchurch New Zealand
DATE:	November 2018 – February 2019

Executive Summary

This report provides an analysis and evaluation of the spatial distribution of a range of socio-economic and demographic indicators aggregated within the sub-catchments of the Ōpāwaho/Heathcote river basin for the Christchurch City Council. The analysis is intended to assist in a targeted approach around local and community waterway health education and engagement. ArcGIS Pro and ArcGIS Online council services were utilised to process and aggregate publicly available census, council and NGO data employing standard geoprocessing tools.

It was discovered that areas of low deprivation overlap with Port Hills sub-catchments, which tend to be wealthier and less populated, and the distribution seemed to have a stronger correlation with elevation within the catchment than with the basin's hydrological patterns. Areas of high deprivation were mainly distributed throughout southern and eastern sub-catchments of low elevation. These inferences are also supported by income level and tertiary qualification data by sub-catchment.

In carrying out this project, some challenges were encountered around limited availability of high-quality data at the level of detail required for the analysis. Public data sites such as canterburymaps.govt.nz and data.linz.govt.nz, while hosting hundreds of sets of high-quality data, did not have data at the level of local sub-catchments that were needed to produce accurate, clean outputs. Additionally, the NIWA sub-catchment boundaries were useful at a large scale, but it remains unclear how accurate these actually are in the local-level urban environment; particularly in the highly urbanised, commercial and light industrial portions of the catchment, where the surface hydrology is highly modified by infrastructure and the stormwater network. Other limitations that were encountered involved time and access to auxiliary data.

Future work to build on this research might involve updating the figures with 2018 census data, mapping additional variables, conducting further analysis with different administrative boundaries (such school zones) and other features (such as cycle ways, parks, proximity of properties to waterways, or trends in water quality or stream health). Analysis could consider how geospatial information could be relevant to community groups within certain catchments, whether sub-catchments could be categorised into broad 'types' to aid community engagement efforts, and cooperation with the CCC and other third parties to develop and improve the coverage of highly accurate catchment and watercourse data within Canterbury (e.g. using LiDAR data). These avenues of investigation would broaden the scope of what was covered in this report, and serve as a platform for future research that could benefit Council's engagement in this space.

Table of Contents

Section 1 – Introduction

1.1 Background

The aim of this project was to map key socio-economic and demographic characteristics of communities in Christchurch, New Zealand by sub-catchment (or 'stormwater catchment') within the Ōpāwaho/Heathcote river catchment. We anticipated that the various communities within this area would face a range of challenges and issues relating to their access to urban waterways, relation to stormwater infrastructure, and contribution to urban waterways and stormwater management generally. Varying socio-economic characteristics coupled with demographic diversity and ongoing urban development in different sub-catchments arguably necessitates a relatively 'fine-grained' or locally responsive approach to the analysis of urban water management issues and the scoping of community engagement and intervention.

A methodical GIS mapping of relevant socio-economic and demographic variables according to sub-catchments within the Ōpāwaho/Heathcote catchment was carried out as a means to begin to visualise the socio-economic and demographic 'landscape' at the catchment scale. In addition to identifying key community characteristics that could assist the Christchurch City Council in more effectively understanding the needs of, and engaging with, the community around issues of urban water management, this research should also lay a foundation for further work towards designing more targeted and more effective monitoring and evaluation of social and community dimensions of water management in the Ōpāwaho/Heathcote catchment. Such an approach may also be applicable or adaptable to Christchurch more generally, and to other urban settings.

A richer understanding of the composition of and diversity among urban sub-catchments should directly inform research and engagement methods such as household surveys by selected neighbourhood or sub-catchment, collaborative and community projects, and collaborative monitoring or citizen science around urban waterways and stormwater. Furthermore, if the Council decides to further investigate motivators of and barriers to behaviour change among individuals, households, businesses or communities, detailed socio-spatial data at sub-catchment scale will likely be important in informing a tailored and targeted approach. This report outlines the methods used to assemble a sub-catchment scale socio-spatial dataset for the Ōpāwaho/Heathcote catchment, and presents visualisations of the initial mapping of some of these data. The report will also detail some of the limitations and challenges encountered in amalgamating socio-spatial and geospatial data in this case, and suggest areas where further work might be valuable.

1.2 Rationale and GIS mapping approach

The Ōpāwaho/Heathcote catchment is one of Christchurch City's major urban catchments, and is characterised by a variety of land uses and communities. The various tributaries of and sub-catchments of the Ōpāwaho/Heathcote therefore face different environmental challenges, and have different social/demographic characteristics. Waterways in the catchment are vulnerable to numerous pressures stemming from the urban built environment and land-use on the urban fringe, including parts of the Port Hills. A key driver of water quality problems and degraded ecosystem health in the catchment (and in the Ihutai/Avon-Heathcote Estuary) is storm water contamination. While this is not the only issue facing the Ōpāwaho/Heathcote, it is perhaps the most significant and widespread water management problem that the City Council may be able to tackle within the urban and peri-urban space. Stormwater management therefore deserves high priority within wider efforts to manage urban stream health and urban environmental health generally.

Key storm water contaminants in the Heathcote are heavy metals such as copper, lead and zinc, as well as sediment, pathogens and bacteria (such as E. coli), and polycyclic aromatic hydrocarbons (PAHs). These may originate from commercial and domestic buildings, traffic and road run-off, erosion, and human and animal waste. The spatial distribution of contaminant sources and the temporal distribution of contamination events are not uniform across the catchment, but vary widely depending on a wide range of interacting drivers of contamination. Storm water contamination must therefore be addressed through a range of interventions. One component of an integrated approach is the installation of appropriate stormwater treatment infrastructure – both conventional engineering solutions and green infrastructure. Another essential and complementary component centres on community engagement, awareness-raising and behaviour change programmes. However, with both infrastructure and engagement it can be difficult to know where these interventions are best targeted, and what their (positive and negative) impacts are likely to be in a given place or for a given community. An improved understanding of the particularities of communities at the sub-catchment scale will be valuable in addressing this.

A detailed socio-spatial mapping of the Ōpāwaho/Heathcote catchment will potentially also assist the Council in effectively engaging with diverse urban communities – in order to raise awareness, build capacity, and ultimately change behaviour and practices. While there are considerable knowledge gaps, and in some cases a lack of capacity, in urban communities to tackle stormwater contamination, there is also arguably a lack of understanding on the part of authorities as to the specific issues faced by different communities, and the relative strengths and weaknesses of various communities within the catchment. An improved understanding of the characteristics of different communities will also help to address this and underpin productive engagement. Of course a full understanding of community characteristics and priorities cannot be achieved merely through mapping socio-economic

and demographic statistics – engagement and dialogue is required on top of this – but a mapping of socio-spatial data is a useful initial step towards planning such engagement.

The advantages of using GIS tools and techniques to map some of the socio-economic and demographic data indicative of community diversity, is that it provides a powerful means of visualising patterns and distributions of factors that are potentially relevant to tailoring engagement. Drawing primarily on 2013 census data, the GIS mapping carried out for this project highlights key features of the spatial distribution of characteristics within the Ōpāwaho/Heathcote catchment. The maps and databases established in this process will also be reproducible with 2018 census data when this becomes available, in order to reflect how key characteristics have changed over recent years and to capture temporal dimensions of community diversity. This will be an important step given that 2013 census data for Christchurch reflects a time soon after the 2011 earthquakes, where communities were in a highly disrupted state. GIS mapping also allows for socio-spatial and geospatial data to be combined and overlaid in helpful ways. While that was not a focus of the present project, the work has established a dataset that could be overlaid with geospatial data (land use, topography, elevation, vegetation, etc.) for additional insight into how particular issues and interventions may interact and impact on communities and the urban environment in different parts of the catchment.

In summary, given that the Ōpāwaho/Heathcote catchment is not socio-economically or demographically homogenous, and key variables (DPI, Average Household Income, Full Time Employment Percentage, Tertiary Qualification Percentage and Home Ownership Percentage) differ between neighbourhoods and suburbs, blanket approaches to community engagement will likely be ineffective. GIS has been used as a tool to visualise this heterogeneity, and thereby potentially inform development of targeted approaches to awareness-raising and education regarding local stream health problems and solutions, and the wider community's role in the issue of stormwater contamination.

Section 2 – Data

2.1 Map extent data used to generate socio-spatial mapping

The project necessitated some initial work to identify and combine base data on the extent of the Ōpāwaho/Heathcote catchment (Figure 1) and the sub-catchment boundaries within this (Figure 2). The sub-catchment data was sourced from NIWA's River Environment Classification project (version REC 2.4), which may be the best data currently available. It is noted that this data is not necessarily perfect, as the stormwater network alters the hydrology to varying degrees in the urban environment. In particular, certain sub-catchments are more heavily influenced by the stormwater network. The most affected in this respect will be central city areas with large areas of impervious surfaces and roof coverage, whereas the least affected will be outer suburbs with a higher proportion of green space and natural vegetation cover, and undisturbed topography. It is understood that CCC is in the process of creating a GIS layer of the urban stormwater catchments, but this data was not available at the time of the research. When such a dataset becomes available, this may improve the base map onto which the key attributes mapped here could be overlaid.

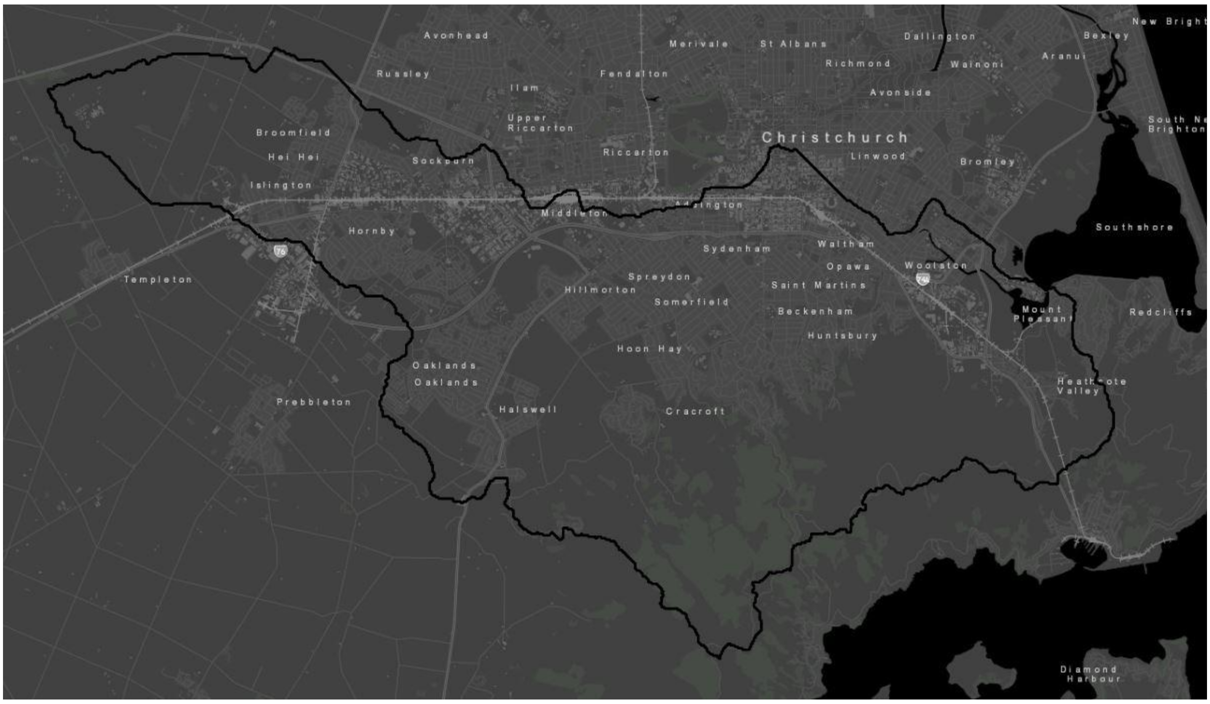


Figure 1: The total extent of the Ōpāwaho/Heathcote catchment. Data sourced from NIWA's River Environment Classification project – version REC 2.4.

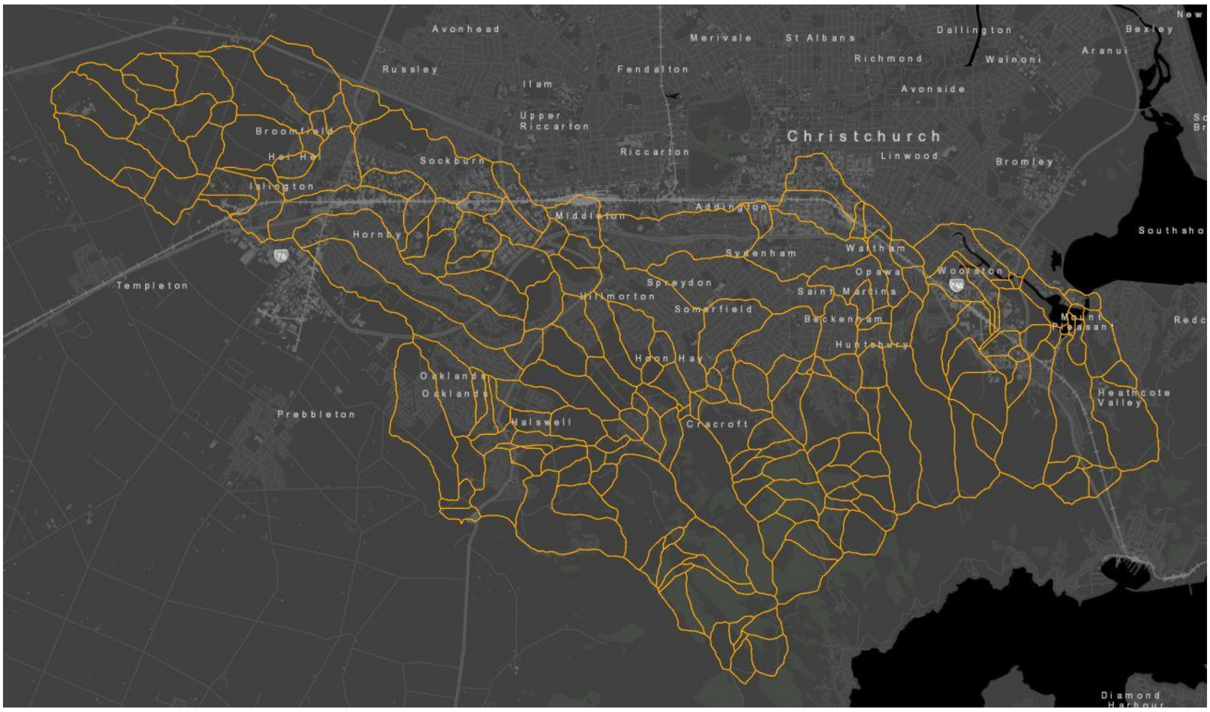
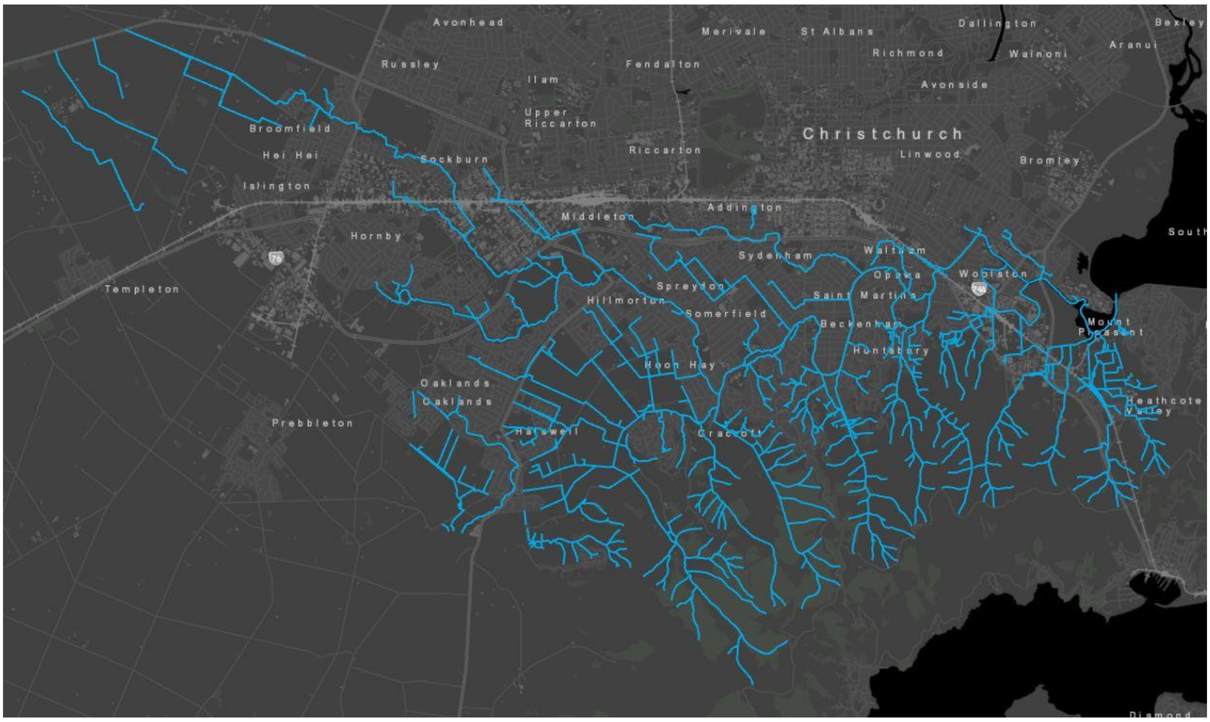


Figure 2: Sub-catchment boundaries within the Ōpāwaho/Heathcote catchment. Data sourced from NIWA's River Environment Classification project – version REC 2.4.

The watercourse data used for this project (Figure 3) was retrieved through the Christchurch City Council's WFS (Web Feature Service) Feeds. This data, in contrast to the NIWA River Environment Classification sub-catchment data, does reflect the modified hydrology in the urban environment (evident in straightened and disconnected channels in parts of the catchment). The degree of modification, as can be expected, is higher in the central city, and lower in the residential outer suburbs and Port Hills. It is not clear, however, how far the data reflects the actual surface and sub-surface hydrology as influenced by the stormwater network. The channels shown include piped and channelised sectors of the network as well as relatively natural watercourses. What is not shown, are surface flows in gutters and on streets. Although these flows inevitably end up in the network they may respond to the natural surface topography to a greater extent than other parts of the network. Figure 4 overlays the Ōpāwaho/Heathcote sub-catchment layer with the watercourse layer for reference.



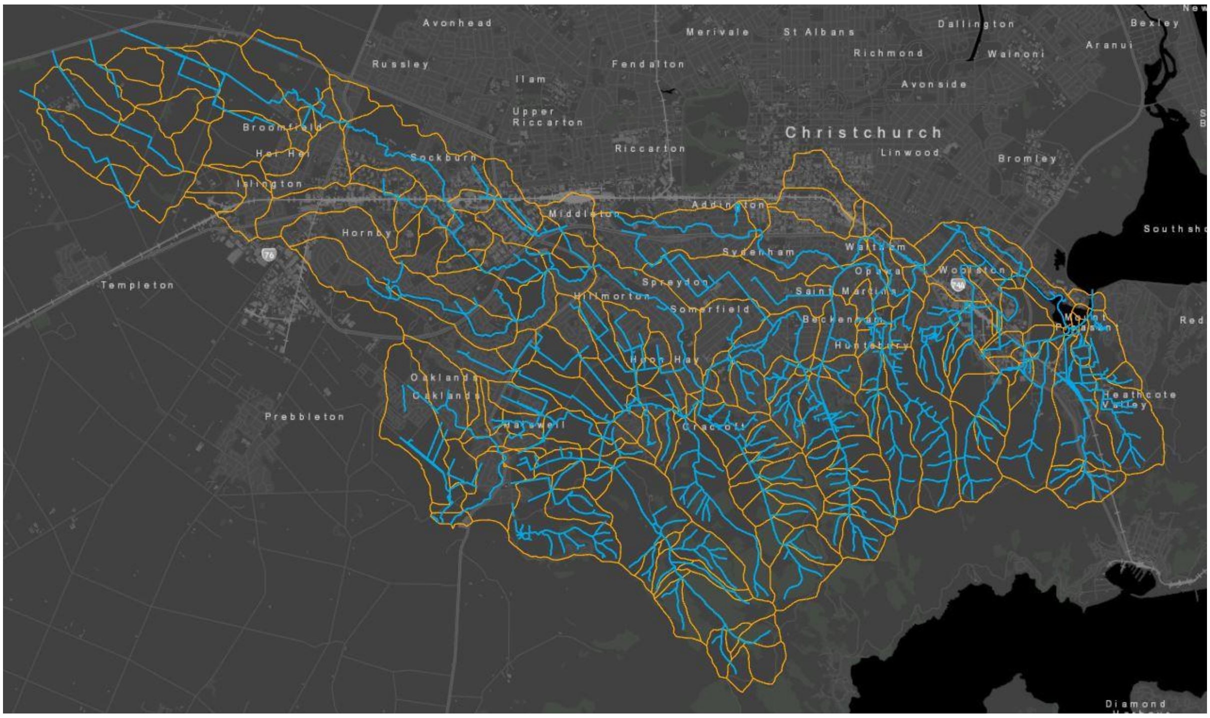


Figure 3 (top): Watercourse data retrieved through the Christchurch City Council's WFS (Web Feature Service) Feeds.

Figure 4 (bottom): Watercourse dataset overlaid over the Ōpāwaho/Heathcote sub-catchment boundaries (from Figure 2) for reference.

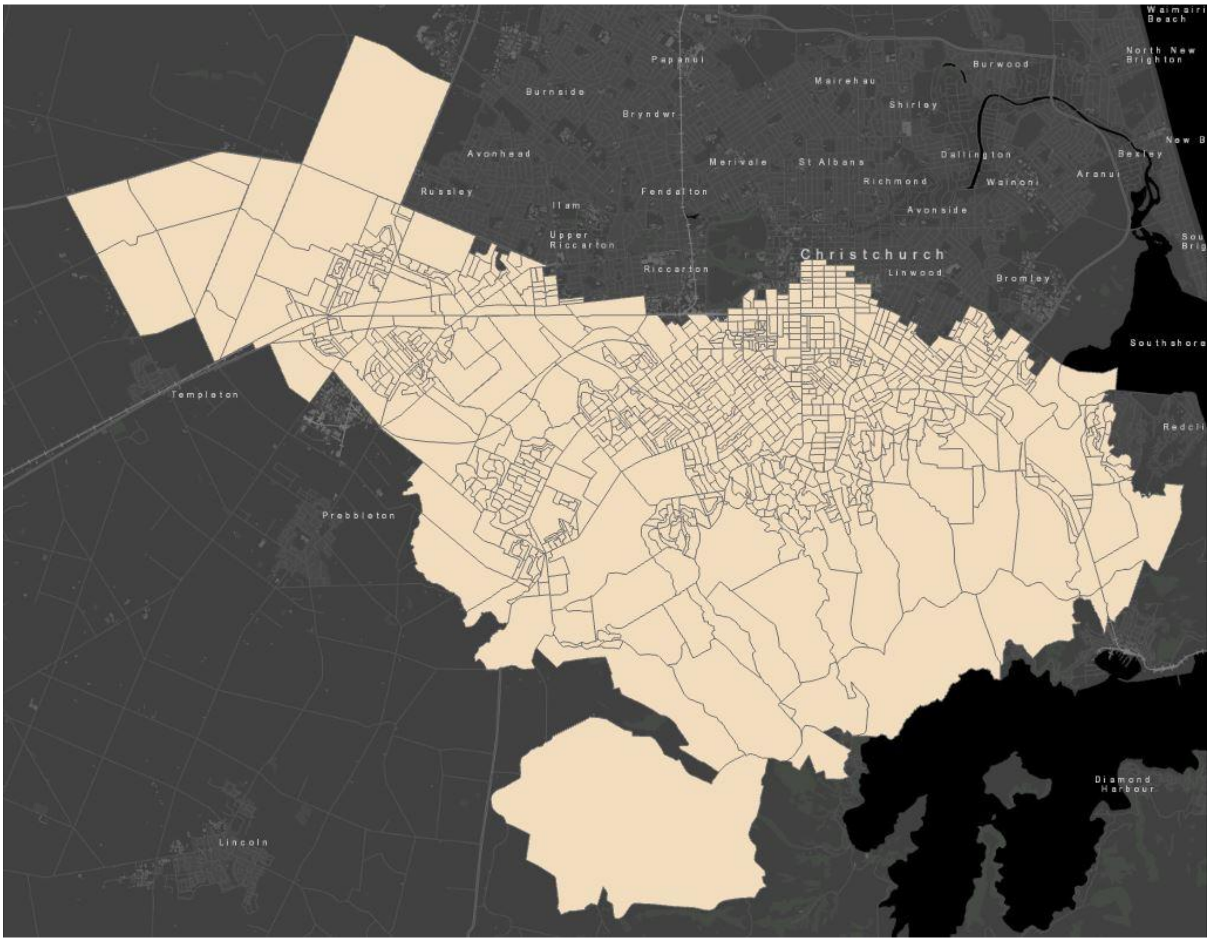


Figure 5: New Zealand census (2013) meshblock boundaries intersecting the Ōpāwaho/Heathcote catchment. Stats NZ data, sourced from Koordinates.com.

The finest scale at which Statistics New Zealand collects census data is at the geographic scale of the meshblock. The meshblock is typically used as the basis for analysis, aggregation and presentation of socio-economic and demographic census data at multiple scales, such as statistical area units, urban and rural areas, and regions. Meshblocks are also used to define electoral districts, territorial authorities, and regional councils. Because meshblock shape and boundaries are defined by a combination of social and environmental factors (e.g. number of dwellings, cadastral boundaries, electorates, topographical features), they are not automatically suited to mapping data to catchment and sub-catchment scales. Figure 5 shows census meshblocks that intersect the Ōpāwaho/Heathcote catchment, and illustrates the variation is meshblock shape and area between the relatively densely populated inner-city and relatively sparsely populated port hills and rural or peri-urban areas to the west of Christchurch. As is apparent below (Figures 6-10), some of the Ōpāwaho/Heathcote sub-catchments contain or intersect multiple meshblocks, whereas some of the larger meshblocks to the south and west of the city centre contain or intersect multiple sub-catchments. The

process of aggregating meshblock data to sub-catchment scale is therefore not straightforward.

Multiple copies of this shapefile were used with the 'Join' tool to attach the census data to each meshblock for further processing. The 'Join' geoprocessing tool allows for two datasets to be joined and exported as one, based on a single common field within the data – in the case of Figures 6-10 the unique meshblock ID was used, as the geographical data and the socioeconomic data both included the ID in their attribute tables. Once the tool has been executed and the joined data exported as a new layer, the spatial data can then be symbolised by the new socioeconomic data that is contained within the attribute table, allowing for further analysis or presentation. In the case of this project, the problem of multiple meshblocks in a single sub-catchment or multiple sub-catchments in a single meshblock was solved through using the 'Summarise within' tool, which aggregates a variable from one set of polygons into another set of polygons with different geometry – this process and its limitations are explained in more detail in Section 4.

2.2 Meshblock Data used for the Final Outputs

A range of socio-economic and demographic data is available at meshblock level. This project has drawn upon 2013 census data, that being the most recent comprehensive official dataset available. As noted above, the mapping exercise should be repeated when 2018 census data becomes available from Statistics New Zealand.

Socio-economic and demographic data may be useful in characterising local communities within and across sub-catchments in ways that can inform more effective and tailored engagement around stormwater and urban waterways. Many factors relating to people's material and social circumstances may impact directly on their motivation and ability to take concrete measures to mitigate impacts on stormwater quality and urban water quality or waterway health more generally. For example, economic factors such as income, affluence, and employment status may mean that many household-level measures (such as maintaining or replacing aging or un-painted zinc roofs, or installing on-site stormwater detention) are not necessarily within the reach of all households. Other factors, such as access to information and communications technology, and levels of awareness or education, may also affect people's capacities to respond to engagement and information or take effective action. Rates of home ownership compared to residential rentals, are also likely to impact on residents' ability and motivation to invest in storm-water reduction or mitigation. These kinds of factors are reflected in the New Zealand Deprivation Index (NZDep2013), which is designed as a general composite indicator of socio-economic deprivation (Atkinson et al. 2014). See Table 1 for the composition of NZDep2013.

Table 1: Variables included in New Zealand Deprivation Index 2013 (NZDep2013)

Variable (proportions in small areas) in order of decreasing weight in the index	**Dimension of deprivation**
People aged <65 with no access to the Internet at home	Communication
People aged 18-64 receiving a means tested benefit	Income
People living in equivalised* households with income below an income threshold	Income
People aged 18-64 unemployed	Employment
People aged 18-64 without any qualifications	Qualifications
People not living in own home	Owned home
People aged <65 living in a single parent family	Support
People living in equivalised* households below a bedroom occupancy threshold	Living space
People with no access to a car	Transport

**Equivalisation: methods used to control for household composition*

Source: Atkinson et al. (2014: 19)

Figure 6 displays socioeconomic deprivation (using NZDep2013) by meshblock, and overlays this with the Ōpāwaho/Heathcote sub-catchment boundaries. Levels of deprivation range from very low (0 / pale yellow) to very high (10 / dark red). Grey areas are due to missing or confidential census data. The map gives an indication of levels of deprivation across the wider Ōpāwaho/Heathcote catchment, and reflects relatively higher levels of deprivation in the part of the catchment that coincides with the southern portion of the city centre, as well as areas to the west and east of the centre. Relatively low levels of deprivation are found in the southern parts of the catchment, which coincide with more affluent hill suburbs and more sparsely populated areas on the Port Hills.

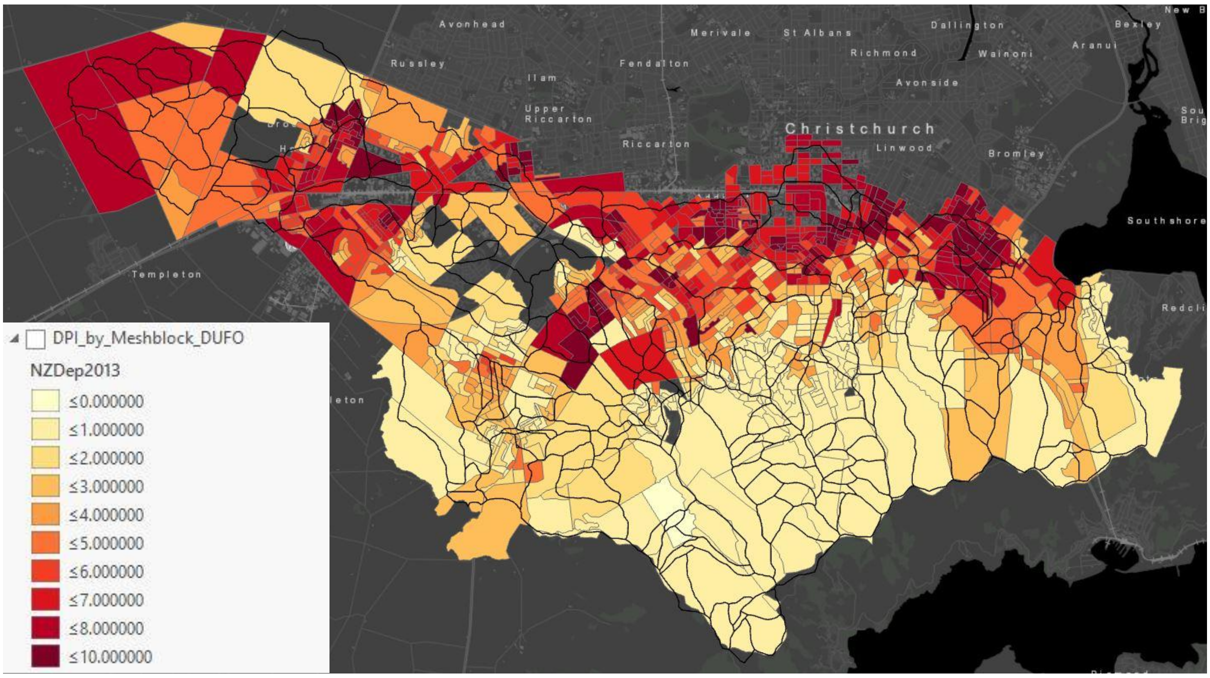


Figure 6: Average Deprivation Index (DPI) score (1-10) per meshblock, with Ōpāwaho/Heathcote sub-catchment boundaries included as a point of reference. Sourced from the Ministry of Health via the University of Otago.

The Deprivation Index is a potentially valuable indicator of social and material wellbeing across the catchment, and as such may be useful in informing public engagement. However, being a composite index, it may also obscure patterns that might emerge when we map individual indicators to the sub-catchments. For this reason, we also map selected components of the NZDep2013 separately. Figure 7 (below), for example, shows average household income per meshblock within the catchment. The household income data is extracted from the New Zealand census data spreadsheets (2013). As just one indicator is mapped, there is a greater number of meshblocks for which there is missing data (grey cells) due to confidentiality considerations or gaps in the census data.

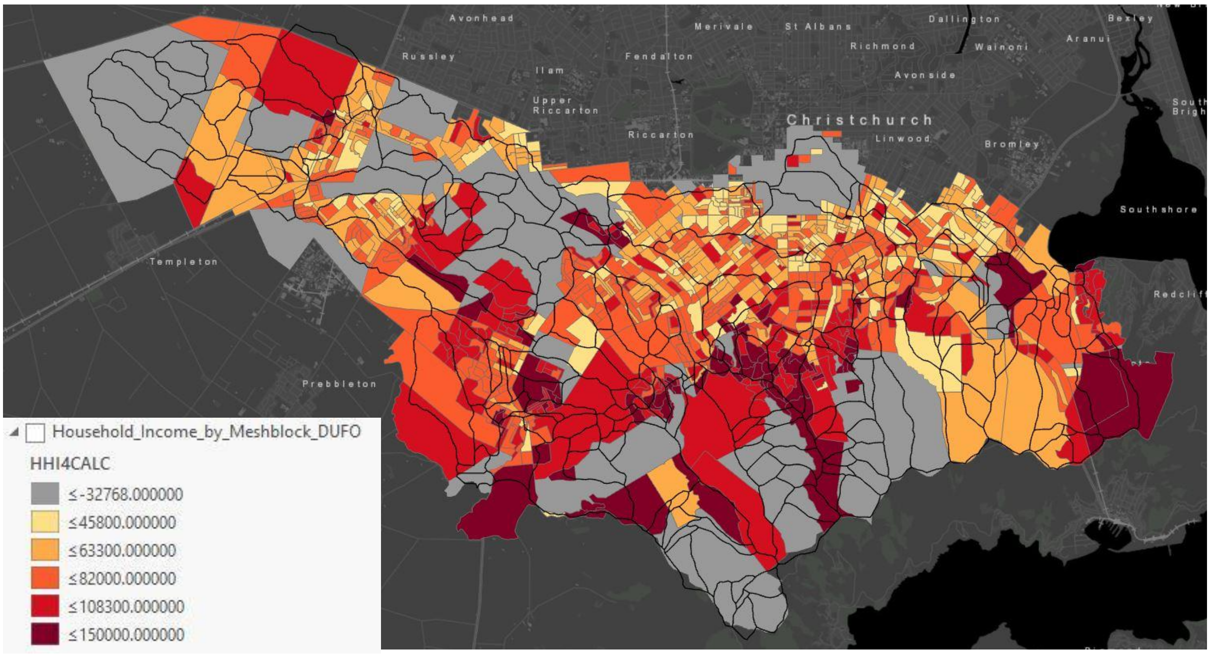


Figure 7: Average household income per meshblock within the Ōpāwaho/Heathcote catchment. 2013 New Zealand census data.

Figure 8 shows rates of employment by meshblock across the catchment. Pale yellow represents low rates of full-time employment, while dark red represents high rates (greater than 67%) of full-time employment.

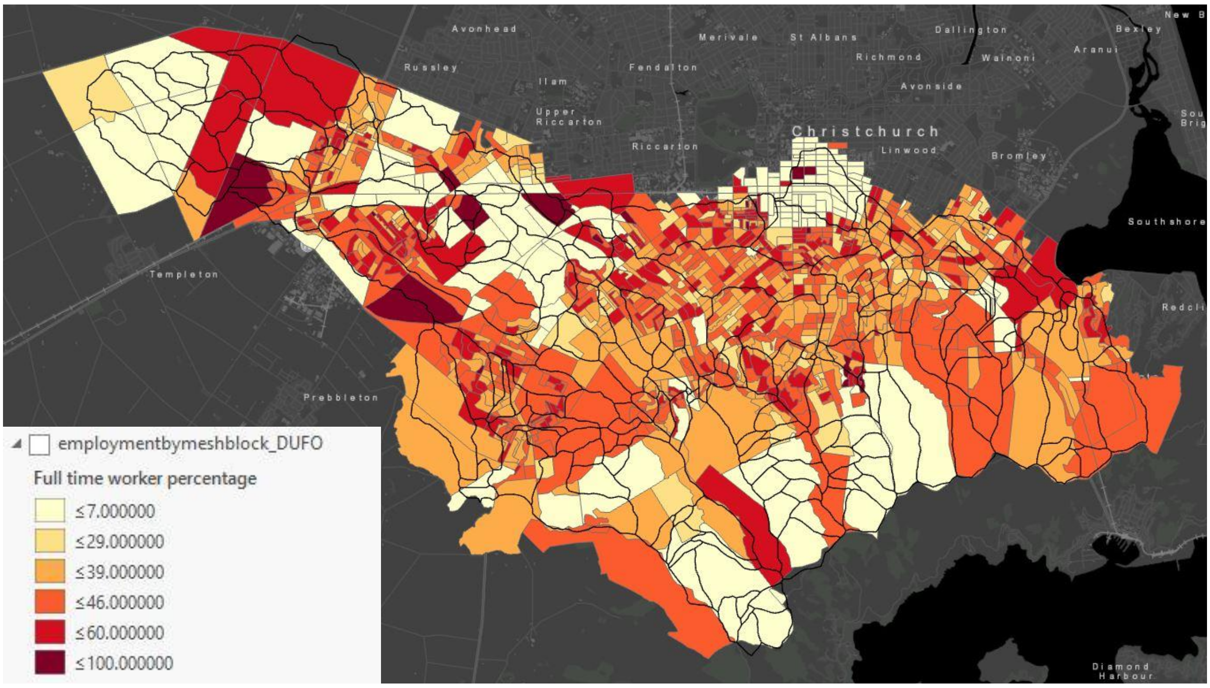


Figure 8: Percentage of people aged 18-64 in full-time employment per meshblock within the Ōpāwaho/Heathcote catchment. 2013 New Zealand census data.

Figures 9 and 10 (below) repeat the meshblock mapping exercise for tertiary qualifications as a proportion of the population aged 18-64, and owner occupied residences a proportion of all census-responding properties respectively.

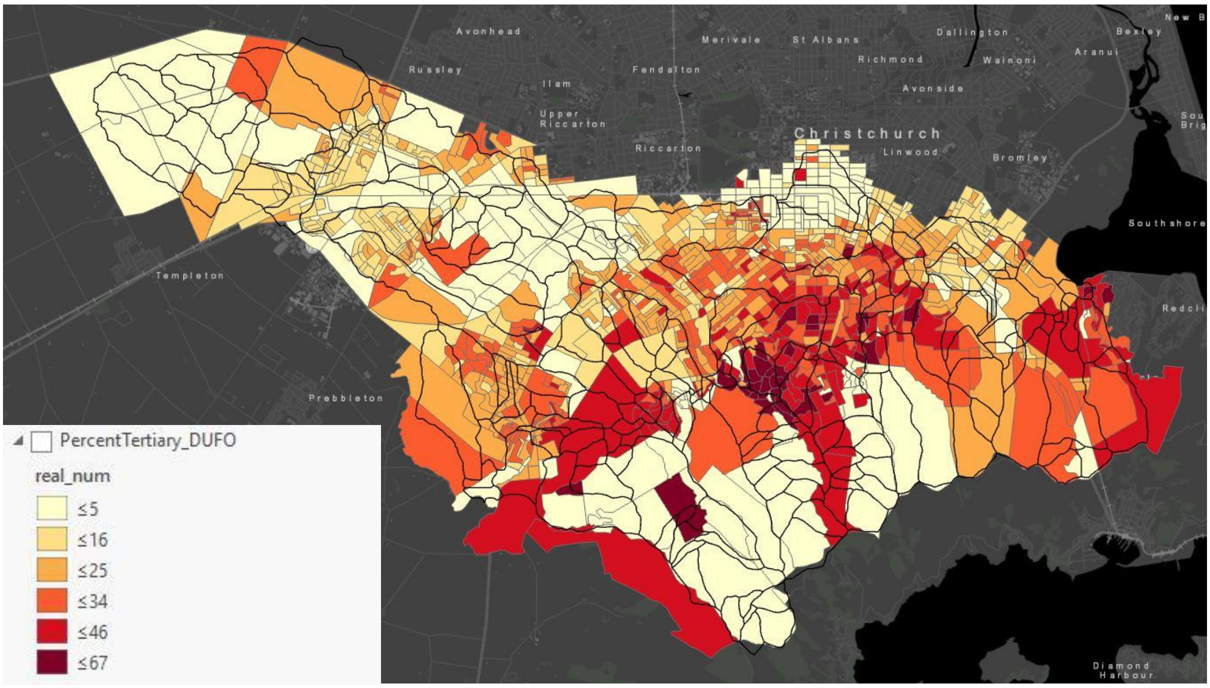


Figure 9: Tertiary qualifications as a percentage of the total working-age population per meshblock within the Ōpāwaho/Heathcote catchment. 2013 New Zealand census data.

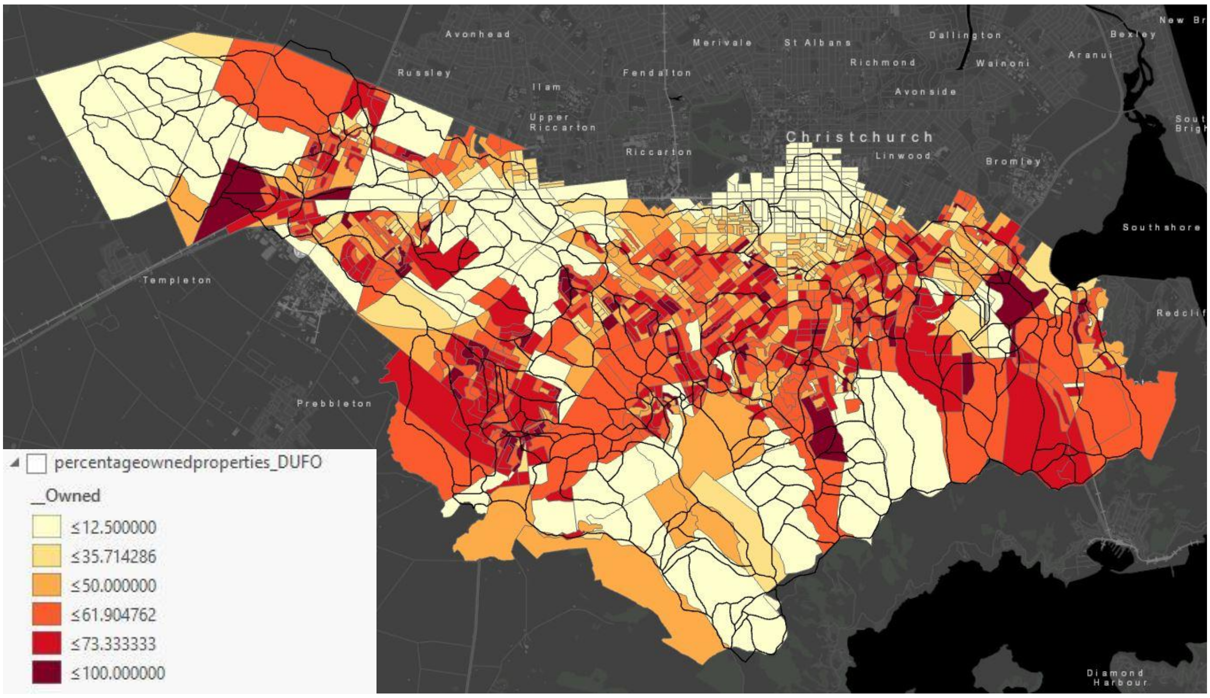


Figure 10: Owner occupied residences as a percentage of total census-responding properties per meshblock within the Ōpāwaho/Heathcote catchment. 2013 New Zealand census data.

2.3 Final Outputs: Socioeconomic Variable Distribution by sub-catchment and Land Use Variation

The final step in calculating and mapping socio-economic data to the sub-catchment spatial scale entailed joining meshblock data using the 'Summarize within' tool in ArcGIS. This computed the average for each sub-catchment, based on meshblock data weighted according to the area that each meshblock covered within each sub-catchment, including portions of meshblock that straddled sub-catchment boundaries. This method identifies particular sub-catchments as being characterised by relatively high deprivation on the northern edge of the catchment (and to the south and east of the inner city), and in the upper reaches of the catchment (to the west of the city). Clearly, areas of low deprivation coincide with many of the Port Hills sub-catchments in the southern half of the catchment, where there are relatively affluent suburbs and relatively sparsely populated areas. The watercourses in these latter sub-catchments are also clearly less modified than those in the urban areas of the middle and northern parts of the catchment. Deprivation within the catchment is unevenly distributed, but appears to vary with elevation (between hillside suburbs and flat suburbs) more than it does through the catchment from upstream to downstream/receiving environments. This geography of socio-economic deprivation, and its intersection with varied surface hydrology is potentially informative for planning, management, and community engagement, and should inform tailored approaches to engaging with the community in different parts of the catchment.

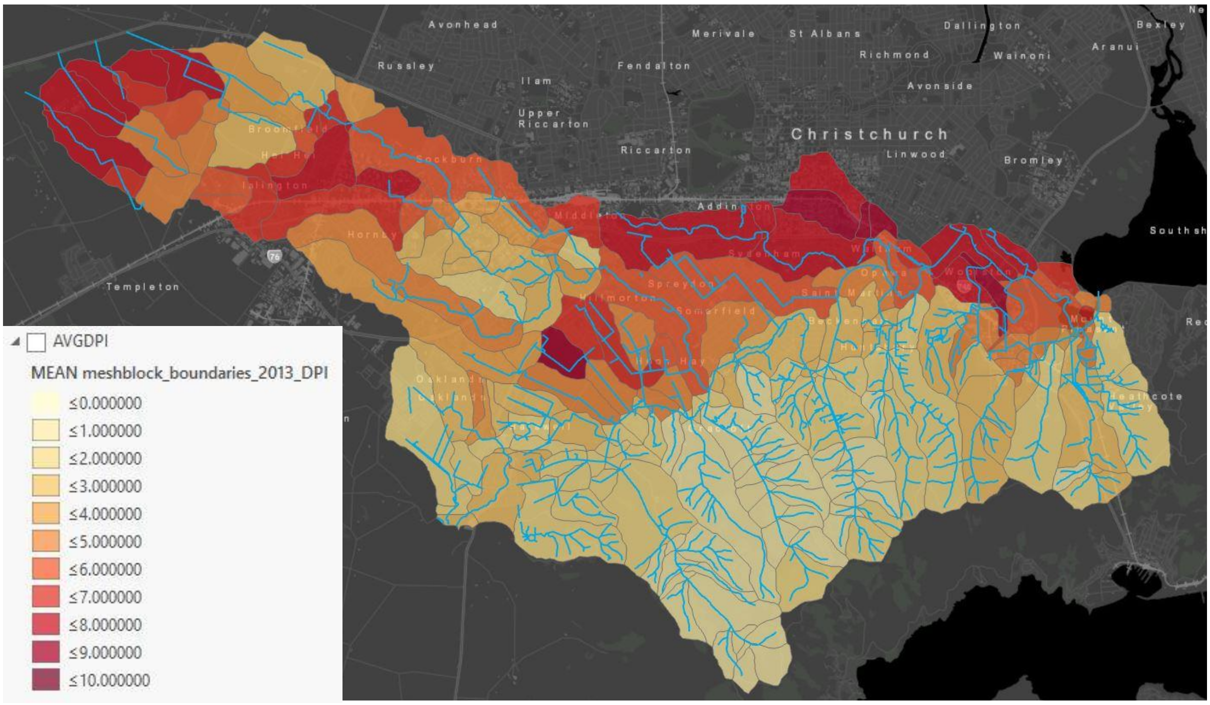


Figure 11: Average Deprivation Index Score per sub-catchment (1-10, where 1 is least deprived and 10 is most deprived). 2013 New Zealand census data.

Figure 12 (below) shows the average household income by sub-catchment (in NZD). It was produced with the same tool and technique as applied for Figure 11, but using household income data. The grey catchments carry over from the missing or confidential meshblock data. While Figure 12 only displays one indicator, it provides a more nuanced picture of the distribution of income levels within the catchment, and may provide information that is relevant to anticipating affordability of various private property-scale or household-scale measures. Income distribution data may also inform considerations of the potential effectiveness of a range of financial incentives (or disincentives) that might be applied within the catchment.

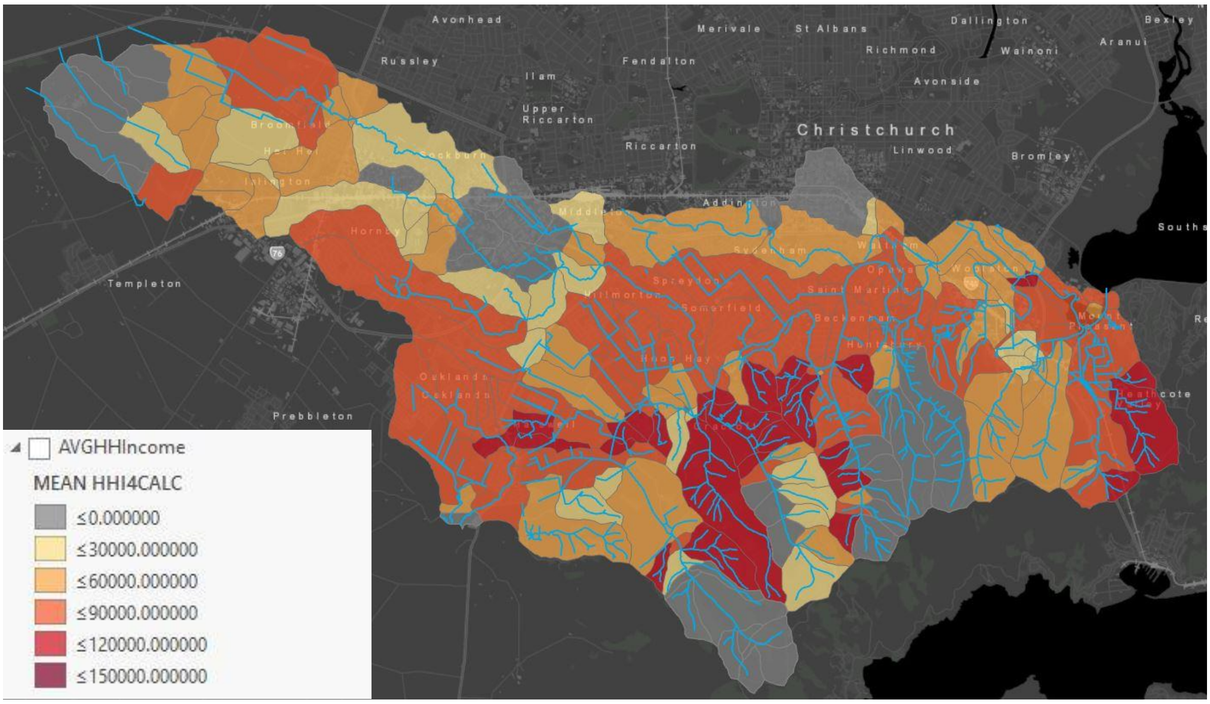


Figure 12: Average household income by sub-catchment. 2013 New Zealand census data.

Figures 13 to 15 (below) are all produced with the same technique as above. Figure 13 shows the weighted average of the percentage of residents in full-time employment by sub-catchment, up to a maximum rate of 56.5%. Figure 14 shows the weighted average of the percentage of residents that hold a tertiary qualification per sub-catchment, up to a maximum of 63.3%. Figure 15 shows the weighted average percentage of owned properties in each sub-catchment, up to a maximum rate of 80.1%.

Employment data can be an indicator of financial security, but requires some careful interpretation. For example, some areas may be characterised by higher numbers of single-earner young families. Similarly, distribution of tertiary qualifications may be an indicator of adult education levels generally, but does not necessarily imply anything specifically about communities' capacity or willingness to engage. Rather, this data may inform initial considerations of different strategies and approaches to engagement in different areas.

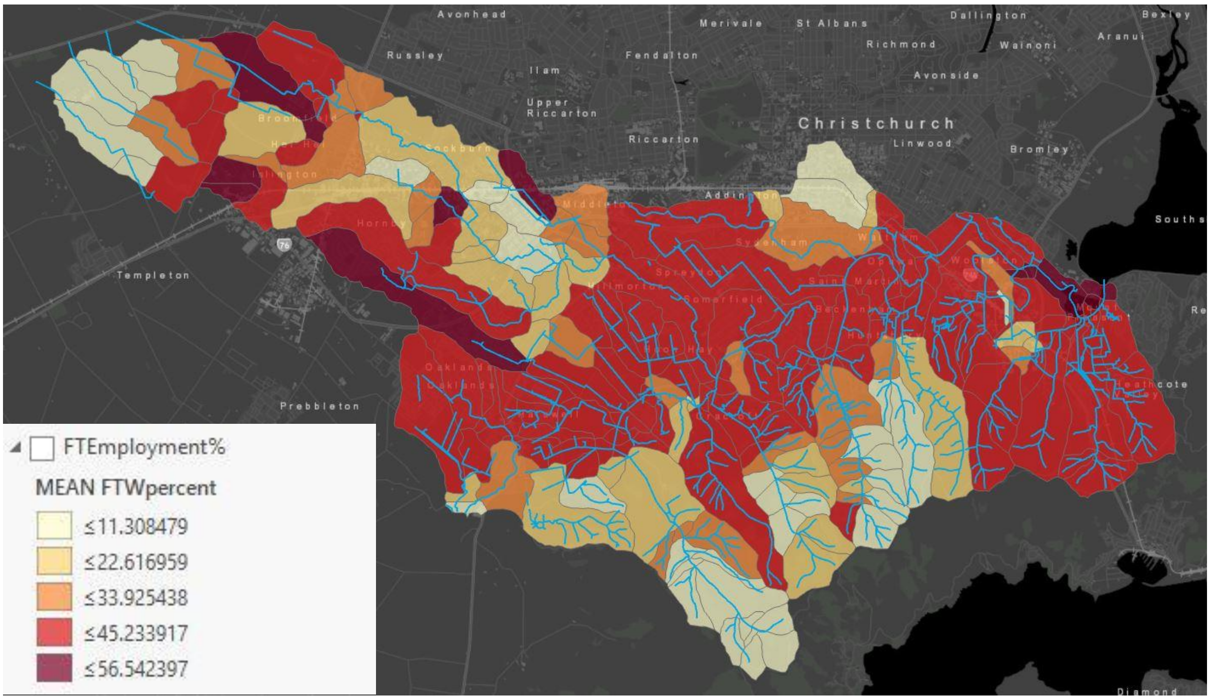


Figure 13: Weighted average of the percentage of working-age people that are employed full time by sub-catchment. 2013 New Zealand census data.

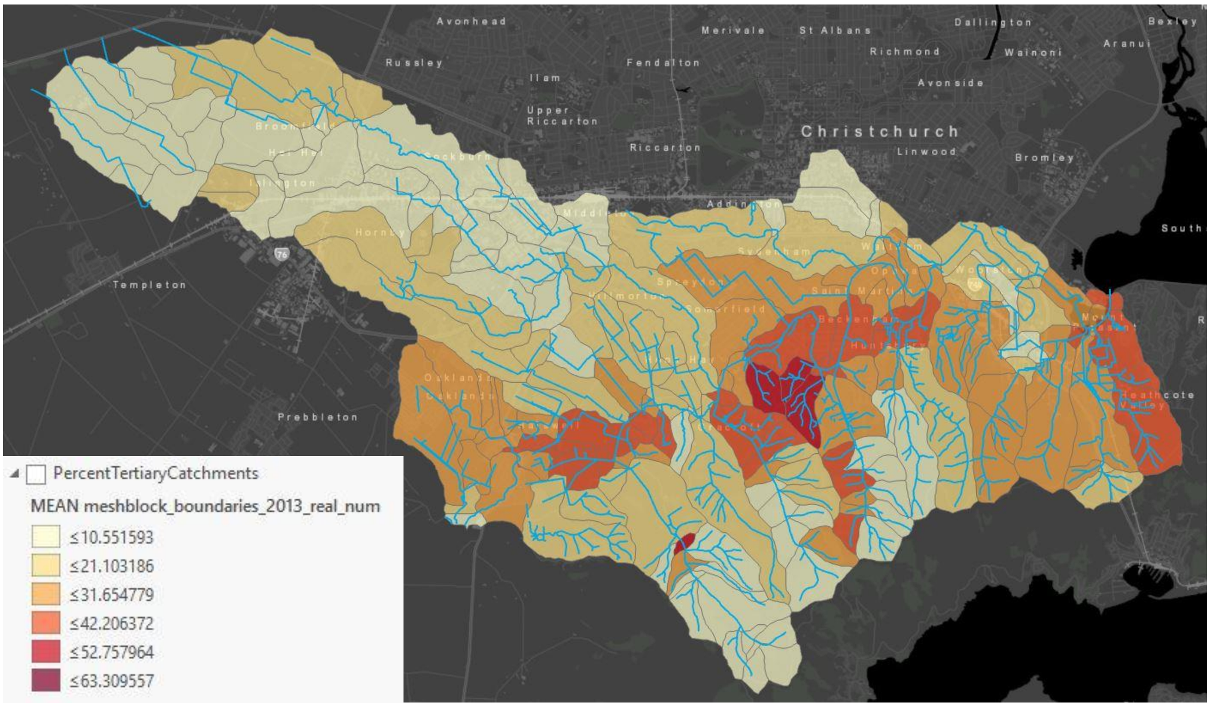


Figure 14: Weighted average of the percentage of working-age people that hold a tertiary qualification by sub-catchment. 2013 New Zealand census data.

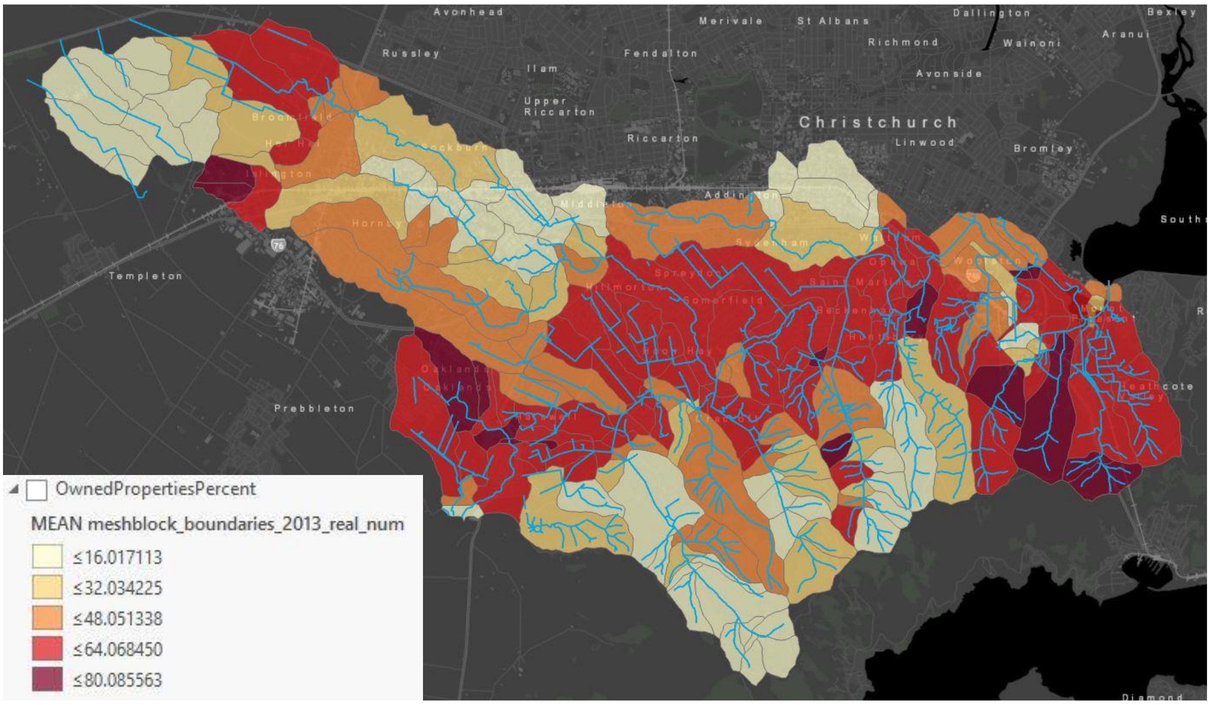


Figure 15: Weighted average percentage of owned properties by sub-catchment.

As discussed above, data on home ownership is potentially useful in designing interventions or initiatives for certain parts of the catchment that rely on uptake by private residents at the residential property scale. The rationales of landlords and tenants are likely to differ significantly when it comes to investing in domestic or private measures to mitigate negative impacts on stormwater or neighbourhood waterways. Owner occupiers not only have a greater direct stake in the long-term value of the property that they occupy, but also a greater stake in environmental quality and amenity values in the surrounding area and neighbourhood. Certain values at the neighbourhood scale can have important implications for quality of life and community wellbeing, as well as for property values. Owner occupiers may therefore also be more tolerant of targeted rates or other levies for stormwater works, urban waterway restoration, or flood risk mitigation. Overall, the incentives and initiatives that work well for renters may be different to those that work for owner occupiers or absentee landlords.

Section 3 – Output Discussion and Analysis

Many patterns begin to emerge through a mapping of selected socio-economic indicators to the Ōpāwaho/Heathcote catchment and its sub-catchments. Average deprivation and household income specifically tend to show similar overall spatial patterns within the catchment, with the Port Hills sub-catchments in the suburbs of Cashmere, Beckenham and Huntsbury, along with parts of the Heathcote Valley and Mt Pleasant in the east, displaying the lowest levels of deprivation and the highest household incomes (Figures 11 and 12). There are also many commonalities – but also some potentially important nuances – among the maps of the other factors: tertiary qualifications, full-time employment, and home ownership. Clearly each of these factors correlates in some way with income, as well as featuring alongside other indicators in the Deprivation Index (NZDep2013). While these factors are therefore all interrelated, a detailed mapping of them (and possibly other factors – see Section 5 below) may suggest strategies for communication and engagement that are adapted for particular socio-economic contexts at the sub-catchment scale. For example, areas of high home ownership in suburbs in the west of the Ōpāwaho/Heathcote catchment, and across the foot of the Port Hills, in suburbs such as Beckenham, Cashmere and Sydenham imply that certain kinds of programmes or incentives for private investment or behaviour change may be more effective in those areas. Similarly, such information can directly inform efforts to engage or consult the community, by helping to ensure that surveys or monitoring efforts target the desired stakeholders, or a representative cross section of the community.

The process of establishing the catchment and sub-catchment shapefiles was important as a basis for this mapping exercise, but it was not straightforward. Challenges were encountered initially in obtaining suitable and accurate sub-catchment data. In particular, the line detail on the NIWA-sourced set of sub-catchment boundary and watercourse shapefiles was inaccurate and blocky. While this cannot be seen from the detail level of the outputs, such as Figure 1, when viewing the figures at closer spatial scales, it is obvious that there are high inaccuracies of the catchment borders at the building/road scale. Unfortunately, there was no publicly available data that was more suitable, so we used the 'Smooth' tool to process and improve the accuracy of data a little and proceeded to use the borders for the figures. However, using this data produced results that left room for improvement (possibly through future LiDAR data) and carried inaccuracies in the base data through to the final outputs. More accurate watercourse shapefiles were accessed from the CCC's private WFS feeds (for the waterways) as well. Attempting to find improved data and resolving these early and fundamental data issues was quite time consuming. While the NIWA sub-catchment data produces tidy sub-catchment boundaries from a large scale, it remains unclear how accurate these actually are in the detailed urban environment, and particularly in the highly urbanised, commercial and light industrial portions of the catchment, where the surface hydrology is highly modified by the stormwater network. A more detailed dataset on these stormwater-influenced sub-catchments would be very useful.

Beyond the census data mapped in this report, there is likely other geospatial data that would be worthwhile mapping and incorporating into analysis of the Ōpāwaho/Heathcote sub-catchments. In particular, City Council data on land use and other zoning, property values, flood risk, sea-level rise scenarios, ecological characteristics, and public amenities (such as reserves and parks, walking and cycling paths, playgrounds) would be useful to map in order to understand how residents in various sub-catchments interact with the waterways. Figure 16 (below), for example, shows predominant land use within the Heathcote catchment by meshblock according to District Plan zone. This is relevant for various reasons. Different land uses imply different stakeholders that might need to be engaged for various urban waterway initiatives. Industrial and commercial zones are likely to require engagement with medium or large businesses, whereas residential zones will require engagement with private households and small businesses, and rural zones potentially with farmers or lifestyle block owners. Different land uses also imply different pressures and impacts on the urban water environment. Furthermore, many of the basic census data should be read in conjunction with other factors such as land use. Income and education data, for example, should be interpreted carefully in the case of inner city commercial and light industrial zones, where there is not a permanent residential population to the same extent as in residential zones. In general, data for very sparsely populated meshblocks may be less reliable than data for densely populated meshblocks, especially where mean values are calculated.

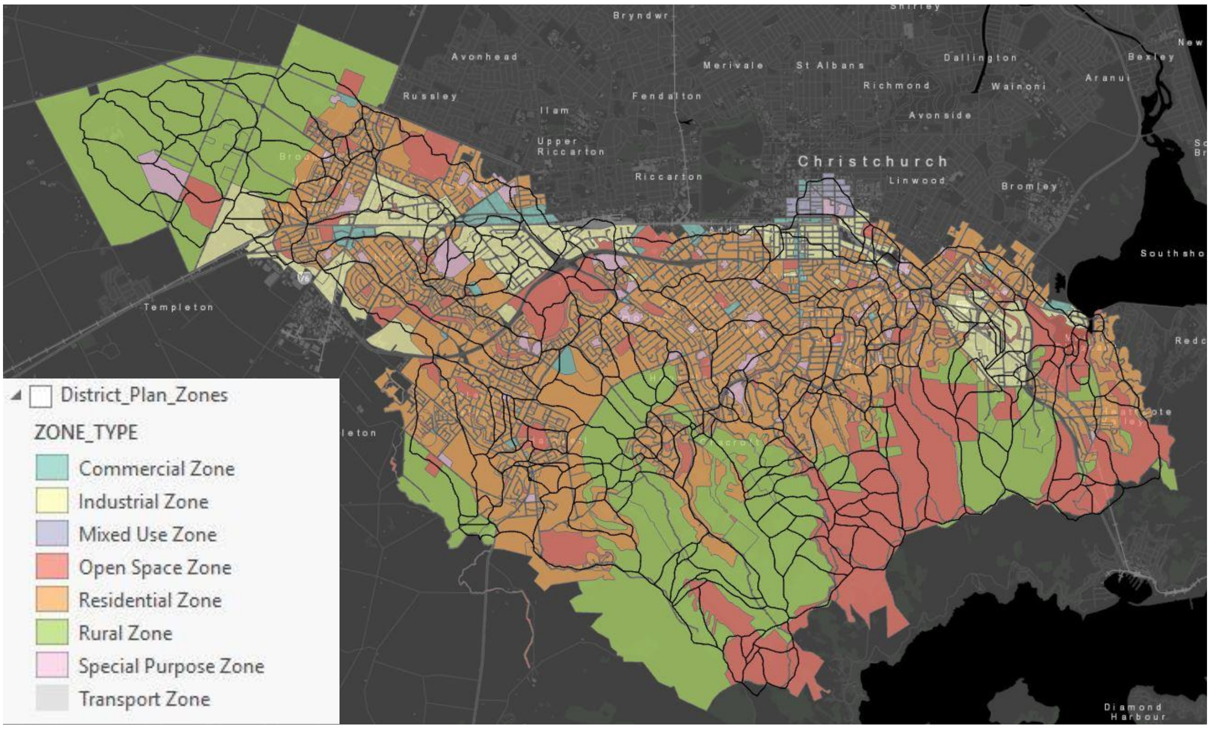


Figure 16: Land use zones in the Ōpāwaho/Heathcote catchment, by meshblock. Data sourced from ECan, via canterburymaps; https://mapviewer.canterburymaps.govt.nz/.

Section 4 – Data Limitations

There were several challenges encountered while carrying out this project. These are documented here so that further work on this topic, or with this data, can be informed by the specific technical issues that arose, and the solutions that we applied. It is likely that further work will be able to refine the key datasets, conduct further and more advanced analyses, and produce more advanced map-based outputs. Some recommendations for further research are made in the concluding section.

The most significant obstacle was the availability of high-quality data at the level of detail required for this kind of GIS analysis. Public data sites such as koordinates.com, canterburymaps.govt.nz, data.linz.govt.nz and geodata.govt.nz, while hosting hundreds of sets of high-quality data, did not have data at the level of local sub-catchments that we needed to produce accurate, clean outputs. The biggest hurdles were finding accurate watercourse line data and sub-catchment boundary polygon data; these were crucial to the completion of the project. For the catchment boundary data, NIWA's River Environment Classification Data version 2.4 was processed to meet our requirements. As the dataset contained catchment boundaries for all of Canterbury, we needed to delete most of the data from the REC 2.4 shapefile to arrive at the Ōpāwaho/Heathcote sub-catchments. Despite the suitability of this dataset, it still presented some problems, as the line detail of the sub-catchment borders was 'blocky' and not particularly accurate. These were smoothed (using the 'Smooth' geoprocessing tool) to remove the 'blockiness' that was characteristic of the whole dataset. This may have altered the exact location of the sub-catchment borders, but the smoothing tolerance was set at 1 metre, so the smoothing changes are assumed to be relatively minor. Smoothing the sub-catchment boundaries had the benefit of providing clean borders for the final socio-economic and demographic outputs.

The watercourse data was accessed via the City Council's Web Feature Service (WFS) feeds. Access to this data, under a data agreement with CCC, was very important for the project. Working with the WFS feeds from off-site however proved challenging. Often, the WFS shapefiles were able to be downloaded and indexed into ArcMap 10.6, but on further inspection of their attribute tables, it was found that geospatial data was missing. We were not able to determine why this occurred, but did manage to get the WFS feeds working sporadically, and managed to access the watercourse shapefile. Similar to the REC 2.4 data set mentioned above, the watercourse shapefile held data for the entire Canterbury region, and had to be processed to show only the tributaries within the Heathcote Basin. Once this was completed, the watercourse data were overlaid with the sub-catchment borders, which matched well.

Some issues were also encountered when joining 2013 Census Data to the meshblock shapefile. As is common with census data, several meshblocks contained missing (<Null>) or confidential (C..) data, which posed problems for ArcGIS. The solution to both the confidential and missing data was setting the rows that were absent to -32768 within the Excel

spreadsheet, which ArcGIS Pro reads as a <Null> value, allowing it to be joined to the meshblock shapefile and calculations to be performed on the remaining data. These cases are represented by grey sub-catchments within the final outputs.

When using the ‘Summarise Within’ tool in ArcGIS to take an average value from each meshblock and summarise it within each sub-catchment border, several complications arose. Most often, the tool would return ‘ERROR 999999’, without supplying further detail on why the code executed incorrectly. The issue was therefore difficult to diagnose. Eventually it was determined that the main problem lay with ArcGIS Pro, which was interpreting the excel spreadsheets (and therefore the attribute tables) of the shapefiles incorrectly; often the category being used to summarise an averaged variable (e.g. DPI) was the wrong data type, and the python code underlying the Summarise Within tool could not recognise the field that was attempting to be calculated. The problems were solved by cleaning up the data as described above in relation to the <Null> values in Excel and creating new fields within the attribute table containing the correct data type for the tool to read from. In cases where the output to be mapped was a percentage (e.g. full-time employment), three new fields were created for each meshblock; one with the number of people employed full time, one with the total number of working-age people in each meshblock, and one which calculated the percentage of full-time workers from the previous two categories. Using this method, the Summarise Within tool worked for all outputs, but resolving the issue was time consuming principally because ArcGIS Pro returned no information regarding where the tool was executing incorrectly. It was one of the major hurdles in the completion of this project.

Other limitations that were encountered involved time and access to auxiliary data. In a project with a longer time horizon there would be more opportunity to develop maps to display additional information, such as cycle ways, proximity of properties to waterways, or trends in water quality or stream health. Maps such as these would be potentially informative, but access to readily available data may also be a constraining factor, as some of this data may need to be gathered especially or processed into a suitable format.

Section 5 – Conclusion

This project represents an initial attempt to map a range of socio-economic data at the sub-catchment level within the Ōpāwaho/Heathcote catchment – one of the major catchments in Christchurch City. The Ōpāwaho/Heathcote is important to map in this way, as it represents one of the two major rivers draining into the Avon-Heathcote Estuary/Ihutai, and drains a large part of Christchurch City and surrounds, including highly developed parts of the Port Hills, as well as reserve land, and rural and peri-urban land. The catchment is relatively diverse geographically and socio-demographically, and contains a wide range of land uses. Therefore, a fine-grained view of the socio-economic and demographic characteristics of the catchment and its sub-catchments should allow for a better understanding of catchment communities, and scope for different kinds of public engagement around stormwater management and urban waterway health. The project has established the availability of some key geospatial data to underpin this, and conducted an initial mapping exercise, which has allowed us to take a closer look at the 'human' landscape within the catchment via sub-catchment scale analysis of factors such as Deprivation Index (DPI), household income, full time employment, educational attainment, and home ownership. The project has indicated that GIS mapping is a useful means by which to explore and visualise some of the socio-economic and demographic variation within the catchment.

It is hoped that the maps produced might inform further work to analyse a wider range of factors at sub-catchment scale, and in doing so inform more targeted, efficient and effective community engagement, awareness raising, and capacity building within the Ōpāwaho/Heathcote. The data presented here, but equally the challenges faced and the solutions found, should provide a strong foundation for additional exploration and analysis. Insofar as there is an urgent need for effective community engagement around stormwater and urban waterways we suggest that work to build on this initial study would be timely and worthwhile. It should make a valuable contribution to tailoring engagement methods to different sectors of our catchment communities, as well as to effective monitoring and evaluation of particular engagement initiatives.

We suggest further work in the following areas:

- The analysis should be repeated and updated with 2018 census data when this becomes available. This will not only provide a current snapshot of socio-economic and demographic characteristics of the sub-catchments, but will also allow a temporal comparison and identification of important shifts over time.
- Additional variables should be mapped. Data on age, household type, and property values for example would be relevant.
- Watercourse data and sub-catchment boundaries could be overlaid with ward boundaries or other administrative boundaries, and school catchments/zones. This may be instructive in terms of aligning groups of sub-catchments with certain

communities or jurisdictions in ways that could inform approaches to accessing certain communities and stakeholders.

- It would be worthwhile, and perhaps necessary, to explore how geospatial information and maps could be relevant to relevant community groups that are active within the catchment. Further work might consult with community groups and elicit input on how to productively engage with sub-catchments, and where engagement might usefully focus (e.g. in ecological 'hot spots' that would benefit from immediate attention, or to address other community priorities).
- It would be useful to explore whether mapping allows for any characterisation of broad 'types' of catchments on the basis of socio-economic/demographic and biophysical characteristics, which could be matched to different kinds of community engagement strategies. For example, flood-prone downstream communities are likely to have a different set of concerns and motivations to upstream rural or peri-urban communities, where residents may not even realise they are part of the catchment.
- Further work could cooperate to a greater extent with the CCC GIS and land drainage teams to identify and map as accurately as possible the stormwater network and stormwater catchments in the urban environment. There may be scope to develop a GIS model of stormwater catchments using the stormwater network and high resolution digital elevation data. A better understanding of how the stormwater network modifies the hydrology at the sub-catchment scale would provide a sound basis for further work.

References and data

Atkinson, J., Crampton, P., & Salmond, C. (2014). *NZDep2013 Index of Deprivation.* Wellington: Department of Public Health, University of Otago. Retrieved from https://www.otago.ac.nz/wellington/departments/publichealth/research/hirp/otago020194.html

Canterbury Maps Open Data. (2019). Retrieved from Canterbury Maps: http://opendata.canterburymaps.govt.nz/

Census Data Tables. (2013). Retrieved from Stats NZ: http://archive.stats.govt.nz/Census/2013-census/data-tables.aspx

Christchurch City Council. (2019). WFS Data Feeds. *Watercourse Data*.

GIS Map Data for New Zealand. (2019). Retrieved from Koordinates: https://koordinates.com/data/global/oceania/new-zealand/

New Zealand Meshblock 2013. (2014). Retrieved from Koordinates: https://koordinates.com/from/datafinder.stats.govt.nz/layer/8347/

River Environment Classification. (2012). Retrieved from NIWA: https://www.niwa.co.nz/freshwater-and-estuaries/management-tools/river-environment-classification-0

Waterways Centre for Freshwater Management
University of Canterbury & Lincoln University
Private Bag 4800
Christchurch
New Zealand

Phone +64 3 364 2330
Fax: +64 3 364 2365

www.waterways.ac.nz