MINISTRY OF TRANSPORT
TE MANATŪ WAKA

Domestic Transport Costs and Charges Study

Local Roads Asset Valuation

Final Report

Prepared by Abley Limited, in association with ECPC Limited

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Glossary of terms and abbreviations

Term	Definition
AADT	Annual Average Daily Traffic
AMDS	Asset Management Data Standard
AWM	Asset & Work Manager
CBA	Cost Benefit Analysis
DRC	Depreciated Replacement Cost
DTCC	Domestic Transport Costs and Charges
FED	Fuel Excise Duty
GDP	Gross Domestic Product
IPSAS	International Public Sector Accounting Standards
IPWEA	Institute of Public Works Engineering Australasia
LINZ	Land Information New Zealand Toitū Te Whenua
MBCM	Monetised Benefits and Costs Manual, NZ Transport Agency
MoT	Ministry of Transport Te Manatū Waka
NLTF	National Land Transport Fund
NZTA	New Zealand Transport Agency Waka Kotahi
ODRC	Optimised Depreciated Replacement Cost
ONF	One Network Framework
ONRC	One Network Road Classification
ORC	Optimised Replacement Cost
PBE	Public Benefit Entity
RAMM	Road Assessment and Maintenance Management
RCA	Road Controlling Authority
Stats NZ	Statistics New Zealand Tatauranga Aotearoa

SA1	Statistical Area 1
SA2	Statistical Area 2
STCC	Surface Transport Costs and Charges
TA	Territorial authority
WP	(DTCC) Working Paper
WTP	Willingness to Pay

Executive Summary

Background

This report summarises research to develop methodologies for valuing local road assets in New Zealand. This project forms part of the Domestic Transport Costs and Charges (DTCC) annual research programme. The objectives of the project are to develop a methodology or methodologies that provide consistent valuation of network land and roading assets across New Zealand, and to demonstrate these through a targeted set of case studies.

Currently, valuation of the state highway network and local roads is performed separately by NZ Transport Agency Waka Kotahi (NZTA) and territorial authorities (TAs – local and district councils), respectively. While valuation approaches for roading assets are approximately standardised across regions, approaches to valuing land assets vary widely.

The lack of robust estimates for the value of the local road network is a key knowledge gap and may distort decisions around investment, maintenance and user charges. The Ministry of Transport (MoT) have commissioned this research to address this valuation knowledge gap.

Literature and Current Practice Review

A literature review covered the theoretical basis of road valuation and examined prior research and current practices regarding estimating the value of road networks.

There are multiple potential approaches to determining the value of an asset. Direction from MoT indicated a preference for cost-based valuation approaches, rather than valuation based on the economic benefit streams arising from the asset. On this basis, the most suitable valuation perspective was determined to be the *fair value* approach, widely used in accounting and valuation professions to reflect an estimated fair market price for an asset. In the context of road valuations, the fair value is commonly estimated as the optimised depreciated replacement cost (ODRC) of the non-land roading assets and a market-based assessment of land under the road network. This accords with valuation approaches taken by NZTA and local government for non-land assets.

Examination of previous DTCC and other New Zealand research highlighted significant disparities in road land valuations between TAs (which tend to use varied valuation approaches, including historic cost or infrequently-updated market valuations), and NZTA (which uses an *over-the-fence* method based on recent valuation data for adjacent land parcels, averaged at the Statistical Area 1 level).

A data review highlighted the quality and coverage of data sources that could be used to estimate local road valuations. Land parcel and valuation data were widely available, while some uncertainties remained around the availability and completeness of non-land road asset and valuation data.

Valuation Methodology Development and Case Studies

A preliminary multi-criteria analysis process was used to rank potential valuation options and inform the preferred valuation methodology. The preferred valuation approach used a hybrid methodology. TA-reported valuations for non-land assets were applied, except for valuations identified as outliers, which were re-estimated using top-down or bottom-up methods based on asset class. Land valuation used an over-the-fence approach based on averaging at the Statistical Area 1 or 2 level.

The preferred approach was applied to five case study areas: Newtown, Wellington; Wellington City; Banks Peninsula, Canterbury; Totara Park, Upper Hutt; and Upper Hutt City. Two potential approaches to outlier identification and re-estimation were explored:

- an *implied unit rate* approach where average unit cost (per unit length or area, depending on asset class) was estimated for each asset class / road type pairing and outliers identified based on a confidence interval of unit rates across case study areas, and
- a *regression* approach where individual asset values (at the road section level) were modelled using available covariates of traffic volume, terrain, and section length and width.

Case study valuations showed small differences in valuation from these two approaches. The dominant component of the case study valuations were land values, which represented between 50% and 90% of estimated total asset value across the case studies.

Approximate nationwide extrapolation of the case study results gives a total estimated value of local road assets between $288 billion and $333 billion (as of June 2024). This is significantly higher than both the 2018 DTCC estimate of the local road network value ($61 billion) and the 2024 NZTA valuation of the state highway network ($85 billion).

Rollout Plan

Insights from the case study exercise informed the development of a rollout plan for a preferred nationwide valuation methodology. The regression approach is recommended for high-value and data-rich carriageway assets (formation, surface, basecourse and subbase), while more approximate implied unit rates or top-down estimates are recommended for other asset categories. There are also potential refinements that could be applied to the regression modelling approach as more data becomes available.

TA asset characteristic data is expected to be generally available for a nationwide valuation through standard asset management systems, however uncertainty remains around the availability of existing TA valuation datasets and the effort required to align these with asset datasets. The rollout plan recommends a survey of TA valuation datasets to inform the feasible sample size of TA valuations used for development of the final valuation model.

Given the wide range of land value estimates provided in this study, it is recommended that further engagement with land valuation experts is sought to determine the appropriate averaging scale used for land valuation (SA1 or SA2).

1 Introduction

An understanding of the true economic costs of the provision, use and operation of the New Zealand domestic transport system is critical to informing optimal policy, pricing and investment decisions. As the largest land transport asset within the system, accurate and transparent valuation of the national road network is a key piece of this understanding.

Currently, valuation of the state highway network and local roads is performed separately by NZ Transport Agency Waka Kotahi (NZTA) and territorial authorities (TAs – local and district councils), respectively. While the valuation methods applied to non-land roading assets are approximately standardised across regions, approaches to valuing land assets vary widely, including some uses of historic cost valuation, or a lack of any published valuation whatsoever.

Prior Ministry of Transport (MoT) research to value the local road network indicated a value per route-kilometre much lower than that of the state highway network and identified significant inconsistencies in TA roading valuations. The lack of consistent estimates for the value of the local road network is a key knowledge gap and may distort decisions around investment, maintenance and user charges. MoT have commissioned this research to address this valuation knowledge gap.

1.1 Objectives

The purpose of this research is to develop a generalisable and well-documented valuation methodology for local roads in New Zealand that consistently values network land and roading assets, and to demonstrate this methodology through a targeted set of case studies.

The high-level objectives of this research are:

1. A **review** of the current practice of valuation of road networks, including a review of existing NZTA valuation methodologies, international literature and available datasets.
2. **Selection and development of appropriate valuation model(s)** that are suitable for use with the available data and flexible enough to be applied to varied urban, suburban and rural settings in a consistent manner.
3. **Demonstration of preferred valuation model(s)** across a representative set of case studies.
4. **Evaluation** of the suitability of the model(s) and datasets to full valuation of the local road network.

1.2 Context

This research forms part of the Domestic Transport Costs and Charges (DTCC) study programme. The DTCC study aims to identify all the costs associated with the domestic transport system on the wider New Zealand economy including costs (financial and non-financial) and charges borne by the transport user. The main DTCC report was released in June 2023 (Ian Wallis Associates, 2023).

A number of working papers were prepared as part of the DTCC study main report. Of particular relevance to the present work are the following reports:

- WP-C2 – The Valuation of the Road Network (Richard Paling Consulting & Ian Wallis Associates Ltd, 2023),

- WP-C1.2 – Road Infrastructure – Total and average cost (David Lupton & Ian Wallis Associates Ltd, 2023),
- WP-C7 – Parking (Veitch Lister Consulting & Ian Wallis Associates, 2023a) and
- WP-C8 – Walking and Cycling (Veitch Lister Consulting & Ian Wallis Associates, 2023b),

These documents collectively estimated the value of built structures and land that make up public walking, cycling and road networks (including parking).

The DTCC programme also follows similar studies in 1995 (Ministry of Transport, 1995) and 2005 (Booz Allen Hamilton, 2004b, 2004a, 2005).

Methodologies and findings from previous valuations of the New Zealand road network are discussed further in Section 2.6.

1.2.1 Project Steering Group

The Project Steering Group (PSG) for this research is made up of representatives from MoT and NZTA, including staff involved in the NZTA state highway valuation process and subject matter experts in economics, roading asset data and geographic information systems.

1.3 Scope

The scope of this project is to develop a consistent approach to estimate the value of land and infrastructure associated with the New Zealand local road network and to illustrate the recommended approach(es) through the use of case studies. The specific scope has been refined in discussions with the Project Steering Group. The valuation is intended to generally include road components within the road reserve, including (but not limited to):

- land,
- formation,
- road surface,
- kerbing / drainage,
- structures (e.g. bridges, tunnels, culverts, overpasses),
- on-road cycle / bus lanes and kerbside parking.

The following components are not included in the scope of this valuation exercise:

- off-street parking areas,
- off-street walking / cycling paths,
- paper roads or private roads not vested with councils,
- roads for which a TA is not the road controlling authority, such as roads on university or hospital campuses

1.3.1 Cost- vs. benefit-based valuation

Given the focus of the DTCC study on assessing cost and charges, the Project Steering Group have also advised that the valuation is intended to reflect the cost of the network, rather than being based on the economic benefit streams it generates. This is discussed further in Section 2.1.

2 Valuation Literature and Current Practice Review

This chapter provides a brief overview of the purpose of valuation, different perspectives and objectives of valuation, an overview of how roads have been valued in New Zealand and a discussion of potential valuation methods for the local road network.

A discussion is also included around the potential valuation perspectives that could be applied. The authors primarily make the case here for use of the *fair value* approach to valuing local roads, given that this approach is used internationally and by NZTA and TAs.

2.1 Purpose of valuation

The purpose of the valuation of local roads in the context of this project is not narrowly focused on one specific outcome. Earlier DTCC studies have stated an aim to contribute to the understanding of transport outcomes by providing consistent methods for (a) estimating and reporting economic costs and financial charges; and (b) understanding how these costs and charges vary across dimensions that are relevant to policy, such as location, mode, and trip type. Furthermore, estimates of road network valuation can be used, via applying the target rate of return, to provide an estimate of the economic costs which could be attributed to road users and should in principle be recovered from them over time (Richard Paling Consulting & Ian Wallis Associates Ltd, 2023).

These objectives follow from the general theme expressed in *National Roading Account – The Cost of Roading Infrastructure* (Ministry of Transport, 1995), an early predecessor of the DTCC study, where consistent costing and pricing between the public and private sectors was sought, so as to enable allocative efficient choices made by consumers. If roads are supplied at below their opportunity cost then people will likely overuse roads when they could be deriving higher welfare/utility with other consumption (Lavee, 2015; Litman, 2021).

In practical terms, knowing the current cost of a road does provide a value that informs:

a) a price to apply for parties wishing to use the road, including use of the roadside, the road lanes and the area above or beneath the road corridor;

b) a price to apply when roads are transferred between NZTA, Councils and/or other entities; and/or

c) a cost of capital to apply to the use of public funds by a road controlling authority.

A change in ownership of roads, or more often parts of roads, can occur (e.g., when a State Highway is revoked and passes back to a TA) and appraisal and negotiation processes already apply. A readily available and consistent database of road values may simplify this process. Other areas where pricing applies to roads is tolling for road use and fees applied for easement.

For territorial authorities, roading assets make up a significant proportion of their balance sheets. Accurate valuation of roading networks allows TAs to understand their financial position and associated implications on borrowing and insurance.

Last, for context, it is noted that the NZTA and TAs are not subject to a capital charge. A Ministry of the Crown pays a capital charge on its equity, with the rate set to the current public sector discount rate (The Treasury New Zealand, 2024). The NZTA and Councils do not pay a capital charge to the Crown as their revenue is considered to come from "third party fee payers", being the payers of the excise duties, vehicle registration fees and road user charges for NZTA and local property rates for Councils. Booz Allen Hamilton (2005) provides suggestions as to how the NZTA funding system[1] could be refined to better match current revenue and fixed costs.

2.2 Valuation perspectives

There are various perspectives on the measurement of value, and value may be estimated differently even within each perspective. For completeness, a full discussion of these perspectives is provided in Appendix B and summarised in Table 2.1.

Table 2.1 Summary of valuation perspectives

Measure	Comment
Intrinsic value	• Typically considered intangible • Typically treated outside of valuation in decision-making • Can be relevant for indigenous land
Economic (instrumental) value	• Used in cost-benefit analysis • Based on opportunity cost and willingness to pay • Includes (difficult) non-market valuation • Excludes intangible values above
Current market value	• Readily observed, but only for traded goods • Not observed for roads or land under roads • Excludes non-market values (e.g., roads) and intangibles above
Fair market value	• The Accounting Standard used by NZTA and Councils • Provides an estimate of current market value • Does not capture all non-market values and excludes intangibles • Can require sophisticated estimation • Mixed application for roads
Historic (market) value	• Generally accurate at the time, though quickly becomes irrelevant • Excludes non-market values and intangibles

MoT have indicated that the present valuation exercise should take a cost-based perspective, rather than a valuation derived from the benefit stream or economic value of the network. Potential future research into valuations based on user demand or economic benefit streams would complement the cost-based approaches that are the focus of this work.

2.2.1 Fair value

The preferred valuation perspective for this research is *fair value*. The concept of fair value has evolved in the accounting and valuation professions to estimate a fair exchange value for assets where a market does not exist.

In abstract terms, the fair market value can be thought of as the price that an investor would pay for the entire NZ road network. The purchase would be on an 'as is' basis and would then be operated for the financial gain of the investor. The investor would price the network with the conception in mind that a similar road network (with similar expected returns) could be built

[1] Referred to as a Pay As You Go (PAYGO) or fully allocated cost (FAC) approach, which is widely used internationally

elsewhere at a similar price. It is the cost of this competing investment that determines the fair market value of the NZ road network.

A widely applied estimate of the fair value of a road network is the optimised depreciated replacement cost of roading assets plus the estimated market value of land assets. This is currently used by NZTA and TAs to value their road networks. Optimised replacement costs refer to the cost of a replacing an asset to achieve an equivalent level of service, using modern equivalent assets and construction methods.

The fair value approach allows differences in land valuation and replacement valuation assumptions, so some variation is possible between entities is due to methodological differences. It will also not capture non-market effects and may understate the overall economic benefit of the road network

2.3 Methods of road valuation being applied

The discussion now turns to different methods that are being applied for road valuation, drawing heavily from a guide published by the US National Cooperative Highway Research Program (NCHRP) (National Academies of Sciences, Engineering, and Medicine, 2022) and from a property valuation textbook (Blackledge, 2009).

The NCHRP Guide refers to six steps to undertake in any transport asset valuation: (i) define analysis scope; (ii) establish initial value; (iii) determine treatment (ie. renewal) effects; (iv) calculate depreciation; (v) calculate value; (vi) communicate results. See illustration in Figure 2.1.

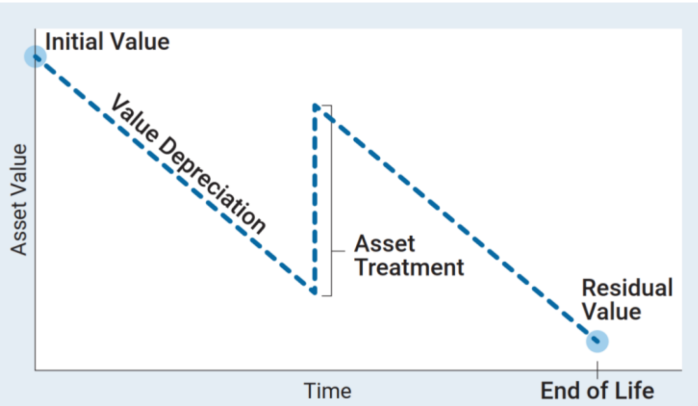

Figure 2.1: Stylised asset value over life of the asset (Source: NCHRP, 2022)

The NCHRP Guide also refers to four potential values: (a) the historic or purchase cost of the asset; (b) the current replacement value; (c) the current market value, should a market exist; and (d) the economic value, defined to be the present value of the benefits. Methods (b) to (d) pertain to deriving a current value.

Last, the NCHRP Guide also warns that the best approach for valuation is often a trade-off between simplicity and complexity and that the valuation approach should be adapted so that it provides the information of greatest use, where the needs of public agencies can be a mix of financial recording, economic appraisal and regulation compliance.

The methods are split below into those applying to the components of a road[2] and those applying to the land under and surrounding the road. The split value can vary considerably, with land values being a relatively small portion of total road value in rural areas but a large share in large urban areas.

2.3.1 Non-land asset valuation

The non-land components of a road are typically valued at optimised depreciated replacement cost (ODRC). The principle applied as expressed by the UK National Highways is to calculate "*the value of the [network] to a theoretical buyer based on how much it would cost to construct a network of equivalent service potential*". This assumes any replacement network would be built on empty land (National Highways, 2024). The NCHRP Guide lays out six steps as follows:

- Step 1. Determine Units of Measure
- Step 2. Collect Data on Replacement Costs including optimising the asset to replace, effectively replacing an asset with its modern equivalent rather than replacing an asset in-kind
- Step 3. Adjust Costs for Inflation
- Step 4. Determine How to Group Assets
- Step 5. Calculate Unit Costs for Each Group
- Step 6. Apply Unit Costs

This process is similar to that recommended by New Zealand Asset Management Support (NAMS) and Institute of Public Works Engineering Australasia (IPWEA) in their International Infrastructure Management Manual and by ISO Standard 55000 Asset Management Standards.

A similar approach is applied to other NZ public assets, such as those within the health and education sectors (The Treasury New Zealand, 2007).

The determination of depreciation and optimisation requires an element of judgement. The condition of roads will depend on the renewal treatments, as well as more regular maintenance. In turn, the current road condition will affect the expected residual life of the road and hence its current value. Maintenance, renewal treatments and general road condition can vary significantly across New Zealand. The optimisation adjustment requires realigning the current road being considered in the replacement valuation to meet expected demand and modern standards. For example, a road may no longer be required or may today be constructed with different materials. The optimisation of NZ road assets was believed to be small due to economies of scale and little technological change (Ministry of Transport, 1995) but this is a matter for further research.

2.3.2 Land valuation

A common land valuation approach is the "over-the-fence"[3] valuation method, whereby the market value of the corridor is related to the value of adjacent land. Typically, corridor land is assumed to be worth at least as much as the adjacent land through which it passes, such that a valuation based on adjacent land values represents a minimum value for the corridor. Such valuation methods are widely applied to value railroad or transmission corridors in the United States and may include an 'enhancement' premium or discount applied (Seymour, 2002).

[2] Otherwise referred to as network assets, roading assets, infrastructure assets
[3] Also known as "across-the-fence" valuation

Variations include using land values for certain land use types and for different area sizes. Some examples include:

- Transport for NSW values land by 'the urban Average Rateable Value per hectare within each Local Government Area'[4], adjusted by an open-space ratio (Transport for NSW, 2023a).
- The UK National Highways values land 'based on its [unspecified] geographic location' (National Highways, 2024).

The wider land areas used in the Transport for NSW study may have arisen due to considerations of proximity bias but this could not be confirmed. There were no instances found whereby the value of road land was adjusted for the endogeneity created by accessibility.

2.3.3 Combined asset valuation

Having derived an asset valuation by combining methods presented or similar to the above, it may be that asset use is impaired in some way (e.g., a large slip blocks part of the road or a change in demand makes more than two lanes unnecessary). An estimate of how any impairment affects the value of a road is required, although generally impairments for roads are few due to economies of scale and network effects.

2.4 NZTA state highway valuation

The New Zealand state highway network is valued by the NZTA on an annual basis. Assets are valued using an Optimised Depreciated Replacement Cost (ODRC) approach, though land and formation are not depreciated. The Optimised Depreciated Replacement Cost approach assumes modern construction techniques are used to recreate the current physical asset, including any substandard geometry or service levels, if applicable (NZTA, 2023)

The valuation and associated methodology is presented in NZTA annual reports (NZTA, 2024b) and the State Highway Valuation Handbook (NZTA, 2023). WSP, as a valuation consultant, is responsible for the valuation of existing network assets as well as reviewing other valuation components, and provides detailed reporting of the valuation process (WSP, 2023, 2024).

In the NZTA 2024 Annual Report[5], the estimated total optimised depreciated replacement cost of the state highway network is estimated as $85.3 billion. The largest components of the valuation are land ($23.0 billion, 27%) and formation ($20.6 billion, 24%). The valuation components are shown in Table 2.2.

[4] NSW is split into 128 local government areas, similar to NZ TAs.
[5] There are minor discrepancies between the *2024 Valuation of the State Highway Network Report* (WSP, 2024) and the NZTA 2024 annual report. We have used the latter.

Table 2.2 2023/2024 state highway valuation (NZTA, 2024b)

State highway component	2023/24 ODRC ($m)	Proportion
Land	22,969	27%
Formation	20,593	24%
Pavement – basecourse	11,570	14%
Pavement – surface	2,296	3%
Drainage	3,196	4%
Traffic facilities	2,199	3%
Bridges	15,440	18%
Culverts and subways	1,014	1%
Tunnels and other structures	5,515	6%
Miscellaneous	514	1%
Total	85,306	

2.4.1 Network asset valuation

Non-land assets that make up the state highway are valued on an ODRC basis. In general, valuation is based on separately estimated quantities and unit cost rates. Existing state highway assets are valued using estimated quantities from NZTA data and unit costs derived from industry sources and indexation.

2.4.1.1 Asset data

Most transport assets in the state highway network are registered in the RAMM (Road Assessment and Maintenance Management) system, including formation, pavement, drainage and traffic facilities. The RAMM valuation module allows standardised computation of asset values by combining database information – such as construction attributes, age and condition – with user-defined inputs and valuation rules. Remaining useful life, replacement cost and annual depreciation are calculated by this module.

Bridges and culverts are valued using an NZTA spreadsheet tool, with inputs from condition and construction data in the Highway Structures Information Management System (HSIMS). Custom business rules are required to determine whether a structure is a bridge or culvert, as this information is not readily available from HSIMS.

Assets constructed or renewed in the current financial year are valued as capital expenditure (see Section 2.4.1.5) and are excluded from the RAMM or HSIMS asset valuation process.

2.4.1.2 Unit cost rates

Unit cost rates are re-estimated from industry data every three years and updated in other years using index adjustments. BondCM are engaged by NZTA to determine unit cost rates.

Unit costs are developed for the following asset groups:

- Pavement
- Drainage

- Signs
- Railings / Barriers
- Bridges
- Culverts and Subways
- Retaining Walls

Unit cost rates are in some cases adjusted to reflect regional differences by applying a scaling factor in selected regions.

Annual changes in unit cost rates are estimated by BondCM from a combination of updated industry data and NZTA cost indices (NZTA, 2024a). The NZTA Construction index is used to adjust all non-land asset categories except tunnel linings, bridges and culverts, which use the NZTA Structures index.

2.4.1.3 Depreciation

Depreciated replacement costs are estimated using assumed useful lifespan by asset type, with straight line depreciation by age. Assumed asset lifespans are shown in Table 2.3.

Table 2.3 Selected asset lifespan assumptions

Asset Type	Expected Useful Life
Land	Not depreciated
Formation	Not depreciated
Pavement – subbase	Not depreciated
Pavement – basecourse	75-150 years
Pavement – surface	10-13.5 years
Drainage	50 years
Signs	10 years
Railings and barriers	25 years
Other traffic facilities	15 years
Bridges	90-100 years
Culverts	50-75 years

Where asset age data are not available or of low quality, assets are assumed to be halfway through their useful lifespan. Assets that are near or beyond their expected lifespans are assigned a nominal minimum remaining life. Depreciating assets are assumed to have zero residual value at the end of their useful life (NZTA, 2023).

2.4.1.4 Miscellaneous assets

Minor and low-value miscellaneous assets are valued in a top-down manner, as an estimated percentage of asset value. These assets include:

- Intelligent Transportation Systems, Traffic Management Units, and tolling assets
- Bailey bridges

- Minor structures (e.g. sea/river protection, rockfall netting & fords, weigh stations, walls not in RAMM)

In the 2024 valuation, depreciated replacement cost of miscellaneous assets is assumed to equal 1.6% of the total depreciated replacement cost of other assets, excluding land and formation.

2.4.1.5 CAPEX and WIP

Construction and renewals for projects completed in the current financial year are treated as capital expenditure (CAPEX). Construction and renewal costs incurred for incomplete projects are classified as work in progress (WIP). The following procedures are used to value WIP and CAPEX:

- Current-year recorded expenditure is allocated to CAPEX or WIP based on an assumed split by expenditure classification: “new” (10:90 CAPEX: WIP) or “renewal” (80:20).
- Current-year CAPEX and WIP expenditure is included in the valuation with no indexation or depreciation.
- Expenditure occurring in previous years is indexed to the valuation date using NZTA procurement cost indices.
- CAPEX before the current year is adjusted to account for depreciation.
- WIP is not depreciated.
- CAPEX totals are apportioned across asset types according to expected distributions by work category.
- Major projects that are completed but not yet included in the NZTA roading asset system are valued as WIP.

CAPEX for the 2023/24 valuation included $304m of improvements, $440m of renewals and $1,420m WIP, or around 2.5% of total ODRC.

2.4.1.6 Other considerations

An additional allowance is included in estimated replacement costs to reflect the environment in which renewal or replacement is likely to take place. Work on brownfield sites is expected to come at a higher cost to greenfield construction, due to the greater intensity of existing development and higher costs of managing construction impacts. The brownfield allowance is 15% for motorway and urban assets, and 5% for rural assets. It is only applied to depreciable assets.

Allowances for internal costs, professional fees, and preliminary and general costs are included as shown in Table 2.4. Preliminary and general costs include contractor overheads and site setup, establishment, monitoring and disestablishment.

Table 2.4 NZTA valuation allowances

Component	2024 NZTA value
Professional fees	12% of base cost
Internal costs	3% of base cost
Preliminary and general (P&G)	36% of base + professional + internal costs
Overall on-cost allowance	56.4% of base cost

2.4.2 Land valuation

2.4.2.1 Corridor land

Corridor land is valued using an over-the-fence approach, using an automated geospatial process developed by NZTA. The value of land under the road (per unit area) is assumed to equal the average land value of parcels adjacent to the road corridor.

Road parcel data is sourced from LINZ and intersected with the state highway centreline to determine NZTA ownership. CoreLogic valuation data is used to determine average land values (per unit area) for each Statistical Area 1 (SA1), as defined by Stats NZ[6]. These average values are indexed to the desired network valuation date using CoreLogic regional house price indices. To estimate corridor land value, the indexed average land values are applied to road corridor parcels (or parts thereof) that fall within the corresponding SA1.

2.4.2.2 Held property

Property held by NZTA for future network expansion or other purposes is valued separately by an external valuation consultant. Properties are re-appraised according to value, with more frequent revaluation for higher valued properties. Properties that are not manually revalued in a given year instead use index adjustment of previous valuations.

2.4.3 Sensitivity analysis

The NZTA 2024 annual report presents a sensitivity analysis of the state highway network valuation, where the impact of a 10% increase in key parameters is assessed (NZTA, 2024b). The sensitivity analysis shows that the valuation is most sensitive to a change in:

- overall price indices (~7% increase in valuation for a 10% increase in parameter),
- overall unit costs (~3% increase),
- formation unit costs (~2% increase), and
- corridor land costs (~3% increase).

2.5 Territorial authority road valuation

Territorial authorities value their assets regularly, for asset management purposes and to meet financial reporting requirements, in particular to comply with Public Benefit Entity (PBE) Standards IFRS 17 for the reporting of Plant, Property and Equipment[7]. The Office of Auditor General audits accounting processes (External Reporting Board, 2016, 2023). These standards set out alternative methods and provide guidance but there is still scope for different application of alternative methods and alternative judgements made within methods.

2.5.1 Network asset valuation

The regular auditing of TA financial reports ensures that TAs are applying PBE standards, but this still leaves scope for differing assumptions and judgements in the valuation process. In all cases there will be differences between TAs that occur because of genuine differences in assets and the

[6] An SA1 unit is aimed to contain around 100-200 residents while an SA2 (Statistical Area 2) unit combines SA1 units into suburbs or similar (https://www.stats.govt.nz/assets/Methods/Statistical-standard-for-geographic-areas-2023/Statistical-standard-for-geographic-areas-2023.pdf)
[7] To be replaced in 2025 with IPSAS 45 and noting that accrual accounting was only introduced for the public sector in 1989.

environment conditions in which assets exist and differences that may simply reflect differences of opinion or institutional practice[8].

Of particular note are the following aspects of existing practice:

- The historic cost for the same asset (e.g., a bridge) is likely to reflect market values but the component costs and component mix may differ between locations, and assets may be grouped differently by each Council.
- There will be different assumptions made as to the expected life of any asset and TAs can choose either a straight-line or diminishing method of depreciation, although these assumptions should not affect future book values if assets are regularly revalued.
- It is unknown to what extend TAs undertake asset revaluation – it is required where fair value can be measured reliably, but it is possible that this judgement is applied differently.
- It is also unknown to what extend TAs apply different methods to the revaluation of assets, as permitted by the accounting standards.
- Last, the revaluation exercise requires a reassessment of the remaining life of an asset – these will differ for genuine reasons but also will differ due to the differing standards of asset condition scoring.

In summary, the financial reports of the TAs are likely to provide a reasonable estimate of the value of asset components but there will be variation that reflects differing opinions and asset management practices between TAs. It would be difficult to provide any better estimate without knowing local climate and environmental conditions and the condition of local assets.

2.5.2 Land valuation

Previous DTCC research (Richard Paling Consulting & Ian Wallis Associates Ltd, 2023) reports that TAs largely record the value of the land under roads at historic cost. This is generally at the date of purchase or a date around the time that land was brought into the financial accounts, including as far back as 2002.

Examples of the approaches taken include (sourced from their Annual Reports):

- Taupo District Council value according to the adjoining current land value ($47m in June 2023), whereby “land under roads is separated into rural and urban and then valued based on a weighted average rate for each type”;
- Auckland Transport appear to value infrastructural land ($7.4b in June 2023) at the date of purchase, given that recent annual reports do not include an adjustment for revaluation.
- Wellington City Council assume land under and adjacent to roads has a value based on the average value of adjacent land as of 2005, discounted by 50% “to reflect its restricted nature”. Land used for the local road network has not been re-valued since 2005 and subsequent additions are recorded at cost.

It is evident that these approaches are highly variable across TAs and are unlikely to result in consistent estimates for network land value. This represents a significant issue preventing consistent and defensible valuation of local roads, particular given the likely large share of this value represented by land assets.

[8] Australian research found large differences in accounting treatment amongst Australian road controlling authorities and suggested each step in the valuation is problematic (Ivanchak, 2022).

2.6 Previous valuations of the road network

Previous Ministry of Transport research has estimated the value of the state highway and local road networks in New Zealand, most recently in the studies listed in Table 2.5. These studies are referred to by their abbreviation for the remainder of this section.

Table 2.5 Previous studies valuing the NZ road network

Study	Abbr.	Reference
National Roading Account: The Cost of Roading Infrastructure	NRA	(Ministry of Transport, 1995)
Surface Transport Costs and Charges	STCC	(Booz Allen Hamilton, 2005a)
Domestic Transport Costs and Charges – Working Paper C2: Valuation of the Road Network	WP-C2	(Richard Paling Consulting & Ian Wallis Associates Ltd, 2023)
Domestic Transport Costs and Charges – Working Paper C8: Walking and Cycling	WP-C8	(Veitch Lister Consulting & Ian Wallis Associates, 2023b).

The NRA, STCC and WP-C2 studies estimated the road network value as core part of their respective research projects. An alternative estimate for the land value of the road network was also provided in WP-C8, which was otherwise focused on the valuation of walking and cycling infrastructure. This alternative estimate implied a significantly higher land valuation for local roads than in WP-C2.

Table 2.6 shows a summary of previous road network valuations.

Aside from the alternative valuation in WP-C8, previous valuations of the land under local roads have relied on reported TA valuation data, with various imputation and extrapolation methods used to infer missing data and estimate the relative proportions of asset and land values.

The NRA study (Ministry of Transport, 1995) extrapolated valuations from a representative sample of TAs (comprising 24% of local road network length) to estimate the total value of the local road network. This study does not identify the proportion of local road value estimated to come from land, though this figure is estimated at 12% for the state highway network.

The STCC study (Booz Allen Hamilton, 2005) used TA valuations which did not disaggregate land and non-land asset values. The authors assumed the same land value proportion for local roads as the state highway network (29%).

WP-C2 (Richard Paling Consulting & Ian Wallis Associates Ltd, 2023) also used TA valuations as a primary source to value local roads. Additionally, some missing land values were imputed based on observed land value proportion from similar TAs, representing around 10% of total local road land values.

In WP-C8 (Veitch Lister Consulting & Ian Wallis Associates, 2023b), the authors applied an over-the-fence methodology to estimate the land value of walking/cycling infrastructure, based on average land values by Statistical Area 2 (SA2)[9]. In an appendix, this methodology was extended

[9] SA2s in urban (city council) areas generally have a population of 2,000-4,000 residents, while SA2s in more rural (district council) areas generally have a population of 1,000-3,000 residents (https://www.stats.govt.nz/assets/Methods/Statistical-standard-for-geographic-areas-2023/Statistical-standard-for-geographic-areas-2023.pdf)

to generate a high-level estimate of the national road network land value, which was estimated at $222 to $517 billion, under various assumptions of average corridor width.

Table 2.6 Summary of previous road network valuations

	National Roading Account (1995)	STCC (2005)	DTCC (2023) WP-C2	DTCC (2023) WP-C8
Valuation date	June 1993	June 2002	June 2018	June 2018
Valuations ($m) – Depreciated Replacement Cost				
State highways (SH)	7,430	11,950	49,700	-
Land	*944*	*3,430*	13,744	-
Other assets	*6,486*	*8,520*	*35,956*	-
Local roads (LR)	18,400	25,360	61,500	-
Land	- [a]	*7,278* [b]	*17,007*	-
Other assets	- [a]	*18,082* [b]	*44,493*	-
Total	**25,830**	**37,310**	**111,200**	**-**
Land	**-** [a]	***10,710***	***33,400***	***221,600*** [c]
Other assets	**-** [a]	***26,600***	***77,800***	**-**
LR proportion of total value	71%	68%	55%	-
Land proportion of SH value	13%	29%	28%	-
Land proportion of LR value	- [a]	29%[b]	32%	-
Network length (km)				
Local roads	81,868	81,598	84,273	-
State highways	10,438	10,766	11,000[d]	-
Total	***92,306***	***92,364***	***95,300***[d]	***120,000***
Value by route length ($m / km)				
State highways	0.71	1.11	4.50	-
Land	*0.09*	*0.32*	*1.24*	-
Other assets	*0.62*	*0.79*	*3.26*	-
Local roads	0.23	0.31	0.73	-
Land	- [a]	*0.09*	*0.20*	-
Other assets	- [a]	*0.22*	*0.53*	-
Total	***0.28***	***0.40***	***1.17***	**-**
Land	**-** [a]	***0.12***	***0.35***	***1.85***
Other assets	**-** [a]	***0.29***	***0.82***	**-**
Price indices (June 1993 = 1.0)				
Consumer price index	1.00	1.19	2.07	2.07
House price index	1.00	1.56	7.06	7.06

Notes

[a] *No breakdown of LR land value provided in the National Roading Account study.*
[b] *LR land proportion assumed to equal SH land proportion in the STCC study*
[c] *DTCC C8 estimated total network land value between $221-517 billion. The low estimate is used here.*
[d] *Not provided, estimated from value per route-km*
Sources: Booz Allen Hamilton, 2005; Ministry of Transport, 1995; Richard Paling Consulting & Ian Wallis Associates Ltd, 2023; Veitch Lister Consulting & Ian Wallis Associates, 2023b, *RBNZ*

2.6.1 Potential issues with local road valuations

In previous full valuations of the road network (NRA, STCC and WP-C2), the estimated local road value per route-kilometre was significantly lower than that of the state highway network. Most previous studies noted this difference and suggested that local roads may be systematically undervalued.

Local road valuations have also represented a decreasing proportion of the total value of the road network over time, despite the proportion of these roads by network length remaining approximately constant. Additionally, between the June 2002 (STCC) and June 2018 (DTCC WP-C2) valuations, value per route-kilometre for state highways increased by a factor of four, but only a factor of two for local roads.

The authors of WP-C8, while focused on estimating the value of the walking and cycling network, also highlighted discrepancies between their valuation of land and that presented in WP-C2. The authors took the view that this discrepancy was most likely due to the valuation of land under local roads. In an appendix, they applied an over-the-fence methodology to approximately estimate the land value of the entire road network at between $222 to $517 billion, 6-16 times greater than the WP-C2 analysis. This analysis relied on an approximate estimate of total network length around 26% higher than the official estimate provided WP-C8, but even correcting for this difference, land value estimates per route-kilometre are still significantly higher (by at least a factor of five) in WP-C8 than in WP-C2.

Taken together, these results suggest a significant underestimation of local road values. Differences in land valuation approaches between TAs, as discussed in Section 2.5, were highlighted in previous research as a likely contributor to under-estimates of local road value, in contrast to more standardised valuation of non-land assets. In particular, WP-C2 noted that many TAs value land under roads on an historic cost basis, use infrequent revaluation and no indexation, or do not separately identify the value of land under roads at all.

In general, TA valuation of land used for roads is significantly different to the over-the-fence approach followed by NZTA.

2.7 Summary and discussion of valuation methods

The chapter has discussed the theoretical background to the valuation of the roads and how it has been applied in New Zealand to date. The objective of this report is to ascertain a method to employ when collating the value of New Zealand's local roads, which requires a trade-off between the various approaches. The following summary of the discussion is presented around some key criteria that will apply when forming a recommended valuation approach.

2.7.1 Use of fair value approach

The approach used by NZTA at present, and set out by accounting standards, is to value a road according to the current adjacent land values for the land and the ODRC for the non-land network assets. This approach is only partially being applied by TAs, as some TAs are still using historic land purchase prices or an historic price set when land was brought into the TA's financial accounts. Applying a methodology that is similar to NZTA to local road valuation would provide a consistent set of values for NZ roads – consistent with accounting standards and consistent between state highways and local roads.

However, this is not the same as saying roads of the same class or similar road structures will have the same value in all locations. There is a natural variation in road assets, and the life of these assets, that will be shown as different values across the country.

Capturing this natural variation requires either accessing valuations already undertaken by TAs or accessing considerable detail about the assets and building up values from unit costs and adjacent land values.

The 'fair value' approach has the added advantage of being reasonably transparent and builds off available data, putting aside the many judgements required to build up the asset value database.

2.7.2 Land valuation

The standard practice to estimate land value for a single property is to examine the recent sale price of nearby properties. This requires a careful selection of similar properties as the benchmark. This customised selection is not possible when valuing many properties if an accurate value is sought and the method is inaccurate when valuing a network that in turn influences the value of adjacent land. Practical compromises are required around the unit of land value analysis and the treatment of endogeneity.

2.7.2.1 Unit of analysis

Fair value land valuations mentioned in this chapter have been based on land areas ranging from SA1 areas used by NZTA, to SA2 areas used in WP-C8, to district-wide areas used in New South Wales (Transport for NSW, 2023b). No doubt, there are many other variations of 'adjacent' interpretations.

There are three potential problems if the adjacent land area is small, which require consideration when selecting the land unit to apply in this study. These include:

- It is possible that properties immediately adjacent may be atypical – they may be unusual shapes and sizes, or have strict zoning restrictions – and hence are not reflective of the value of the road parcel, or typical parcels in the nearby area;
- There may be properties that are outliers for other reasons (e.g., valuation errors) and which have an undue influence on the average price in the area;
- The localised effects of a road network on nearby property values are likely to be more prominent at smaller units of analysis. This is discussed further in the following section.

2.7.2.2 Endogeneity

Roads can impact nearby land values due to effects on access, public transport provision, pollution, noise and visual impact. These effects operate at varying spatial scales and in potentially opposing directions. For example, residential properties immediately adjacent to a busy motorway are likely to be valued less than those further away, though there may be an offsetting value increase for properties with better motorway access. Conversely, commercial property near a busy road that benefits from pass-by traffic flow can have higher than average land prices.

The adjacency effects can be addressed with the selection of a comparable land unit. It is not clear to what extent these accessibility impacts of the road network should be reflected in network land valuation. In general, we can expect that the road network increases property values in aggregate, as it facilitates higher levels of economic activity. However, it is difficult to determine the size of this effect or apportion it by location, and it is not clear how to define the counterfactual when defining opportunity or replacement cost.

At present the solution to the interdependency issue would involve considerable research and a clear result is not assured, as the relationship between road networks and property prices is complex and there is limited direction from the literature as to how this should be factored into road valuation. This is simply noted as an uncertainty inherent in the fair value calculation and, as above, reason to be mindful of the purpose of any valuation exercise.

3 Data Review

3.1 Overview

The chapter details a technical review of available datasets that could potentially inform valuation of the New Zealand local road network (in whole or part). The review includes road geometry, road asset, land parcel and land valuation datasets. Datasets reviewed include those from NZTA, Land Information New Zealand (LINZ), Territorial Authorities (TAs), and Open Street Map.

The complete dataset review is presented in full in Appendix C and is summarised in the following sections.

Note that while the research team has experience with RAMM and AMDS datasets, no specific local datasets were studied in detail at the time of this review, as the refinement of valuation case study locations and associated discussions with TAs around data supply were ongoing.

3.2 Purpose and dataset characteristics

The valuation methodology for local roads should ideally be based on up-to-date network and valuation data, using a process that can potentially be repeated at regular intervals. For this reason, datasets that have been updated recently (are updated frequently and likely to be maintained in the future) are preferred.

While the objective of this research is valuation of local roads, NZTA state highway datasets have been included in this review, both to get a general sense of data completeness and validity, and as a means to exclude state highway land and infrastructure from local road valuations.

3.3 Road geometry and land data

Datasets containing road and land information generally include geometric representation of relevant features which enable their locations and extents to be mapped. These geometries are generally locationally correct but occasionally have incorrect extents.

Features may be captured as points, polylines and polygons. These may be referred to by other names such as centrelines (polylines) or areas (polygons) for example.

Some datasets may represent the same physical feature differently, such as capturing a road as a polygon (a shape with area) or a polyline (a line approximating the centre of the road). Similar occurrences can occur with valuation data and the capture of unit titles (apartments, etc) where valuation units may not reflect the exact location of the unit, but the general vicinity and where rating unit may overlap or be placed side by side.

3.3.1 LINZ Landonline Survey and Title

The Landonline Survey and Title dataset is the legal recording of New Zealand's cadastre. Consisting of over 80 relational tables, the Landonline dataset provides key details of survey and title information. A single table does not contain enough information to be useful for the purposes of this research, therefore tables have to be joined to construct appropriate data for further analysis. LINZ does provide some amalgamated datasets that can form the basis of input data, such as Primary Parcels. For this project there are several key tables/fields that can be used to determine parcels that have a roading purpose, including:

- NZ Primary Road Parcels (LINZ amalgamated from Landonline tables),

- NZ Strata Parcels– for example, bridges, pipes, tunnels that sit above or below the ground (LINZ amalgamated from Landonline tables). These do not contain a purpose which has to be assigned from other datasets,
- Title Estate purpose (the purpose of the Title) associated with local government or the Crown (obtained through Title Estate, Owners and Estate Share tables),
- Gazette references that define a purpose for the land (obtained through several Statute tables or extracted from NZ LINZ Primary Parcel amalgamated layer).

As these land datasets have been added to over time, with legal wording entered as received, there is a lack of consistency in how records are entered and updated. Interpretation requires searching the legal descriptions for specific keywords, or the extraction of known owners associated with parcels.

Not all parcels under local roads (or state highways) are identified as Primary Road Parcels, requiring some analysis of the other text fields above to determine if a parcel is used for roading.

Table 3.1 outlines indicative numbers of parcel from the Landonline dataset that have been identified by the analysis. These numbers do not differentiate between parcels that are controlled by NZTA or TAs. In some cases, the same parcel may be identified twice (e.g., a parcel may be found both in Non-Road Primary parcels with road-related gazette and Non-Road Primary parcels with Road-related Title Purpose.

Table 3.1 Summary of road parcel datasets

Type	Indicative Parcels
Primary Road Parcels	307,000
Strata Parcels related to Roads and Tunnels	400
Non-Road Primary parcels with Road-related Gazette	6,000
Non-Road Primary Parcel with Road-related Title Purpose	6,000

3.3.2 LINZ NZ roads

LINZ NZ Roads data replaced the Landonline Electoral Roading dataset. It uses a centreline to describe the general location of the underlying road[10]. While the dataset is consistent across New Zealand, unlike the Electoral Roading dataset it does not appear to distinguish consistently between formed and unformed roads, so may capture paper roads.

3.3.3 NZTA corridor land parcels

NZTA have provided a dataset containing what they consider to be their own roading parcels (not held land), which appear to be a mix of Primary Road Parcels and Primary Land Parcels with a roading purpose. This dataset also includes split parcels where NZTA believe they do not own the full cadastre parcel. Strata parcels do not appear to be included in this dataset.

3.3.4 NZTA CoreLogic RAMM

This dataset is created by CoreLogic that associates TA RAMM data with a CoreLogic centreline. As the RAMM data comes from TAs it is subject to some regional variation and lack of consistency.

[10] https://data.linz.govt.nz/document/12628-nz-roads-data-dictionary/

There are some restrictions placed by NZTA on the use of this dataset, as this is a licensed dataset, which may mean that RAMM and AMDS (2.5.1) may be more appropriate datasets, as the often have more open licensing when supplied by relevant TAs.

3.3.5 OpenStreetMap

OpenStreetMap is an open-source and frequently updated street network map source. Data is crowd-sourced so the quality of asset coding in this database can vary significantly. Quality and completeness of the data is difficult to verify without comparison to other data sources, and the association of the network with a TA or Road Controlling Authority (RCA) must be done separately (e.g., to distinguish private roads).

3.4 Land valuation data

3.4.1 LINZ District Valuation Roll (DVR)

This dataset aggregates DVR data from TAs into a complete property valuation dataset for New Zealand. The valuations themselves are collected by local councils (typically through a specialist valuation firm such as QV) according to the Rating Valuations Act 1998, and consist of separate land and improvement values as of a given valuation date, in addition to information pertaining to the structures, zoning and use of the property. The land value is most useful for the purposes of this study as it provides information about the land value of any adjacent roads.

The valuations for commercial and residential property are expected to be largely consistent and complete, as a result of high turnover in those markets and ready access to comparable sales data to estimate market value. It is not clear from the dataset how other properties, such as road parcels, parks or Crown land holdings are valued, though an initial inspection indicates that these tend to have valuations inconsistent with surrounding residential or commercial land value. This necessitates an alternative approach (for example, over-the-fence valuation) to determine their value appropriately.

There are some differences in how TAs record some property types (e.g., unit titled property).

3.4.2 CoreLogic House Price Index

The CoreLogic House Price Index[11] includes national and regional indices describing the change in average property values and is available as a monthly dataset from December 2003. It is estimated from sales data adjusted for the composition of properties sold in a given period.

This dataset is used by NZTA to index land valuations to a common valuation date and is expected to be suitable for indexing estimated local road land values.

3.5 Asset data

3.5.1 RAMM and AMDS

Territorial Authority (TA) roading asset data has historically been captured using the RAMM system[12]. TAs are currently in the process of moving to the Asset Management Data Standard

[11] https://www.corelogic.co.nz/news-research/reports/house-price-index
[12] Recently renamed to Asset and Work Manager (AWM), https://www.thinkproject.com/products/asset-and-work-manager/

(AMDS)[13] system over a five-year implementation timeframe expected to finish in 2027[14]. Both software systems are provided by the same vendor, Thinkproject. RCAs that were expected to implement AMDS by July 2024 (according to the implementation timeline) include those covering TAs in Wellington, Wairarapa, Queenstown-Lakes, Otago, Christchurch and Manawatu.

While the RAMM system is common to all TAs, the data structures and details of asset recording can vary widely by TA. AMDS aims to standardise and bring a higher level of consistency and accuracy to TA data reporting. In particular, AMDS makes several asset attributes mandatory which may be missing from existing RAMM data.

Capture processes for RAMM asset data also vary, which impacts the timeliness of the data. For example, in Christchurch some local road changes associated with the state highway network took over two years to be reflected in the RAMM dataset.

In general, it is expected that TA asset data (RAMM or AMDS) will be sufficient to value roading assets on the network within the scope identified in Section 1.3. AMDS is likely to be preferable for this purpose, as it may provide more complete and consistent data, and will be the standard for asset reporting going forward. However, RAMM data is expected to contain generally similar information (though the specifics will vary by TA), and is used for the existing NZTA network valuation process. Further discussion with TAs and examination of their datasets is required to determine the practical differences between the data contained in RAMM and AMDS, and whether this has a material impact on the valuation methodology and results.

3.5.1.1 Data quality

The Road Efficiency Group Te Ringa Maimoa (REG) publishes asset data quality metrics for each road controlling authority (RCA)[15] based on RAMM or AMDS data.

Figure 3.1 shows a sample of data quality results, including the distribution of results across TAs. These results indicate that carriageway length and width data is generally complete and of reasonable quality for most TAs. Some asset records relating to surfacing type and pavement layers have inconsistencies, potentially limiting their use for a nationwide valuation. Secondary assets such as footpath/pathway, streetlights, signs, culverts and stormwater have major data quality issues for many TAs.

Traffic volume estimates are generally available for the entire RAMM dataset at the road segment level, although the quality of these estimates is informed by each TA’s traffic count programme. REG metrics indicate that traffic counts are not always targeted appropriately to capture the majority of vehicle travel on the network, and estimated traffic volumes are not always consistent with recent count data.

There are fewer metrics reported by REG around asset condition, so it is not clear the general level of quality of this data.

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[13] https://www.nzta.govt.nz/roads-and-rail/asset-management-data-standard/
[14] https://www.nzta.govt.nz/roads-and-rail/asset-management-data-standard/implementation/implementation-timeframes-and-activities/
[15] https://www.nzta.govt.nz/planning-and-investment/planning/road-efficiency-group/transport-insights-and-performance-reporting/data-quality/

Category	Ref	Metric Description	Dimension	Importance	ONRC Customer Outcome	ONRC Metric	Result	Trend	Comparison of all RCAs
Network: **Carriageway**	CWAY1	Road network data complete	**Accuracy**	Information Only	AMENITY COST EFFICIENCY SAFETY		98.5	—	95 96 98 100
Network: **Carriageway**	CWAY7	Sealed/unsealed network correctly defined	**Accuracy**	High	AMENITY COST EFFICIENCY SAFETY	✔	97.8	—	95 96 98 100
Network: **Carriageway**	CWAY6a	Rural carriageways are generally not short	**Accuracy**	Information Only	AMENITY COST EFFICIENCY SAFETY	✔	98.1	—	95 96 98 100
Network: **Carriageway**	CWAY6b	Urban carriageways are generally not short	**Accuracy**	Information Only	AMENITY COST EFFICIENCY SAFETY	✔	98.5	—	95 96 98 100
Network: **Carriageway**	CWAY2a	Rural number of lanes matches carriageway width	**Accuracy**	Low	AMENITY COST EFFICIENCY SAFETY	✔	98.2	—	95 96 98 100
Network: **Carriageway**	CWAY2b	Urban number of lanes matches carriageway width	**Accuracy**	Low	AMENITY COST EFFICIENCY SAFETY	✔	97.5	—	95 96 98 100
Network: **Treatment Length**	TREAT1	Treatment Length dimensions match sealed area	**Accuracy**	High	AMENITY		97.0	—	90 95 100
Network: **Treatment Length**	TREAT2a	Treatment Lengths are generally not short	**Accuracy**	Low	AMENITY	✔	94.6	—	90 95 100
Network: **Treatment Length**	TREAT2b	Treatment Lengths are not too long	**Accuracy**	Low	AMENITY	✔	99.3	—	90 95 100
Network: **Treatment Length**	TREAT3	Treatment Lengths match major surfaces	**Accuracy**	High	AMENITY	✔	94.2	—	85 90 95 100
Asset Inventory: **Pavement & Surfacing**	PAVE2	Pavement layer records have valid attribute data	**Accuracy**	High			71.5	▲	5 50 100
Asset Inventory: **Pavement & Surfacing**	SURF2	Surface records have valid attribute data	**Accuracy**	High			98.6	—	95 96 98 100
Asset Inventory: **Pavement & Surfacing**	SURF3	Surface records correctly located	**Accuracy**	High		✔	85.4	▼	85 90 95 100
Asset Inventory: **Pavement & Surfacing**	SURF6	Surface records newer than pavement	**Accuracy**	Moderate		✔	89.4	—	80 85 90 95 100
Asset Inventory: **Pathways**	FOOT3	Footpath data valid	**Accuracy**	Moderate			99.9	—	20 40 60 80 100
Asset Inventory: **Drainage System**	DRAIN3	Culvert data valid	**Accuracy**	Moderate			51.1	▲	20 40 60 80 100
Asset Inventory: **Drainage System**	SWC3	SWC data valid	**Accuracy**	Moderate			68.0	—	65 70 80 90 100
Asset Inventory: **Traffic Facilities & Streetlights**	RAIL3	Railing data valid	**Accuracy**	Low			98.9	—	95 96 98 100
Asset Inventory: **Traffic Facilities & Streetlights**	SIGNS5	Sign data valid	**Accuracy**	Low			94.9	—	65 70 80 90 100
Asset Inventory: **Traffic Facilities & Streetlights**	LIGHTS4	Streetlights data valid	**Accuracy**	Low			97.5	—	85 90 95 100

Figure 3.1: Example REG data quality metrics for Auckland Transport, distribution across RCAs shown on right

3.5.2 BondCM unit costs

BondCM provide national average unit cost rates to NZTA for common roading assets including formation, surfacing, drainage, minor structures, signs, standard bridges and retaining walls. NZTA have provided the rates dated June 2023.

With the exception of major/custom structures, these unit rates are sufficient to estimate replacement costs for most common roading assets, assuming that local authorities have substantially similar construction costs to NZTA. Additional regional adjustments may be required (per the NZTA valuation method) for areas with construction costs higher or lower than average.

3.6 Summary

The findings of the dataset review can be summarised as follows:

- There exist suitable datasets to estimate land value of road parcels, via LINZ DVR data, though further analysis is required to infer road land values from residential/commercial property valuations (e.g., over-the-fence valuation)
- Determining local road parcels is most likely achievable, though there remain uncertainties regarding:
    - The completeness and accuracy of RAMM data (which will likely vary by TA) - engagement with TAs as part of the case study refinement and data supply discussions will aim to address these uncertainties
    - The identification of formed roads vs. paper or unformed roads - there should be sufficient information in road parcels datasets, Gazette information and title purpose to determine which parcels are related to roading, but further research and testing is required
- Valuation of roading assets (non-land) is dependent on the specifics of TA RAMM and AMDS data
- There should be sufficient coverage and accuracy of RAMM data for key road assets to inform this project, that is those that will contribute significantly to the valuation total (e.g., formation, surfacing, drainage)
- The completeness and accuracy of data may be better for TAs that have implemented AMDS, and this will be the standard asset reporting system going forward, likely aiding future valuations and/or a nationwide rollout of a valuation methodology
- The project team will gain more insight into RAMM and AMDS through subsequent engagement with TAs

4 Valuation Methodology Selection

Initial selection of suitable valuation methodologies followed a Multi-Criteria Analysis (MCA) approach. The full MCA is described in Appendix D and summarised here.

Potential valuation options were shortlisted based on the literature review of existing valuation approaches, available data and the likely feasibility of the method. Options were excluded if they exhibited fatal flaws, including non-fair value methods and options relying on black box or proprietary data.

The shortlisted options were analysed against the criteria outlined at the project outset and subsequently refined in discussions with the Project Steering Group. These included consistency, reliability, repeatability, data availability and transparency.

At the MCA stage, insufficient dataset detail was available to fully explore the implications of each valuation methodology option. The MCA therefore reflects a preliminary ranking of options, with the preferred option(s) refined further as the case studies progressed and familiarity was gained with the TA datasets.

The MCA process highlighted multiple potential approaches to valuing land and non-land roading assets shown in Table 4.1.

Table 4.1 MCA preferred valuation options

Valuation Option	Description
Non-land assets:	
Top-down outliers	TA valuations for non-land assets are used by default. Non-land TA valuations that appear to be outliers are revalued using top-down methods – where the road asset value is based on average per-kilometre values for comparable road types or areas, or similar.
Bottom-up outliers	Uses the same outlier filtering approach as above, but valuations that are outliers are revalued using bottom-up estimates – based on unit cost rates and detailed asset information for a representative sample of similar local roads
Land assets:	
SA1 land valuation	Average land values (from LINZ District Valuation Roll data) by Statistical Area 1 (SA1) are used as a proxy for the average land value of the roads running through that SA1. This is the method used by NZTA to estimate the value of land under the state highway network.
SA2 land valuation	As above, but the value of road land is estimated using average land value by Statistical Area 2 (SA2). This approach will tend to capture less local variation of land values and reduce the impact of any outlier land valuations.

The MCA was not considered conclusive at this stage. The provisional recommendation based on this MCA process was that one or both of top-down and bottom-up approaches would be applied in the case studies, with the exact preferred approach refined further as familiarity is gained with the relevant datasets.

The incremental effort of applying both Variants A and B for land valuation was not expected to be large (relative to applying a single variant), and as such both these variants were expected to be explored as part of sensitivity testing during case study valuations.

The final case study methodology is described in Section 6.

5 Case Study Selection and Datasets

This section provides an overview of the selected case study locations used to demonstrate the valuation method(s) and the scope of the case studies.

5.1 Selection considerations

Case study areas were selected based on coverage of different urban and rural development typologies, TA response to engagement, and granularity of available data. The PSG also indicated a desire to include a TA using the AMDS data standard.

5.1.1 Data granularity

As the preferred valuation methodology options presented in Section 4 included those that rely on extrapolation and imputation from TA valuation data, the spatial granularity of case study areas depends on the aggregation of asset and valuation data as it is held by the relevant TA.

To implement the preferred methods identified in the MCA it was required that TAs have valuation data disaggregated by at least subregion or road type, and ideally at the individual asset level.

5.1.2 Data quality

Data quality metrics published by Road Efficiency Group Te Ringa Maimoa (REG) highlight the wide variation in reporting and asset recording by TA / RCA. Given that the aim of this project is to explore valuation methods that can be widely applied across the entire local road network, data quality was not used as an explicit criterion when selecting case study candidates. Indeed, case studies of areas where data quality is relatively poor are likely useful for assessment of the suitability of a given valuation methodology to a nationwide rollout. Poor data quality is also likely to indicate where a top-down approach may be preferred.

5.2 Selected case studies

Table 5.1 shows the final selected case study locations for each of the five typologies specified in the research brief.

Table 5.1 Selected case study locations

Case Study	Location Typology	Approx land area	Notes
Wellington City	Main urban area with a CBD	290 km^2	Entirety of Wellington City Council area
Newtown, Wellington	Central city suburb	2 km^2	Subset of Wellington City case study area
Upper Hutt	Provincial city	540 km^2	Entirety of Upper Hutt City Council area
Totara Park, Upper Hutt	Provincial city suburb	4 km^2	A subset of the Upper Hutt case study area
Banks Peninsula	Rural settlement	970 km^2	Entirety of rural Banks Peninsula ward of Christchurch City Council

5.3 Case study datasets

Christchurch City Council (CCC), Wellington City Council (WCC) and Upper Hutt City Council (UHCC) were selected as potential case study candidates and agreed to provide data for this research. These TAs provided itemised asset and valuation data for their most recent valuation, and the accompanying valuation reports outlining the process followed.

No land valuation information was provided by the TAs. Land valuation is typically undertaken by a different party to road asset valuations.

The details of the valuation process are summarised for each TA in Table 5.2 and the details of the provided datasets in Table 5.3.

Table 5.2 Case study TA valuation details

TA	Valuation years	Asset format	TA valuation method	Notes
UHCC	2021, 2024	RAMM (2021), AMDS (2024)	RAMM/AMDS valuation module, set up by valuation consultant	• No significant road assets outside AMDS • Full AMDS tables provided
WCC	2022, 2025 (in progress)	RAMM (2022)	Other software used to extract AMDS data, provided to valuation consultant as spreadsheets, returned with itemised valuations	• AMDS v1.3 used (as of 2025) • Land valuation handled by property team • Stormwater valued separately, provided as lump sum
CCC	2022, 2025 (in progress)	RAMM (2022)	Spreadsheet + RAMM valuation by consultant. Partial use of RAMM valuation module	• 85-95% through AMDS transition (as of 2025) – a lot of assets previously outside RAMM will be in AMDS

Table 5.3 Details of provided case study datasets

TA	Valuation year	Data provided	Notes
UHCC	2024	Direct AMDS access, including ORC, ODRC and annual depreciation (AD) from valuations	• 2024 asset valuations stored in AMDS
WCC	2022	Single spreadsheet of asset valuations (ORC, ODRC, AD), including a subset of RAMM values used in valuation.	• Suburb, hierarchy, and road id information for all assets except stormwater • No direct RAMM access or other spatial data
CCC	2022	Spreadsheet containing valuation of RAMM assets (ORC, ODRC, AD) Spreadsheet containing valuation of non-RAMM assets (ORC, ODRC, AD) Direct RAMM access	• RAMM valuation spreadsheet had limited detail • Direct RAMM access only made available later in the project • No valuation data stored in RAMM • Non-RAMM data missing some location information

In RAMM and AMDS, assets associated with the road surface and subsurface (surface, subbase, basecourse and formation) are defined as *treatment lengths*, or contiguous sections of similar road surface, traffic volume and other carriageway variables. Treatment lengths have associated length, area and other geometric attributes.

Where a non-treatment length asset was missing road hierarchy or seal information, it was estimated based on the hierarchy and seal of the road with matching road ID. This matching is approximate, as the same road (ID) may have sections with different road type.

5.3.1 Upper Hutt City Council

UHCC provided full AMDS tables as of February 2025. Valuations in these tables are based on the 2024 valuation, except for assets that are new or modified since June 2024. Spatial carriageway and non-spatial treatment length tables were also provided.

Upper Hutt City Council is the only council involved in the case studies where the latest available valuation (2024) uses AMDS data, which is also the most recent valuation dataset received. The roading valuation relies solely on AMDS data and valuation modules, with no other data sources or spreadsheet valuations.

Figure 5.1 shows selected recent REG data quality metrics for UHCC[16]. These metrics show some issues with pavement and surfacing data accuracy, culvert data completeness, and footpath data validity. Carriageway, road network and traffic volume data are assessed by REG to be of generally high quality (not shown).

Category	Ref	Metric Description	Dimension	Importance	ONRC Customer Outcome	ONRC Metric	Result	Trend	Comparison of all RCAs
Network: **Treatment Length**	TREAT3	Treatment Lengths match major surfaces	**Accuracy**	High	AMENITY	✔	89.2	—	85 90 95 100
Asset Inventory: **Pavement & Surfacing**	PAVE2	Pavement layer records have valid attribute data	**Accuracy**	High			75.0	NEW	5 50 100
Asset Inventory: **Pavement & Surfacing**	SURF2	Surface records have valid attribute data	**Accuracy**	High			94.9	▼	90 95 100
Asset Inventory: **Pathways**	FOOT3	Footpath data valid	**Accuracy**	Moderate			94.7	—	20 40 60 80 100
Asset Inventory: **Drainage System**	DRAIN5	Culvert assets known	**Completeness**	Moderate			24.7	—	10 50 100

Figure 5.1: Selected REG 2023/24 data quality metrics for Upper Hutt City Council

5.3.2 Wellington City Council

WCC provided asset and valuation data for their 2022 valuation. All assets are itemised except for stormwater assets, which are valued separately and included as a lump sum. The WCC valuation includes RAMM and non-RAMM asset data sources combined into a single valuation spreadsheet.

At the time of engagement, WCC were currently undergoing a valuation process for 2025, including partial use of AMDS data, although outputs were not available in time for inclusion in this study.

Assets associated with roads without hierarchy status were excluded, as these represented off-road paths, sports fields or similar non-road environments.

Figure 5.2 shows selected recent REG data quality metrics for WCC. Data quality metrics are generally in the upper half of TAs, with exceptions for railing data and stormwater data validity.

[16] *Transport Insights - Data Quality Dashboard*, Road Efficiency Group Te Ringa Maimoa https://transportinsights.nz/DataQuality2

Carriageway, road network and traffic volume data are assessed by REG to be of generally high quality (not shown).

Category	Ref	Metric Description	Dimension	Importance	ONRC Customer Outcome	ONRC Metric	Result	Trend	Comparison of all RCAs
Asset Inventory: **Drainage System**	DRAIN3	Culvert data valid	**Accuracy**	Moderate			97.4	–	20 40 60 80 100
Asset Inventory: **Drainage System**	SWC5	SWC asset known	**Completeness**	Moderate			99.9	–	65 70 80 90 100
Asset Inventory: **Drainage System**	SWC3	SWC data valid	**Accuracy**	Moderate			99.0	–	95 96 98 100
Asset Inventory: **Traffic Facilities & Streetlights**	RAIL4	Railing assets known	**Completeness**	Low			97.6	–	10 50 100
Asset Inventory: **Traffic Facilities & Streetlights**	RAIL3	Railing data valid	**Accuracy**	Low			96.3	–	95 96 98 100
Asset Inventory: **Traffic Facilities & Streetlights**	SIGNS4	Sign assets known	**Completeness**	Low			99.2	–	35 40 60 80 100
Asset Inventory: **Traffic Facilities & Streetlights**	SIGNS5	Sign data valid	**Accuracy**	Low			98.2	–	65 70 80 90 100
Asset Inventory: **Traffic Facilities & Streetlights**	LIGHTS4	Streetlights data valid	**Accuracy**	Low			96.9	–	85 90 95 100

Figure 5.2: Selected REG 2023/24 data quality metrics for Wellington City Council

5.3.3 Christchurch City Council

CCC provided asset and valuation data for their 2022 valuation. All assets are itemised and included as separate valuation spreadsheets for RAMM and non-RAMM assets. Spatial carriageway and non-spatial treatment length tables were also provided (via direct RAMM access), though this was only made available later in the methodology development timeframe.

At the time of engagement, CCC were currently undergoing a valuation process for 2025, including partial use of AMDS data, although outputs were not available in time for inclusion in this study.

Assets associated with road IDs corresponding to cycleways or other off-road paths were excluded.

Assets without a provided valuation were excluded. Analysis of a sample of these assets indicated they were not owned by the TA and thus excluded from their valuation.

Some non-RAMM and RAMM assets in the CCC valuation data could not be matched to a location and/or road type. The details and indicative value of the affected assets is shown in Table 5.4. Stormwater assets without matched locations represent the most significant valuation impact.

Table 5.4 Christchurch assets unable to be matched to location and/or road type

Asset	Unmatched asset value (% of asset class ORC)	Unmatched asset value (% of overall ORC)
Stormwater	73%	5.1%
Other (surfacings, markings, cameras)	60%	0.8%
Lights/signals/signs	14.2%	0.7%

Figure 5.3 shows selected recent REG data quality metrics for CCC. These metrics support the findings above of some data quality issues for stormwater and lights/signals/poles assets. There are also some indications of poor traffic volume estimate coverage, as measured by the COUNT1 and COUNT3 metrics which relate to the proportion of estimated vehicle travel where recent (within six years) counts are available.

Carriageway data quality metrics (not shown) indicate good coverage and accuracy of network, carriageway and seal type data.

Category	Ref	Metric Description	Dimension	Importance	ONRC Customer Outcome	ONRC Metric	Result	Trend	Comparison of all RCAs
Demand/Use: **Traffic Count**	COUNT1	Well targeted traffic count programme	**Completeness**	High	AMENITY, COST EFFICIENCY	✓	25.0	—	20 40 60 75
Demand/Use: **Traffic Count**	COUNT3	Traffic loading understood	**Completeness**	High	AMENITY, COST EFFICIENCY	✓	16.7	▼	15 20 40 60 70
Asset Inventory: **Drainage System**	DRAIN5	Culvert assets known	**Completeness**	Moderate			15.5	▲	10 50 100
Asset Inventory: **Drainage System**	SWC5	SWC asset known	**Completeness**	Moderate			98.3	—	65 70 80 90 100
Asset Inventory: **Traffic Facilities & Streetlights**	RAIL4	Railing assets known	**Completeness**	Low			35.2	▲	10 50 100
Asset Inventory: **Traffic Facilities & Streetlights**	SIGNS4	Sign assets known	**Completeness**	Low			45.1	▲	35 40 60 80 100
Asset Inventory: **Traffic Facilities & Streetlights**	LIGHTS5	Streetlight assets known	**Completeness**	Low			99.0	—	15 50 100
Asset Inventory: **Structures**	RETAIN5	Retaining Wall assets known	**Completeness**	Moderate			83.0	—	50 60 80 100

Figure 5.3: Selected REG 2023/24 data quality metrics for Christchurch City Council

6 Detailed Valuation Methodology

The chosen valuation approach follows a hybrid of the valuation options that emerged from the MCA process described in Section 4.

TA valuations for non-land assets are used by default, with both top-down and bottom-up re-estimates of outlier values are used depending on the specific asset class. Additionally, the value of asset classes with limited available data or low materiality are estimated using a top-down approach.

An alternative regression-based outlier identification and re-estimation approach is also presented. This was applied only to the Wellington and Banks Peninsula case studies due to data limitations.

Outlier determination and re-estimation are applied on an Optimised Replacement Cost (ORC) basis. The final reported valuation is the Optimised Depreciated Replacement Cost (ODRC), which is estimated from ORC by applying TA depreciation ratios, as described in Section 6.4.

Land values are estimated using adjacent land values estimated from both SA1 and SA2 areas to provide a valuation range.

Valuations are estimated based on a June 2024 valuation date. All TA valuations are updated to June 2024 costs using the NZTA construction index.

The details of the approach are discussed in the following sections.

6.1 Asset scope, grouping and valuation treatment

Appendix E shows TA and NZTA valuation asset inclusions for significant asset classes (making up > 1% of reported ODRC for at least one TA), including whether they are valued and how they are classified. The asset scope used for this valuation exercise has been chosen in discussion with the PSG to capture the set of common asset types included in TA and NZTA valuations.

The asset groupings and scope for this valuation are shown in Table 6.1.

Table 6.1 Asset groupings used in valuation

Asset	Description
Land	Land value of road parcels associated with the local road network, generally encompassing the full road reserve including berms.
Formation	
Basecourse and subbase	
Surfacing	Road seal
Kerb and channel	
Pathways	Footpaths
Lights / signals / poles	Street lighting, traffic signals, road signs,etc.
Stormwater	Sumps, leads, catchpits as per TA valuations
Retaining	Retaining structures, including retaining walls and sea walls
Tunnels	
Bridges	

Asset	Description
Other	Miscellaneous assets including cameras, road markings, street furniture, PT shelters, etc.

The following assets are excluded:

- Berm (asset value) – this asset was not valued by all TAs and data for berm extent is not consistently available. Note that for TAs valuing berm assets, this reflects an asset replacement value, not a land value. The land value component of the berm is still included in the current valuation exercise, to the extent that the berm lies within the road land parcel.
- Off-road cycle and walking paths – assets associated RAMM carriageways that represent off-road walking and cycling paths are excluded per the agreed scope of the research
- Off-street parking – TA-owned off-street parking areas are partially recorded in TA surfacing and road base data but are excluded from this valuation per the agreed scope of the research
- WIP / CAPEX – No data was readily available to estimate how WIP or CAPEX may impact valuations. As such WIP and CAPEX are excluded from the valuation.

Asset valuations and outlier analyses are presented by *road type*, a simplified grouping estimated from RAMM/AMDS hierarchy, urban/rural classification and seal versus unsealed roadways (detailed in Appendix F). This is required due to differing TA road hierarchy terminology and granularity reported in RAMM/AMDS.

6.1.1 Idiosyncratic assets

The total value of bridges, retaining structures, and tunnels varied substantially across TAs. Given that these assets classes often represent a small number of assets with large individual values, and acknowledging their relationship to geographic and topographical conditions, differences in valuation were assumed to reflect actual differences in asset makeup (in the absence of better information) and were assumed to be inliers. These assets are termed *idiosyncratic assets*.

Bridges, tunnels and retaining structures are assumed to be idiosyncratic assets.

6.1.2 Data-limited and low-valued assets

These were asset classes where:

- TA data was not sufficiently detailed to identify assets or asset locations, or
- TA asset groupings appeared to be inconsistent, or
- Assets were low-valued (representing a small share of likely valuation total)

Table 6.2 lists asset shares of TA-reported total ORC, less the idiosyncratic assets noted above. The variation in road surface/subsurface, pathway, and kerb and channel asset classes are largely explained by differences in network characteristics, as these assets are generally not identified as outliers on a unit rate basis.

Table 6.2 Asset share of TA-reported ORC excluding bridges, retaining and tunnels

Asset	CCC	UHCC	WCC
Formation	14%	20%	24%
Subbase	9%	7%	3%

Asset	CCC	UHCC	WCC
Basecourse	20%	12%	4%
Surface	8%	10%	10%
Kerb and channel	13%	21%	14%
Lights/signals/poles	5%	3%	3%
Pathway	13%	18%	12%
Stormwater	8%	5%	13%
Other	1%	1%	2%

The valuation treatment of stormwater varied significantly across case study TAs:

- Valued by UHCC entirely within AMDS
- CCC assets recorded across RAMM and spreadsheet data sources, separately valued. Many CCC assets were missing location information.
- WCC asset valuation included as a lump sum as valued by Wellington Water (not disaggregated by asset or location)
- Reported stormwater TA valuations varied from 5-13% of total ORC less tunnels, bridges and retaining.

Assets categorised as Other represented a small share of reported TA valuation (1-2% of ORC), showed some inconsistencies in asset groupings between TAs, and had some missing location data.

Assets categorised as Lights/Signals/Poles had significant missing location information and represented a small share of reported TA valuations (3-5% of ORC).

Data-limited or low-value assets had values re-estimated using top-down approaches, as discussed in Section 6.3.1.

6.2 Identification of outlier valuations

Outliers were taken to be those valuations that appear inconsistent with those of other TAs / case study areas. ORC valuations were used for this purpose to remove the impact of differences in asset age and condition and instead highlight areas where replacement cost assumptions differ.

Valuation differences may reflect one (or both) of the following causes:

- Fundamental differences in assets held and the costs associated with these assets, or,
- Differences in asset valuation assumptions, data reliability or coverage, or other valuation approach differences.

Outlier analysis was focused on asset classes with likely material impact on the overall valuation, and where detailed road type information was available. As a result, data-limited, low-value and idiosyncratic assets were excluded from the outlier analysis.

6.2.1 Outlier identification approaches

The following approaches were used to identify outlier valuations:

a) The implied unit rate (ORC) by asset class and road type, with unit rates either calculated by length or by area of road

b) An alternative approach to a) for surface / subsurface asset using a regression model fitted to per-section TA valuations to identify individual assets with outlier valuations

The implied unit rate approach is the default used unless otherwise indicated, with the regression approach included as a sensitivity test for the Wellington and Banks Peninsula case studies.

The outlier identification approaches are summarised in Table 6.3.

Table 6.3 Summary of outlier identification approaches

Approach	Measure	Outlier Identification	Applied
Implied unit rate	The average implied unit rate (ORC) of components, with unit rates either calculated by length of road or by area of road	Outside of 90% confidence interval from mean and standard deviation of unit rates by case study area.	Per asset class / road type
Regression	Regression model used to predict ORC based on length, width, traffic volume, terrain.	Assets with reported ORC that falls outside the regression model 95% prediction interval.	Per asset (surface / subsurface assets in CCC & WCC case studies only)

6.2.1.1 Implied unit rate

Implied unit rates (ORC) were estimated based on aggregated RAMM/AMDS asset data. For road surface and subsurface assets (formation, subbase, basecourse and surfacing) unit rates were estimated per unit carriageway area (treatment length multiplied by treatment width). For all other assets unit rates were estimated per unit carriageway (centreline) length. Note that unit rates for assets such as pathways and kerb and channel are normalised by road centreline length, rather than the asset length.

The filter used to identify outliers was an approximate 90% confidence interval[17] derived from the mean and standard deviation calculated for each component-road type combination across the five study areas. This filter is arbitrary at present but proved useful to isolate the few component-class valuations that were extremely different to their peers (higher or lower). A larger dataset might allow other filtering methods to be used, including by percentile rather than making a distributional assumption, or benchmarking by identifying TAs considered to have high-quality data and methods.

Details of the distribution of implied unit rates and outlier determination process are provided in Appendix G.

The implied unit rate analysis identified the outlier assets shown in Table 6.4.

Table 6.4 Identified outliers in case study implied unit rate valuations

Asset	Case study area	Description
Basecourse	Banks Peninsula	High outlier - Per-sqm rate for urban collector > 2x other case study TAs

[17] Given the small sample size for this exercise a 90% threshold was used but the standard 95% threshold is recommended for a wider rollout, where a larger sample size is expected

Kerb and channel	Banks Peninsula	Low outlier - Per-centreline-km rate for urban roads < 0.5x other case study TAs
Pathway	Banks Peninsula	Low outlier - Per-centreline-km rate for urban roads < 0.5x other case study TAs

Only values for some urban roads in Banks Peninsula were identified as outliers based on implied unit rate approach. Given the more rural nature of Banks Peninsula as compared to the other case study areas, this may reflect differences in underlying infrastructure.

The confidence intervals used to identify outliers are large (noting there are only three TAs in the case studies) and most valuations lie within these bounds. It is envisaged that with a wider rollout of this method, the number of areas is expanded, thus allowing more precise estimates of the means and variances and more sensitive identification of outliers.

6.2.1.2 Regression approach

For road surface / subsurface assets (formation, subbase, basecourse, and surface), an alternative approach to outlier identification was also explored using per-section regression modelling of asset values. This approach, and findings from the regression modelling, are described in detail in Appendix H.

The regression model predicts ORC based on the area and width of the road section, with additional covariates for TA, road type, traffic volume category and terrain category. This detailed data was only provided for WCC and CCC, so the modelling is limited to these areas.

Outliers are identified as individual assets where the reported ORC falls outside the 95% prediction interval of modelled ORC. Appendix H contains additional detail around the value and number of road sections identified as outliers.

6.3 Asset value estimation

Various valuation approaches were used to estimate asset values.

TA valuations were used where:

- Assets are “idiosyncratic” – TA valuations are assumed to reflect asset, condition and topographical differences
- TA valuations were determined to be inliers

Bottom-up estimates were used where:

- Assets were determined to be outliers based on implied unit rate or regression analysis

Top-down estimates were used where:

- Assets were data-limited or low-valued, as described in Section 6.1.1.

Table 6.5 shows the valuation approach used for each asset class in the preferred approach.

Table 6.5 Valuation approaches by asset class

Asset	Description	Valuation estimate
Formation	Inlier	TA valuation
Basecourse and subbase	Outlier – Banks Peninsula (urban collector) Inlier – other areas	Bottom-up estimate – Banks Peninsula

Asset	Description	Valuation estimate
		Use TA valuation – other areas
Surfacing	Inlier	Use TA valuation
Kerb and channel	Outlier - Banks Peninsula (urban roads) Inlier – other areas	Bottom-up estimate – Banks Peninsula Use TA valuation – other areas
Pathways	Outlier - Banks Peninsula (urban roads) Inlier – other areas	Bottom-up estimate – Banks Peninsula Use TA valuation – other areas
Lights / signals / poles	Data-limited / low-value	Top-down estimate
Stormwater	Inconsistent asset grouping / data-limited	Top-down estimate
Retaining	Idiosyncratic	TA valuation
Bridges	Idiosyncratic	TA valuation
Tunnels	Idiosyncratic	TA valuation
Other	Inconsistent asset grouping / low-value	Top-down estimate

6.3.1 Top-down estimates

Top-down estimates are defined for this valuation exercise as asset values estimated as a given percentage of total ORC.

Top-down percentages are taken as the average of TA-reported ORC shares, with a sensitivity range of the lowest and highest reported shares. This could be refined with the addition of further TAs to the valuation dataset. Values and sensitivity ranges are shown in Table 6.6.

Table 6.6 Top-down valuation details

Asset	Estimated ORC Share	Range
Stormwater	9%	5-13%
Lights/signals/poles	4%	3-5%
Other	1.5%	1-2%

Top-down estimates are applied such that the asset's share of non-land ORC (excluding idiosyncratic assets – bridges, retaining and tunnels) matches the desired share. The shares are assumed to apply uniformly across road types.

Due to the prevalence of missing location information in the valuations provided for these assets (as discussed in Section 6.1.1) this analysis was undertaken at the TA level (not the case study level), and it was not possible to estimate the top-down proportion with finer granularity (for example, by road type).

6.3.2 Bottom-up estimates

6.3.2.1 Implied unit rates

Bottom-up estimates are used to re-estimate values for asset class / road type groupings identified as outliers on an implied unit rate basis. Urban subbase, kerb and channel and pathway values for Banks Peninsula have been re-estimated. Estimated unit rates are taken from the average and range of implied unit rates for urban road types across all case study TAs.

Table 6.7 Bottom-up valuation details – Banks Peninsula only

Asset	Unit rate	Unit rate estimate	Range
Kerb and channel (urban collector/local)	Per carriageway length	$380 /m	$270-430 /m
Basecourse & subbase (urban collector/local)	Per sealed area	$37 /m^2	$23-56 /m^2
Pathways (urban collector/local)	Per carriageway length	$39 /m	$30-44 /m

6.3.2.2 Regression estimates

Where the regression approach is used, individual asset valuations identified as outliers (outside the 95% prediction interval of the model) are replaced with the ORC predicted by the regression model.

6.4 Depreciation

Given the lack of independent asset age and condition information, for most assets the TA-provided depreciation ratio (by asset class) was applied to ORC values to estimate the ODRC. The depreciation ratio measures the ratio of remaining asset life.

The depreciation treatment of formation and subbase was standardised by assuming that the asset does not depreciate. This accords with the valuation assumptions used by most TAs and NZTA.

Non-land depreciation ratios are shown in Table 6.8. Land assets are not depreciated.

Table 6.8 Current assumed depreciation ratios by asset and TA

Asset class	CCC	UHCC	WCC
Formation	1.00	1.00	1.00
Basecourse	0.44	0.55	0.43
Subbase	1.00	1.00	1.00
Surface	0.41	0.32	0.50
Bridge	0.41	0.49	0.40
Tunnel	N/A	0.55	0.86
Kerb and channel	0.50	0.28	0.59
Pathway	0.50	0.37	0.41
Retaining	0.33	0.48	0.59
Stormwater	0.11	0.33	0.52

Asset class	CCC	UHCC	WCC
Lights/signals/poles	0.50	0.60	0.65
Other	0.12	0.50	0.59

6.5 Road land valuation

6.5.1 Identification of road land parcels

Land parcels that correspond to roads are identified using a number of parcel attributes:

- Primary road – as stored in LINZ primary parcels
- Parcel purpose – primary parcels with a purpose that indicates use as a road
- Road legality – primary parcels that have a legality that indicates use as a road
- Strata – strata parcels with details that indicate use as a road

Parcels meeting any of these criteria are included as potential road parcels. This includes both NZTA road parcels, and a large number of parcels that relate to unformed or paper roads.

Any parcels identified by NZTA as being part of the State Highway network are then removed. However, this process does not exclude land held by NZTA for future roading or other purposes.

To exclude unformed/paper roads and other parcels not currently in use as roads, the identified parcels were clipped to within a 20m buffer of RAMM/AMDS carriageway (for UHCC and CCC) or OpenStreetMap network[18] (for WCC).

Road type for land parcels was estimated based on RAMM/AMDS carriageway hierarchy / seal type (for CCC and UHCC case studies) and NZTA One Network Framework (ONF) classification of the nearest road centreline (used for WCC case studies, available nationwide). Road land value is combined for Arterial and Collector for reporting purposes as ONF was not sufficient to distinguish these road types in the data.

6.5.2 Valuation of road land

District Valuation Roll (DVR) data provided by LINZ aggregates council rating valuations into a national dataset. The average land value (per unit area) of road parcels is assumed to be the same as the average value of land within the encompassing statistical area (SA1 or SA2).

Valuation parcels in the DVR dataset are not generally aligned with SA1 or SA2 boundaries, and so estimation of average land value per statistical area (SA) consists of the following steps:

1. Valuations are matched with valuation geometry (areas). Note that not all valuations have spatial representation so there is not complete coverage. Conversely, some valuations, for example unit titled apartments, may overlap spatially. Where valuation areas overlap, the corresponding valuations are aggregated to a single valuation area before further processing.
2. Valuation areas are clipped to be within the SA.

[18] The driveable OSM network polylines, excluding “trunk” or “motorway” road types, which correspond to state highways

3. For each valuation record, the land value within each SA is estimated by pro-rating the original average value to the clipped area.
4. All valuations, and the corresponding valuation areas, within the statistical area are summed to give total land value and total area (corresponding to valuation records within the SA).
5. The geometry of identified road parcels is subtracted from the SA geometry to give the net area of the SA excluding roads.
6. Identified road parcels are clipped to the original SA geometry, and their value is estimated by applying average value (total SA value per net SA area) to the parcel area.

Note that the computed area of the parcel geometry (rather than reported survey area) is used to calculate all values. Where road parcels are clipped to available network data, land values are pro-rated to the clipped area.

6.5.3 Indexation

Land values are indexed to June 2024 using a combination of regional house price indices provided by NZTA (available until June 2023) and national house price index from NZ Treasury (June 2023 to June 2024).

Base dates for indexing are assumed to be the same for all valuations in a TA, based on the modal reported valuation date.

7 Case Study Results

The following sections describe results and discussion for each case study valuation.

Asset values are shown by road type, with arterial and collector road types combined for land value estimates and overall total value due to data limitations discussed in Section 6.5.

Low and high sensitivity scenarios are shown for assets with re-estimated values. For land assets, low and high values represent the minimum and maximum of the land values estimated at the SA1 and SA2 level (with central estimates being the average of these two values).

Index-adjusted TA valuations for non-land assets are also shown by asset class, where available.. In some cases even if TA ORC valuations were not re-estimated, the presented ORDC valuation differs from the TA value due to differences in depreciation assumptions and scale[19]. TA-reported land values are not reported as these were not provided.

The implied unit rate method was applied to all five case studies used, with the regression method only shown for Wellington and Banks Peninsula. Due to time constraints, the regression approach is provided for illustrative purposes only, and would require further testing and refinement to be applied nationwide (as discussed in Section 8).

[19] Formation and subbase are depreciated by some TAs but not in the preferred approach. Depreciation ratios are estimated at the TA level but applied at the case study level, which may cause discrepancies for case studies which are a subset of the overall TA area.

7.1 Wellington

This case study covers the Wellington City Council area, representing a main urban area with a CBD. The valuation is based on the TA valuation (indexed to June 2024).

For road surface and subsurface assets, either average implied unit rate or regression approaches were used to identify Outlier valuations for road surface and subsurface assets were identified and (if required) re-estimated their using both average implied unit rate and regression approaches.

Both methods also include the following re-estimated assets:

- Stormwater, Lights/Signals/Poles, Other – re-estimated using a top-down approach (average share of ORC across TAs per road classes), as discussed in 6.3.1.

7.1.1 Implied unit rate method

No outlier assets were identified based on implied unit rates. Table 7.1 shows the estimated valuation. The non-land total value is re-estimated to be $1,294m, slightly less than the reported $1,368m.

Table 7.1 Wellington ODRC by asset and road type – implied unit rate method

Asset	Central ODRC by road type (2024$m)					Overall ODRC (2024$m)			
	Arterial	Urban collector	Urban local	Rural other	Unsealed	Central	Low	High	TA Valn.
Land[1]	6,750.7		9,258.0	27.4	-	16,036.1	14,411.4	17,660.9	-
Formation	74.7	121.4	247.7	26.7	-	470.6			470.6
Base / subbase	18.3	26.1	44.2	5.1	-	93.7			93.7
Surfacing	20.5	26.7	47.6	3.2	-	97.9			97.9
Bridges	11.0	3.0	2.6	1.1	-	17.7			17.7
Tunnels	25.0	11.2	22.4	-	-	58.6			58.6
Kerb and channel	20.3	41.2	100.2	4.7	-	166.4			166.4
Pathways	16.0	26.0	54.3	0.1	-	96.3			96.3
Retaining walls	49.8	52.0	54.1	10.5	-	166.4			166.4
Stormwater[2]	11.8	19.0	39.0	2.7	-	72.5	37.8	111.9	130.5
Lights / signals / poles[2]	6.6	10.6	21.9	1.5	-	40.6	28.6	54.3	42.5
Other[2]	2.2	3.6	7.4	0.5	-	13.8	8.6	19.7	27.7
Non-land subtotal	256.2	340.7	641.4	56.1	-	1,294.4	1,242.6	1,353.3	1,368.3
Total	**7,347.6**		**9,899.4**	**83.5**	**-**	**17,330.6**	**15,654.0**	**19,014.2**	**-**
Treatment length (km)	78.4	161.9	402.3	57.9	-	700.5			
Treatment area (ha)	89.7	148.7	305.4	34.7	-	578.4			
Land area (ha)	371.7		800.1	106.2	-	1,278.0			

7.1.2 Regression method

An alternative valuation applying the regression approach to identify outliers in surface / subsurface assets is shown in Table 7.2. Applying the regression approach to re-estimation would decrease the non-land total further, to $1,275m.

Table 7.2 Wellington ODRC by asset and road type – regression method

Asset	Central ODRC by road type (2024$m)					Overall ODRC (2024$m)			
	Arterial	Urban collector	Urban local	Rural other	Unsealed	Central	Low	High	TA Valn.
Land[1]	6,750.7		9,258.0	27.4	-	16,036.1	14,411.4	17,660.9	-
Formation[3]	70.0	114.1	244.1	26.7	-	454.9	454.8	455.0	470.6
Base / subbase[3]	17.4	26.5	42.5	5.6	-	92.0	91.8	92.2	93.7
Surfacing[3]	20.7	26.7	47.7	3.0	-	98.2	98.1	98.2	97.9
Bridges	11.0	3.0	2.6	1.1	-	17.7			17.7
Tunnels	25.0	11.2	22.4	-	-	58.6			58.6
Kerb and channel	20.3	41.2	100.2	4.7	-	166.4			166.4
Pathways	16.0	26.0	54.3	0.1	-	96.3			96.3
Retaining walls	49.8	52.0	54.1	10.5	-	166.4			166.4
Stormwater[2]	11.5	18.6	38.7	2.7	-	71.6	37.3	110.5	130.5
Lights / signals / poles[2]	6.4	10.4	21.7	1.5	-	40.1	28.3	53.6	42.5
Other[2]	2.2	3.5	7.4	0.5	-	13.6	8.5	19.4	27.7
Non-land subtotal	250.3	333.2	635.7	56.4	-	1,275.6	1,224.1	1,334.2	1,368.3
Total	**7,334.3**		**9,893.7**	**83.8**	**-**	**17,311.8**	**15,635.5**	**18,995.1**	**-**
Treatment length (km)	78.4	161.9	402.3	57.9	-	700.5			
Treatment area (ha)	89.7	148.7	305.4	34.7	-	578.4			
Land area (ha)	371.7		800.1	106.2	-	1,278.0			

1. Low/high values represent SA2/SA1-based valuation

2. Low/high values represent range of top-down estimates

3. Low/high values represent mean confidence interval of regression model, though these are implausibly narrow due to the assumption of independent valuations within a TA

7.1.3 Discussion

There are no unsealed local roads reported in the WCC data.

As discussed in Section 7.2.1 below, there appear to be gaps in the identified road land parcels in the Wellington area that have not been valued.

The major departures from the TA-provided asset valuations are for the Other and Stormwater asset classes, for which the top-down estimate is below the TA valuation.

Total valuations for the implied unit rate approach are around $19m higher than the regression approach (~1.5% of the non-land asset total).

7.2 Newtown, Wellington

This case study covers the Wellington suburb of Newtown, as a representative urban suburb of a major city.

The implied unit rate approach was used to identify asset classes with outlier valuations. No outliers were identified on this basis.

The valuation is based on the TA valuation (indexed to June 2024), aside from the following re-estimated assets:

- Stormwater, Lights/Signals/Poles, Other – re-estimated using a top-down approach (average share of ORC across TAs per road classes), as discussed in 6.3.1.

Table 7.3 shows the estimated valuation.

Table 7.3 Newtown network ODRC by asset and road type

Asset	Central ODRC by road type (2024$m)					Overall ODRC (2024$m)			
	Arterial	Urban collector	Urban local	Rural other	Unsealed	Central	Low	High	TA Valn.
Land[1]	254.4		232.2	-	-	486.6	363.0	610.3	-
Formation	0.6	2.8	3.4	-	-	6.8			6.8
Base / subbase	0.2	1.0	1.0	-	-	2.2			2.2
Surfacing	0.3	1.8	1.5	-	-	3.6			3.9
Bridges	-	-	-	-	-	-			-
Tunnels	-	-	-	-	-	-			-
Kerb and channel	0.4	1.6	2.3	-	-	4.2			4.3
Pathways	0.4	1.7	2.1	-	-	4.2	-	-	3.6
Retaining walls	0.1	0.0	1.0	-	-	1.1			1.0
Stormwater[2]	0.2	0.8	0.9	-	-	1.9	1.0	3.0	N/A[3]
Lights / signals / poles[2]	0.1	0.5	0.5	-	-	1.1	0.8	1.4	1.4
Other[2]	0.0	0.2	0.2	-	-	0.4	0.2	0.5	0.5
Non-land subtotal	2.3	10.4	12.8	-	-	25.4	24.1	27.0	23.6
Total	**267.1**		**245.0**	**-**	**-**	**512.1**	**387.1**	**637.2**	**-**
Treatment length (km)	1.4	6.2	8.5	-	-	16.1			
Treatment area (ha)	1.4	7.1	7.3	-	-	15.7			
Land area (ha)	13.7		13.4	-	-	27.1			

1. Low/high values represent SA2/SA1-based valuation

2. Low/high values represent range of top-down estimates

3. TA stormwater valuation not available by suburb/road type

7.2.1 Discussion

Newtown includes some assets that lie on suburb boundaries. The valuation follows WCC suburb classification for assets which may or may not reflect the precise geographic boundary of the suburb. In general, this is not expected to be a limitation with a wider roll-out of the method when applied to larger valuation areas.

This case study also highlights the large disparities in land value between SA1 areas, also shown in Figure 7.1. Even within the small area of Newtown there is a >15x difference in land value per unit area between the lowest value and highest value roads.

The valuations are broadly in line with the TA-provided valuations, although stormwater valuation data by suburb was not available for Wellington.

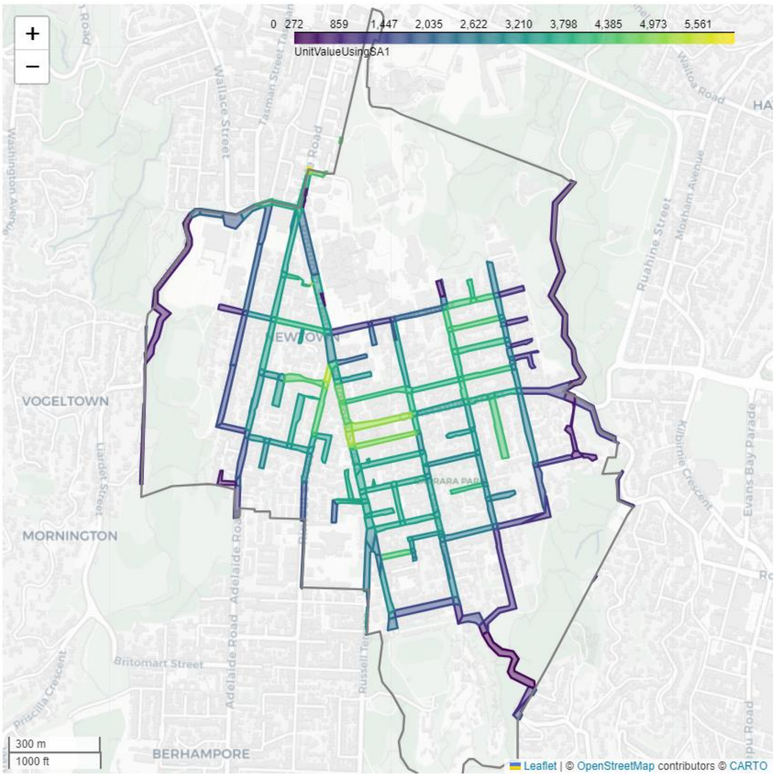

Figure 7.1: Newtown local road parcels and indicative value per square metre (estimated from SA1)

7.3 Upper Hutt

This case study covers the entire Upper Hutt City Council area, as a representative provincial centre.

The implied unit rate approach was used to identify asset classes with outlier valuations. No outliers were identified on this basis.

The valuation is based on the TA valuation (indexed to June 2024), aside from the following re-estimated assets:

- Stormwater, Lights/Signals/Poles, Other – re-estimated using a top-down approach (average share of ORC across TAs per road classes), as discussed in 6.3.1.

Table 7.4 shows the estimated valuation.

Table 7.4 Upper Hutt network ODRC by asset and road type

Asset	Central ODRC by road type (2024$m)					Overall ODRC (2024$m)			
	Arterial	Urban collector	Urban local	Rural other	Unsealed	Central	Low	High	TA Valn.
Land[1]	325.7		808.5	27.6	-	1,161.8	920.9	1,402.8	-
Formation	4.7	10.8	25.6	35.9	-	77.0			77.0
Base / subbase	6.0	12.8	23.4	12.0	-	54.2			51.7
Surfacing	2.2	2.6	6.2	1.8	-	12.9			12.9
Bridges	5.9	8.5	5.8	14.2	-	34.3			34.3
Tunnels	0.2	-	0.2	-	-	0.4			0.4
Kerb and channel	1.4	5.6	14.3	1.6	-	22.9			22.9
Pathways	2.5	6.9	16.0	0.3	-	25.8			25.8
Retaining walls	0.4	1.3	0.4	4.5	-	6.6			6.6
Stormwater[2]	1.1	2.6	6.0	2.3	-	12.0	6.3	18.5	7.1
Lights / signals / poles[2]	0.9	2.1	4.9	1.8	-	9.7	6.8	12.9	7.6
Other[2]	0.3	0.6	1.5	0.6	-	3.0	1.9	4.3	1.2
Non-land subtotal	25.6	53.8	104.4	74.8	-	258.8	249.1	269.9	247.6
Total	**405.1**		**913.0**	**102.4**	**-**	**1,420.7**	**1,170.0**	**1,672.6**	**-**
Treatment length (km)	11.6	43.2	120.5	77.1	-	252.3			
Treatment area (ha)	13.1	42.9	96.7	45.3	-	198.0			
Land area (ha)	91.4		211.0	181.3	-	483.7			

1. Low/high values represent SA2/SA1-based valuation

2. Low/high values represent range of top-down estimates

7.3.1 Discussion

There is less than 1km of unsealed road reported in the AMDS carriageway table for Upper Hutt, the majority of which corresponds to off-road cycle trails. Unsealed roads are therefore not reported in the analysis.

The central estimated valuations for Stormwater, Lights/Signals/Poles, and Other asset classes are higher than TA-provided valuations, indicating that Upper Hutt valued these assets at a lower share of ORC than the average of the case study TAs.

Figure 7.2 shows coverage and indicative unit land values for the urban area of Upper Hutt City. There is significant variation (10x) in SA1-estimated average land values between the lowest and highest value roads.

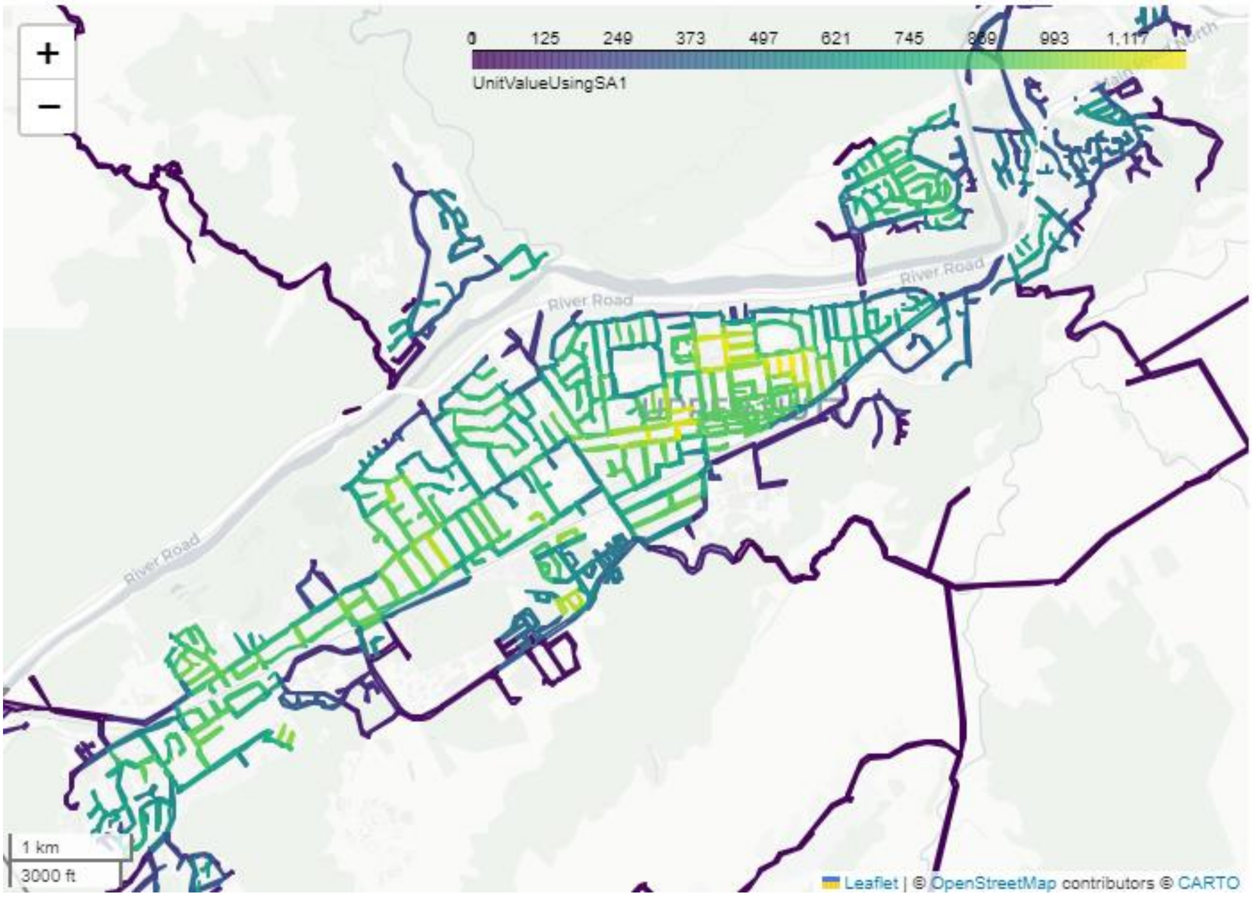

Figure 7.2: Local road parcels and indicative value per square metre (from SA1 average) in central Upper Hutt

7.4 Totara Park, Upper Hutt

This case study covers the Upper Hutt suburb of Totara Park, as a representative provincial suburb.

The implied unit rate approach was used to identify asset classes with outlier valuations. No outliers were identified on this basis.

The valuation is based on the TA valuation (indexed to June 2024), aside from the following re-estimated assets:

- Stormwater, Lights/Signals/Poles, Other – re-estimated using a top-down approach (average share of ORC across TAs per road classes), as discussed in 6.3.1.

shows the estimated valuation.

Table 7.5 Totara Park network ODRC by asset and road type

Asset	Central ODRC by road type (2024$m)					Overall ODRC (2024$m)			
	Arterial	Urban collector	Urban local	Rural other	Unsealed	Central	Low	High	TA Valn.
Land[1]	5.8		78.5	-	-	84.3	62.2	106.4	-
Formation	-	1.0	1.8	-	-	2.8			2.8
Base / subbase	-	1.1	2.0	-	-	3.1			3.3
Surfacing	-	0.2	0.3	-	-	0.6			0.7
Bridges	-	5.6	-	-	-	5.6			4.8
Tunnels	-	-	-	-	-	-			-
Kerb and channel	-	0.6	1.1	-	-	1.7			1.3
Pathways	-	0.7	1.2	-	-	1.9			1.6
Retaining walls	-	-	0.0	-	-	0.0			0.0
Stormwater[2]	-	0.3	0.5	-	-	0.7	0.4	1.1	0.3
Lights / signals / poles[2]	-	0.2	0.4	-	-	0.6	0.4	0.8	0.6
Other[2]	-	0.1	0.1	-	-	0.2	0.1	0.3	0.0
Non-land subtotal	-	9.7	7.5	-	-	17.2	16.6	17.9	15.6
Total	**15.4**		**86.1**	**-**	**-**	**101.5**	**78.8**	**124.3**	**-**
Treatment length (km)	-	4.6	8.9	-	-	13.5			
Treatment area (ha)	-	3.8	6.8	-	-	10.6			
Land area (ha)	2.4		19.1	-	-	21.5			

1. Low/high values represent SA2/SA1-based valuation

2. Low/high values represent range of top-down estimates

7.4.1 Discussion

The boundary of the Totara Park SA2 crosses the Totara Park Road bridge, which is a significant asset, particularly given the small size of the suburb. This valuation follows UHCC suburb classification for assets which may or may not reflect the precise geographic boundary of the suburb. In general, this is not expected to be a limitation for a wider roll-out of the method when applied to larger valuation areas.

As is consistent with the Upper Hutt case study, the central estimated valuations for Stormwater, Lights/Signals/Poles, and Other asset classes are higher than TA-provided valuations.

Indicative average road land value in Totara Park is shown in Figure 7.3.

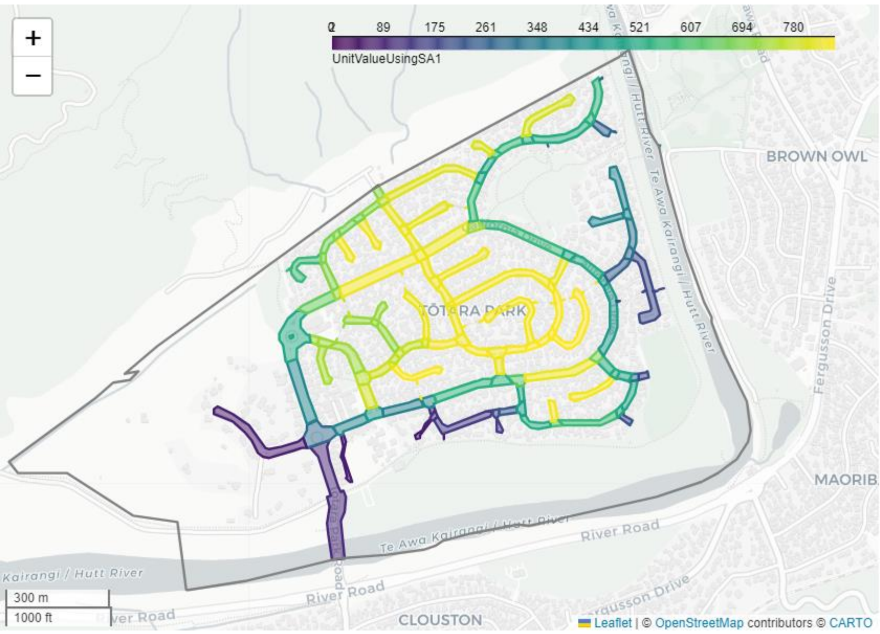

Figure 7.3: Totara Park local road parcels and indicative value per square metre (from SA1 average)

7.5 Banks Peninsula, Canterbury

This case study covers the Banks Peninsula ward of Christchurch City. This area is largely rural, though includes the Lyttelton and Akaroa urban areas.

The valuation is based on the TA valuation (indexed to June 2024), aside from the following re-estimated asset class:

- Stormwater, Lights/Signals/Poles, Other – re-estimated using a top-down approach (average share of ORC across TAs per road classes), as discussed in 6.3.1.

7.5.1 Implied unit rate method

Table 7.6 shows the estimated valuation using the implied unit rate method, with the following re-estimated outlier asset class values:

- Basecourse (high outlier), kerb and channel (low outlier), pathways (low outlier) – re-estimated using average implied unit rates across TAs, as discussed in 6.3.2.

Table 7.6 Banks Peninsula network ODRC by asset and road type – implied unit rate method

Asset	Central ODRC by road type (2024$m)					Overall ODRC (2024$m)			
	Arterial	Urban collector	Urban local	Rural other	Unsealed	Central	Low	High	TA Valn.
Land[1]	35.2		223.4	53.8	29.2	341.6	297.2	386.0	-
Formation	9.9	5.3	19.7	39.0	43.4	117.3			117.3
Base / subbase[3]	13.8	2.1	8.2	51.1	36.3	111.5	107.6	116.9	125.0
Surfacing	1.2	0.5	1.3	3.5	5.1	11.6			6.1
Bridges	1.0	2.6	3.2	14.3	9.8	30.9			28.7
Tunnels	-	-	-	-	-	-			-
Kerb and channel[3]	2.9	2.5	11.3	8.4	1.1	26.2	22.2	28.0	12.7
Pathways[3]	0.8	0.3	1.2	0.0	0.0	2.3	1.9	2.4	3.5
Retaining walls	12.3	4.0	24.2	5.1	5.8	51.4			59.6
Stormwater[2]	0.5	0.2	0.7	1.6	1.5	4.4	2.2	7.0	14.9[4]
Lights / signals / poles[2]	1.0	0.4	1.4	3.4	3.0	9.2	6.2	12.7	3.0
Other[2]	0.1	0.0	0.1	0.3	0.3	0.8	0.5	1.2	2.6
Non-land subtotal	43.2	17.8	71.3	126.9	106.4	365.7	351.9	379.6	373.3
Total	**96.3**		**294.7**	**180.7**	**135.6**	**707.3**	**649.2**	**765.6**	**-**
Treatment length (km)	31.5	13.1	59.5	200.7	345.4	650.1			
Treatment area (ha)	20.8	9.1	34.9	100.6	128.0	293.4			
Land area (ha)	18.0		117.5	623.3	527.3	1,286.1			

1. Low/high values represent SA2/SA1-based valuation

2. Low/high values represent range of top-down estimates

3. Low/high values represent range of bottom-up estimates

4. Excludes assets with missing location information

7.5.2 Regression method

An alternative valuation applying the regression approach to identify outliers in surface / subsurface assets is shown in Table 7.7.

Table 7.7 Banks Peninsula network ODRC by asset and road type – regression method

Asset	Central ODRC by road type (2024$m)					Overall ODRC (2024$m)			
	Arterial	Urban collector	Urban local	Rural other	Unsealed	Central	Low	High	TA Valn.
Land[1]	35.2		223.4	53.8	29.2	341.6	297.2	386.0	-
Formation[4]	10.2	5.1	19.0	38.6	45.0	117.8	117.6	118.0	117.3
Basecourse and subbase[4]	13.8	4.4	11.0	51.7	36.4	117.3	117.2	117.3	125.0
Surfacing[4]	1.0	0.5	1.3	3.5	5.1	11.4	11.4	11.4	6.1
Bridges	1.0	2.6	3.2	14.3	9.8	30.9			28.7
Tunnels	-	-	-	-	-	-			-
Kerb and channel[3]	2.9	2.5	11.3	8.4	1.1	26.2	22.2	28.0	12.7
Pathways[3]	0.8	0.3	1.2	0.0	0.0	2.3	1.9	2.4	3.5
Retaining walls	12.3	4.0	24.2	5.1	5.8	51.4			59.6
Stormwater[2]	0.5	0.2	0.8	1.6	1.5	4.5	2.3	7.1	14.9[5]
Lights / signals / poles[2]	0.9	0.4	1.6	3.4	3.1	9.4	6.5	12.7	3.0
Other[2]	0.1	0.0	0.1	0.3	0.3	0.9	0.5	1.3	2.6
Non-land subtotal	43.4	20.0	73.6	127.0	108.1	372.2	362.1	380.6	373.3
Total	**98.6**		**297.0**	**180.9**	**137.3**	**713.8**	**659.3**	**766.7**	**-**
Treatment length (km)	31.5	13.1	59.5	200.7	345.4	650.1			
Treatment area (ha)	20.8	9.1	34.9	100.6	128.0	293.4			
Land area (ha)	18.0		117.5	623.3	527.3	1,286.1			

1. Low/high values represent SA2/SA1-based valuation

2. Low/high values represent range of top-down estimates

3. Low/high values represent range of bottom-up estimates

4. Low/high values represent mean confidence interval of regression model, though these are implausibly narrow due to the assumption of independent valuations within a TA

5. Excludes assets with missing location information

7.5.3 Discussion

Banks Peninsula was the only TA where outlier valuations were identified based on analysis of implied unit rates. Given the rural nature of Banks Peninsula, the identified low outlier valuations for pathway and kerb/channel assets may reflect different prevalence of footpaths or different road typology (not captured in the broad categories used for valuation), rather than actual differences in valuation approach.

Total valuations for the implied unit rate approach are around $6m lower than the regression approach (~2% of the non-land asset total).

The case study area has extensive paper roads and public walkways where land parcels have a registered roading purpose but are not recognised by CCC as part of the local road network.

Figure 7.4 shows the road parcels identified in Banks Peninsula according to carriageway match. Only around 30% of identified road land area is within 20m of a RAMM carriageway centreline.

As expected, the largest differences between TA-provided and estimated valuations are for the assets that were re-estimated using bottom-up methods – basecourse/subbase, kerb and channel, and pathways.

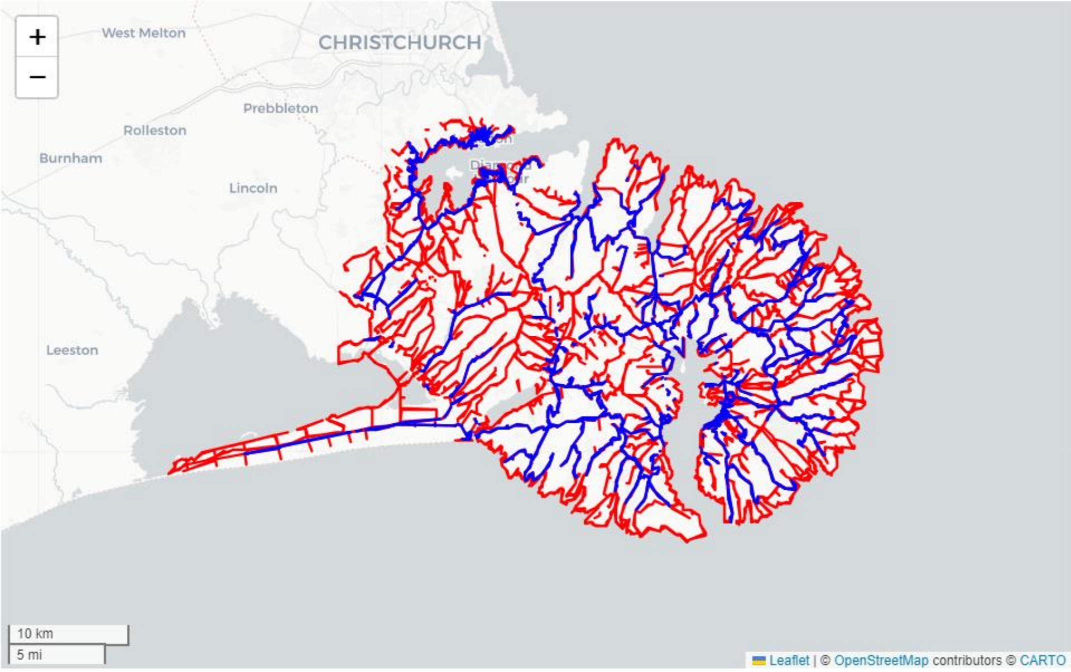

Figure 7.4: Banks Peninsula identified road parcels not matched (red) and matched (blue) to RAMM carriageway

7.6 Summary and Discussion

Table 7.8 summarises average values by case study area and road type. Values are normalised by centreline length (from treatment length data) or land area (from road parcel data). Additionally, Table 7.9 compares total and per capita local road ODRC estimates, based on usually resident population data from the 2023 Census. Results from the implied unit rate approach are shown for all case studies.

Table 7.8 Case study average ODRC by road type

	Central ODRC by road type					Overall ODRC			
	Arterial	Urban collector	Urban local	Rural other	Unsealed	Central	Low	High	TA Valn.
Avg. non-land value ($m / centreline km)									
Wellington	3.27	2.10	1.59	0.97	-	1.85	1.77	1.93	1.95
Newtown	1.63	1.66	1.51	-	-	1.58	1.49	1.68	1.46
Upper Hutt	2.21	1.25	0.87	0.97	-	1.03	0.99	1.07	0.98
Totara Park	-	2.11	0.84	-	-	1.27	1.23	1.32	1.15
Banks Peninsula	1.37	1.36	1.20	0.63	0.31	0.56	0.54	0.58	0.57
All case studies	2.68	1.89	1.40	0.77	0.31	1.20	1.15	1.25	1.24
Avg. land value ($m / centreline km)									
Wellington	28.1		23.0	0.5	-	22.9	20.6	25.2	-
Newtown	33.3		27.5	-	-	30.2	22.6	37.9	-
Upper Hutt	5.9		6.7	0.4	-	4.6	3.7	5.6	-
Totara Park	1.3		8.8	-	-	6.2	4.6	7.9	-
Banks Peninsula	0.8		3.8	0.3	0.1	0.5	0.5	0.6	-
All case studies	20.9		17.7	0.3	0.1	10.9	9.8	12.1	
Avg. land value ($ / parcel m^2)									
Wellington	1,816		1,157	26	-	1,255	1,128	1,382	-
Newtown	1,854		1,731	-	-	1,793	1,338	2,249	-
Upper Hutt	356		383	15	-	240	190	290	-
Totara Park	241		411	-	-	392	289	495	-
Banks Peninsula	195		190	9	6	27	23	30	-
All case studies	1,478		912	12	6	575	513	638	
Avg. total value ($m / centreline km)									
Wellington	30.6		24.6	1.4	-	24.7	22.3	27.1	-
Newtown	35.0		29.0	-	-	31.8	24.0	39.6	-
Upper Hutt	7.4		7.6	1.3	-	5.6	4.6	6.6	-
Totara Park	3.4		9.6	-	-	7.5	5.8	9.2	-
Banks Peninsula	2.2		5.0	0.9	0.4	1.1	1.0	1.2	-
All case studies	23.1		19.1	1.1	0.4	12.1	10.9	13.4	

Table 7.9 Case study total and per capita ODRC

Case Study	Local Road Estimated ODRC (2022)	
	Central estimate ($m)	Per capita ($)
Wellington	17,330.56	85,503
Newtown	512.07	56,111
Upper Hutt	1,420.68	32,303
Totara Park	101.49	35,130
Banks Peninsula	707.33	82,874

7.6.1 Outlier estimation

Two approaches to the identification of outlier valuations have been explored in the case studies – the *implied unit rate* and *regression* approaches. The regression approach identifies individual asset outlier valuations, and was applied to road surface/subsurface assets only due to data limitations.

The outlier identification process highlighted some asset or asset class valuations which differed from other case studies substantially. However, this outlier identification process cannot determine whether outliers reflect differences in valuation assumptions/processes or actual differences in asset composition and replacement cost.

Note, the range used to determine per-TA outlier valuations in the case studies is necessarily wide due to the small number of TA datasets available. Including more TA valuations would be expected to narrow the expected unit value range and identify a greater number of outliers, plus allow benchmarking within groups of TAs to be undertaken.

While the alternative regression approach also led to sections being treated as outliers which may be explainable with more covariates, the approach produced only modest changes to estimated valuations, less than 2% of non-land valuation totals for the Wellington and Banks Peninsula case studies. However, given the approach was only applied to two case studies it is not clear if the minor impact seen here would generalise beyond these areas.

7.6.2 TA valuation variability

There is a large variation in the aggregated valuations reported between the five case study areas. For example, the implied unit rate for formation averaged (unweighted) $47/sqm over the five case study areas and ranged from $26/sqm to $81/sqm, with a standard deviation of $23/sqm or 49% of the average. The variation was larger for bridges and retaining walls. Some variation is to be expected given that each area will have different natural characteristics (e.g., slope, soils).

The implied unit rate approach did identify some extreme variants, but the implicit assumption is that most of the variation in observed values reflects variation in the physical environment, in road widths and in the number and size of adjoining assets. In particular, most councils estimate the value of major assets such as formation and surfacing, using additional variables such as terrain, traffic volumes and local unit rates. In the absence of extreme outliers, this can reasonably be expected to reflect local conditions appropriately as the more detailed regression analysis where extra data were available did not change valuations materially.

However, a per-section regression analysis of TA valuations, detailed in Appendix H, still showed significant differences in ORC valuations by TA even after accounting for observable differences in road length, width, road type, traffic volume and terrain. Notably, different TA effects were estimated for different asset classes. For example, WCC valuations for formation and surface were 33% and 100% higher than for CCC assets with similar characteristics, respectively, while subbase and basecourse were valued 50-60% lower than CCC. The large magnitude and varied direction of these effects may indicate differences in valuation approach and apportionment of road asset values[20], rather than true differences in the replacement cost of these assets by council area.

7.6.3 RAMM/AMDS comparison

In general, similar variables were available for TAs regardless of whether RAMM or AMDS data formats were used, particularly for the highest value assets such as carriageway components and road surface/subsurface.

Stormwater assets were recorded inconsistently across case study TAs (including using RAMM, AMDS, or recorded outside of RAMM/AMDS), however there was not sufficient information to indicate whether the asset reporting format was a factor in the observed valuation differences.

7.6.4 Alignment of asset and valuation data

In general, asset data within RAMM or AMDS was found to be relatively complete in terms of valuation-relevant variables. However, aligning the asset databases with valuation records was not straightforward, requiring a bespoke process for each case study TA due to inconsistent valuation reporting made available by councils. This may limit the practicality of rolling out detailed per-section modelling (as in the regression approach to outlier identification) to all TAs.

7.6.5 Land valuation

Land value represented the single largest asset value in all case studies, even for the rural Banks Peninsula area. A further indicative comparison is that the estimated land valuation for the Wellington case study alone is almost equal to the prior DTCC estimates of the value of the entire local road network[21] (Richard Paling Consulting & Ian Wallis Associates Ltd, 2023). This supports the alternative valuation put forward in the DTCC Walking and Cycling working paper (Veitch Lister Consulting & Ian Wallis Associates, 2023b) which implied that the central DTCC estimate of land value was potentially an order of magnitude too low.

In all case studies, SA2-derived land values were lower than SA1-derived. This indicates that SA1 average land values tend to be higher near roads than SA2 values, which may reflect local effects of the road on land values, or other confounding differences between road-adjacent and non-adjacent land, such as higher density zoning or different land use patterns (e.g., industrial areas). The SA2-derived valuation will reflect a value more typical of land not immediately adjacent to the road.

Given that the SA1 and SA2 valuations differ by 20-50%, this highlights the importance of either refining the estimation of land values or appropriately reporting the uncertainty in these estimates. To highlight the magnitude of this uncertainty, the *difference* between these two estimates is approximately equal to the *total* estimated value of all non-land assets in most case studies.

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[20] For example, whether there are differences in what is considered basecourse vs. subbase, or subbase vs. formation.

[21] Although these are not directly comparable due to different valuation years.

8 Valuation Rollout Considerations

This chapter details how the preferred valuation approach might be applied to estimate the total value of the local road network in New Zealand. Particular focus is given to how case study results map to the entire local road network, limitations and potential variants of the preferred approach, and any variation in the availability or quality of valuation datasets by location. Finally, recommendations for a nationwide rollout of the valuation methodology are discussed.

8.1 Case study coverage

Table 8.1 compares the network included in the case studies against the national network (excluding state highways) as reported by Transport Insights[22]. Average non-land values from the case studies are extrapolated to estimate approximate national valuation by road type.

In terms of both network length and estimated value, the chosen case studies over-represent urban roads, particularly urban local roads. The Banks Peninsula case study contains the only significant rural area in the case studies. There is likely to be variation in rural road costs and/or valuation practices that is not captured in the Banks Peninsula case study, for example in more rural TAs, inland areas, or areas with flatter terrain.

Table 8.1 Comparison of case study and national road network composition (length and non-land asset value)

Road type	Case studies (km)	National network (km)	Road type coverage	Case study avg. non-land value ($m/km)	Case study non-land value ($m)	Fraction of total value	Estimated national network value ($m)	Fraction of total value
Arterial	121	3,699	3%	2.68	325	17%	9,897	13%
Urban collector	218	6,685	3%	1.89	412	21%	12,634	17%
Urban local	582	10,878	5%	1.40	817	43%	15,267	21%
Rural other	336	33,541	1%	0.77	258	13%	25,756	35%
Unsealed	345	32,623	1%	0.31	106	6%	10,050	14%
Total	1,603	87,426	2%		1919	100%	73,605	100%

Notes:
- Case studies network includes UHCC + WCC + Banks Peninsula
- National network excludes NZTA roads

Regarding land values, the TAs used for case studies represent two of the three largest urbanised areas in New Zealand, and thus land values (the largest component of the valuation) are likely higher than the national average for a given road type. However, given that national datasets are used in the preferred model to estimate land values, it is expected that land value differences between urban and remote areas would be appropriately captured in a national rollout.

[22] Data from Road Efficiency Group Te Ringa Maimoa – *Transport Insights*, www.transportinsights.nz. The national network road type is estimated based on Transport Insights-reported One Network Road Classification (ONRC) values, as detailed in Appendix F.

8.1.1 Approximate nationwide land valuation

Table 8.2 shows an approximate nationwide land valuation of the local road network based on available land parcel data. ONF is used to approximately estimate road type. Parcels with unknown ONF classifications are excluded. Network length and average corridor width are also shown based on national ONF network data from Transport Insights.

Table 8.2 Approximate land valuation of nationwide local road network

Road type	Land value from SA2 ($m)	Land value from SA1 ($m)	Land area (ha)	Network length (km)	Average land value ($/m2)	Average corridor width (m)
Arterial / Collector	82,255	93,908	10,485	5,227	840	20
Urban local	122,777	156,395	24,957	13,808	559	18
Rural other / Unsealed	10,045	9,913	132,233	66,343	8	20
Overall	**215,077**	**260,217**	**167,675**	**85,378**	**155**	**20**
Case studies	**15,629**	**19,449**	**30,477**	**1,603**	**575**	

8.2 Recommended rollout valuation approach

For a nationwide rollout, the recommended approach is a hybrid valuation methodology, with different valuation techniques by asset class.

The preferred asset categorisation and valuation approaches are summarised in Table 8.3. TA valuations of non-land assets are adjusted to correct for outliers using top-down estimates for low-value or data-limited assets, and bottom-up estimates (from average implied unit rates or regression modelling) for other assets.

The regression approach is recommended for road surface/subsurface assets to enable flexible inclusion of covariates and leverage the higher-quality data available for these assets. The implied unit rate approach is preferred for kerb and channel and pathway assets due to the lower-quality data and lower relative value of these assets.

Land is recommended to be valued using an over-the-fence approach based on average land values in SA1 or SA2 areas adjacent to the road network.

Table 8.3 Preferred valuation approaches by asset class

<table>
<tr><th>Asset</th><th>Valuation approach</th><th>Valuation estimate</th></tr>
<tr><td>Land</td><td>Over-the-fence</td><td>Based on SA1/SA2 average land value</td></tr>
<tr><td>Formation</td><td rowspan="3">Regression (by asset)</td><td rowspan="3">Outliers and areas without valuation data – bottom-up estimate from regression model
Inliers – TA valuation</td></tr>
<tr><td>Basecourse and subbase</td></tr>
<tr><td>Surfacing</td></tr>
<tr><td>Kerb and channel</td><td>Implied unit rate (by asset class/road type pairing)</td><td>Outliers and areas without valuation data – bottom-up estimate from implied unit rate
Inliers – TA valuation</td></tr>
</table>

Asset	Valuation approach	Valuation estimate
Pathways	Implied unit rate (by asset class/road type pairing)	Outliers and areas without valuation data – bottom-up estimate from implied unit rate Inliers – TA valuation
Lights / signals / poles	Data-limited / low-value	Top-down estimate
Stormwater	Inconsistent asset grouping / data-limited	Top-down estimate
Retaining	Idiosyncratic	TA valuation
Bridges	Idiosyncratic	TA valuation
Tunnels	Idiosyncratic	TA valuation
Other	Inconsistent asset grouping / low-value	Top-down estimate

8.2.1 Limitations

The preferred approach has limitations as noted below. In some cases, further research or decision as part of a wider rollout may be able to address or overcome limitations of the approach. These cases are discussed further in the rollout plan below.

8.2.1.1 Reliance on TA valuations for non-land assets

Fundamentally, the preferred approach assumes that TA valuations are accurate representations of the replacement cost of non-land assets, unless the valuations differ markedly from those of assets or asset classes with similar characteristics. This appears to be a reasonable assumption as TAs are likely to be familiar with local variation in replacement costs.

Although the methods to determine outlier valuations attempt to control for road network and asset characteristics, they cannot distinguish between divergent or erroneous valuation processes and actual differences in replacement costs based on regional or asset-specific factors. Additionally, if TA valuations are systematically biased away from true replacement costs, the preferred approach will not accurately capture the fair value of the network.

Inclusion of regional cost indices or similar could provide additional information to determine if outliers reflect likely replacement cost differences.

In cases where TA valuation differentials vary significantly by asset class – for example, WCC having formation and surface costs exceeding those of CCC, but significantly lower basecourse and subbase costs – this may warrant further investigation of specific valuation assumptions. If it is suspected that road components are apportioned differently between TAs, assets could be aggregated together for valuation purposes to reduce the impact of these variations, for example valuing all road subsurface layers together.

8.2.1.2 Availability of TA valuation data

Experience from case studies and discussions with TAs and NZTA has suggested that valuation data is not as consistently formatted as asset data. It is expected that alignment of a larger sample of TA valuations with asset data could require considerable effort, unless TAs have consistent reporting (perhaps within RAMM/AMDS) of asset valuations. Of the case study TAs, only UHCC reported asset valuations within RAMM/AMDS.

8.2.1.3 Implied unit rate outlier identification

The outlier selection process based on implied unit rate uses a filtering approach based on the summary statistics of the TA implied unit rates, by asset class. This filtering was coarse for the case studies due to the small number of case studies (five areas representing three TA valuation approaches). For a wider rollout, a larger set of TA valuations should allow refinement of the intervals used to identify outliers.

The use of a more fine-grained road type classification (for example, the One Network Framework classification) would also capture more variation in network asset makeup and would be expected to improve outlier estimates.

8.2.1.4 Limited covariates

The regression analysis of road surface/subsurface asset valuations show strong TA effects after controlling for road length, width, traffic volume, type and terrain. This could reflect either substantial differences in valuation practice or replacement costs, either of which are not captured by other covariates in the model. It is possible there are significant missing covariates (such as regional construction costs or climate) that would explain some or all of this difference.

Alternative modelling approaches are also likely to address some of the residual heterogeneity in valuations unable to be explained by existing covariates. In particular, inclusion of random effects in the model (at the street or suburb level) is likely to allow more precise coefficient estimates for the remaining covariates. This is discussed further in Appendix H.

8.2.1.5 Non-normality of regression residuals

Statistical tests indicate that the residuals in the regression analyses are not normally distributed, potential causing unreliable parameter estimates and limited applicability of the model to other TAs. While the normality of the residuals would be expected to improve with a larger sample of TA valuations[23], this non-normality may reflect a general characteristic of TA valuation datasets. Transformation of the dataset or alternative functional forms of the model may be required to improve model fit.

8.2.1.6 Impact of outliers on model fit

Preliminary results presented in Appendix H indicate that the regression model fit is influenced by the presence of outliers. An iterative approach where modelled outliers are excluded and the model re-fitted could produce more reliable model estimates, and hence improve both the final identification of outliers, and the model replacement of these outlier values.

There appear to be some covariates in the case study datasets with potentially spurious values, such as road segments with near-zero length, width or area. Due to time constraints no cleaning of these values has been applied in this work (in either regression or implied unit rate approaches), however this could be applied to improve model estimates for a wider rollout, and would likely also improve the normality of the regression residuals.

8.2.1.7 Depreciation treatment

The preferred approach depreciates ORC values based on reported average depreciation ratios per asset class. This again assumes that TAs are accurately estimating and reporting asset depreciation given local age, condition and lifespan factors. While there did not appear to be major

[23] Noting that valuations within a TA are correlated, so the case study models fitted represent only 2 independent valuation approaches

differences in depreciation ratios across TAs, the outlier analysis could be extended to age, condition or lifespan assumptions to highlight where valuation assumptions differ materially.

8.2.1.8 Land valuation scale

Land valuation has been estimated by aggregating adjacent valuations at either the SA1 or SA2 level. These two approaches resulted in case study land valuations that differed significantly (20-50%), with SA1-based valuations typically higher.

SA2-based valuations will tend to include less endogeneity between the road value and the adjacent use value, and SA1-based valuations will provide a more accurate valuation if only a subset of the road were to be converted to an alternative use without diminishing the utility of the roadway.

While statistical area boundaries are not developed for the purposes of road valuation, because they aim to include similar levels of population, they will generally provide more granularity in locations with higher land values and where valuation data is more dense (urban areas).

In principle, the parcel-level data could be used with a more flexible or continuous averaging approach which does not rely on fixed spatial boundaries. However, this will not remove the need to select both the scale and functional form of the spatial averaging method used (analogous to the choice between SA1-based and SA2-based valuations). Valuations using a continuous averaging method would be very sensitive to these assumptions, and depending on assumptions could be higher or lower than SA-derived valuations. It is also likely that a practical averaging scale will vary across urban and rural areas, which is to some degree accounted for by using statistical area averages.

On balance, land valuation based on SA1 or SA2 area averages is considered a pragmatic approach which aligns with NZTA practices and appropriately captures the additional variability and materiality of land values in urban areas.

8.2.1.9 Missing land valuations

Spatial information for some valuations is missing from the LINZ District Valuation Roll (DVR) dataset used to estimate SA1/SA2 land values. An illustration of the extent of missing data in the suburban Auckland is shown in Figure 8.1.

Missing valuations are likely to cause bias, particularly in remote areas where there are larger gaps. It is not clear whether extrapolating from nearby valuations is appropriate, particularly if missing valuations cover a large proportion of the SA1 or SA2.

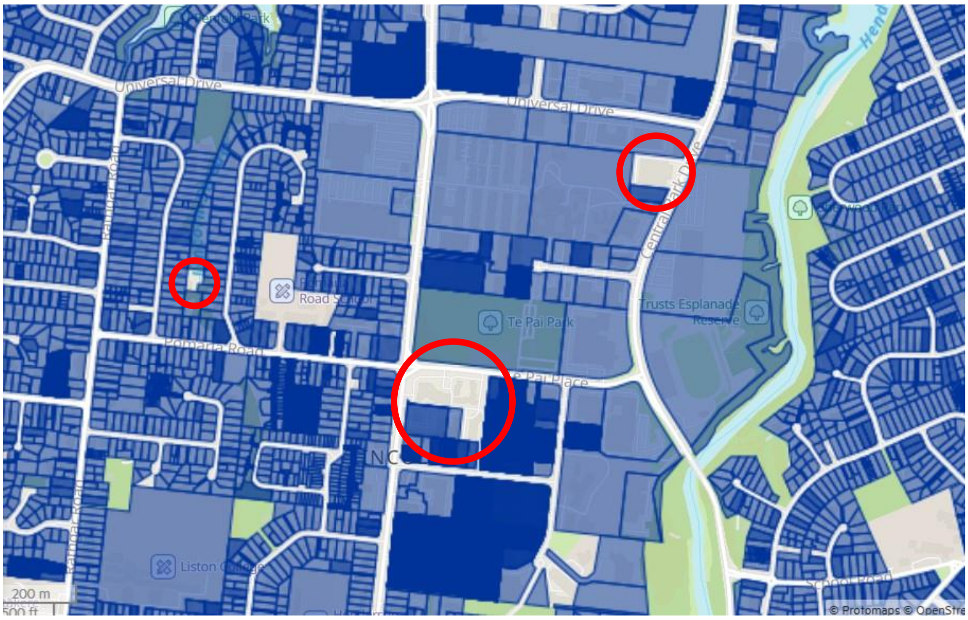

Figure 8.1: Example LINZ DVR spatial valuation data in Henderson, Auckland (left) showing gaps in spatial coverage (red) excluding schools and reserves – from left to right: a residential property, a commercial shopping centre and an industrial site.

8.3 Rollout data requirements

The following sections document specific data requirements and recommendations apply to the full valuation rollout.

8.3.1 Land valuation

8.3.1.1 Road centreline

To exclude unformed/paper road parcels, the preferred valuation methodology clips road land parcels based on proximity to the RAMM or OpenStreetMap road centreline.

The RAMM centreline data is likely available from all TAs and aligns well with the TA-identified local road network. It will also contain road classification (ONF/ONRC) and seal information. However, it must be provided individually by each TA or extracted from RAMM/AMDS.

OpenStreetMap has nationwide coverage and is expected to exclude unformed roads as required, though it may be less complete than the TA centreline data. Issues may arise if OpenStreetMap road type is miscoded or inconsistently labelled, however no missing or miscoded local roads were observed in OpenStreetMap data during the case study valuations. OpenStreetMap also does not contain consistent information regarding road hierarchy or seal.

Given that the centreline data is used for filtering land parcels only, OpenStreetMap data is expected to be appropriate for a nationwide rollout (and is applied in the national estimate in Section 8.1.1), unless valuations based on fine-grained road hierarchy are required, in which case RAMM centreline is preferred.

8.3.2 Non-land valuation

The preferred valuation methodology relies on TA-reported valuations for non-land assets, and standardises these by treatment length and area to determine whether valuations are outliers.

8.3.2.1 Valuation data

TA valuation data for this purpose needs to include the following information:

- Asset Optimised Replacement Cost (ORC)
- Asset Optimised Depreciated Replacement Cost (ODRC)

For the implied unit rate approach, valuations need to be provided at a granularity such that they can be aggregated by road type and asset class. If the regression approach is to be used to identify surface and subsurface outliers, individual asset valuations are required for these assets.

8.3.2.2 Asset data

Asset data is required in a format that can be linked to TA valuations, either in aggregate or per-asset. This data at a minimum should include:

- Carriageway / treatment length
- Carriageway / treatment width
- Road hierarchy

These variables are assumed to be available across TAs for carriageway assets, given largely standardised asset recording in RAMM/AMDS, but this has not been confirmed. NZTA have indicated that bulk collection of nationwide asset data may be possible via the RAMM/AMDS software vendor (Thinkproject).

Minor assets and those with expected inconsistent reporting, such as stormwater, lights/signals/poles and miscellaneous assets, are not required for all TAs, as these are re-estimated via top-down methods in the preferred valuation approach. However, more reported valuations for these assets will allow refinement of the top-down estimates.

8.3.2.3 Road hierarchy

In the case studies, road hierarchies reported in the provided valuation extracts varied significantly across TAs, and did not map straightforwardly to standard road classifications such as ONF or ONRC. As such, bespoke mappings were required to transform TA hierarchy information to a common road type (Appendix F). For a nationwide rollout, using consistent hierarchy reporting such as ONF will aid this step of the analysis.

8.4 Proposed rollout plan

The following plan is recommended for rolling out the preferred valuation approach to the nationwide local road network. In some cases, differences are noted from the case study approaches as a result of experience gained during the case studies, likely data limitations or uncertainties, and subsequent feedback from the Project Steering Group and peer reviewers.

The proposed steps are listed in Table 8.4.

Table 8.4 Rollout plan steps

Rollout plan steps
1. Compile consistently formatted nationwide asset and covariate data • Undertake an audit of TAs asset data storage and format practices to inform the design of the asset dataset to support a nationwide valuation. • Define consistent road road/type/hierarchy for all assets (ONF is recommended for this purpose) • Collate asset data for all TAs, ideally with assistance from other agencies using bulk asset data, such as Road Efficiency Group Te Ringa Maimoa. Assess and collect available road section (treatment length) covariate data, in particular carriageway length/width, traffic volume, terrain and seal type.
2. Identify additional covariates and refine land valuation scale • Engage with council / NZTA valuation staff and external valuers to identify any other available covariates (including outside of asset data) that are expected to have a significant impact on asset valuations.   ○ This could, for example, include independent data sources which account for regional differences in construction costs, asset lifespans or similar. • Engage with land valuation experts to determine the appropriate scale of land valuation, whether based on SA1/SA2 or a continuous spatial averaging approach. This discussion should consider how endogeneity might be expected to influence land valuations, and to what extent this can or should be corrected for.
3. Identify availability and format of TA road valuation datasets • Conduct an audit of TAs to establish those able to provide itemised TA asset valuations, and in what format. • During this process, identify any major differences in TA valuation scope (for example, any major asset classes included/excluded).

4. Determine TA sample and collect data
• **Based on the outcome of the previous step, determine the size and composition of the TA sample that will be used to develop the valuation model.**
  ○ **The extent of this sample will depend on the consistency of valuation data available (and hence the effort required to align across TAs and with asset datasets), the ease of requesting this data from TAs, and the time and effort available to conduct this exercise.**
  ○ **The sample should capture variation in geographies, network composition, and other expected differences in construction costs and asset composition.**
• Collect TA valuation and asset data.
• Once collected, align TA valuation data with asset datasets and mapped to a common asset class categorisation.

5. Refine valuation models with additional data
• Refine the regression approach to modelling road surface and subsurface asset values, including exploration of:
  ○ **Addition of any new covariates identified in previous steps**
  ○ **Inclusion of random effects at the street or suburb level** (in preference to TA fixed effects, which do not allow extrapolation beyond the sample)
  ○ **Cleaning of spurious segment geometry values before fitting model**
  ○ Non-normality of residuals with larger sample
  ○ Potential iterative approaches to model fitting and outlier estimation/exclusion, to reduce outlier impact on model fit
• Fit ORC valuation models to the sample of TA valuations. Models will include regression, implied unit rate, or top-down estimates by asset type, as shown in Table 8.3.

Rollout plan steps

6. Estimate non-land asset values

- Apply the updated valuation models to estimate non-land asset values for the entire local road network, as per Table 8.3 As it is not anticipated that valuation data will be available for all TAs, this step includes full model-based re-estimation of asset values for TAs without valuations.
    - **If the sample of TA valuations is small, the valuation principle in effect shifts from filtering of outlier TA valuations to extrapolation. In this case, it may be pragmatic to simplify the approach by entirely replacing TA valuations with model-predicted values (rather than only replacing outliers).**
- For areas without provided TA valuations, it will not be possible to use local depreciation ratios to convert from ORC to ODRC. In such cases, a national average depreciation ratio by asset class should be used.

7. Estimate land asset values

- **Identify road land parcels as per preferred approach**.
- **Clip road land parcels to the local road network**:
    - **Either the OpenStreetMap or RAMM/AMDS centreline** can be used, depending on data availability and whether valuations need to be separated by road hierarchy / seal type
- Calculate land values per parcel according to the preferred approach. Land values to be averaged at the scale(s) agreed in Step 2.
- Assess materiality of missing land valuations and land averaging scale. Given the materiality of the land valuation estimates and uncertainty around the impact of endogeneity, it may be appropriate to present a valuation range rather than a point estimate.

8.5 Summary and recommendations

There do not appear to be any major data or technical limitations precluding a rollout of the preferred methodology for valuation of the nationwide local road network.

Suitable non-land asset data is likely to be available for most TAs. RAMM or AMDS datasets are expected to contain sufficient asset information to inform valuations. These datasets should be available in consistent formats if accessed directly through the asset management systems.

A key uncertainty is the availability and format of TA valuation data for non-land assets. If valuation data is not available in a standard format, alignment of asset and valuation data will potentially require significant effort, which may constrain the feasible size and/or coverage of the TA valuation sample. An audit stage in the rollout is recommended to determine TA valuation dataset formats and availability, and the resulting feasible size of the valuation sample.

The presence of a significant TA fixed effects in the case study regression analyses also highlights potential missing covariates, although given the limited sample this may just reflect the natural variation between TA valuation approaches. A larger sample of TA valuations and potential inclusion of further covariates will help differentiate these effects.

Land values are expected to represent the dominant component of the nationwide local road valuation. It is therefore recommended that engagement with expert valuers is sought to refine the appropriate averaging scale of land valuation. It is acknowledged that due to theoretical and practical challenges in isolating the endogenous effects of the road network on surrounding land values, it may be appropriate to present a range of values rather than a point estimate.

9 Conclusion

This research has explored potential valuation approaches for the local road network in New Zealand. A valuation based on fair value principles is recommended as an appropriate perspective to capture the value of this network, which generally corresponds to the ODRC of roading assets, and a market-based valuation of the land underneath the road network. This approach is expected to arrive at significantly different estimates than existing TA-reported valuations, particularly for land values.

A preferred valuation approach based on provided TA valuations has been developed and applied to five case studies. This approach replaces valuations determined to be outliers with average or imputed values estimated from a wider sample of TA valuations (using implied unit rate, regression, or top-down approaches). Land values are estimated independently by following a process similar to that used by NZTA for state highway land valuation. Land values are estimated from adjacent land values averaged at either the SA1 or SA2 level.

A rollout plan has been outlined which applies a refined valuation methodology and highlights the steps required to clarify knowledge gaps regarding data availability, relevant covariates, land valuation details and the robustness of the regression modelling.

Again, it is noted that the uncertainties in land valuations are of a similar magnitude to the overall value of non-land assets, highlighting the importance of refining these estimates or appropriately communicating their uncertainties.

Using nationwide land parcel data, and an approximate extrapolation of non-land asset values by road type, the total estimated value of local road assets is between $288 billion and $333 billion. This estimate is substantially higher than the $61 billion valuation presented in the 2018 DTCC study, reinforcing the motivation for the present research.

This research has further highlighted inconsistencies in TA road asset valuations, specifically a substantial underestimation of asset values. While it is important to note that the national estimates above are only approximate, applying these figures to council balance sheets would result in a significant upward revision of total TA assets, most recently reported at $183 billion[24].

[24] *Local authority financial statistics: Year ended June 2023*, StatsNZ https://www.stats.govt.nz/information-releases/local-authority-financial-statistics-year-ended-june-2023/

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Appendix B. Valuation Perspectives

There is no universally accepted measure of “value”. There are various perspectives on the measurement of value, and value may be estimated differently even within each perspective. The different perspectives on valuation are discussed within this section as tiered concepts, with increasingly expansive definitions of what constitutes value.

Intrinsic value

Philosophically there is a distinction between an *intrinsic value* and an *instrumental value*. An intrinsic value potentially exists on all things and this value is independent of their use to humans. A commonly quoted example is the value of wildlife. However, an intrinsic value is not identifiable and its relevance to existing roads is substantially reduced by institutional arrangements, such as processes that will prevent roads running through the last remaining natural habitat of kiwi. The intrinsic value will not be considered further in this study but it is acknowledged that intrinsic value is at least partially included in estimates of *instrumental value*, be it due to people deriving pleasure from nature or value from others enjoying nature (vicarious value) or from valuing the possibilities of nature (quasi-option value) (Gilpin, 2000).

Economic value

An instrumental value for an asset can, in theory, be derived from the human wellbeing or utility provided by the asset. In practice, there would be many challenges to using this approach to quantify the value of a whole road network. The term *economic value* is used in the following discussion to describe value derived from wellbeing- or utility-based instrumental values.

The value that a consumer places on a good or service – such as a trip between two locations – is taken as their willingness to pay (WTP), and is assumed to match the (gross) utility or wellbeing they derive from the good or service. The value of a consumer’s net benefit – the *consumer surplus* – is their WTP less the price paid. In this framework, the relevant economic value is the change in consumer surplus, plus or minus any externalities.

The other resources applied to enable consumer benefits from the road network are the capital and operating expenditure required to provide, maintain and renew the infrastructure. The decision to invest in an infrastructure project typically requires positive net economic benefits, so, at least at the time of investment, the incremental wellbeing or value to society of the extra infrastructure is expected to exceed the resource costs. This is an important point: the economic value of a road derives from its use[25], not necessarily its cost; and at the time of investment most roads are valued above their costs.

It would be relatively simple to undertake an assessment of economic value for divestment of an isolated or redundant road section. The decremental approach would test whether removing a road section (or some road width) reduces benefits more than the increased value of the land and any pavement that is released. Such a valuation exercise is likely to show that the pavement itself has a low or negative value, and the land is likely to have value similar to adjacent properties.

However, there are two major challenges to applying this approach to large sections of the network, to the whole network or even to some small parts of the network.

[25] Taking this further, road users value the service provided by the road and not necessarily its engineering characteristics (Hartmann & Ling, 2016)

First, there is the change in opportunity cost that occurs once resources are committed to an irreversible investment. Consider removing a redundant bridge on the road network. There is likely to be no opportunity, or only a low value opportunity, to use the bridge or the bridge components for anything else. Before investing in the bridge, its incremental value to society would have been estimated as the additional benefits of the service provided by the bridge less the resource costs to build and maintain the bridge; after investing, the incremental value of the bridge is primarily the additional road user benefits it provides. This highlights that context can make a difference to an economic valuation.

A second challenge comes when extending the decremental approach to larger parts of the network and arises from interdependency, or network effects. The decremental value of, say, all roads in a suburb depends on what other roads exist. This interdependence within the network can lead to large inconsistences in road values unless the decrement was taken to its extreme: what is the loss of value/benefits if all roads were removed? The counterfactual New Zealand without a road network would be so different that it would be extremely challenging to quantity the loss of benefits, or in other words, the lost value to society that is currently provided by the road network.

These two challenges imply that pursuing an economic value approach to the whole local road network is challenging and unlikely to produce a value that is easily defendable, given the many judgements and assumptions that would be required within the analysis. However, the economic value of the road network is significant, and likely to exceed the largely cost-based methods discussed below.

Market value

For many goods and services there is a market that determines their price. The price revealed provides an important but potentially partial measure of the value currently placed on an item or service. For example, the market value of an incremental unit of petrol or concrete is typically taken as its price in the marketplace, often benchmarked for practical purposes to a standard delivery time, delivery place and product quality. The price can also include indirect taxes and excise duties, which represent transfer payments between people.

The major appeal of market value for valuation it that it provides an objective measure of the cost of resources being applied that is either matched or exceeded by its use value, although it does not measure externalities. The market value of the resources is the price less such transfer payments, but this market value may still not fully capture the external impacts to society of the good or service. These external effects are not traded but can be estimated using non-market methods, such as stated or revealed preference techniques. The total economic value to society of petrol use is the sum of market and non-market valuations.

In the context of valuation of the road network, market values exist for most road components (but the not road in its entirety).

Estimating a market asset value

Products and assets are not always traded in markets. While there have been many methods applied to estimate a market value, this is not necessarily straightforward: the value of assets derives from future expectations, which invariably involves uncertainty and interdependencies; and there are multiple factors influencing value. Even where asset markets do exist, they can often be illiquid and hence the price may not be representative of expectations.

It should not be surprising then to learn that enterprise valuation, as an example of an asset valuation, is imprecise and often relies on triangulation of several methods (Holmes et al., 2003). These methods include: analysis of comparable enterprise sales; rule of thumbs which estimate the value of an enterprise as a multiple of profits, cashflows, sales, number of customers; and analysis of expected earnings using models such as the discounted cashflow (DCF) model.

For this project, it is worthwhile considering some of the issues involved with the DCF model. This approach estimates the current value of an asset from the future cashflows generated by the asset. For example, the price of an office block will be heavily influenced by the expected future rental stream, net of costs, to be derived from the building. However, in practice, there are many other factors that will also influence asset prices, including market factors such as interest rates, credit conditions, asset price expectations, market liquidity and in some cases, given the non-homogeneous nature of some properties, can be influenced by the preferences of only a few individuals. Partial calibration of the DCF approach is possible where markets exist by use of different discount rates. There are also entity specific factors such as real options, which are more difficult to represent within a DCF approach[26].

The lack of a road asset market creates a challenge for the valuation of roads. There are no markets in which roads are traded, and hence no market price. There is also no price per se for most road use although a proxy could be developed, as discussed in the Fair Value section.

Land valuation

Land is an asset of importance to this study, and one that is generally traded in property markets.

However, these markets do not extend to land used for roads, a point returned to in the Fair Value section below. Before doing so, the many influences on property prices are noted, grouped as natural, institutional and economic factors.

The natural influences will include the physical attributes of the land that affect production or building: its slope, the fertility of the soil, the stability of the land. Then there are locational factors such as weather patterns, proximity to and views of rivers, lakes and sea and the generally negative influences of proximity to volcanic zones.

The institutional influences include establishing areas for national parks or military zones, the ownership of land by indigenous people and the zoning of property by local Councils that defines permitted activities and permitted buildings. Also of influence is the availability of insurance for a property, an issue that is compounded with natural risks.

The economic factors include the economic return from the physical attributes of the land, in turn influenced by product prices and production technologies that will change over time, and the accessibility of a location. Accessibility is generally measured in terms of the travel time or travel cost to reach attractions or opportunities, such as workplaces, shops, schools, parks or beaches (Hansen, 1959). There are also the negative influences of proximity to rubbish dumps, airports,

[26] A real options approach to road valuation would differentiate between the probable future scenarios that shape expectations of future earnings, or in this case future road use, into mainstream scenarios and those scenarios that are contingent on a future event. The value associated with contingent scenarios can be considered as the value of a real option. Examples would include having extra corridor width to enable the addition of extra lanes should demand reach capacity (an option to expand) or having alternative routes to enable other roads to be used should a road become temporarily unavailable (an option to switch). Generally, these options add resilience to the network of roads and can often mean that the value of the road network exceeds the sum of the components.

high voltage power lines and transport links such as railway lines and busy roads, with the latter also having a conflicting positive value, to be discussed below.

For completeness, it is noted that the natural, institutional and economic factors can combine to result in land previously considered an asset becoming a liability. For example, property rates and insurance risks combined with a land slippage or biohazards may lead to the annual costs of a property exceeding its benefit[27] (Ledbetter, 2023). This is different to the 'two-way road effect' referred to in CBAs (Welde & Tveter, 2022), whereby a new road may reduce the value of property in an area. Here the land under the road retains value but the road will have some negative spatial impacts.

Fair value

The concept of *fair value* has evolved in the Accounting and Valuation professions to estimate a fair exchange value for assets where a market does not exist. The Accounting standards are discussed first, then property appraisal.

A fair value is defined in the New Zealand Equivalent to International Financial Reporting Standard 13 Fair Value Measurement (NZ IFRS 13) as "the price at which an orderly transaction to sell the asset or to transfer the liability would take place between market participants at the measurement date under current market conditions" (External Reporting Board, 2018).

A distinction can be made between "fair market value" and "fair value" when shares in an asset are considered. The former allows for joint owners in an asset to have different share values, such as the shares held by the controlling shareholder being valued higher than those of minority shareholders. The fair value treats all shares as having the same value (Rodgers Reidy New Zealand, 2020). The International Valuation Standards profession use the term "equitable value" instead of "fair value" to make a similar differentiation (Property Institute, 2019). The valuation of interest to this project is the total ownership of roads, so this distinction is not pertinent.

The NZ IFRS 13 mentions several valuation techniques to be employed for the private sector:

- the market approach
- the cost approach
- or the income approach.

The NZ IFRS 13 also guides users to prefer methods that rely on observable inputs: "*When a price for an identical asset or liability is not observable, an entity measures fair value using another valuation technique that maximises the use of relevant observable inputs and minimises the use of unobservable inputs*".

The accounting standards for NZ Public Entities is more restrictive and only allows a cost approach, being either the historic cost or the replacement cost (External Reporting Board, 2023), on the basis that markets and incomes do not exist for public entities.

Market approaches were discussed in the previous section and also become relevant for estimating the replacement costs of land to be discussed below.

Looking closer at the cost approaches, replacement cost is preferred by The Treasury (The Treasury New Zealand, 2007, 2024) for state assets over historic cost. The rationale for replacement cost is that potential buyers would be prepared to pay the cost of reproducing the

[27] Although it may retain a spiritual value and an intrinsic value

asset themselves, assuming that (a) the asset could be reproduced, (b) the asset does provide the utility or service expected and (c) the asset is being put to its highest or best use (The Treasury New Zealand, 2007).

More generally, accounting standards refer to the necessity of balance between the qualitative characteristics of the information presented: on the one hand seeking "*relevance, faithful representation, understandability, timeliness, comparability, and verifiability*"; while on the other hand there is the constraint of the cost of estimation and the associated materiality. The replacement cost approach offers relevance to issues of current costs and capacity and provides comparable and consistent values across an entity, regardless of when assets were acquired, but can introduce a complexity that adds to cost estimation and which can affect representational faithfulness, timeliness, comparability and verifiability (External Reporting Board, 2016).

Potential income approach to road valuation

The DCF approach discussed earlier is an example of an income approach. In the private sector the DCF is permitted within accounting standards even if discount rates are not observable, and hence market price calibration is limited. Putting aside accounting standards, it would be possible to replicate this approach for public assets such as roads by treating, say, the Fuel Excise Duty (FED) plus the Road User Charge (RUC) as a price paid by road users and an income to the road controlling authority. This approach would require the following considerations:

- FED/RUC do not currently reflect the costs of current roads, as the charges include cost recovery for road upgrades, public transport and cycle lanes and exclude costs for current local roads that are paid through local authority rates.
- For such an analysis the proportion of rates revenue applied to the road network could be considered as a "fixed charge" to access the system
- The circularity comes from the valuation being dependent on the pricing policy adopted (Booz Allen Hamilton, 2004a), in this case hypothetically for roads; and
- An added complication is that judgement is required as to the discount rate to apply – a public sector discount rate or one of the many private sector discount rates

While an income-based approach may be considered by decision-makers in future it is not pursued further here.

Fair value in property valuation

The land component of roads also often requires a fair valuation estimation as there is no trading in the land class "roads", unlike where markets exist for properties such as residences, offices and farms.

The fair value of a property relies heavily on adjusted market values of comparable properties, as opposed to the bottom-up approach to the other road components within the replacement cost approach above.

Land valuation: Comparable sales approach

Generally, a valuer would find comparable properties which have sold recently and then adjust the comparable price derived from these sales for specific differences of the property being valued. Adjustments will vary for the class of property being valued but can include a range of factors such as access to transport links, topography and soil conditions, easements, and proximity to noise/dust/odours, to name a few factors (Blackledge, 2009).

A common approach with roads is to value the land based on adjacent property values and then adjust for specific factors. This has two challenges. It may be possible to sell some of the road width and that land be used in a similar fashion to adjacent properties, in which case the adjacent properties provide a fair representation of the value of the road land being sold, subject to other adjustments for size, topography etc. However, in many cases the road affects the value of adjacent land, so selling the land under the road – the what-if scenario implicit in the valuation – changes the value of the adjacent properties and a direct comparison with existing property values does not provide a fair value of the land under the road. This road-to-local area effect can be due to proximity and due to accessibility.

Proximity provides positive effects on local property prices, such as the road providing direct vehicle access to the property or connecting potential customers to businesses. There are also negative effects such as the disbenefit of being very close to busy roads (Seo et al., 2019). This road effect on nearby prices produces a proximity bias for the calculation of road land prices which can be reduced by using a wider pool of properties for comparison or by estimating an adjustment factor. There are practical difficulties with both approaches: individual situations can vary significantly so customising price adjustment can be complex; while location comparability may be compromised with a wider pool of properties.

The accessibility effect can occur over a wider range. A large body of literature now exists globally and locally in New Zealand[28] that seeks to quantify the effect of accessibility on land prices, typically applying hedonic pricing methods that regress land prices or change in land prices against measures of accessibility. In general, land prices will increase with higher accessibility, which is typically highest near a city centre where the density and value of activity is high.

The interdependency between land prices and transport creates an attribution challenge when estimating the opportunity cost of roads. Without roads, land prices tend to be highest near the centre of the city. Adding radial roads to a city, as has been a widespread practice, tends to dampen the difference between fringe and central city land prices. People still value the access that a central city location offers but are willing to trade off extra travel for a lower city-fringe house price whilst maintaining a similar level of accessibility. As an example, the transport links of significance for an office block can include roads (or train stations) near the office block and roads that are distant to the office block (e.g., a new tunnel 5-20 kilometres away).

It is possible to apply other land valuation methods in specific cases but the methods presented below are not suited to the valuation of a whole roading network.

Land valuation: Income multiple/DCF approach

The income approach to property valuation applies when a property will earn an annual income. Various ratios between expected annual income net of expenses have been applied for different property types or a present value can be calculated after estimating the future cashflows.

As discussed previously, an income is not available for most roads (not being tolled) and there are no known examples of the use of multipliers such as, say, a value-to-AADT[29] ratio, so this approach is treated as academic only for this report.

[28] (Abley & Halden, 2013; Auckland Transport, 2016; Grimes & Liang, 2008; Stroombergen et al., 2021; Torshizian et al., unpublished)
[29] AADT: average annual daily traffic

Residual cost approach

The residual cost approach takes the value of the land to be the sum left over after valuing the redeveloped site and deducting all other development costs. These costs will include clearing the site for the new development, such as the removal of road pavement and accompanying structures. The residual cost is likely to be the price realised should a road controlling authority sell a section of the road network but differs to the fair market value concept considered appropriate for the valuation of the whole network.

Replacement cost

The replacement cost approach considers the cost to buy and form a new and similar road, including the costs of preparing the new site for road formation, such as removal of current structures. This approach acknowledges that a greenfield site may not be possible, and costs would be involved in clearing the alternative site. The replacement cost is likely to be the cost if a section of the network were to be reconstructed in a new location but, as above, differs to the fair market value concept considered appropriate for the valuation of the whole network.

Summary of Fair Value

In abstract terms, the fair market value can be thought of as the price that an investor would pay for the entire NZ road network. The purchase would be on an ‘as is’ basis and would then be operated for the financial gain of the investor. The investor would price the network with the conception in mind that a similar road network (with similar expected returns) could be built elsewhere at a similar price. That is, a similar network could be built from scratch but to the same condition in, say, another country that was similar to NZ except did not have a road network. It is the cost of this competing investment that determines the fair market value of the NZ road network.

Clearly this is abstract as an alternative road investment opportunity does not exist but, nonetheless, the value provided is consistent with other revealed market values of assets. However, this abstract value does not represent the total use value of the network, nor the opportunity cost of resources currently applied to the network. The adjustments required to the fair market value to derive values that align with different decisions are discussed below.

Historic value

Taking the value of an asset to be the historic price paid for the asset has the advantage of being objective. However, this is not always the case. Land that has been held by public entities for a long time will often not have a purchase price recorded, either because there was no purchase or transfer price or because the information has not been retained.

The major difficulty with the historic price is it does not focus on the current prices of resources, nor the price people are willing to pay for the service provided.

Summary of valuation perspectives

Table B-1 groups and summarises the valuation perspectives discussed above.

Table B-1 Summary of valuation perspectives

Measure	Comment
Intrinsic value	• Typically considered intangible • Typically treated outside of valuation in decision-making • Can be relevant for indigenous land
Economic (instrumental) value	• Used in cost-benefit analysis • Based on opportunity cost and willingness to pay • Includes (difficult) non-market valuation • Excludes intangible values above
Current market value	• Readily observed, but only for traded goods • Not observed for roads or land under roads • Excludes non-market values (e.g., roads) and intangibles above
Fair market value	• The Accounting Standard used by NZTA and Councils • Provides an estimate of current market value • Does not capture all non-market values and excludes intangibles • Can require sophisticated estimation • Mixed application for roads
Historic (market) value	• Generally accurate at the time, though quickly becomes irrelevant • Excludes non-market values and intangibles

Adjusting valuation to align with purpose

Previous sections have discussed various measures of value, and that the value measurement required will differ with the decision to be made. The likely adjustments required to the fair value to derive the value of relevance to specific questions are shown in Table B-2[30].

Table B-2 Adjustment required to fair value for selected questions

If asking:	Adjustment required to fair value	New value above/below fair value
Value that New Zealanders place on the road network	Consider roads removed, leading to substantial loss of GDP and decline in property values.	Total is unknown but will be substantially above fair value.
Recovery amount from sale of a road section	Deduct road clearance costs and buyback of any easement Plus/minus contextual issues	Likely below
Cost to rebuild whole network	Plus costs to clear brownfields sites	Above
Cost to expand network	Contextual but likely to exclude large sunk costs in existing network	Likely below average 'fair value' for similar section
Value of network expansion	Not measured by fair value but rather by user and non-users benefits net of costs	Likely above (given BCR>1 investment threshold)

[30] A more detailed discussion of the issues below can be found in Booz Allen Hamilton (2005a)

If asking:	Adjustment required to fair value	New value above/below fair value
Capital charge to apply	Apply required return to fair value less value of indefinite assets	Below
Opportunity cost of the network	Deduct value of non-recoverable assets Add cost of resource recovery	Ambiguous

As can be seen from the table, the fair value is often not the asset value required to address significant questions and inform important decisions. Nonetheless, the fair value is a useful concept derived from a generally accepted practice, and hence provides a reasonable and transparent starting point from which to estimate purpose-specific valuations.

Appendix C. Data Review

Dataset	Licensed by	Description of contents	Accuracy of data	Consistency	Completeness	Limitations	Access/ Availability	Frequency of Updates
LINZ DVR (including restricted content)	LINZ[31]	We use district valuation roll (DVR) data from territorial authorities (TAs) to create properties datasets and associated data tables (including a national DVR dataset) which are available to local and central government agencies via the LINZ Data Service (LDS). More information in the data dictionary[32]	Each TA is likely to capture their valuation data differently. For instance, unit titles (e.g. apartments) may be captured as the whole parcel, small polygons next to each other, or small polygons on top of each other, but it is expected to fall on underlying parcel	While there will not be consistency at in this capture, for our purposes where we are assigning valuations to a higher-level unit, the data is expected to be consistent	As a national dataset form authoritative suppliers, it is expected that the level of completeness is high	There is anecdotal evidence that valuations applied to crown-based land holding (parks, roads, etc) is below surround areas land value	Valuation data is restricted to Government-related organisations	Weekly

31 https://data.linz.govt.nz/license/linz-agreement-national-dvr-data/
32 https://data.linz.govt.nz/layer/113968-nz-properties-unit-of-property/attachments/22999/

Dataset	Licensed by	Description of contents	Accuracy of data	Consistency	Completeness	Limitations	Access/ Availability	Frequency of Updates
LINZ Landonline datasets (including restricted datasets)	LINZ[33]	The Landonline Survey and Title dataset is the legal recording of NZ's cadastre. It consists of many relational tables. For this project there are several key tables/fields that we are examining to highlight parcels that have a roading purpose: This includes Primary Road Parcels, Strata Parcels, Title Estate purpose (the purpose of the Title) associated with local government or the Crown, Gazetted references. data dictionary located at: https://data.linz.govt.nz/document/11095-lds-full-landonline-data-dictionary-and-models/	The dataset on the whole provides a very good level of accuracy, with LINZ stating that they have a 99% match of title to parcels. Parcel positions can be variable, but on the whole is accurate. While not used, mark accuracy (and therefore parcel accuracy) can be obtained by confirming if it is survey-accurate (SDC_STATUS)	Textual data is likely to be very accurate (based on what has been provided to LINZ), however there is no consistency in the names that can be supplied, or a requirement to update historical data to reflect new names of organisations. For instance, owners such as "Her Majesty the Queen" (now deceased) are found in the dataset, and the display of that has many variations (e.g. HMQ, etc). Similar examples for local government occur. As an example, Riccarton Borough Council (which formed part of Christchurch City Council in 1989).	The data comes from historical records initially captured in the early 2000s, and subsequentially captured in a digital system. Records post 2000 (and specifically 2007 when all data was required to be captured digitally) have high integrity	There are still known issues with the data, where title to parcel links may be incorrect, or where Gazettes have been applied to an entire parcel when only a partial parcel has been taken.	Most data is freely available, with details such as owners requiring an agreement to consume personal data	Weekly

33 https://data.linz.govt.nz/license/linz-licence-for-personal-data-23/

Dataset	Licensed by	Description of contents	Accuracy of data	Consistency	Completeness	Limitations	Access/ Availability	Frequency of Updates
LINZ Roading Data	LINZ	LINZ Road data replaced the Landonline Electoral Roading dataset and is detailed here. https://data.linz.govt.nz/document/12628-nz-roads-data-dictionary/ It is designed to improve the system for managing road data, and contains a wide range of associations, such as road type which is meant to show if a road is formed. However, unlike the previous electoral dataset it does not have any information where roads are formed/unformed. Therefore, it provides a good reference of all roads (private/public/paper) but does not provide good definitions of each	Roads are shown as a single polyline in the general location of the underlying road	The data appears to be consistent across NZ	The whole of NZ is captured	Available details in the dataset may not distinguish between paper, private and public roads.	Free	Weekly
NZTA CoreLogic Ramm Dataset	NZTA (NZTA approval for specific projects)	Dataset created by CoreLogic for NZTA that creates an association between TA RAMM data and CoreLogic centreline. Dataset provides a quick way to see all RAMM carriageways for all TAs	RAMM data capture varies between TA and often there is a delay to when a road is formed/owned and when it gets into RAMM. This means there are often gaps and other errors in the dataset.	Lacks consistency across NZ		Licensing restrictions and may not provide additional benefits, but does provide backup in certain circumstances	Restricted	Monthly

Dataset	Licensed by	Description of contents	Accuracy of data	Consistency	Completeness	Limitations	Access/ Availability	Frequency of Updates
RAMM/ AMDS	Individual council	RAMM and AMDS are stored in ThinkProjects RAMM. They are designed to capture roading assets in a flexible table structure, with the ability to add additional tables and fields. This means that the structure of RAMM data can be quite specific to each council when looking at assets in detail. AMDS (Asset Management Data Standard) is a modern standard that informs activity management divisions and aims to bring a higher level of consistency and accuracy to the data.	RAMM is the predecessor to AMDS and RCAs are actively moving to AMDS over the next few years (through to end of 2027).	Lacks consistency across NZ	Data is specific for each RCA, and each of their capture processes will differ. There is sometime a delay in the inclusion of data into these datasets. As an example, Christchurch City Council RAMM dataset did not contain certain roads related to changes in the State Highway for around 2 years after they opened.	Will vary between RCAs	Need individual permission from each RCA to gain access to their data	Unknown
State Highway Unit Cost Rates	NZTA	Unit cost rates for state highway infrastructure, developed by BondCM for NZTA valuation of the state highway network. Includes formation, surfacing, drainage, minor structures, signs, standard bridges and retaining walls.	Regularly adjusted from price indices or re-estimated from industry research.	Represents a broad national average, regional adjustment may be required where cost systematically differ.	Covers roading assets representing the bulk of non-land asset values.	Potential licensing restrictions.	Proprietary	Typically annual. Some minor updates based on NZTA price indices.

Dataset	Licensed by	Description of contents	Accuracy of data	Consistency	Completeness	Limitations	Access/ Availability	Frequency of Updates
OSM	OSM (ODbL 1.0[34])	Worldwide capture of different elements like cycleways. OSM often provides what is visible or formed, rather than what is legally defined.	User captured.	As the data is often "crowd-sourced", coding of assets can vary significantly. So, while the location accuracy and general asset capture correct, there can be a significant variation is specific attribute capture. It is also unknown how much data is "missed" as there is no requirement for all attributes or extents to be captured	Hard to verify without a separate dataset. In New Zealand the capture appears to be relatively comprehensive for basic roading assets	No QA process is undertaken before the data is released	Free	Near-real time from capture
NZTA Corridor Land Parcels	NZTA	The data that NZTA has created to show their own Roading parcels (not held land). Includes splitting of cadastre parcels where they believe they do not own the full parcel	While the dataset says it contains Primary Road Parcels, it appears to hold Primary Road Parcels and some Primary Land Parcels that have a roading purpose. But there are a significant number of parcels that have a roading purpose (i.e. that fall on a State Highway) that are not included. There also does not appear to be the inclusion of Strata parcels on the State Highway		Is not a full dataset of State Highway parcels (owned by NZTA),but may still be meeting what NZTA wanted from the dataset.		Unknown - Provided by NZTA	Yearly

34 https://opendatacommons.org/licenses/odbl

Appendix D. Multi-Criteria Analysis

Valuation criteria

This project is (at least in part) a response to previously inconsistent reporting of local road values by TAs. Hence, a major objective – and criterion – is to find valuation approaches that provide consistent results at one point in time and that can be consistently applied over time.

More generally, the valuation approach should meet the following criteria:

- **Consistency** – does the valuation method align with the study objectives, including consistency and future applicability?
- **Robustness** – is the method robust to missing or uncertain data inputs?
- **Reliability** – is the method likely to accurately value the local road network?
- **Transparency** – is the method transparent, readily understood and not overly complex?
- **Repeatability** – is the method straightforward to replicate and repeat?
- **Data availability** – does the method use recent and/or frequently updated data?
- **Flexibility** – can the method be applied to varied geographic areas and rural/urban contexts, in terms of either process or data requirements?

These seven attributes form the criteria for the subsequent MCA as described in the following sections.

Shortlisting process

Based on the review of existing valuation processes and relevant literature, high-level valuation methodology options were identified for potential valuation of the entire local road network. The options are intended to cover a representative range of current and historical valuation approaches, with additional options including different levels of valuation detail.

In the shortlisting process, engagement with case study candidates was at an early stage and first-hand examination of TA asset datasets had not been carried out. As such, the detail of each methodology is at a high-level only and will be expanded upon later for the preferred approach.

Fatal flaws

Table D-1 lists the fatal flaws used to exclude valuation methods from the short list. These include models that do not use readily available data, are overly complex or opaque, or do not arrive at a cost-based fair value valuation.

Given the objectives of this research, options not likely to arrive at a cost-based, fair value approach were considered fatally flawed, such as valuation based on benefit streams (economic valuation, or historic cost approaches.

Table D-1 Fatal flaws

Fatal flaw	Discussion
Reliance on restricted data	Methods using data that is proprietary, restricted or otherwise unavailable are not suitable for replication or validation
Black-box valuation model	A valuation model that is not transparent or is overly complex is not amenable to replication across locations and is harder to validate.

Fatal flaw	Discussion
Valuation based on benefit stream	This research seeks to understand costs of the road system, rather than to measure the benefits it provides. As such, valuation methods based on economic benefit streams are excluded.
Non-fair value approaches	As presented in Chapter 2, a valuation approach that estimates fair value is recommended for this research. Methods that do not estimate Fair Value are excluded.
Historic cost approaches	Valuation approaches relying on historic cost alone are excluded as they are unlikely to accurately represent Fair Value of land and road assets.

Valuation methodology options

The shortlisted valuation methodology options are shown in Table D-2. These options include both a "do minimum", which relies on TA valuations as per prior DTCC research (Option 1), and a method which attempts to apply the current NZTA state highway valuation process to the local road network (Option 4). The remaining options (2 and 3) apply approximations to estimate the value of non-land roading assets that are deemed to have outlier TA valuations, using either top-down or bottom-up estimates.

Additionally, two variants are included for options which use over-the-fence land valuation (Options 2, 3 and 4) relating to the scale of comparison area for land valuation. These variants are described in Table D-3.

The options and variants are discussed further in the following sections.

Table D-2 Shortlisted valuation options

Valuation Option	Description
1. TA valuations (do minimum)	TA-reported land and roading asset values are summed to estimate a network total land and asset value. Minor interpolation of missing values may be required where TA data is not available. This method is used in DTCC Working Paper C2 – Valuation of the Road Network (Richard Paling Consulting & Ian Wallis Associates Ltd, 2023).
2. Top-down outliers	TA valuations for non-land assets are combined with over-the-fence land valuation. Non-land TA valuations that appear to be outliers are revalued using top-down methods – where the road asset value is based on average per-kilometre values for comparable road types or areas, or similar.
3. Bottom-up outliers	Option 2 uses the same outlier filtering approach as in Option 1 but non-land valuations that are outliers are revalued using bottom-up estimates – based on unit cost rates and detailed asset information for a representative sample of similar local roads
4. Bottom-up all	Non-land assets are independently estimated based on detailed asset data, unit cost rates, and adjustments for asset lifespan and condition. Land is estimated using an over-the-fence approach. This is the current valuation approach used by NZTA for valuing the state highway network, using Variant A below (SA1 land valuation).

Table D-3 Option variants – land valuation

Option Variant	Description
A: SA1 land valuation	Average land values (from LINZ District Valuation Roll data) by Statistical Area 1 (SA1) are used a proxy for the average land value of the roads running through that SA1. This is the method used by NZTA to estimate the value of land under the state highway network.
B: SA2 land valuation	As per Variant A, but the value of road land is estimated using average land value by Statistical Area 2 (SA2). This approach will tend to capture less local variation of land values and reduce the impact of any outlier land valuations.

Identification of outlier non-land valuations

Options 2 and 3 rely on identifying TA valuations of non-land assets that appear to be outliers. If individual asset valuations are available, it is anticipated that regression analysis could inform outlier identification, through regression of individual asset valuations on variables such as length, width, road/seal type, and urban or rural location. Alternatively, outliers may be identified at the aggregate valuation level (total non-land asset value per TA), by asset class and/or by road type (for example, seal costs or urban road assets) if the valuation data with appropriate granularity is available. In general, operating at higher levels of aggregation is preferred, as it will make the method more readily applicable to other TAs without detailed valuation data available.

Top-down valuation of non-land assets

Option 2 uses a top-down approach to value non-land assets that have TA valuations considered to be outliers. This is likely to involve comparison with other asset types within the case studies and, if required, with stereotypical asset groupings from other TAs known to have strong asset management systems. The outliers will be replaced with average values for the stereotypical asset groupings. The groupings are yet to be determined and will be informed by initial case study analysis. Data will largely be drawn from accounting databases that record the value of the assets within the TA.

Bottom-up valuation of non-land assets

Options 3 and 4 require bottom-up estimation of road component values. The definition of components will depend on the breakdown of asset data available and will be determined within the case study phase. Data will largely be drawn from the asset management databases that record the nature and quantity of each asset.

Land valuation scale and endogeneity

The two land valuation scales represent a trade-off between the variability of the land value estimate and its responsiveness to local variation in land prices. SA2-level averages will smooth spatial variation in land values to a greater degree, while SA1 averages will reflect fine-grained differences in land value by location.

The validity of the over-the-fence valuation of road corridors relies on the similarity of nearby land parcels to the corridor parcels being valued. Ideally comparison parcels would be located as close as possible to the corridor to reflect locational effects on land values. However, the value of parcels in close proximity to a road may be directly affected by the presence of the road, either positively or negatively, as discussed in Section 2.

In the context of this valuation exercise, it is not clear whether, or to what extent, these endogenous effects (both positive and negative) of the road on nearby land values should influence an over-the-fence valuation. The two land valuation methods (Variants A and B) allow testing the sensitivity of valuation outcomes to changes in the scale of land value comparisons.

Preferred model selection and discussion

A Multi-Criteria Analysis (MCA) process was used to inform selection of preferred valuation method(s) from the shortlisted options.

At the MCA stage, insufficient dataset detail was available to fully explore the implications of each valuation methodology option. The MCA therefore reflects a preliminary ranking of options, with the preferred option(s) refined further as the case studies progressed and familiarity was gained with the TA datasets.

Multi-criteria analysis (MCA)

Table D-4 lists the criteria used in in the MCA, developed from the criteria presented above. Each shortlisted option is assigned a score depending on the level to which the option is anticipated to meet each criterion, from one (least likely to meet) to five (most likely to meet). Weightings were determined in consultation with the Project Steering Group.

Table D-4 MCA criteria and weighting

Criteria	Description	Weighting
Consistency	Does the valuation method align with the study objectives, including consistency?	6.6%
Robustness	Is the method robust to missing or uncertain data inputs?	6.6%
Reliability	Is the method likely to accurately value the local road network?	6.6%
Transparency	Is the method transparent and readily understood?	20%
Repeatability	Is the method straightforward to replicate and repeat?	20%
Data availability	Does the method use recent and frequently updated data?	20%
Flexibility	Can the method be applied to varied geographic contexts, in terms of process and data requirement?	10%

Table D-5 summarises the results of the MCA process. Option 2 (Top-down outliers) is narrowly preferred over Option 3 (Bottom-up outliers) as a result of this analysis, while Options 1 and 4 are ranked lowest. There are only minor differences in the scoring of land valuation variants. The full MCA table is shown in Table D-6.

Table D-5 MCA option rankings

Rank	Alternative	Score	Remarks
1	Option 2: Top-down outliers	4.2	Preferred due to balance of accuracy and complexity. Minor differences between top-down and bottom-up approaches
2	Option 3: Bottom-up outliers	3.8	
3	Option 4: Bottom-up all (NZTA)	3.1	Penalised due to complexity and reliance on detailed asset data
4	Option 1: TA valuations (Do Min)	2.9	Penalised due to lack of accurate valuations from TAs
1	Variant A: SA1 land valuation	4.6	Minor differences between land valuation variants for Options 2-4
2	Variant B: SA2 land valuation	4.4	

MCA summary

The MCA is not considered to be conclusive at this stage. The provisional recommendation based on this MCA process is that a Options 2 and 3 will be applied in the case studies.

The incremental effort of applying both Variants A and B for land valuation is not expected to be large (relative to applying a single variant), and as such both these variants are expected to be explored as part of sensitivity testing during case study valuations.

Table D-6 MCA results

Option / Variant	Transparency	Robustness	Repeatability	Reliability	Data availability	Flexibility	Consistency	Score	Rank
Weights	0.20	0.07	0.07	0.07	0.20	0.20	0.20		
Option 1: Do Min (Paling)	A simple collation exercise that is readily repeatable	Directly impacted by variable TA valuations	A simple collation exercise that is readily repeatable	Land values known to be wrong	Land valuations typically not up to date	Can be applied to all areas	Unlikely to meet consistency requirements	2.9	4
Option 2: Top-down outliers	Requires identification and replacement of outliers	Broad averaging of non-land values improves robustness	Readily repeatable, outlier adjustment may vary	Requires some averaging to derive values for outliers	TA non-land valuation updates variable across TA	Somewhat sensitive to TA variation in valuations	Consistent land valuation, non-land adjusted to improve consistency	4.2	1
Option 3: Bottom-up outliers	Requires identification and replacement of outliers	Requires subset of detailed asset data	Readily repeatable, some sensitivity to TA asset data	Requires extrapolation to derive outlier values	TA non-land valuation and asset data updates variable across TA	Affected by TA variation in asset data recording	Consistent land valuation, non-land adjusted to improve consistency	3.8	2
Option 4: Bottom-up all (NZTA)	Requires extensive data collection and processing	Directly impacted by asset data limitations	Extensive processing required, sensitive to changes in asset data	Expected good accuracy for non-land assets	Asset data updates variable across TAs	Most affected by TA variation in asset data recording	Aligns closely to NZTA	3.1	3
Variant A: SA1 land valuation	Some processing required but conceptually straightforward	Spatial average improves robustness	Largely automatable land valuation	Land values expected to be broadly accurate - SA1 level will capture local variation	Valuation roll receives regular updates	Can be applied to all areas	Aligns closely to NZTA method	4.6	1
Variant B: SA2 land valuation	Some processing required but conceptually straightforward	Wider spatial average improves robustness	Largely automatable land valuation	Land values expected to be broadly accurate - SA2 level will smooth local variation	Valuation roll receives regular updates	Can be applied to all areas	Variation to NZTA method	4.4	2

Score key	1	2	3	4	5

Appendix E. TA and NZTA Valuation Asset Scope

Asset	Included in network valuation				In Scope
	UHCC	WCC	CCC	NZTA	
Formation / base / subbase / surface	✓	✓	✓	✓	✓
Kerb and channel	✓	✓	✓	✓	✓
Lights/signals/poles	✓	✓	✓	✓	✓
Tunnels (Road and Ped.)	✓	✓	N/A	✓	✓
Bridges	✓	✓	✓	✓	✓
Stormwater / Drainage	✓ AMDS Chamber / Pipe / Culvert Pipe	✓ Sumps and leads (valued by Three Waters team)	✓ Sumps/catchpits (RAMM) + leads (non-RAMM)	✓	✓ - unlikely to be a precise estimate given data limitations
Berm	✓	No	✓	✓ Part of traffic facilities	No – not consistently valued by TAs. Land under berms (if in road reserve) to be included
Retaining walls (incl. sea walls)	✓	✓	✓	✓	✓
Pathways	✓	✓ Includes some off-street cycleway sections	✓ Includes some off-street cycleway sections	✓	✓ - with exclusions for off-street paths
Access paths (off-street walkways)	Some included in pathways	✓	Some included in pathways	Unclear, likely N/A	No – off-road path
Accessway retaining walls		✓	No	Unclear, likely N/A	No – generally related to off-road paths
Off-street carpark	✓	Negligible	No	N/A	No
Notes	No road tunnels in network	No itemised stormwater data available	No road tunnels in network Pathways include off-street cycleways. Pathways use both RAMM and non-RAMM data sources used		

Appendix F. Road Type Classification

Road type	Reported hierarchy included in road type				
	UHCC	WCC	CCC	One Network Framework (ONF)	One Network Road Classification (ONRC)
Arterial	All Arterial	All Arterial, or Principal	All Minor Arterial / Major Arterial		Any: High Volume, Regional, Arterial
Urban collector	Urban: Collector, Distributor	Urban: CBD Golden Mile, Collector, Sub-Collector, Suburb Shopping	Urban: Collector		Urban: Primary Collector, Secondary Collector
Urban local	Urban: Local, all others	Urban: CBD Business, CBD Shopping, Local, Residential, Service Lane, all others	Urban: Local, Service lane, Mall, all others		Urban: Access, Low Volume, all others
Unsealed	N/A	N/A	Any: Unsealed		All unsealed
Rural other	Rural: all others	Rural: all others	Rural: all others		Rural: all others less unsealed
Notes:				Current national network categorisation available for all identified road land parcels. Seal information not available. Difficult to distinguish	Used only for approximate mapping from case studies to nationwide network based on Transport Insights ONRC data.

Appendix G. Implied Unit Rates

An exercise was undertaken to identify implied unit ORC averages in any case study area that was markedly different from its peers, as measured against the other case study areas. This prompted either closer examination and/or re-estimation of the apparent inconsistency or a what-if analysis to test the sensitivity of total road valuation to the apparent inconsistency.

The first step undertaken was to collate the data within each TA by road type and asset component. All values were converted to 2024 dollars. The next step was to calculate unit averages by road type and asset component. The averages were applied either per-sqm (road area) or per-m (road length) for a combination of road asset components by road type types, i.e., potentially 48 cells (averages) per TA for the 12 asset components by four road types. The four road construction components were assumed to have a per-sqm unit cost while all other components were more directly related to road length, with asset components of an urban nature valued against urban road length only. The averages varied by asset component, being either based on per-sqm of sealed roads (within TA of the road type), per-m of roads or per-m of urban roads (see table below for denominator for each asset component).

The rule applied to test for an inconsistent unit rate was whether the value was outside the interval of 1.65 standard deviations either side of the mean of the unit rates across the other four case study areas (90% two-tailed confidence interval).

Results

An example of the initial crosstabulation is shown for Wellington City below. The average basecourse ORC was $17.5 per sqm of arterial roads, the average kerb and channel ORC was $420.6 per meter of urban roads within the ‘urban local’ road type and the average ORC for bridges was $45.4 per metre of all roads of the ‘rural other’ type. Stormwater values were not available in WCC by road type and no arterial or ‘rural other’ road passed through a tunnel.

Asset components that are not evenly distributed across the network will show widely different average values when calculated in this manner. An average across all road types (Sub-total) will better describe the average case study area cost in these situations. It was also of interest to calculate the average cost for the combined subbase, basecourse and surface components as this aggregated average showed less variation across case study areas, hinting at differences in definitions of each component.

Table G-1 Average implied unit ORC for Wellington City (2024$), by road type and asset component

	Arterial	Rural other	Urban collector	Urban local	Subtotal	Denominator
Basecourse	$17.5	$15.2	$16.1	$14.5	$15.2	all-sqm
Formation	$89.0	$76.5	$82.1	$81.1	$81.4	all-sqm
Kerb and channel	$345.6	$170.2	$433.0	$420.6	$424.0	urban-m
Lights/signals/poles	$245.4	$10.2	$147.9	$70.2	$100.5	urban-m
Other	$205.4	$40.3	$86.5	$56.6	$69.4	urban-m
Pathway	$396.4	$21.1	$429.4	$330.9	$367.2	urban-m
Subbase	$21.4	$8.3	$11.2	$8.3	$9.7	all-sqm

Surface	$41.3	$18.3	$39.5	$31.2	$33.9	all-sqm
Bridge	$1,673.7	$45.4	$87.8	$16.2	$62.8	all-m
Retaining	$144.1	$318.2	$738.9	$226.4	$402.0	all-m
Stormwater	N/A	N/A	N/A	N/A	$359.8	all-m
Tunnels	N/A	N/A	$183.5	$65.0	$97.8	all-m
Base+Sub+Surface	$80.3	$41.9	$66.9	$53.9	$58.8	all-sqm

A table for each asset component follows, showing the implied unit rate for each road type by case study area, plus the average, standard deviation and coefficient of variation (CV) across the study areas.

For example, the average WCC value mentioned above ($17.5/sqm) shows in the cell for the WCC arterial as $18/sqm. The (unweighted) average of the five basecourse values for arterial roads is $32, the standard deviation is $18, which is 57% of the average.

The tables generally show that there is high variation between the average ORC for each asset component across the five case study areas.

Table G-2 Average implied unit ORC by road type and case study area for basecourse

ORC $2024 per sqm	Banks Peninsula	WCC	Newtown	Upper Hutt	Totara Park	Average	St Dev	CV
Arterial	$55	$18	$17	$36	N/A	$32	$18	0.57
Rural other	$52	$15	N/A	$23	N/A	$30	$20	0.65
Unsealed	$47	N/A	N/A	N/A	N/A	$47	N/A	N/A
Urban collector	$49	$16	$16	$19	$19	$24	$14	0.59
Urban local	$41	$14	$16	$24	$28	$25	$11	0.44

Table G-3 Average implied unit ORC by road type and case study area for formation

ORC $2024 per sqm	Banks Peninsula	WCC	Newtown	Upper Hutt	Totara Park	Average	St Dev	CV
Arterial	$48	$89	$42	$32	N/A	$53	$25	0.47
Rural other	$39	$76	N/A	$78	N/A	$65	$22	0.35
Unsealed	$34	N/A	N/A	N/A	N/A	$34	N/A	N/A
Urban collector	$58	$82	$40	$25	$27	$46	$24	0.52
Urban local	$56	$81	$46	$26	$26	$47	$23	0.49

Table G-4 Average implied unit ORC by road type and case study area for kerb and channel

ORC $2024 per m	Banks Peninsula	WCC	Newtown	Upper Hutt	Totara Park	Average	St Dev	CV
Arterial	$182	$346	$486	$438	N/A	$363	$134	0.37
Rural other	$84	$170	N/A	$75	N/A	$109	$53	0.48
Unsealed	$7	N/A	N/A	N/A	N/A	$7	N/A	N/A
Urban collector	$144	$433	$427	$461	$487	$390	$140	0.36
Urban local	$181	$421	$452	$427	$451	$386	$116	0.30

Appendix Table G-5 Average implied unit ORC by road type and case study area for Lights/signals/poles

ORC $2024 per m	Banks Peninsula	WCC	Newtown	Upper Hutt	Totara Park	Average	St Dev	CV
Arterial	$21	$245	$196	$138	N/A	$150	$97	0.64
Rural other	$2	$10	N/A	$10	N/A	$7	$5	0.63
Unsealed	$2	N/A	N/A	N/A	N/A	$2	N/A	N/A
Urban collector	$40	$148	$178	$91	$110	$113	$53	0.47
Urban local	$43	$70	$73	$53	$72	$62	$14	0.22

Table G-6 Average implied unit ORC by road type and case study area for ‘other’ asset components

ORC $2024 per m	Banks Peninsula	WCC	Newtown	Upper Hutt	Totara Park	Average	St Dev	CV
Arterial	$57	$205	$65	$15	N/A	$86	$83	0.97
Rural other	$6	$40	N/A	$4	N/A	$17	$20	1.22
Unsealed	$3	N/A	N/A	N/A	N/A	$3	N/A	N/A
Urban collector	$19	$87	$63	$8	$0	$35	$38	1.07
Urban local	$27	$57	$38	$13	$2	$27	$21	0.79

Table G-7 Average implied unit ORC by road type and case study area for Pathway

ORC $2024 per m	Banks Peninsula	WCC	Newtown	Upper Hutt	Totara Park	Average	St Dev	CV
Arterial	$50	$396	$733	$579	N/A	$440	$294	0.67
Rural other	$0	$21	N/A	$10	N/A	$10	$10	1.01
Unsealed	$0	N/A	N/A	N/A	N/A	$0	N/A	N/A
Urban collector	$133	$429	$665	$429	$381	$408	$189	0.46
Urban local	$83	$331	$599	$356	$372	$348	$183	0.53

Table G-8 Average implied unit ORC by road type and case study area for Subbase

ORC $2024 per sqm	Banks Peninsula	WCC	Newtown	Upper Hutt	Totara Park	Average	St Dev	CV
Arterial	$42	$21	$7	$22	N/A	$23	$14	0.63
Rural other	$28	$8	N/A	$14	N/A	$17	$10	0.61
Unsealed	$8	N/A	N/A	N/A	N/A	$8	N/A	N/A
Urban collector	$27	$11	$7	$19	$19	$17	$8	0.46
Urban local	$14	$8	$7	$11	$14	$11	$3	0.29

Table G-9 Average implied unit ORC by road type and case study area for Surface

ORC $2024 per sqm	Banks Peninsula	WCC	Newtown	Upper Hutt	Totara Park	Average	St Dev	CV
Arterial	$14	$41	$46	$53	N/A	$39	$17	0.44
Rural other	$9	$18	N/A	$12	N/A	$13	$5	0.38
Unsealed	$10	N/A	N/A	N/A	N/A	$10	N/A	N/A
Urban collector	$13	$40	$51	$19	$20	$28	$16	0.57
Urban local	$9	$31	$41	$20	$15	$23	$13	0.55

Table G-10 Average implied unit ORC by road type and case study area for Bridges

ORC $2024 per m	Banks Peninsula	WCC	Newtown	Upper Hutt	Totara Park	Average	St Dev	CV
Arterial	$76	$1,674	N/A	$1,031	N/A	$927	$804	0.87
Rural other	$175	$45	N/A	$374	N/A	$198	$166	0.84
Unsealed	$70	N/A	N/A	N/A	N/A	$70	N/A	N/A
Urban collector	$493	$88	N/A	$399	$2,466	$862	$1,084	1.26
Urban local	$132	$16	N/A	$99	N/A	$82	$60	0.73

Table G-11 Average implied unit ORC by road type and case study area for Retaining

ORC $2024 per m	Banks Peninsula	WCC	Newtown	Upper Hutt	Totara Park	Average	St Dev	CV
Arterial	$1,184	$144	$86	$72	N/A	$372	$543	1.46
Rural other	$77	$318	N/A	$122	N/A	$173	$128	0.74
Unsealed	$51	N/A	N/A	N/A	N/A	$51	N/A	N/A
Urban collector	$924	$739	$8	$64	N/A	$434	$466	1.07
Urban local	$1,235	$226	$192	$8	$4	$333	$514	1.54

Table G-12 Average implied unit ORC by road type and case study area for Stormwater

ORC $2024 per m	Banks Peninsula	WCC	Newtown	Upper Hutt	Totara Park	Average	St Dev	CV
Arterial	$69	N/A	N/A	$66	N/A	$67	$2	0.04
Rural other	$56	N/A	N/A	$57	N/A	$56	$1	0.02
Unsealed	$43	N/A	N/A	N/A	N/A	$43	N/A	N/A
Urban collector	$66	N/A	N/A	$102	$89	$85	$18	0.21
Urban local	$31	N/A	N/A	$98	$121	$83	$47	0.57

Appendix H. Regression Modelling

Purpose

An exercise was undertaken to analyse the factors determining the ORC of formation, subbase, basecourse and surface assets, at the individual road section level, and to then replace extreme sectional values with model estimates.

Note, this was possible because more data were available for road sections within RAMM for these four asset types, including importantly the categorisation of the terrain. However, this level of detail was not available for the other non-land road components and hence any outlier analysis and re-estimation of these values can only be done (given the data available to this project) at a TA level, or possibly at a suburb level.

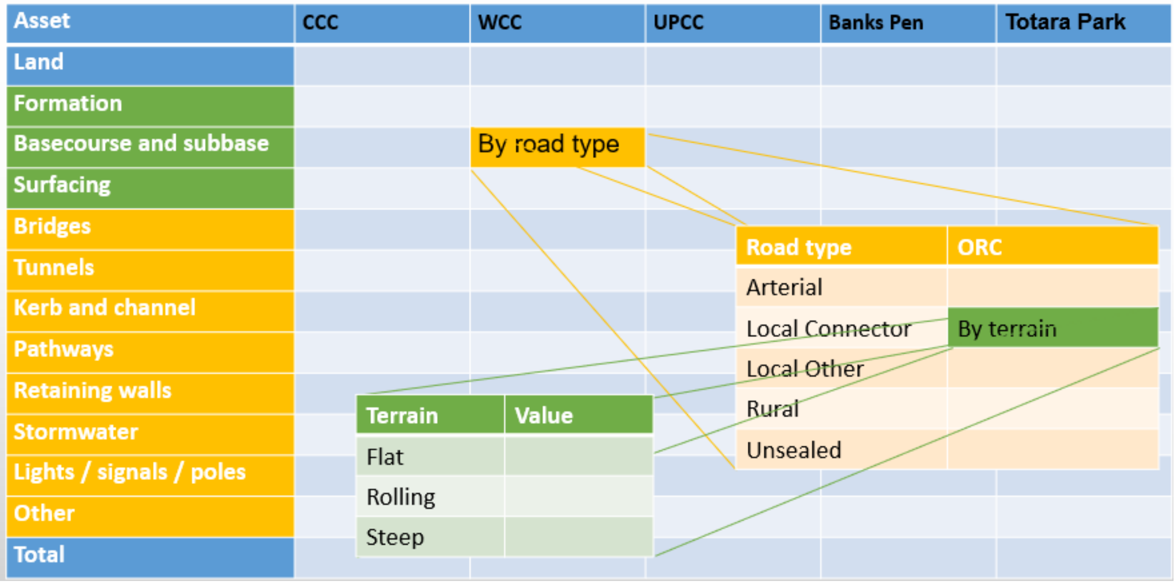

Figure H-1 Framework for estimation of road asset values

For this exercise, an outlier was taken to be an asset (for a given road section) where the reported valuation was outside the 95% prediction interval of the regression model. The re-estimation entailed replacing the reported valuation with the estimated value from the model (i.e., effectively assuming the residual should be zero).

This issue of defining an outlier is addressed further at the end of this appendix.

Data description

RAMM has a wide range of data available by road section. The following were selected as suitable for modelling, being likely relevant to valuation and being available for the majority of section records.

- ORC, denominated in dollars per section
- Depreciated value, dollars per section
- Road type (see Appendix E for classification)
- Section road length, metres
- Section average road width, metres

- Section road area, which can also be derived from the length and width fields above and hence is correlated with length and area
- Section terrain, categorised as flat, rolling or steep/mountainous
- AADT category for section, categorised as ADT > 20000, 10000-20000, 4000-10000, 2000-4000, 500-2000, 100 – 500, < 100. This variable will show some correlation with road type.

Form of model

The functional form of the regression models (one per asset component) is as follows (for road segment i):

$$ln(ORC)_i = \beta_1^p road\_type\_category_i + \beta_2^q AADT\_category_i + \beta_3^r terrain\_category_i + \beta_4 \ln(area_i) + \beta_5 \ln(width_i)$$

The model and independent variables are discussed in turn below.

TA valuations scale the value of a road section by the area of the section. Hence, the fundamental relationship between OCR and road area is multiplicative and a log model is appropriate.

However, it is also known that in some (not all) cases the unit cost in the valuation process is applied to an adjusted road area, accounting for (for example) a lower proportion of shoulder area for wider roads. This effect can be approximated by including a (logged) road width term in the regression model. The width and area terms in the current specification could be equivalently replaced with length and width terms, which would remove the correlation between width and area. However, the chosen form is preferred to highlight the largely linear relationship between area and ORC, and the economies-of-scale effect associated with road width.

It is also known that different road types will also have different unit costs. This can be incorporated into the model by applying a multiplicative factor β_1^p for each category of road type p. The exponential of the regression coefficient is the multiplicative factor.

It is also known that different unit costs are applied to road sections on different terrain. This also can be incorporated into the model as a multiplicative factor for each category of terrain (assuming one level to have a factor of 1, in this case flat land) and hence becomes a different constant β_3^r for each road terrain category r in the log regression model.

Last, it was considered possible that the road type categorisation may not fully capture the use of the road and that AADT might provide further information. The categories of AADT were also added to the model as multiplicative factors, or in log terms as further constants β_2^q for each level of AADT q (with the AADT level 100-500 assumed to have a multiplicative factor of 1).

The generic regression model for each asset component will provide an estimation of the ORC according to the formula:

$$ORC_i = \exp(\beta_1^{p_i}) \times \exp(\beta_2^{q_i}) \times \exp(\beta_3^{r_i}) \times area_i^{\beta_4} \times width_i^{\beta_5}.$$

It is expected that e and possibly d will be between 0 and 1, providing an economy-of-scale effect for larger road section areas.

For this exercise, a multiplicative dummy variable (additive in log form) was also added for the TA. This term may not be required when more TAs are included in a model. This issue will be discussed in the next section on data and again at the end of the appendix.

Data included

A RAMM data set was provided for each of the three TAs within the case studies, which were combined for the regression analyses. The total number of road sections across the three TAs was over 20,000. A road section ranges from 1m to over 6000m and averages around 150-200m in the three data sets.

In the initial comparison, the case study areas included subsets of the TAs, Totara Park within Upper Hutt and Newtown within Wellington. For the regression exercise, Totara Park and Newtown were not explicitly analysed as the focus was on the usefulness of the model rather than specific estimates for each case study area.

The following road sections were excluded from the regression analyses:

- All road sections in Upper Hutt were excluded because there was no terrain variable available.
- Road sections in Christchurch and Wellington that also did not have all explanatory variables were excluded (typically road length, road width and/or terrain missing but also some road types were “unknown”).

The number of sections in each regression was 16,779.

Results

The four regression analyses were undertaken using the Python *statsmodels* library.

A sample output is shown below for the formation regression. Note that the coefficients pertain to a log model. For categorical variables multiplicative factors are found by taking the exponential of the coefficient. Coefficients for logged continuous variables can be interpreted as an elasticity exponent of the underlying (non-logged) variable (area or width). Base categories (omitted from the model) are shown with zero coefficients.

Table H-1 Output of regression of ln(ORC) of formation

Dep. Variable:	np.log(orc)	R-squared:	0.913
Model:	OLS	Adj. R-squared:	0.913
Method:	Least Squares	F-statistic:	1.175e+04
Date:	Thu, 10 Apr 2025	Prob (F-statistic):	0.00
Time:	14:07:09	Log-Likelihood:	-5426.9
No. Observations:	16779	AIC:	1.089e+04
Df Residuals:	16763	BIC:	1.101e+04
Df Model:	15		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
road_type[Arterial]	3.7202	0.029	129.558	0.000	3.664	3.776
road_type[Rural other]	3.0137	0.027	109.815	0.000	2.960	3.068

	coef	std err	t	P>|t|	[0.025	0.975]
road_type[Unsealed]	3.3822	0.030	112.419	0.000	3.323	3.441
road_type[Urban collector]	3.8759	0.028	139.942	0.000	3.822	3.930
road_type[Urban local]	3.7404	0.026	146.304	0.000	3.690	3.791
tl_terrain[T.Flat]	0					
tl_terrain[T.Mountainous]	1.4149	0.012	122.878	0.000	1.392	1.437
tl_terrain[T.Rolling]	0.8109	0.008	103.533	0.000	0.796	0.826
tl_pavement_use[T.ADT < 100]	-0.0913	0.010	-8.912	0.000	-0.111	-0.071
tl_pavement_use[T.ADT 100-500]	0					
tl_pavement_use[T.ADT 500-2000]	-0.0094	0.007	-1.306	0.191	-0.023	0.005
tl_pavement_use[T.ADT 2000-4000]	-0.0422	0.010	-4.258	0.000	-0.062	-0.023
tl_pavement_use[T.ADT 4000-10000]	-0.0433	0.012	-3.568	0.000	-0.067	-0.020
tl_pavement_use[T.ADT 10000-20000]	0.0543	0.016	3.392	0.001	0.023	0.086
tl_pavement_use[T.ADT > 20000]	0.0452	0.029	1.561	0.119	-0.012	0.102
TA[T.CCC]	0					
TA[T.WCC]	0.2881	0.008	38.027	0.000	0.273	0.303
np.log(tl_area)	1.0072	0.003	367.348	0.000	1.002	1.013
np.log(tl_width)	-0.2851	0.010	-27.724	0.000	-0.305	-0.265

A more intuitive summary of the results is provided in the table below, by applying model predictions to an arbitrary fixed road section length and width. For example, the formation unit cost of a flat urban local road in Christchurch with an AADT of 100-500 is estimated to cost $26.5 per sqm (26.5 x 1.0 x 1.0 x 1.0), for a road section of length 100m and width 6m. Alternatively, a rolling urban road in Wellington with an AADT of 500-2000 has an estimated formation cost of $78.7 per sqm (approximately: 26.5 x 2.25 x 0.99 x 1.33).

Note, the per unit cost will differ by the size of the road section, due to the economies of scale effects. The two costs above would be $21.8 and $64.9 per sqm respectively should the 100m by 6m section be changed to 100m x 12m (not evident in the table below, requires use of coefficients in previous table).

Table H-2 Summary of ORC regression coefficients for all 4 models in antilog form

Covariate	Formation	Subbase	Basecourse	Surface
Cost per sqm*				
Arterial	$25.9	$25.5	$48.1	$19.5
Rural other	$12.8	$22.1	$48.7	$12.9
Unsealed	$18.5	$11.2	$45.4	$16.9

Covariate	Formation	Subbase	Basecourse	Surface
Urban collector	$30.3	$20.8	$44.1	$17.2
Urban local	$26.5	$13.7	$35.4	$15.5
Multiplied by below factors for terrain, AADT and TA				
Flat	1.00	1.00	1.00	1.00
Rolling	2.25	0.94	1.02	0.87
Mountainous	4.12	0.84	1.00	1.03
ADT < 100	0.91	0.83	0.91	0.89
ADT 100 - 500	1.00	1.00	1.00	1.00
ADT 500-2000	0.99	1.10	1.01	0.89
ADT 2000-4000	0.96	1.12	1.01	0.94
ADT 4000-10000	0.96	1.17	1.06	1.12
ADT 10000-20000	1.06	1.18	1.09	1.44
ADT > 20000	1.05	1.29	1.11	1.67
CCC	1.00	1.00	1.00	1.00
WCC	1.33	0.52	0.41	2.08
*** based on 100m long x 6m wide**				

Generally, the regression models had a high goodness of fit, as measured by the R^2 (and also adjusted R^2) with the Surface model having the least fit. All regressions produced residuals that were not normally distributed, as evident from Skew and Kurtosis statistics (thus weakening hypothesis testing), with the models tending to poorly explain relatively high observed values. This does raise questions as to whether the model is correctly specified, discussed further below.

Table H-3 Summary of ORC regression diagnostics for all 4 models

	Formation	Subbase	Basecourse	Surface
R2	0.913	0.89	0.89	0.589
Skew	2.001	0.029	0.404	0.493
Kurtosis	31.623	13.542	26.774	3.715

As an example of the models' residuals, boxplots of the standardised residuals are shown below for the formation regression, which was the model with the largest diversion from normally distributed residuals. These graphs show that rural roads have tended to be given a below-observed value in Wellington and show a wide variation in Christchurch.

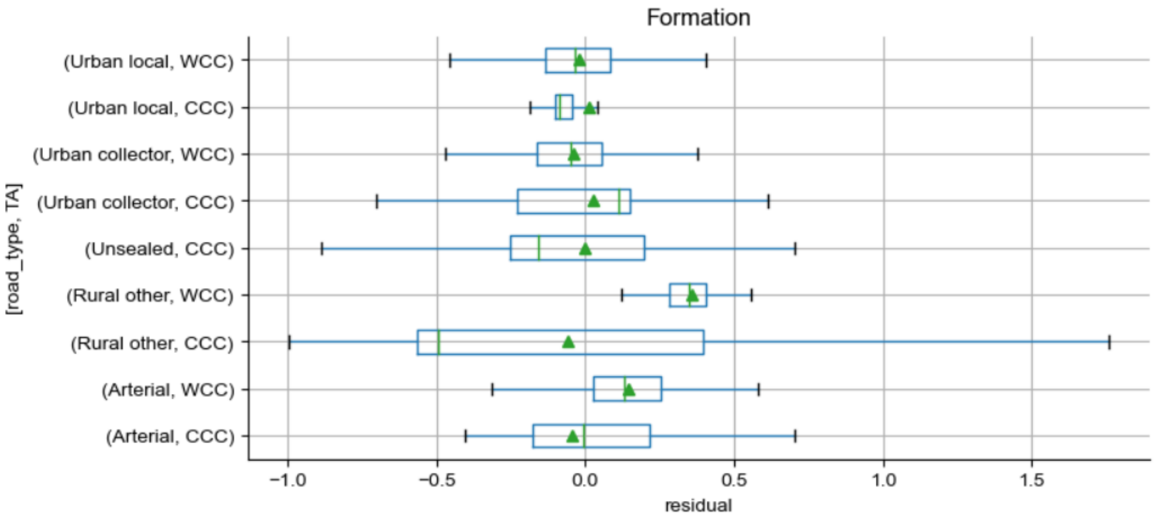

Figure H-2 Boxplot of regression residuals by covariate categories from formation model (triangle indicates mean value)

The outcome of the regression analysis was to identify outliers and re-estimate the values for the outliers. Outliers were identified as reported valuations outside the 95% prediction interval of the regression model, with 300-1000 sections identified. Replacing these outliers with the model estimates has the net effect of lowering the sum of the four road components values by $16.9m in Christchurch and $43.0m in Wellington.

Table H-4 Summary of ORC regression outlier re-estimation for all 4 models

	Formation	Subbase	Basecourse	Surface	Combined
WCC					
Number of sections	36	909	5	57	
Valuation effect ($m)	-$15.7	-$1.7	$0.0	$0.5	-$16.9
CCC					
Number of sections	930	71	603	299	
Valuation effect ($m)	-$35.7	$0.1	$7.9	-$15.4	-$43.0

Robustness Checks

Some initial robustness checks were applied to the model.

Correlation between valuations within TAs may indicate that clustered standard errors are appropriate. Further regression analyses using clustered (with clusters being TAs) or heteroskedasticity-robust standard errors showed wider coefficient standard errors (as expected), but these translated into minor differences in corrected outlier values, on the order of 0.1% of total ORC for a given asset class.

Figure H-3 shows an example scatter plot of reported and model-predicted formation ODRC. Banding is evident in these results, indicating that there is unobserved heterogeneity in the valuations not explained by the included covariates. This is likely due to the smaller set of common covariates used in the regression modelling as opposed to more detailed, TA-specific covariates used in the original valuations. The inclusion of random effects at the street (road ID) or suburb level would be expected to reduce this banding and improve bias in the coefficient estimates. A random effects model (as opposed to TA fixed effects) also can more readily be used to predict values for datasets outside that which the model is fitted to. However, random effects modelling would introduce further model complexity and may be computationally expensive when applied to larger data sets.

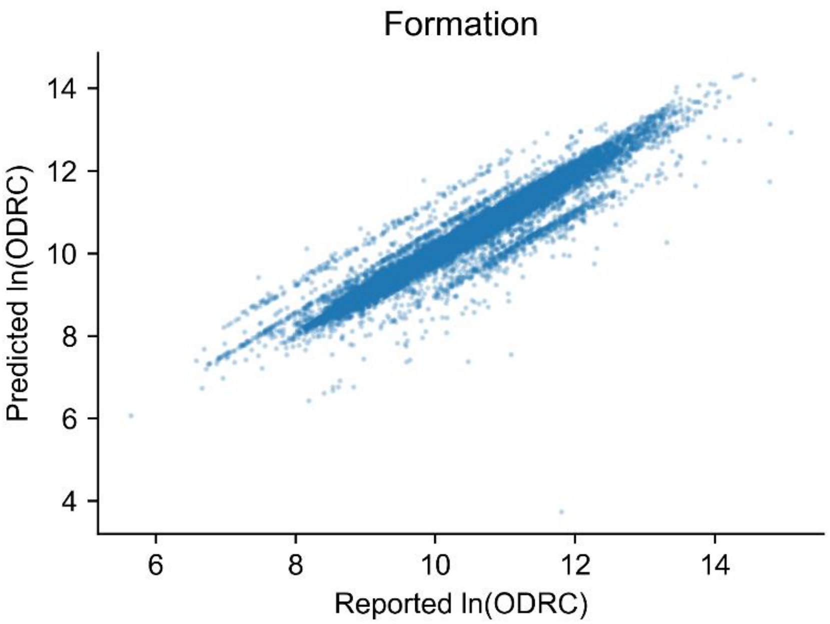

Figure H-3 Scatter plot of predicted vs observed formation ODRC

Table H-5 shows the difference in ORC correction when using a model fitted without outliers (as identified by the 95% prediction interval based on the original model fit). Basecourse and formation show significant differences in overall asset ORC estimates (5% and 2%, respectively) between the original model and that fitted with outliers removed. This indicates that outliers have some influence on the valuation model parameters for these assets. This analysis should be repeated with a wider TA valuation sample to see if this effect persists.

Table H-5 Effect on estimated asset class ORC of removing outliers before model fit

Asset	Change in asset ORC from replacing outliers - Base model	Change in asset ORC from replacing outliers - Model fitted without outliers
Formation	5.0%	7.2%
Surface	2.9%	3.2%
Basecourse	-0.9%	-5.2%
Subbase	0.4%	0.1%

Discussion

The regression analysis enabled a more detailed assessment of explanatory variables, including accounting for variation in terrain. Specifically, the categorisation provided adequately described terrain differences, at least for the four main components of the construction of the road (but not other road components such as drains and signs etc).

However, the rewards of the exercise in terms of outlier adjustment were modest: it is not clear whether the regressions have failed to model relatively high-but-genuine sectional value or whether inconsistent valuation assumptions have led to the apparent outliers; and the resulting adjustment to total ORC is modest if the latter is assumed.

It may be, though, that the modelling serves other purposes and that the modelling can be improved as more data points and more explanatory variables become available.

The regression analysis increases focus on the difference between TAs that was discussed within the earlier crosstabulation analysis. A regression of the sectional data with only road type and TAs as covariates provides a similar result as the crosstabulation exercise and shows that this simple categorisation explains a large portion of the variation in ORCs (R^2 of 0.73 for formation model). Put another way, the regression and the crosstab show that implied average unit ORCs varies across the TAs. In the sectional regressions reported above, the WCC effect was statistically significant for all four asset components but was 33% and 108% higher than CCC (which was the only other TA in the regression) for formation and surface costs and 48% and 59% lower for subbase and basecourse costs – these effects were present after allowing for the different mix of road types and terrain between the two TAs.

While there are known valuation method differences – such as WCC adding adjacent footpath width to the road width when calculating formation costs whereas CCC uses only road width with a formulaic correction (the RAMM data and hence the regressions are based on road width only) – there are likely to be genuine unit cost differences as well. The cause of these differences was not obvious in the crosstabulation analysis and was also not revealed in the more detailed regression analysis (but differences were confirmed). A more detailed analysis of individual valuations and/or more explanatory variables in the regression models would be required to further split valuation inconsistences and spatial construction cost variation.

The detailed regression analysis may or may not have identified sections that are outliers, but any adjustment to values would be relatively modest if these are indeed outliers. Whilst the regression analysis confirms that cost variation exists between TAs, it cannot identify whether these remaining differences are real spatial differences or not.

The regression analysis indicated some non-normality in the fitted data. This may reflect the fact that the valuation data points being fitted do not represent independent samples of some “true” valuation distribution, rather they reflect the valuation procedures followed by each TA. The regression model aims to capture key determinants of these valuations and compare the effects across TAs. As such there is expected to be some systematic error which will vary by TA, reflecting some combination of methodology differences (perhaps including the use of variables outside our model) and local variation in replacement costs. However, inclusion of more TA datasets is expected to improve the normality of the data as further independent valuation approaches are incorporated.

Advantages and disadvantages of regression outlier re-estimation

Undertaking a similar regression analysis within a rollout of valuation across all or many local roads in New Zealand has several advantages and disadvantages.

The advantage of applying a per-section regression model for each of the four road surface / subsurface components would be:

- The approach to replace outliers is statistically grounded and repeatable, although questions remain around preferred model form, and further refinement is required for a wider rollout.
- This process does include the known explanatory variable terrain, which is not possible with comparisons made at a TA level (at least with any precision).
- The model can be progressively improved as more explanatory variables become available.
- A what-if analysis can be undertaken to examine, for example, what value would occur if all road widths were standardised (i.e., a method to improve the 'optimisation' in the ORC method)?
- The model provides an insight into the major determinants of value and in some sense is simpler than trying to unravel the varying inputs to the initial valuations that were undertaken (although there do not appear to be sufficient covariates to establish that outliers are necessarily incorrectly valued by the TA).

The disadvantages are as follows:

- Values are being replaced when they could be genuine if the model fails to recognise genuine rationale for the apparent inconsistency (note that this applies to the implied unit rate approach also)
- The regressions require detailed data and non-trivial alignment of TA asset and valuation data.
- The end result, in terms of adjustments to valuations, is relatively modest and risks being immaterial to those decisions informed by the valuations (note that this applies to the implied unit rate approach also, although that approach is less complex). Even the most significant non-land asset values (road surface and subsurface) have considerably lower values than the associated land values, implying that effort should be focused on refinement of land value estimates.

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