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Waikato land use 2023

Waikato integrated scenario explorer (WISE)

Land Use (2023 Baseline), Zoning, Overlays, and Future Growth Layer Update

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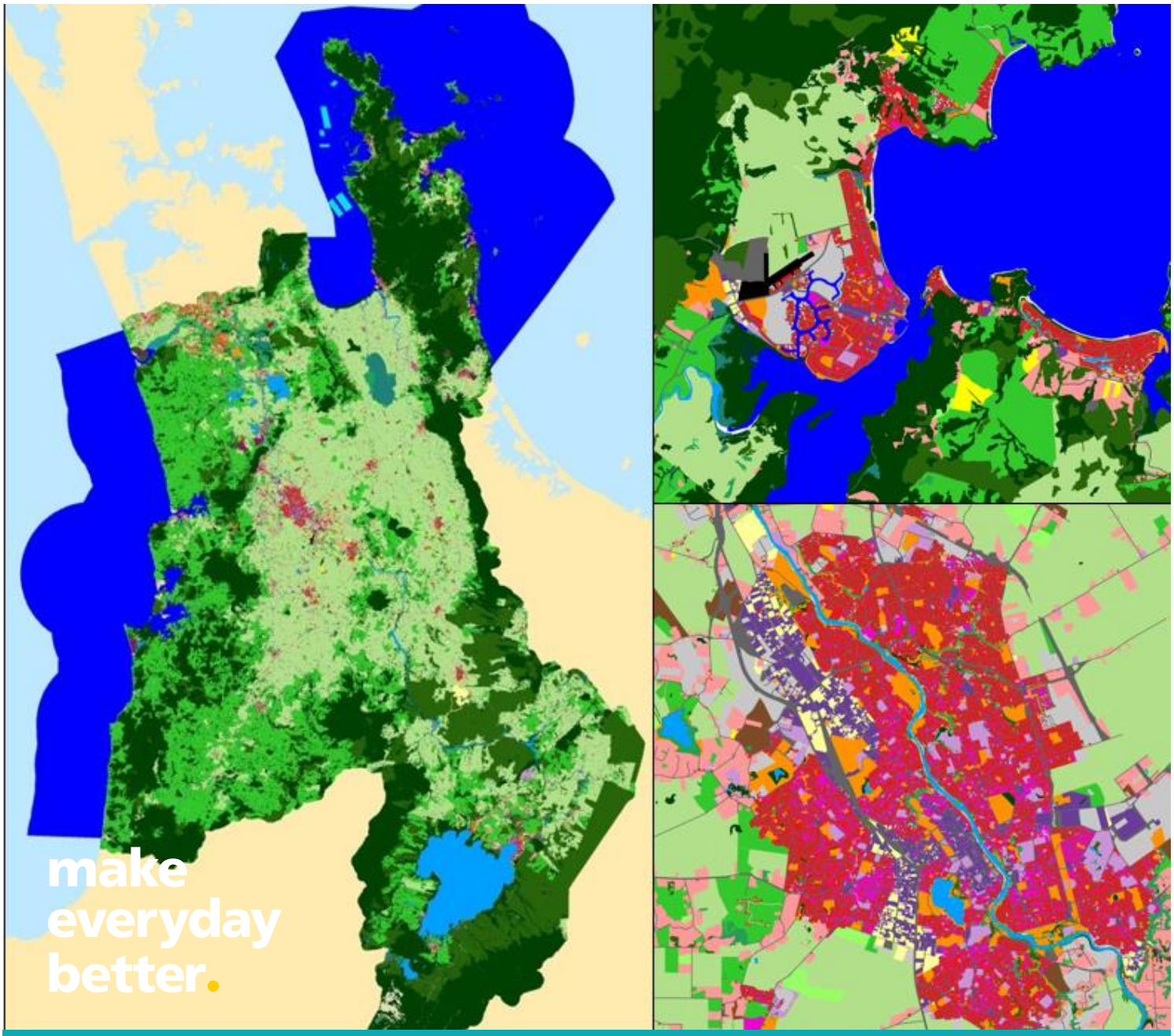
Prepared for Waikato Regional Council
Prepared by Beca Limited
31 January 2025



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Contents

1. Overview

The Waikato Integrated Scenario Explorer (WISE) model is a dynamic spatial tool developed for the Waikato Region to help evaluate effects and trade-offs of long-term, future-focused planning policies and scenarios. The WISE model evaluates the cumulative effects of decisions and their environmental, economic, social, and cultural links and trade-offs with context to space and time (https://www.creatingfutures.org.nz/).

All spatial inputs to the WISE model are formatted as 100m raster (grid) layers in New Zealand Map Grid (NZMG) projection with the spatial extent defined to identically match that of the existing data in the WISE model to ensure alignment. Every WISE raster input must have a non-null class value assigned to the grid value of 0, which should cover a substantial area, making up the majority of the 100-meter pixel size for accurate representation in the output. If this class is too small to be represented, then a different class that can endure the raster resampling process should be assigned the 0 value. Once all classes have been allocated numeric values starting from 0, any NULL values present should be replaced with the next highest available value as a placeholder class.

The WISE land use layer covers the Waikato Region plus a 1.6 km buffer beyond its boundary. This buffer accommodates neighbouring land uses in its cellular automata[1]modelling, avoiding default classifications like "Area outside Territory" or "Marine area outside region." Zoning, overlay, and future growth areas are specific to each territorial authority (TA) and, unlike the WISE land use layer, are not merged into a single regional layer.

Periodically, the WISE model's baseline data, which it utilises for scenario analysis, and to develop the Waikato land use, population and economic projections (https://www.creatingfutures.org.nz/waikato-projections-demographic-and-economic/) requires updates. This document will detail updates related to land use, zoning, overlays (such as precincts and natural hazards), and future growth areas.

Documentation for the previous 2018 WISE land use layer update, as well as background on earlier versions are available from: https://www.creatingfutures.org.nz/waikato-projections-demographic-and-economic/. For a comprehensive overview and context, this document will summarise certain aspects of the previous documentation. Information on zoning, overlays, and future growth aspects that are not present in that earlier documentation was gathered through emails and discussions with Tony Fenton.

2. Land use

2.1 Earlier WISE land use layers

V1.0-1.3 (2006)

The first version (V1.0-1.3) of the WISE land use layers was developed in 2006 by Landcare Research which utilised ArcView 3.2 Avenue scripts to process and generate 200m ESRI grids from the following datasets:

- Land Cover Database version 2 (LCDB2)
- Waikato Regional Council data (Valuation Database
- Road verges, railway corridors, aquaculture)
- Topomap Airports
- Department of Conservation - Conservation Estate Map.

1 Cellular automata are mathematical models composed of a grid of cells, each of which can exist in a finite number of states. The state of each cell changes over discrete time steps according to a set of rules that consider the states of neighbouring cells. Cellular automata are used to simulate complex systems and processes, such as fluid dynamics, biological growth, and population dynamics, where local interactions lead to emergent global behaviour.

V1.4-1.5 (2013)

The 2013 version (V1.4-1.5) developed by Tony Fenton employed a similar approach as V1.0-1.3 but generated a greater resolution 100m ESRI grid output, utilising 3 key datasets:

- Land Cover Database version 4 (LCDB4.1)
- regional valuation database
- AgriBase (rural land use data).

This version involved a mix of bulk polygon analysis with raster conversion and sum by LU class. This was followed by manual corrections of anomalies based on comparison against the previous (2006) land use layer, comparison against aerial imagery and feedback from the territorial authorities.

V1.6 (2018)

Tony Fenton also developed the 2018 version (V1.6) leveraging the same source datasets (LCDB4.1 from Landcare Research, AgriBase from AssureQuality, Property Valuation Database (VDB) from Waikato Regional Council) in addition, this version included LINZ Road parcels and Waikato Regional Council's Biovegetation Layer based on LCDB4.1, as well as analysis of 2012 WRAPS imagery which better delineated indigenous and exotic forestry and wetlands. A variation on the previous 'inference' script-based approach was used in which the higher confidence data matches were first processed, followed by a more specific detailed assessment of remaining polygons against the WRAPS imagery.

2.2 2023 Land use layer update

The 2018 WISE Land Use (LU) documentation served as a crucial reference for developing the 2023 WISE LU update. This documentation aims to provide insights into the 2023 update without duplicating the 2018 content, which remains a valuable resource for detailed analysis specifics.

To create the updated 2023 WISE LU layer, the criteria from the 2018 model has been applied, utilising a data-driven analytical process with updated datasets from the same sources (e.g. LCDB 5 from Landcare Research, AgriBase from Assure Quality, Property Valuation Database and Biovegetation both from Waikato Regional Council, LINZ road parcels). Initially, a matrix (Table 1) was compiled to illustrate how each data input contributed to the different WISE land use classes. Given the complexity of numerous datasets and the extensive list of fields to be classified, this would result in a highly fragmented layer with multiple fields and numerous permutations of variables and logic. This necessitated a break-down of tasks, automating most of the analysis to preprocess and classify each input layer before integrating them with other intermediate layers.

For this update, the analytical process (Figure 1) has been largely built in FME (Feature Manipulation Engine as an automated model). In addition to the established logic from the 2018 update, we introduced bridging logic to classify previously unclassed items more efficiently, thus minimising the need for manual review. Table 2 provides a summary of the key considerations for each land use class and indicates which model each classification takes place in.

Table 1 Data inputs to WISE land use classes.

WISE Land Use Classification			Input Data Sources									Visual Reference
Colour Hex code	LU Code	LU Description	AgriBase	LCDB	Property VDB	WRC Bioveg	LINZ Road Parcels	LINZ Topo50	WRC Aquaculture	Stats NZ Regional boundaries	2018 WISE LU	WRAPS
E1D7B9	0	Bare		y							y	y
C8C8C8	1	Vacant - urban land			y						y	y
004000	2	Indigenous		y		y					y	y
23A156	3	Other Exotic		y		y					y	y
1E8278	4	Wetlands		y		y					y	y
FB9A99	5	Lifestyle	y		y						y	y
E31A1C	6	Low Density Residential	y		y						y	y
F002D0	7	Medium to High Density Residential	y		y						y	y
6A3D9A	8	Commercial			y						y	y
CA95D6	9	Community Services			y						y	y
FFFF00	10	Horticulture	y		y						y	y
FE248A	11	Biofuel Cropping										
C86E32	12	Vegetable Cropping	y		y						y	y
7D4B28	13	Other Cropping	y								y	y
B2DF8A	14	Dairying	y		y						y	y
33C82C	15	Sheep and Beef	y		y						y	y
99FF66	16	Other Agriculture	y								y	y
28640A	17	Forestry	-	y	y	y					y	y
FFFF99	18	Manufacturing			y						y	
0000FF	19	Marine								y		
00E1E1	20	Aquaculture							y			
646464	21	Utilities			y		y				y	y
960A6B	22	Mines and Quarries			y			y			y	y
FF9200	23	Urban Parks and Recreation			y	y					y	
019FFF	24	Freshwater		y							y	
000000	25	Airports			y			y			y	
EFDBBA	26	Area outside region								y		
C8DFF7	27	Marine areas outside the region								y		

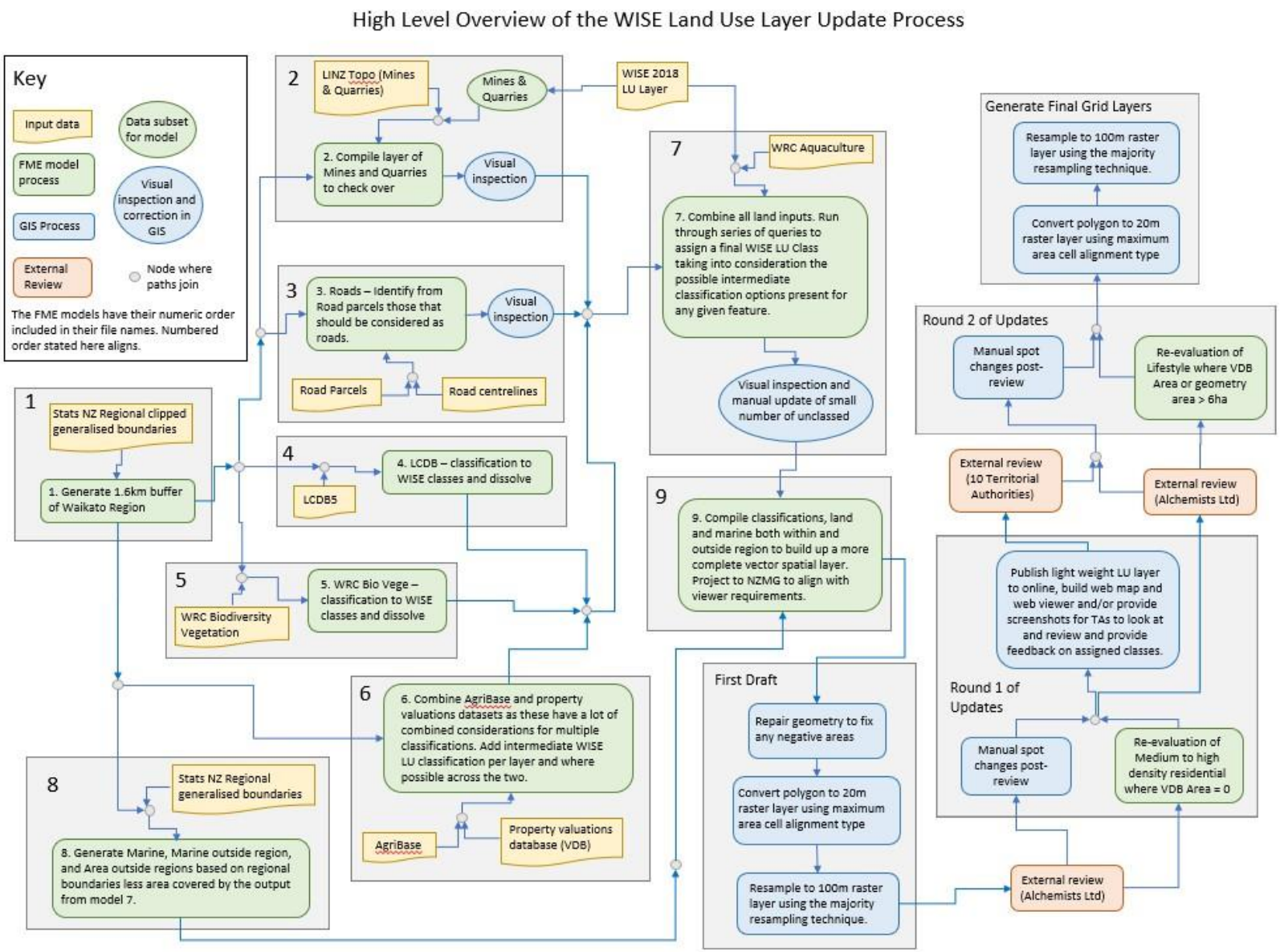


Figure 1 High Level Overview of the WISE 2023 Land Use Layer Update Process.

Table 2 Summarised general criteria (does not account for when multiple criteria across different inputs exist for the same feature)

LU Code	LU Description	Source Dataset/s	Main considerations	Reference Notes	Related FME Models
0	Bare	LCDB5	*Name_2018* In ("Sand and Gravel", "Landslide", "Gravel and Rock", "Permanent Snow")		4 - LCDB layer 7 - Compile Inputs and classify
1	Vacant - urban land	VDB	• *LANDUSE* codes 99, 29, 79, 89 • Where *LANDUSE* code is 99 and capital value less land value = 0 These areas are assumed to be zoned for development in/for urban areas and should change readily from vacant land use to required use when the WISE model runs. A manual check against the most recent aerial imagery is useful to sense check these areas are in fact urban and vacant.	*LANDUSE*: • 29 – Vacant in Lifestyle, • 79 – Vacant in Industrial • 89 – Vacant in Commercial • 99 – Vacant in Residential	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify

2	Indigenous	LCDB5 and Waikato Biodiversity Vegetation 2012 layers	Waikato RC Biodiversity_Vegetation_2012
			• *LCDB2_NAME* in ('Alpine Grass-/Herbfield', 'Broadleaved Indigenous Hardwoods', 'Depleted Tussock Grassland', 'Fernland', 'Flaxland', 'Indigenous Forest', 'Manuka and or Kanuka', 'Grey Scrub', 'Sub Alpine Shrubland', 'Tall Tussock Grassland', 'Sand Dunes', 'Mangrove')
			
			LCDB5:
			• *Name_2018* in ('Alpine Grass/Herbfield', 'Broadleaved Indigenous Hardwoods', 'Depleted Grassland', 'Fernland', 'Flaxland', 'Indigenous Forest', 'Manuka and/or Kanuka', 'Matagouri or Grey Scrub', 'Sub Alpine Shrubland', 'Tall Tussock Grassland', 'Mangrove')
				The LCDB5 selection differs slightly from the selection in WISE 2018 LU layer based on LCDB4.1. This includes the:
				• absence of (as item doesn't appear in the 1.6 km buffered region clip):
				  ○ 'Sand Dunes'
				• renaming of (at source of information, i.e. has not been renamed as part of this process):
				  ○ 'Manuka and or Kanuka' to 'Manuka and/or Kanuka'
				  ○ 'Grey Scrub' to 'Matagouri or Grey Scrub'
				  ○ 'Depleted Tussock Grassland' to 'Depleted Grassland'
				  ○ 'Alpine Grass-/Herbfield' to 'Alpine Grass/Herbfield'
					4 - LCDB layer
					5 - WRC_BioVege layer
					7 - Compile Inputs and classify

3	Other Exotic	LCDB5 and Waikato Biodiversity Vegetation 2012 layers	Waikato RC Biodiversity_Vegetation_2012: • *LCDB2_Name* In (Deciduous Hardwoods, Gorse and Broom, Mixed Exotic Shrubland, Sand Dunes - Highly Modified) LCDB5: • *Name_2018* in ('Deciduous Hardwoods', 'Gorse and Broom', 'Mixed Exotic Shrubland')	The LCDB5 selection differs slightly from the selection in WISE 2018 LU layer based on LCDB4.1. This includes the: • absence of: ○ 'Sand Dunes – Highly Modified' - This class doesn't appear in the 1.6 km buffered region clip.	4 - LCDB layer 5 - WRC_BioVege layer 7 - Compile Inputs and classify
4	Wetlands	LCDB5 and Waikato Biodiversity Vegetation 2012 layers	Waikato RC Biodiversity_Vegetation_2012: • *LCDB2_Name* In ('Herbaceous Freshwater Vegetation', 'Herbaceous Saline Vegetation') LCDB5: *Name_2018* in ('Herbaceous Freshwater Vegetation', 'Herbaceous Saline Vegetation')		4 - LCDB layer 5 - WRC_BioVege layer 7 - Compile Inputs and classify

LU Code	LU Description	Source Dataset/s	Main considerations	Reference Notes	Related FME Models
5	Lifestyle	VDB and AgriBase	Valuations Database: • Primary Classification is Lifestyle ○ *LANDUSE* codes 20, 21, 22, 29 and some 02 ○ VDB AREA SQM >2,500m^2 and < 60,000m^2 ○ AgriBase FARM_TYPE_CODE is LIF or Null/Missing • Primary Classification is Residential ○ Land use codes 90, 91, 92, and some 99 ○ Area (VDB AREA_SQM or Geometric area) >2500m^2 and <60,000m^2 ○ Area per dwelling >2500m^2 and <60,000m^2 Categorising "Lifestyle" land use is complex because it straddles both larger residential areas and smaller rural or horticultural land uses. For parcels <2500m^2, it might be classified as a residential category, whereas parcels over 6 hectares could fall under horticultural or vegetative classes. Another challenge arises when input classifications suggest a "lifestyle" designation, but the dwelling's land area exceeds 6 hectares. In such cases, it might be necessary to refer to the previous WISE Land Use (LU) classifications or conduct a visual assessment using recent aerial imagery to determine the most accurate land use category. Historically, areas with ambiguous classifications in 2018 often defaulted to categories like Sheep and Beef, Dairying, Indigenous, or Other Exotic. It is recommended to use geometric area measurements over VDB area measurements. Although they are typically similar, VDB areas can sometimes be less reliable. The number of dwellings was determined by examining the VDB IMPROVEMENTS field. First, any numeric values were identified in this field, followed by residence type codes such as DWG (Dwelling), UNIT, or FLAT. A further check was performed to see if two residence type codes, such as DWG and UNIT, were present. The geometric (Shape) area was then divided by the dwelling count to calculate the area per dwelling. If the resulting area per dwelling was between 2500m^2 and 6 hectares, the "Lifestyle" classification was considered if it met the previously mentioned land use selection criteria.	*LANDUSE*: • 02 – Multiuse Lifestyle • 20 - Multi-use within lifestyle • 21 - Single unit 1 • 22 - Multi unit 2 • 29 – Vacant within Lifestyle • 90 - Multi-use within residential • 91 - Single unit excluding bach • 92 - Multi-unit • 99 – Vacant within Residential	6 – Combine AgriBase and VDB.fmw 7 - Compile Inputs and classify.fmw Lifestyle_Review.fmw (standalone assessment to review areas >6 ha that were classed Lifestyle in the 2023 draft)
6	Low Density Residential	VDB	• VDB Primary Classification is Residential ○ Land use codes 90, 91, 92, and some 99 ○ Area (VDB AREA_SQM or Geometric area) ≥400m^2 and ≤2500m^2 ○ Area per dwelling ≥400m^2 and ≤2500m^2 • VDB Primary Classification is Lifestyle ○ Land use codes 20, 21, and some 22, 29 ○ Area (VDB AREA_SQM or Geometric area) >400m^2 and ≤2500m^2 ○ AgriBase FARM_TYPE_CODE is either LIF or Null/Missing	*LANDUSE*: • 02 – Multiuse Lifestyle • 20 - Multi-use within lifestyle • 21 - Single unit 1 • 22 - Multi unit 2 • 29 – Vacant within Lifestyle • 90 - Multi-use within residential • 91 - Single unit excluding bach • 92 - Multi-unit • 99 – Vacant within Residential	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify

LU Code	LU Description	Source Dataset/s	Main considerations	Reference Notes	Related FME Models

7	Medium to High Density Residential	VDB	• VDB Primary Classification is Residential
			  ○ Land use codes 90, 91, 92, and some 99
			  ○ Area (VDB AREA_SQM or Geometric area) <400m^2 - ***Note: if VDB AREA_SQM = 0 then should check Area per dwelling***
			  ○ Area per dwelling <400m^2
			
			• As a secondary option where VDB Primary Classification is Commercial
			  ○ Land use codes 81, 82, 83, 84, 85
			  ○ Area (VDB AREA_SQM or Geometric area) <400m^2 - ***Note: if VDB AREA_SQM = 0 then should check Area per dwelling***
			  ○ Area per dwelling <400m^2
			
			• Additional
			  ○ VDB_Secondary_Name in (Multi unit 2, Multi-unit)
			
			Note: Initially, properties with a VDB AREA_SQM of 0 square meters were classified as Medium to High Density Residential (MHDR), as per the 2018 documentation. This led to an overrepresentation of MHDR. After a review by Tony Fenton, all areas categorised as MHDR with a VDB area of 0 m^2 were re-evaluated based on their geometric area, rather than relying on the AREA_SQM attribute.
			To determine the number of dwellings, the VDB IMPROVEMENTS field was analysed. This involved identifying numeric values followed by residence type codes (e.g. DWG, UNIT, FLAT) and checking for combinations of two residence type codes, such as DWG and UNIT. Additionally, active address points were considered to more accurately capture the dwelling count, thereby helping to assess the residential land area per dwelling. If this area was <400m^2, the classification remained as MHDR. For areas >400m^2, a reassessment was conducted to determine whether the classification should be low-density residential, lifestyle, or another category.
				LANDUSE:
				• 90 - Multi-use within residential
				• 91 - Single unit excluding bach
				• 92 - Multi-unit
				• 99 – Vacant within Residential
				
				• 81 - Retail
				• 82 - Services
				• 83 - Wholesale
				• 84 - Offices
				• 85 - Car parking
				
				Area_per_dwelling (added after review):
				• Dwelling count: Derive sum of all DWG, FLAT, UNIT, and APARTMENT items listed in IMPROVEMENT field
				• Calculate geometric area
				• Divide area by dwelling count
					6 – Combine AgriBase and VDB
					7 - Compile Inputs and classify
					
					MHDR_Review.fmw (standalone assessment to review VDB AREA_SQM = 0 that were classed as MHDR in the 2023 draft, but should have been evaluated on geometric area)

8	Commercial	VDB	*LANDUSE* codes 81-85, 93, 94 and some 08, 80, 89, 95, 96 with further assessment IMPROVEMENTS contains • MOTEL, HOTEL, or HOSTEL • LODGE, ACCOM, BACKPACKERS • CAFE, SHOP, OFFICE, SUPERMARKET LANDUSE codes 82-85 and AREA_SQM >10,000m^2 – check. Some VDB LANDUSE 89 (vacant) can be parking which is better coded as Utilities. Rest home/care facilities – may be best to split out areas that look LD or MHD residential and community service type facilities.	*LANDUSE*: • 08 – Multiuse commercial • 80 - Multi-use within commercial • 81 - Retail • 82 - Services • 83 - Wholesale • 84 – Offices • 85 - Car parking • 89 – Vacant within Commercial • 93 - Public communal unlicensed • 94 - Public communal licensed • 95 - Special accommodation • 96 - Communal residence dependent on other use	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify

LU Code	LU Description	Source Dataset/s	Main considerations	Reference Notes	Related FME Models
9	Community Services	VDB	• *LANDUSE* codes: 04, 40-52, 54 Additional: • IMPROVEMENTS • Contains any of (SCHOOL, CHURCH, HALL, TOILET, LIBRARY, LBAR, CREMATORIUM, CEMET, SURGERY, KINDERGARTEN, KINDY, CLASS, COMMUNITY, MARAE, DAYCARE, THEATRE, COURT H, CLUB, GYM, PRISON, FIRE ST, FIREST, CLINIC, CHAPEL, CHILD CARE, CHILDCARE, REST HOM, REST HOME, HOSPITAL, AMBULANCE, MED C, MEDICAL, POLICE ST, TEMPLE, MUSE, CENTRE, CTR) Begins with BLDG and does not contain (RACETRACK, STADIUM) and *VDB Primary* is either 4- Community Services or 5 – Recreational. Within the VDB LANDUSE codes there can be a mix of community services and urban parks and recreation type uses across the 4- and 5- codes. In a sense separate indoor and outdoor use, and what might be more sports related from communal facilities that are less focused or less dominantly used for physical activity.	For reference • 04 – Multiuse Community Services • 40 – Multi-use within community services • 41 – Educational • 42 – Medical and allied • 43 – Personal and property protection • 44 – Religious • 45 – Defence • 46 – Halls • 47 – Cemeteries and crematoria • 49 – Vacant within Community Services • 50 – Multi-use within recreational • 51 – Entertainment • 52 – Active indoor • 54 - Passive indoor	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify
10	Horticulture	VDB and AgriBase	• AgriBase *FARM_TYPE_CODE* in (FLO, NUR, FRU, VIT) - flowers, plant nurseries, fruit growing, viticulture • VDB *LANDUSE* code 15 Check against recent aerial imagery. Vegetable cropping is also an option that derives from LANDUSE code 15 so some checking needed to determine which option is more appropriate.	*LANDUSE*: 15 - Market gardens and orchards	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify
11	Biofuel Cropping	N/A	N/A Has not been assessed in the current or past assessments.	Appears to be added as a class that may feature in the future.	N/A
12	Vegetable Cropping	VDB and AgriBase	• AgriBase *FARM_TYPE_CODE* = VEG • VDB *LANDUSE* code 15	*LANDUSE*: 15 - Market gardens and orchards	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify
13	Other Cropping	AgriBase	• AgriBase *FARM_TYPE_CODE* = ARA • Other cropping e.g. Maize When checking against recent aerial imagery, areas that appear cultivated and in cropping but are not classed as vegetable cropping may be classed as other cropping.		6 – Combine AgriBase and VDB 7 - Compile Inputs and classify
14	Dairying	VDB and AgriBase	• AgriBase *FARM_TYPE_CODE* in(DAI, DRY) – dairy, drystock • VDB *LANDUSE* codes 11 and some 12 and 14 • VDB *VNZ_CATEGORY_CODE* in (DFA, DFB) and some (DFC, DFD, DFE, DFF) • May also consider presence of DWG in IMPROVEMENTS with the above criteria	*LANDUSE*: • 11 – Dairy • 12 – Stock finishing • 14 -Store livestock	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify
15	Sheep and Beef	VDB and AgriBase	• AgriBase *FARM_TYPE_CODE* in (BEF, SNB, DEE, SHP) – beef, sheep and beef, deer, sheep • *Some* VDB *LANDUSE* codes 12 and 14	*LANDUSE*: • 12 – Stock finishing • 14 -Store livestock	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify
16	Other Agriculture	VDB and AgriBase	Primary: • AgriBase *FARM_TYPE_CODE* in (GOA, ALA, API, DOG, FIS, HOR, PIG, POU) - goat, alpaca, apiculture, dog, fish, horse, pig, poultry ○ exclude any VDB *LANDUSE* codes 60-66, 69 • VDB *LANDUSE* code 16 Additional: AgriBase FARM_TYPE_CODE in(EMU, OST, CAR, OAN) - These were not specified in the 2018 process but are among the AgriBase agriculture categories present in the region. These represent emu, ostrich, calf rearing, and other animals.	*LANDUSE*: • 16 - Specialist livestock Exclude: • 60 - Multi-use within utility services • 61 – Communications • 62 – Electricity • 63 – Gas • 64 – Water Supply • 65 – Sanitary • 66 – Other • 69 – Vacant within Utilities	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify

LU Code	LU Description	Source Dataset/s	Main considerations	Reference Notes	Related FME Models
17	Forestry	LCDB5 and Waikato Biodiversity Vegetation layers. VDB and AgriBase.	Waikato RC Biodiversity_Vegetation_2012: • LCDB2_Name In (Forest Harvested, Pine Forest - Closed Canopy, Pine Forest - Open Canopy, Other Exotic Forest) LCDB5: • *Name_2018* in ('Forest – Harvested', 'Exotic Forest') Additional • VDB *LANDUSE* code 17. • AgriBase FARM_TYPE_CODE = FOR where WISE LU_NAME2018 = Forestry Note: Since forestry classification relies on LCDB data, which may be outdated, it's important to manually verify and cross-check areas using recent aerial imagery. This helps to accurately identify regions where forests have been harvested and are no longer forested.	*LANDUSE*: • 17 – Forestry Forestry is recorded across these 4 input layers as well as the previous WISE LU layer, so a majority rules approach has been adapted. Where several inputs align with the forestry classification, then this class will then be assigned. The LCDB5 selection differs slightly from the selection in WISE 2018 LU layer based on LCDB4.1. This includes the: • absence of (as these don't appear in the 1.6km regional clip): ○ 'Pine Forest – closed canopy' ○ 'Pine Forest – open canopy' • renaming of: ○ 'Forest Harvested' to 'Forest – Harvested' ○ 'Other Exotic Forest' to 'Exotic Forest'	4 - LCDB layer 5 - WRC_BioVege layer 6 – Combine AgriBase and VDB 7 - Compile Inputs and classify
18	Manufacturing	VDB	• Primary ○ VDB *LANDUSE* codes 71-78 and 07, 70, and 79 with further assessment ○ *IMPROVEMENTS* contains FACTORY, SAWMILL, TIMBERMILL Note: Many of these can be commercial businesses focused on selling services or products rather than manufacturing (e.g. Frankton suburb of Hamilton). It's advisable to verify these classifications by checking recent aerial imagery and considering the classifications of adjacent areas.	*LANDUSE*: • 07 – Multiuse Industrial • 70 – Multi-use within industrial • 71 – Food, drink, and tobacco • 72 – Textiles, leather, and fur • 73 – Timber products and furniture • 74 – Building materials other than timber • 75 – Engineering, metalworking, appliances, and machinery • 76 – Chemicals, plastics, rubber, and paper • 77 – Other industries, including storage • 78 – Depots and yards • 79 – Vacant within Industrial	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify
19	Marine	Stat NZ Region generalised	Waikato Region. Area outside coastline and within Waikato Region.	Waikato Region in the Stats NZ Region generalised minus the Stats NZ Region generalised clipped layer (to subtract land area). This will leave the Waikato marine extent.	8 – Land and Marine extent
20	Aquaculture	WRC Aquaculture layer	Based on WRC Aquaculture layer.		7 - Compile Inputs and classify
21	Utilities	VDB	*LANDUSE* codes 03, 06, 30-34, 39, 61-67, 69 Manual spot check against recent aerial imagery Additional • *IMPROVEMENTS* contains AIRPORT - Where WISE *LU_Name2018* = Utilities • *IMPROVEMENTS* contains LIGHTHOUSE - Where WISE *LU_Name2018* = Utilities • Road parcels where these overlap with road centrelines.	*LANDUSE*: 30 - Multiuse Transport 30 - Multi-use within transport 32 – Parking 34 – Water transport 61 – Communications 63 – Gas 65 – Sanitary 67 – Postboxes 06 - Multiuse Utilities 31 – Road transport 33 – Rail transport 39 – Vacant within Transport 62 – Electricity 64 – Water Supply 66 – Other 69 – Vacant within Utilities	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify

LU Code	LU Description	Source Dataset/s	Main considerations	Reference Notes	Related FME Models
22	Mines and Quarries	Topo Mines and quarry features; VDB	• VDB *LANDUSE* code 18 • IMPROVEMENTS contains QUARRY Topo Mines and Quarries after visual inspection	*LANDUSE*: 18 – Mineral extraction	2 – Mines and Quarries 6 – Combine AgriBase and VDB 7 - Compile Inputs and classify
23	Urban Parks and Recreation	VDB	Primary: • VDB *LANDUSE* codes 05, 53, 55, 59. Secondary: • VDB *LANDUSE* codes 50-52, 54 **- where no building** This classification can be challenging because it encompasses various land types, including Department of Conservation land. As a result, you may find scattered areas within it that might be more aligned to a LCDB landcover derived class. Additional: • IMPROVEMENTS = Reserve • IMPROVEMENTS contains TENNIS, T/COURT, GOLF, PLAYGROUND, STADIUM, POOL • IMPROVEMENTS in (BRIDGE,FG,"FG OB","FG OB OI","FG OBS","FG OBS OI","FG OI",OB,"OB OI","OB OI 2 POOL","OB OI FG",OBS,"OBS OI","OBS OI FG","OBS OI ROAD","OBS OIS",OI,"OI BRIDGE",OX,PLAYGROUND,PONDS,"RESERVOIR OB OI FG",XXX) **– where it may otherwise be community services but lacks a building** • *VDB Primary* = 5 – Recreational and IMPROVEMENTS is either NULL or contains (RACETRACK, STADIUM) or is OB OI. **– Where WISE LU_Name2018 field is NULL**	*LANDUSE*: • 05 – Multiuse Recreational • 50 – Multi-use within recreational • 51 – Entertainment • 52 – Active indoor • 53 – Active outdoor • 54 – Passive indoor • 55 – Passive outdoor • 59 – Vacant within Recreational	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify
24	Freshwater	LCDB5	*Name_2018* in ('Lake or Pond', 'River')	The LCDB5 selection differs slightly from the selection in WISE 2018 LU layer based on LCDB4.1 with the renaming of: 'Lakes and Ponds' to 'Lake or Pond'	4 - LCDB layer 7 - Compile Inputs and classify
25	Airports	VDB	• *LANDUSE* code 35 • *IMPROVEMENTS* in (AIRFIELD, AIRSTRIP, AIRPORT)	*LANDUSE*: • 35 – Air transport	6 – Combine AgriBase and VDB 7 - Compile Inputs and classify
26	Area outside region	Stat NZ Region generalised clipped	Auckland, Bay of Plenty, Taranaki, Hawkes Bay, Manawatu Regions (within required raster extent and not already considered in 1.6km buffer)		8 – Land and Marine extent
27	Marine areas outside the region	Raster extent, Stat NZ Region generalised	Remainder of area not classed as land or marine within the lu_mask area.		8 – Land and Marine extent

2.3 Methodology

Aside from the WISE 2018 raster outputs, all inputs were in polygon topology (vector format). While it is possible to conduct the analysis by first identifying individual land use classes and then creating raster layers, this approach presents issues. Specifically, when combining these raster layers, it becomes difficult to determine which class should take precedence. Additionally, if numeric values are utilised, combining classes can inadvertently produce a numeric code corresponding to an entirely different class. To prevent these complications, the analysis was performed on the vector data before any raster layers were generated.

Given the complexity of:

- input layers and their number of associated attributes,
- WISE land use classes to determine,
- overlapping criteria between inputs and refined decisions to differentiate between one class and another,

it was more efficient to break the process into manageable parts. To facilitate the data-driven approach for the WISE 2023 land use layer update, each input was initially classified at an intermediate level. The likely WISE land use classification within each input was identified, and data was then consolidated based on all necessary fields for further analysis with other inputs. This process combined adjacent features sharing the same values across retained fields, resulting in a simplified, lighter layer for downstream analysis.

The analysis progressed as data became available or in response to identified issues, which means some steps might have been more effectively implemented earlier. An additional complexity involved manual editing to assign classifications when useful information was lacking, highly conflicted, or incorrectly classified compared to recent aerial imagery. Some misclassification was anticipated, given the variability in the recency of input data capture; older data might not accurately reflect the current state.

Screenshots of the annotated models are included in the appendices.

2.3.1 WISE Model Extent

For the WISE Model, all 100m resolution raster inputs must have the same spatial extent to align properly. To ensure the new 2023 data aligns with existing layers in the WISE model that do not need updating, it was crucial to know the required grid (raster) extent. The "*lumask*" raster layer from the 2018 update was provided for this purpose. Since the intention for the 2023 update was to perform the analysis using vector data, this raster layer was converted into a polygon extent (Figure 2).

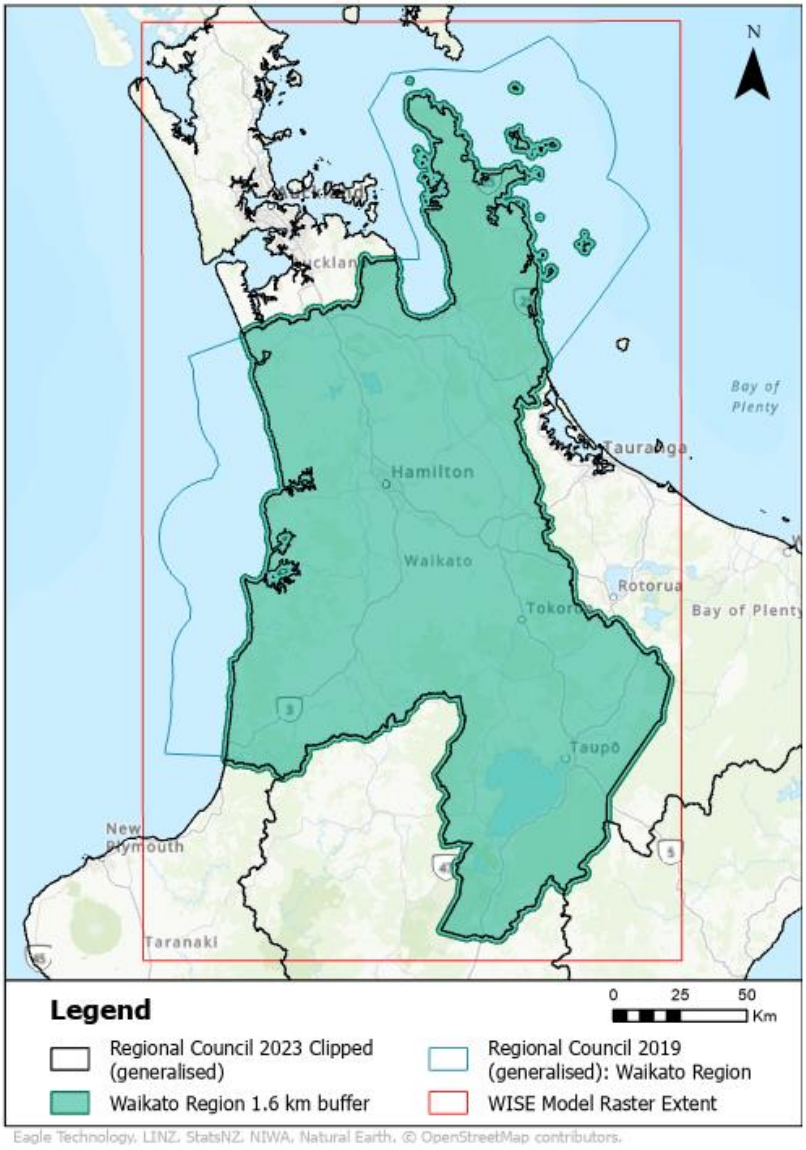


Figure 2 WISE Model required raster extent, the Waikato Region marine area based on generalised regional boundaries, regional boundaries (clipped to coast), and the Waikato Region with a 1.6km buffer applied within which terrestrial land use classes will have a classification other than Area Outside Region.

2.3.2 Regional Extents

For the WISE land use layer, terrestrial classifications are captured for the Waikato Region and extend 1.6km beyond its boundaries. This inclusion of neighbouring areas is important for considering boundary locations during the cellular automata analysis performed by the WISE model. The Waikato Region was selected using the Stats NZ Regional Council (2023) clipped layer (Regional_Council_2023_Clipped__generalised_), and a 1.6km buffer was applied to create this extended layer (Figure 2).

The Stats NZ Regional Council (2019) generalised layer (Stats_Regional_Council_2019_generalised) includes both land and marine environment. By overlaying both the clipped and unclipped regional boundary layers (Figure 2) the Marine areas can be defined as the areas that do not overlap.

The regions neighbouring the Waikato Region in the clipped regional layer were overlayed with the 1.6km buffered Waikato region layer and any overlap removed. The remaining areas of the neighbouring regions were then classed as “Area outside region”. The “Marine areas outside the region” was what was left of the WISE model raster extent after first subtracting the area covered by the clipped regional boundaries and then overlaying all other areas that have a WISE land use classification.

This method (Appendices: WISE Land Use FME Models - Land and Marine extent.fmw) for defining the "Marine," "Areas outside region," and "Marine areas outside the region" classifications was applied later because it was expected that these would be provided as a vector input from the 2018 assessment, which was not the case. The 2018 WISE land use terrestrial classes within the 1.6 km buffer were provided as a vector layer, but all other data was captured in the 100m raster layer. The 2018 WISE LU 100m raster is the result of conversion of polygon to 20m raster then resampled to 100m raster based on the majority classification present within each 100m pixel. Polygon areas derived from pixels in a lower resolution resampled raster layer are less reliable to refer to due to a loss of feature boundary detail. It is better to refer to a more reliable source vector polygon dataset where possible. For this reason, the Statistics New Zealand Regional Boundary polygon layers (both unclipped and clipped to coast) were referred to for both marine areas and the areas outside region.

2.3.3 Intermediate Classification

Intermediate classification was introduced to better align input datasets by pre-classifying them where possible. This approach simplifies and consolidates clusters of similarly classified, smaller adjoining areas into larger features, and reduces the number of fields (columns) in the attribute table. This method helps to:

- Reduce fragmentation
- Simplify complexity
- Decrease file size
- Shorten processing time

2.3.3.1 Land cover derived inputs

The most recent Landcover Database version at the time of this assessment was LCDB5 (2018). LCDB4 was used in the previous 2018 WISE land use update as LCDB5 had not been released at that time. There are some slight differences in class names between these two LCDB versions, which meant some of the selection criteria applied to LCDB5 differs slightly in the 2023 WISE LU update to what was applied to LCD4 in the 2018 update (Table 2).

The Waikato Regional Council's Biodiversity Vegetation 2012 layer is a biodiversity inventory that WRC has derived from LCDB2 as a base with some digitised modifications based on in WRAPS 2012 aerial imagery. This layer was published to the Waikato Data Portal in July 2021 and data update noted as May 2023. There is nothing in the data or metadata to indicate exactly what may have changed and when, however the metadata indicates that it is likely that updates are infrequent, so could assume that the data is relatively up to date.

The intermediate classification of WRC Biodiversity vegetation 2012 groups 22 classes into 4 WISE land use classes (Appendices: WISE Land Use FME Models – WRC BioVege layer.fmw) and 24 LCDB5 land cover classes into 6 WISE land use classes (Appendices: WISE Land Use FME Models – LCDB layer.fmw). In both instances almost half the input land cover values are grouped under the WISE land use Indigenous class.

When comparing these two intermediate layers (Figure 3), they generally align well, but some noticeable differences remain. The LCDB5 layer extends 1.6 km beyond the regional boundary, whereas the Biodiversity layer is confined within the Waikato Region. Additionally, there appears to be less forestry in the LCDB5 layer northeast of Taupo, near Tahorakuri and Rotokawa. Areas like these, where forestry had been cleared, were visually inspected and corrected after the initial draft.

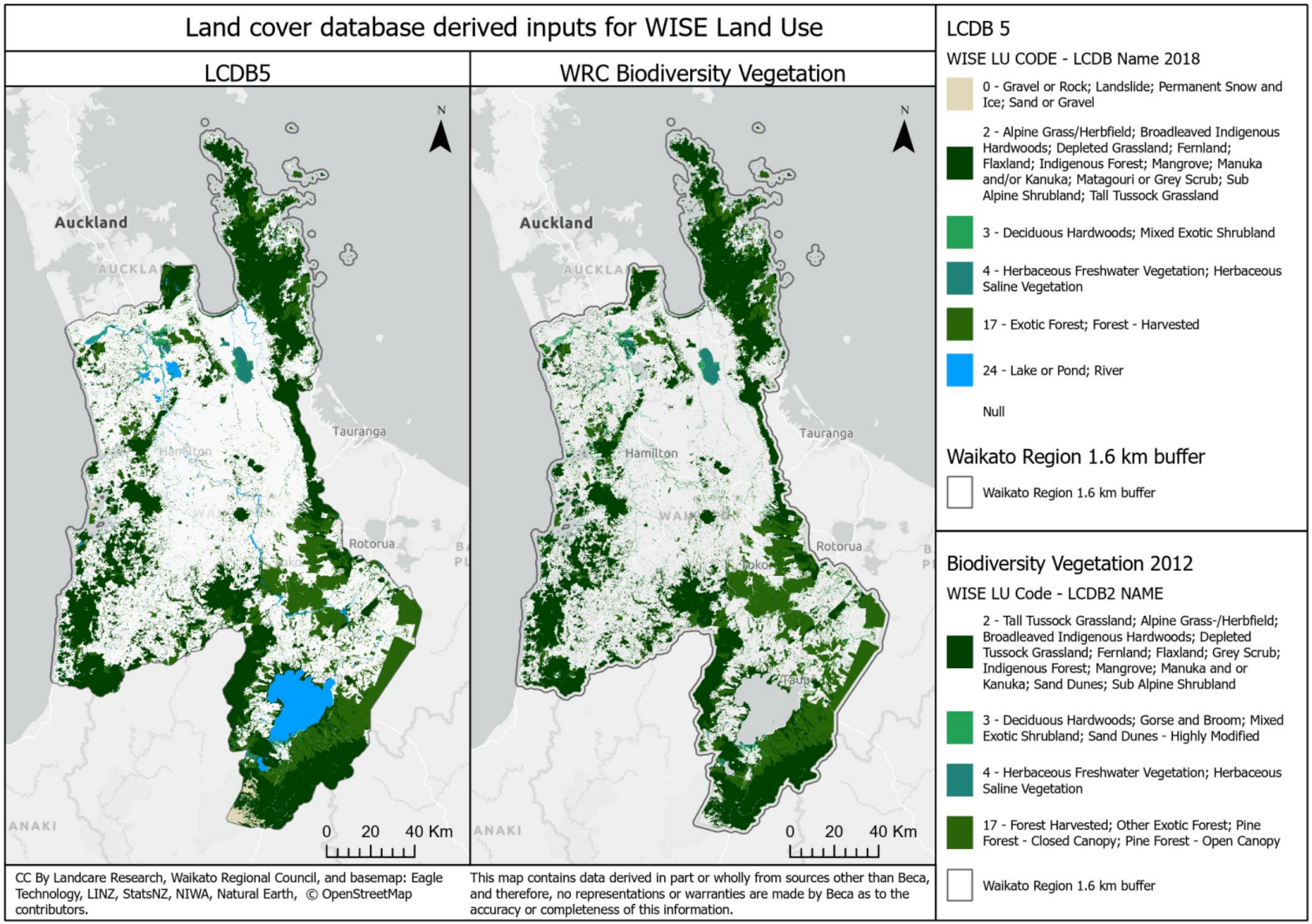


Figure 3 Comparison of intermediate WISE vegetative land use classes and distribution derived from Landcover Database version 5 (LCDB5) and the Waikato Regional Council Biodiversity Vegetation 2012 layer based on LCDB2 and digitisation based on WRAP2012 imagery.

2.3.3.2 Property Valuations Database and AgriBase

The Property Valuations Database (VDB) and AgriBase datasets both contribute to the classification criteria of several of the same WISE LU classes in Table 2. As some WISE LU classes consider values from both input layers in the same assessment, both of these layers were combined in an earlier process to apply an intermediate classification across the two (Temp_WISE_LUC) where possible (Appendices: WISE Land Use FME Models – Combine AgriBase and VDB.fmw).

AgriBase has 34 potential Farm Types, not all of which are present in the Waikato Region or considered for WISE land use classification (Table 10). Before combining with the VDB dataset, the AgriBase dataset underwent an intermediate WISE LU classification (AgB_WISE_Cat) based purely on Farm Type. All adjoining features of the same intermediate class were amalgamated to simplify the content into fewer unique features.

The VDB has 83 land use codes of its own which each have their own Secondary Level Name, each of these falls under 10 different Primary Level Names. This layer has additional fields that are useful to retain in further classification analyses. One of these is the unique Valuation_ID which provides a means to link back to the source dataset at the property level if required later.

The intermediate layers were simplified by consolidating them based on the minimum number of fields necessary for future analyses. For the VDB/AgriBase combined layer, this consolidation was reduced to focus on unique property information and their potential individual and combined WISE classifications at that point in the process.

2.3.3.3 Roads

To effectively incorporate utility areas that roads represent within the 1.6 km buffered Waikato Region extent, it is important to include road parcels. However, the LINZ road parcels may contain land parcels related to statutory actions that do not correspond to actual roads, as verified by aerial imagery. A model (Appendices: WISE Land Use FME Models –Roads.fmw) was developed to spatially filter these parcels, identifying which ones are likely to be roads and which require visual verification and correction. The visual check revealed a few key observations:

- The Waikato Expressway (Huntly and Hamilton sections) are not fully captured – there appear to be parcels missing that should be in the source LINZ roads parcel dataset but are not. This was manually changed at a later date following the initial draft review.
- Road parcels along streambanks where there are no physical roads observed in the aerial imagery – these should not be classed as utility in the WISE LU so are best excluded as these areas are likely to be better represented by a different land use category.
- Road parcels disconnected from other roads; some appear isolated or potentially forest roads. Due to the lack of connectivity and more temporary nature of this use these road parcels are best excluded.

The output forms an input to the mass compilation and classification process (Appendices: WISE Land Use FME Models – Compile Inputs and Classify.fmw).

2.3.3.4 Mines and Quarries

Mines and Quarries were derived from the LINZ topographic 1:50k datasets for these features. The Mines and Quarries classification in the WISE 2018 LU layer was taken as a subset and overlain with these features (Appendices: WISE Land Use FME Models – Mines and Quarries.fmw). A quick check where there were differences was done against the NZ aerial imagery basemap.

2.3.4 Combining intermediate inputs

An initial assessment of the combinations of present and absent values across all intermediate classification fields was conducted. This analysis included applying a majority rules approach, where if multiple intermediate

classification fields share the same value (e.g., forestry in LCDB5, WRC Biodiversity Vegetation 2012, and WISE 2018 LU), that value is prioritised. Additionally, if a single field contains a value while other fields are null or blank, the single value is prioritised.

After classifying the initial straightforward cases, the remaining features were filtered and divided into separate logic streams (Appendices: WISE Land Use FME Models – Compile Inputs and Classify.fmw). The process involved several steps:

1. **Separate Features Lacking WISE 2018 LU Classification:** Identify and segregate features without a WISE 2018 land use classification.
2. **Separate Features Without Primary VDB Classification:** Further segregate features that lack a primary VDB classification.
3. **Filter by Primary VDB Classifications:** Classify features based on their primary VDB classifications, such as Rural, Residential, Commercial, Industrial, Utilities, Community Services, Recreational, Lifestyle, Transport, and Multiuse.

Within each of these filtered categories, a series of top-down selection logic is applied to accurately classify the features.

When uncertainty arose, the standard rule was to adopt the classification from the previous WISE 2018 land use layer. However, this was not always feasible due to gaps in the 2018 WISE land use vector spatial layer. In most instances, the new classification matched the WISE 2018 classification. Discrepancies usually resulted from changes in land use or improvements in classification accuracy.

While the automated process successfully classified most features, some required manual classification. These were assessed through a quick visual examination of aerial imagery, combined with available attribute information, to form the best possible estimate.

The WISE 2018 land use 100m grid (raster) layer used in the WISE model included classifications for "Marine," "Area outside region", and "Marine areas outside the region", but these were absent from the WISE 2018 land use polygon vector layer. These classifications needed to be defined and incorporated as polygon features in the WISE 2023 land use vector layer prior to sampling to a raster grid output. The marine areas and the land area outside region were able to be defined based on the Statistics New Zealand regional boundaries using both the unclipped and clipped by coast datasets (Appendices: WISE Land Use FME Models – Land and Marine extent.fmw). This process involved:

1. Using the clipped regional boundaries to define land areas neighbouring the Waikato Region, specifically parts of the Auckland, Bay of Plenty, Hawkes Bay, Manawatu-Whanganui, and Taranaki regions.
2. Defining the marine extent by subtracting the clipped regional boundary areas from the generalised regional boundaries, both within and outside the region.
3. Clipping the regional land and marine areas to the LU mask extent and overlaying them with other WISE land use classes. If there was an overlap between an existing 2023 class and an out-of-region or marine class, the existing 2023 class was retained, as these might relate to aquaculture and are mostly within the 1.6 km buffer of the Waikato Regional boundary.

Before being sent for external review, some quick, random spot checks were performed on the resulting draft WISE 2023 land use polygon feature layer by Tony Fenton, who are familiar with the WISE land use layer from previous updates.

2.4 External review

External review was undertaken in two parts, first by Tony Fenton. who had previously conducted the WISE spatial layer updates, and secondly by each territorial authority.

2.4.1 Review by Tony Fenton

The review undertaken by Tony Fenton proved to be valuable, as his prior knowledge from earlier assessments allowed him to better identify and note potential problem areas for correction. He highlighted a few issues to address:

- A short list of approximately 100 features recommended for manual update
- Many existing aquaculture areas were missing
- Over representation of medium to high density residential areas, particularly those with a VDB Area of 0 but where the geometric area per dwelling is not <400 m^2
- Over representation of lifestyle areas, particularly areas >6ha which do not belong in that class

The manual updates were processed, with most of the recommended changes implemented. A few items required further discussion with the reviewer before deciding whether to update or not.

Aquaculture was significantly underrepresented because the data provided only included new areas, and features of this class were missing from the WISE 2018 land use vector layer (although they were present in the generalised 100m raster layer). The missing areas of aquaculture were digitised from the WISE 2018 Land Use 100m raster layer and included in the 2023 update prior to review by various territorial authorities. Although the 100m raster does not offer precise polygon extents of existing aquaculture, the digitised areas are intended to ensure that the same pixels are classified as aquaculture in the output. The external review should help identify any instances where aquaculture present in 2018 may have shifted to a different land use.

2.4.1.1 Medium-High Density Review

Following the draft review, it was identified that at medium to high-density residential areas were overrepresented. A closer inspection revealed a common issue: these areas often had an AREA_SQM value of 0 in the Property VDB layer. According to the 2018 documentation, medium to high-density residential properties with a 0 m² "area" were assumed to be multi-unit titles. However, it has since been acknowledged that this assumption may not be entirely accurate. A more reliable approach is to reference the original geometry of the feature to determine its area.

With this understanding, a re-analysis was conducted (Appendices: WISE Land Use FME Models – Medium to High Density Residential Review). The geometric area for all features in the source CRS Property dataset across the region was calculated and then joined via Valuation ID to the subset of fractured features where WISE LU was classified as Medium to High Residential and VDB AREA_SQM was 0 m². Features with a source geometric area < 400 m² remained in their existing classification. Those ≥400 m² underwent further analysis to determine the area per dwelling based on their source geometric area instead of the VDB AREA_SQM.

The IMPROVEMENTS field in the Property VDB layer contains information regarding the number and type of dwellings on each property, which can be extracted by performing a string search for numeric values that precede dwelling type codes or names recorded in the IMPROVEMENTS field. To enhance the accuracy of this review, active address points were also used to help determine the number of dwellings per property, which contributed to calculating the area per dwelling.

2.4.1.2 Lifestyle Review

There was an overrepresentation of Lifestyle areas, with some >6 ha, which should not have been classified as Lifestyle. In many cases where the classification was questionable, the Property VDB layer and AgriBase aligned

with a Lifestyle classification, but the WISE LU 2018 did not, or either VDB or AgriBase was marked as Lifestyle while the 2018 LU classification was missing. Additionally, there might have been inconsistencies or mismatches with the LCDB and Biodiversity inputs.

To address this, a review of the features classified as Lifestyle was conducted (Appendices: WISE Land Use FME Models – Lifestyle Review), followed by an examination of aerial imagery to identify any necessary manual adjustments.

2.4.2 Review by Territorial Authorities

Ten territorial authorities within the Waikato Region (Hamilton City, Hauraki District, Matamata-Piako District, Otorohanga District, South Waikato District, Taupo District, Thames-Coromandel District, Waikato District, Waipa District, Waitomo District) were consulted for feedback on the draft WISE 2023 land use layer. In previous updates each territorial authority (TA) received hard copy maps of their territory and its urban areas for mark up. For this update, they were given access to a web viewer, enabling them to freely navigate, zoom in and out at different scales, and explore the data. They could take screenshots, annotate them, and return them as feedback. Some territorial authorities preferred having an alternative option and were sent screenshots to mark up and return. Two authorities requested extracts of the DRAFT WISE 2023 land use layer for their territory to make changes and provide feedback. They were explicitly informed that the dataset was a draft and was strictly for review purposes to identify necessary updates.

Response times varied among the territorial authorities, with some quicker to provide feedback than others. Efforts were made to follow up with those slower to respond to expedite the process. Updates to the WISE 2023 land use layer were implemented as feedback from each territorial authority was received.

2.5 Converting Vector layer to Raster

The polygon WISE LU layer was reprojected to NZMG coordinate system. Following this, the polygon layer was converted into a 20m grid layer (Figure 4 and Figure 5) using a maximum area cell alignment method to ensure consistent cell size and alignment (Appendices: Generate Raster Grid Layer). The environment settings were configured to ensure the extent met the specified requirements. The 20m grid was then resampled to create a 100m raster (Figure 4 and Figure 5), employing a maximum area method to assign the value of the most prevalent land use class within each cell.

2.6 Considerations

While automation ensures that criteria are applied consistently, reducing inconsistency and human error, it also removes subjectivity. This means that while a scenario might technically meet the criteria, it may not fit perfectly in all situations but is still classified uniformly. It was acknowledged early in the process that the final output will not be perfect.

The 2018 WISE land use vector polygon dataset only had the land-based land use classifications within the Waikato Region, which meant aquaculture, area outside region, marine, and marine outside region were not represented. These features while missing in the 2018 polygon layer were represented in the 100m raster layer. The raster layer is made up of pixels of a given size (e.g. 100m × 100m) which provides a general indication of the majority land use within that area. Unlike vector datasets raster datasets do not have an attribute table, instead they typically consist of a single band (array) of values for a specific characteristic being measured. Raster datasets do not provide the easiest, most accurate or complete reference to compare against when carrying out analyses with polygon vector datasets. The 2023 WISE land use layer update has all WISE LU classifications captured in a single polygon vector format to better facilitate future updates. This approach is preferable to the prior process of compiling various generalised raster layers as it results in a more complete reference dataset that is easier to convert and resample into a 100-meter raster.

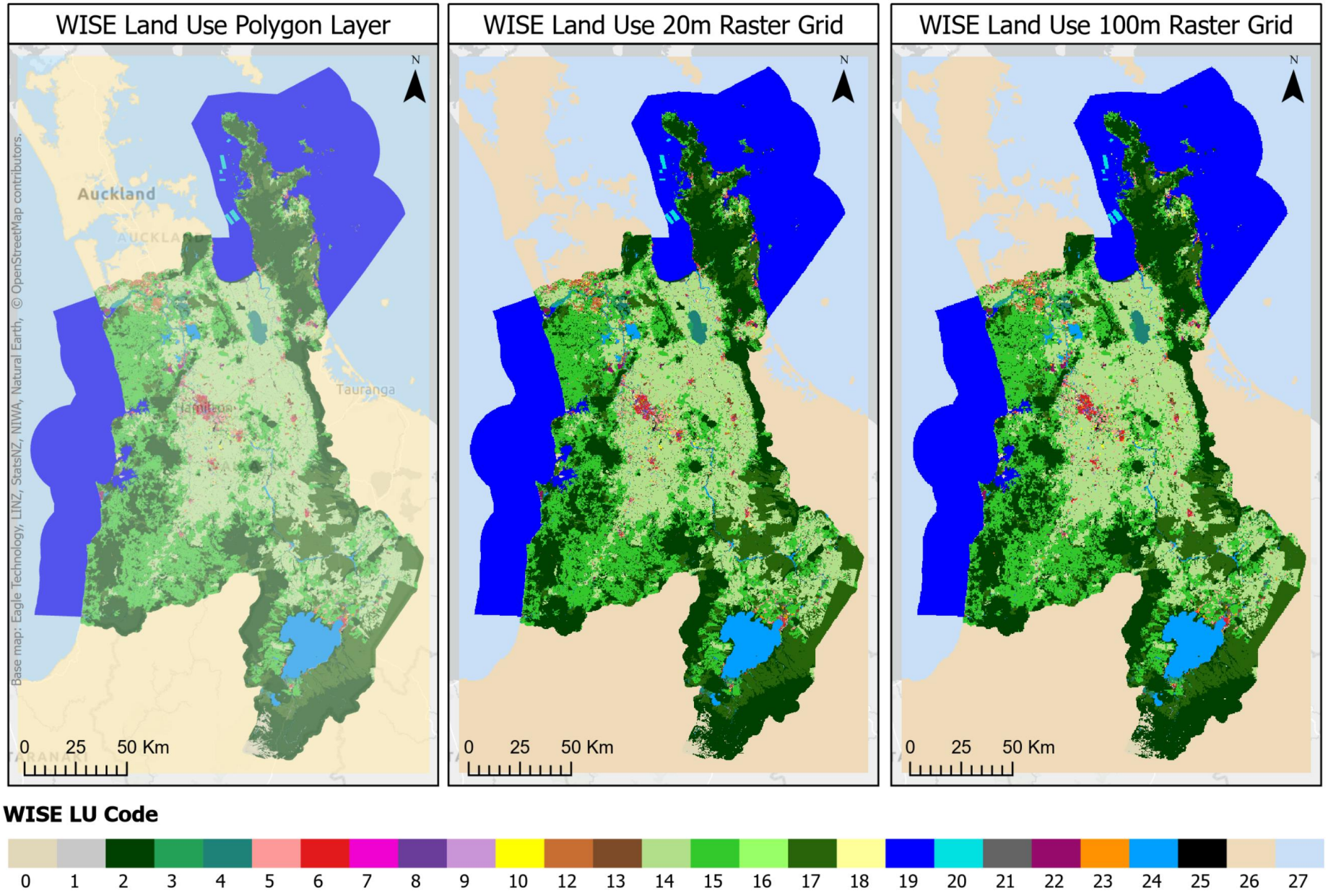


Figure 4 WISE Land Use output layers: view at full extent and transparency applied to polygon layer for some placename context.

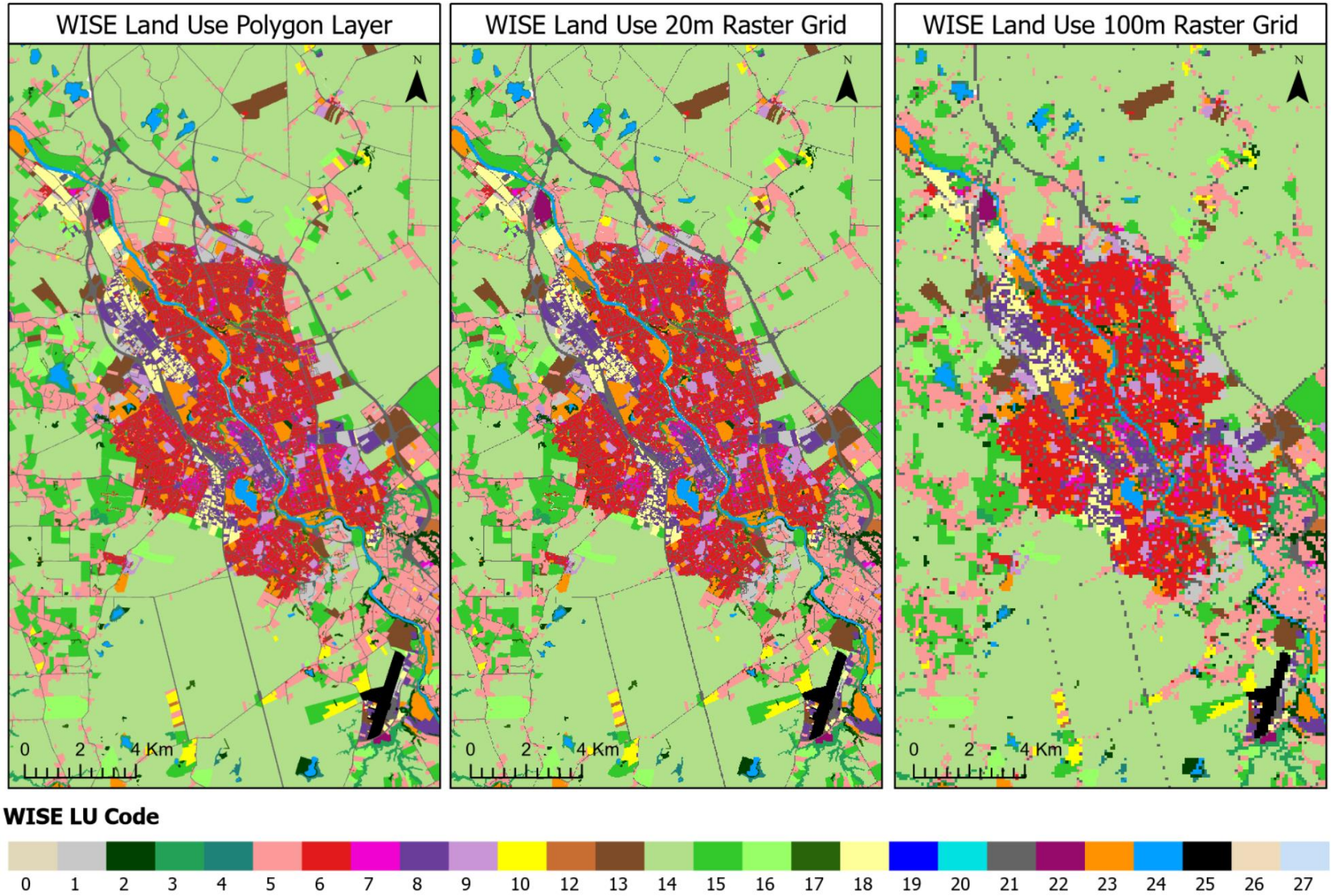


Figure 5 A closer look at the difference between the 3 WISE Land Use output layers (polygon, 20m raster grid, and 100m raster grid) in a close up of Hamilton City.

Additionally, it is important to allow more time to gather feedback from the various territorial authorities for a more comprehensive review

3. Zoning

Zoning is managed separately from land use because zoning defines the planning rules for permissible activities in specified areas, while land use reflects the current use of the land in those areas. Unlike the WISE region-wide land use layer, zoning is specific to each territorial authority. Thus, each territory needs its own 100m grid zoning input to WISE. It is crucial that the zones in each territorial authority's district plan zone spatial layer align with what is input into the WISE Matrix to ensure consistency. Zones are numbered starting from 0, and sometimes multiple similar zones may be given the same grid value.

When a zoning layer requires updating, the proposed district plan zoning data is obtained from the respective territorial authority. This data should contain the same zones as those updated in the WISE Matrix. Zones are assigned grid values and overlaid with the WISE mask extent, which adopts the highest value as an unclassed record.

In the 2023 update, zoning changes were made for both the Waitomo (Table 3 and Figure 6) and Waikato (Table 4 and Figure 7) districts.

Table 3 Waitomo District Zones with grid values assigned.

WISE Grid Value	Zone Name in WISE Matrix	Zone Description from WISE Matrix
0	Residential	Located in Te Kuiti and Piopio where approximately half of the district's population live. Primary purpose is to provide for housing needs of the district.
1	Commercial Zone	Located in Te Kuiti and Piopio, these towns have a defined central business area, providing commercial and retail activities to residents, visitors and the travelling public.
2	Industrial Zone	This zone supports a range of general industrial activities within Piopio and Te Kuiti, acknowledging higher levels of noise, site coverage and reduced amount of on-site amenity.
3	General Rural Zone	Rural areas of the district are primarily a pastoral, working environment that are reliant on the land and soil resource to support a range of activities including farming, forestry, tourism and recreation. Highly Productive land comprises 10% of general rural zone.
4	Rural Production Zone	
5	Rural Lifestyle Zone	
6	Settlement Zone	
7	Open Space Zone	This area relates to Reserves Act and Conservation Act land, and lands owned and administered by Waitomo DC. May include some unclassified reserve land at which community hall and clubrooms may be appropriate.
8	Natural Open Space Zone	This area relates to reserves mostly administered by Department of Conservation and some private land.
9	Future Urban Zone	Greenfield land identified as potentially suitable for urbanisation. Transitional use is mostly rural activities which do not comprise future residential land use. Copies the activity status of the General Rural Zone.
10	Māori Purpose Zone	This zone provides for the social, cultural, environmental and economic needs of mana whenua and seeks to reenable reconnection with sites of ancestral importance.
11	Tourism Zone	This zone provides for future, mixed-use development that complements the tourism focus of the Waitomo caves area.
12	*Unclassed*	*(Empty space covered by raster mask extent. Required to build up complete grid layer of correct extent for WISE model)*

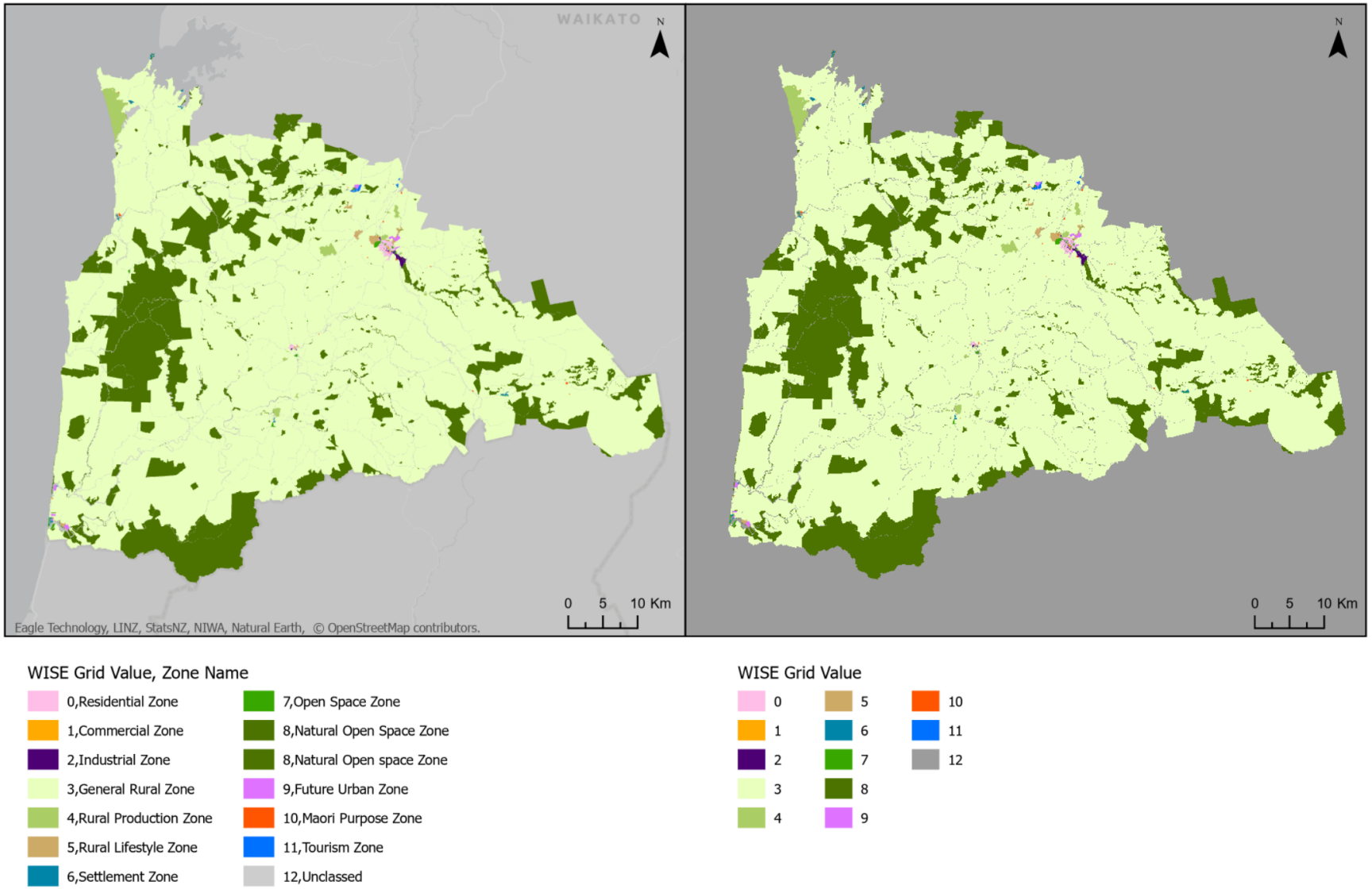


Figure 6 Waitomo District zones - polygon input matching a code to a zone (Left) and the 100m raster output (Right).

Table 4 Waikato District Zones with grid values assigned.

WISE Grid Value	Data Source Value	Zone Name in WISE Matrix	Zone Description from WISE Matrix
0	GRZ	General Residential	The zone covers the predominantly residential areas of the townships within the district. Amenity levels are anticipated to be high, being suitable for residential development with commercial and industrial land uses generally provided for elsewhere within townships.
1	LLRZ	Large Lot Residential	Covers areas on the outskirts of Tuakau, Pokeno and Te Kowhai
2	MRZ	Medium Density Residential	Enable more efficient use of residential zoned land and provide for hight intensity than typically found in General Residential.
3	TCZ	Town Centre	The role of the Town Centre Zones in Raglan, Huntly, Ngāruawāhia, Te Kauwhata, Pokeno and Tuakau are to be recognised and maintained as the primary retail, administration, commercial service and civic centre for each town.
4	LCZ	Local Centre	Provides for a range of commercial and community activities that service the needs of the residential catchment.
4	COMZ	Commercial	Identifies areas used predominately for a range of commercial and community activities.
5	GIZ	General Industrial	The General Industrial Zone provides for a range of industrial and other compatible activities that can operate in close proximity to more sensitive zones due to the nature and relatively limited effects of these activities.
6	HIZ	Heavy Industrial	The Heavy Industrial Zone provides for a range of industrial and other compatible activities that generate potentially significant effects on more sensitive zones.
7	GRUZ	General Rural	Provides for predominantly primary production activities, including intensive indoor primary productions, and occasional community facilities, rural related commercial and industrial activities, and agricultural produce processing facilities.
8	RLZ	Rural Lifestyle	Maintain the semi-rural character of large lot rural-residential development. Typically located on fringe of towns and provides a transition to the surrounding rural area.
9	FUZ	Future Urban	The Future urban zone identifies areas suitable for urbanisation in the future and provides for activities that are compatible with and do not compromise potential future urban use.
10	BTZ	Business Tamahere Zone	Relates to a small commercial area in Tamahere only.
11	SETZ	Settlement Zone	Covers small settlements located within predominantly rural areas. These areas comprise a cluster of residential dwellings and in some cases small-scale community facilities.
12	OSZ	Open Space Zone	The Open Space Zone provides for a range of active and passive recreational activities along with limited associated facilities and structures.
12	MSRZ	Hampton Downs Motor Sport and Recreation	The zone is a regionally significant motor sport and recreation facility.
12	TKAZ	Te Kowhai Airpark	The Te Kowhai Airpark Zone covers land near the existing airfield at Te Kowhai and is described as a strategically significant, safe and economically sustainable airpark that meets the current and future needs of the aviation community.
13	RPZ	Rangitahi Peninsula	The Rangitahi Peninsula Zone applies to land near Raglan that is of a character and scale that reflects its harbour setting and is compatible with Raglan's seaside village character.
14	OHI	Ohinewai Zone	Covers an area at Ohinewai.
15	*NULL*	*Unclassed*	*(Empty space covered by raster mask extent. Required to build up complete grid layer of correct extent for WISE model)*

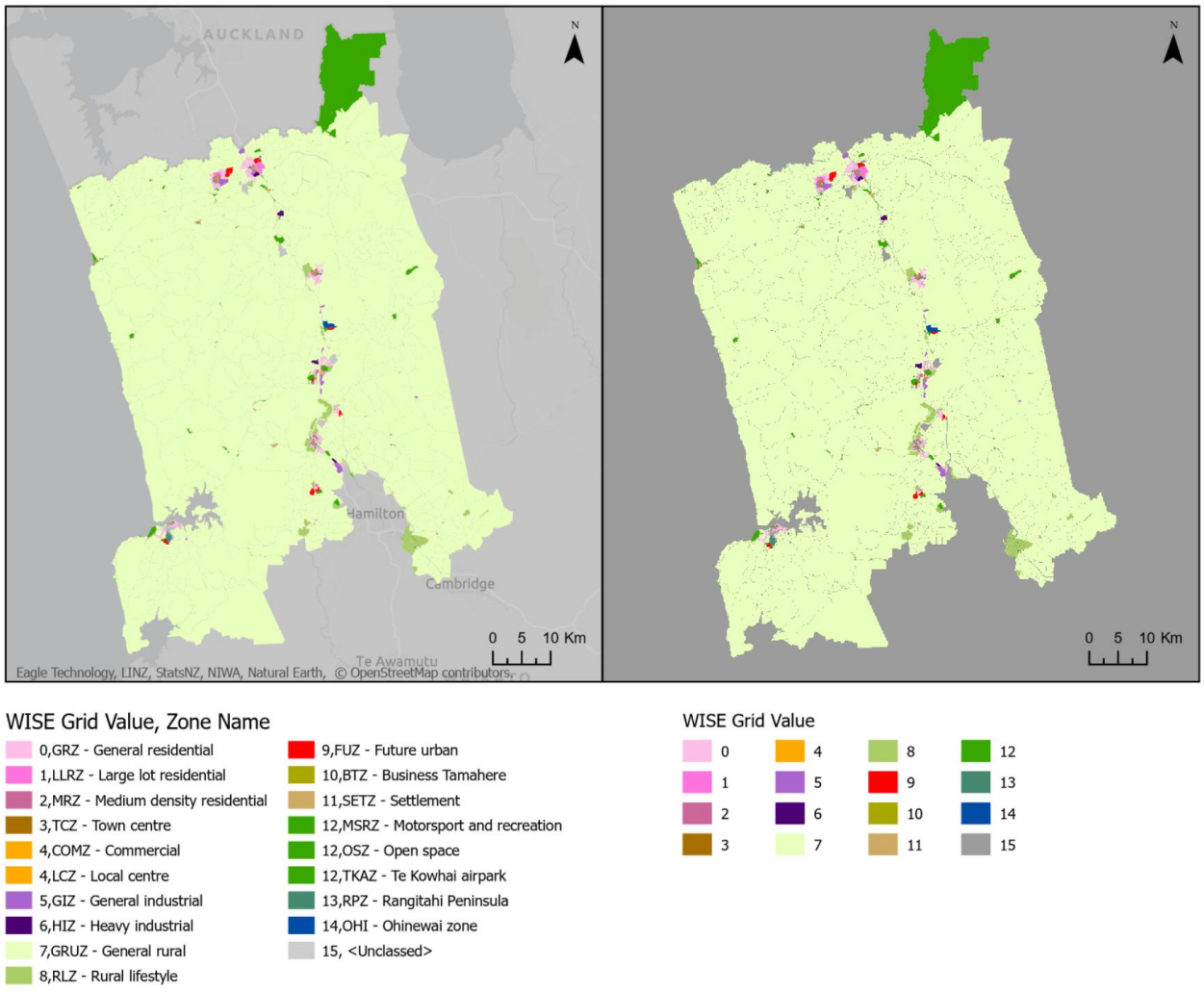


Figure 7 Waikato District zones - polygon input matched to a grid value (Left) and resulting 100m raster (Right).

4. Overlays

Overlays are treated in much the same way as the zoning on a territorial authority basis. The various precincts numbered starting from 0, with the highest value representing the unclassed area that covers the entire WISE model spatial extent. When practical, multiple precincts may share the same assigned grid value if they belong to the same logical grouping. For each territorial authority requiring updates, 100m grid precinct layers were created accordingly.

4.1 Precincts

Since both Waitomo (Table 5 and Figure 8) and Waikato (Table 6 and Figure 9) districts updated their zoning layers, it is logical to also reassess and update the overlays for these districts.

Table 5 Waitomo District precincts and grid codes assigned.

Precinct Name in WISE Matrix	Description	WISE Grid Value
Te Kumi Commercial Precinct	Provide ongoing growth of existing businesses and avoid expansion of commercial and retail outside this precinct. Encourage development that is sympathetic to adjacent railway cottages, and good level of residential amenity is maintained with development.	1
Aerodrome Precinct	This precinct has been established to facilitate the use of the site for commercial and recreational aviation activities without applying some of the more limiting provisions of the underlying general rural zone. Provides commercial aviation activities, refuelling, clubrooms and flight training. Future may include being a small strategic hub due to proximity to state highway.	0
Mokau Commercial Precinct	Promotes future of Mokau by providing a wider range of commercial services, acknowledging some industrial may occur.	2
Te Kuiti CBD Precinct	Economic analysis showed the business zone in previous district plan was too large for the demand, therefore the Te Kuiti CBD precinct was created to consolidate retail and commercial activities.	3
Amenity Precinct	This precinct acknowledges the corridor along SH37 between Hangatiki and Waitomo Caves village, and between Hangatiki along SH3 to the northern district boundary. The previous plan identified this area as an extensive landscape policy area, however this plan prioritises the need to operate and maintain the State Highway corridors. This precinct seeks to manage amenity values along this corridor.	4
Te Maika Precinct	Located at the southern entrance of Kawhia Harbour and situated on the northern point of Te Maika peninsula. The land is mostly administered by Te Maika Trust who exercise mana whenua and kaitiakitanga. The precinct contains a number of significant natural features which the rules in the precinct reflect.	5
Railway Cottage Cluster Precinct	Direct intensive residential developments away from this precinct, maintain character of railway cottages.	6
Unclassed / No Data	*(Empty space covered by raster mask extent. Required to build up complete grid layer of correct extent for WISE model)*	*7*

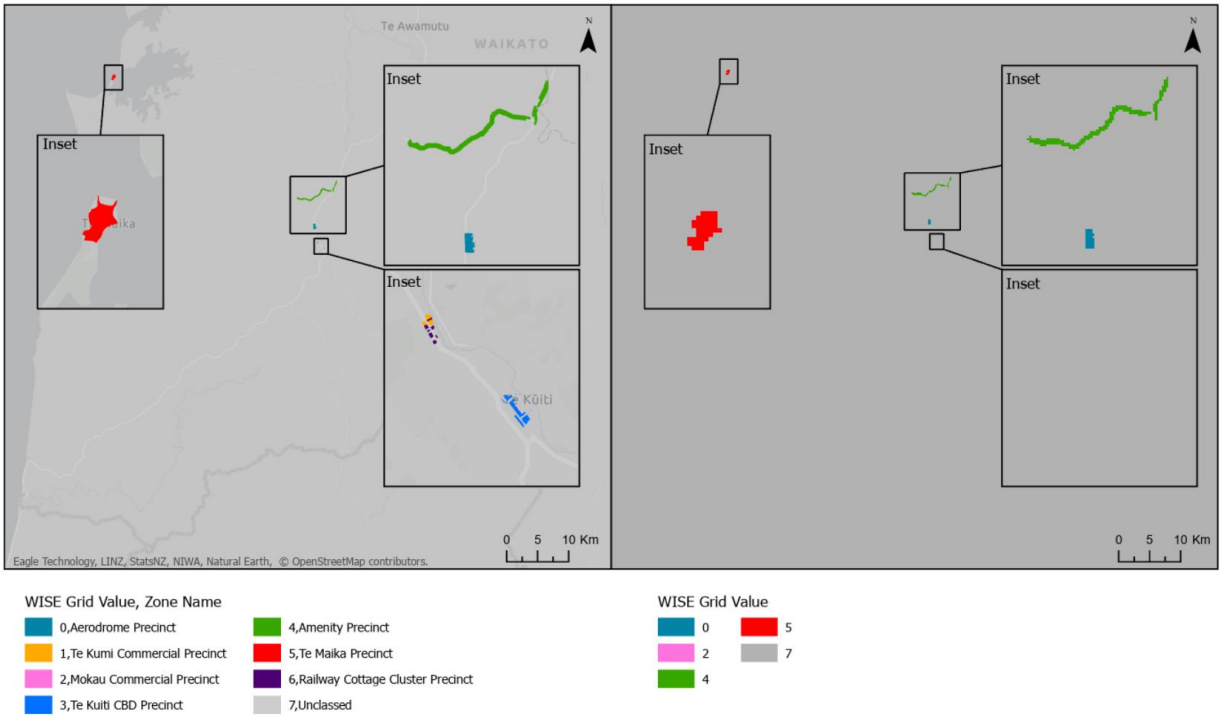
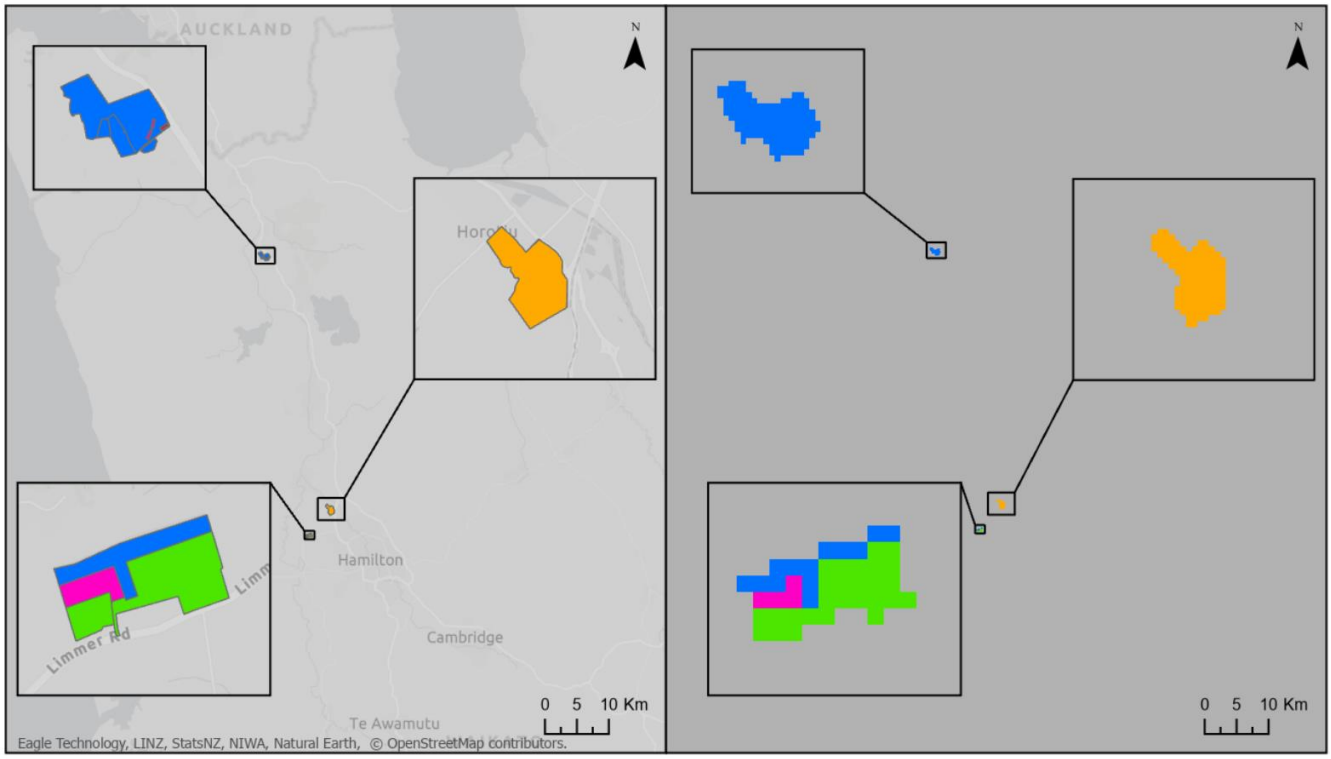


Figure 8 Waitomo District Precincts - note some of the smaller areas do not make up the majority of a 100m x 100m area so do not appear in the 100m raster output as the surrounding unclassed area is more dominant.

Table 6 Waikato District Precincts and grid codes assigned.

	Precinct Name in WISE Matrix	WISE Grid Value
Te Kowhai Airpark Precincts	Precinct A: Runway and Operations	1
	Precinct B: Commercial	2
	Precinct C: Medium Density Residential	3
	Precinct D: Residential	3
Hampton Downs Motorsports Park Precincts	Operational Motorsport Area – Precinct A Activity	1
	Business and Industrial Area – Precinct B Activity	1
	Minor Race Track Area – Precinct C	1
	Residential Apartments – Precinct D	2
	Industrial Units – Precinct E	4
Horotiu Industrial Park		0



WISE Grid Value, Zone Name

- 0,PREC6 Horotiu industrial park precinct
- 1,PREC14 Hampton Downs operational motorsport area precinct
- 1,PREC15 Hampton Downs industrial area precinct
- 1,PREC16 Hampton Downs minor race track area precinct
- 1,PREC27 Te Kowhai runway and operations precinct
- 2,PREC17 Hampton Downs residential apartments precinct
- 2,PREC28 Te Kowhai commercial precinct
- 3,PREC29 Te Kowhai medium density residential precinct
- 3,PREC30 Te Kowhai residential precinct
- 4,PREC18 Hampton Downs industrial units precinct
- 5,Unclassed

WISE Grid Value

- 0
- 1
- 2
- 3
- 5

Figure 9 Waikato District precincts overlay side by side of input and output themed alike.

4.2 Natural Hazards

Along with the update of zoning and precincts, Waitomo District also updated their Natural Hazards overlays (Table 7), so a 100m grid layer has been generated (Figure 10) to update the WISE model.

Table 7 Waitomo District Natural Hazards and grid codes assigned.

WISE Grid Value	
0	Hazard Area
0	Building Platform Suitability Areas A and B
0	Building Platform Suitability Area C
1	High Risk Flood Zone
2	Unclassed / No Data

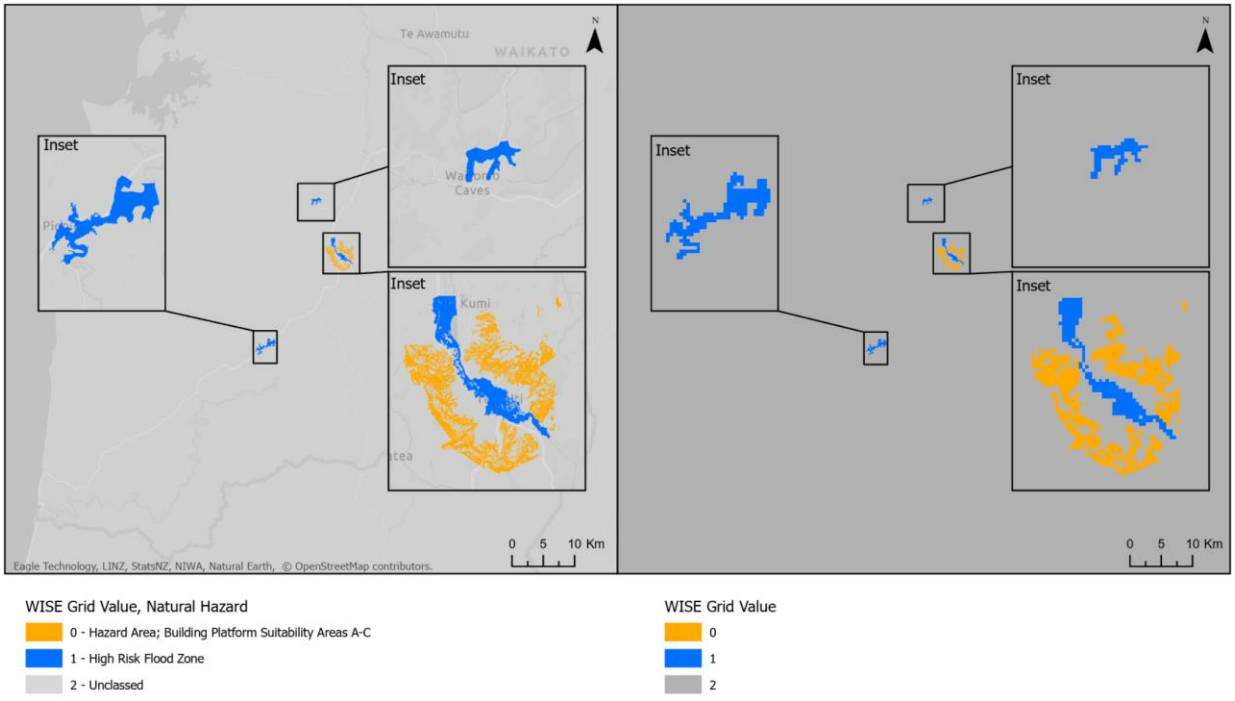


Figure 10 Waitomo District Natural Hazards overlay side by side of input and output themed alike.

5. Future Growth

Future growth projections highlight areas where different territorial authorities anticipate both planned and unplanned, or aspirational growth within their boundaries. Some authorities have detailed what this growth might involve and its projected timeline. Typically, these plans are reflected in their operative district plans and/or growth strategies (e.g., Future Proof), with a local focus that can vary in terms of timeframes and types of growth. To gather this information, each territorial authority was engaged to explain the need for these projections as part of the WISE model's predictive capabilities. They were informed about the specific information sought, including examples of potential land use changes (such as low-density residential, medium to high-density residential, commercial, and industrial) and projected timelines (e.g. 0-5 years, 6-10 years). Since each territorial authority varies, both in characteristics and growth potential, the level of detail in the information provided differed accordingly (Table 8 and Table 9).

Table 8 Future growth categories for territories within the Waikato Region where both land use and timeframe has been identified.

		WISE Future Growth Grid value per TLA					
Land Use	**Time Frame**	**Hamilton City**	**Matamata-Piako**	**South Waikato**	**Taupo**	**Thames-Coromandel**	**Waipa**
Future Urban Zone	0-5 Years			0			
	>5 Years			1			
Low Density Residential	0-5 Years	0	0			0	
	6-10 Years	1	1			1	
	0-10 Years						0
	>10 Years						1
Med-High Density Residential	0-5 Years	2	2			2	
	6-10 Years	3	3			3	
	>10 Years	4				4	
Future Infill and Intensification	0-5 Years			2			
	>5 Years			3			
Large Lot Residential	0-10 Years						2
	>10 Years						3
Future Residential	0-5 Years				0		
	6-10 Years				1		
	>10 Years				2		
Future Residential Greenfield	>5 Years			4			
Commercial	0-5 Years	5					
Industrial	0-5 Years	6	4			6	
	6-10 Years	7	5				
	0-10 Years						4
	>5 Years			5			
	>10 Years						5
Mixed	0-5 Years			6		6	
	>5 Years			7			
Unclassed / No Data	*Null*	8	6	8	3	7	6

Table 9 Future growth categories for territories where no timeframe has been specified.

	WISE Future Growth Grid value per TLA		
Land Use	**Otorohanga**	**Waikato**	**Waitomo**
Future Growth Area			0
Urban Expansion Area		0	
Urban Limited Service	0		
Factory Site	1		
Unclassed / No Data	2	1	1

Appendices

WISE Land Use Input Datasets

Codes for AgriBase

AsureQuality provided the AgriBase data for the 2023 WISE Land Use update under a data use agreement. To comply with the agreement's terms, the raw data is not displayed as a map in this document. However, the list of Farm Type codes and their descriptions (Table 10) is included, as it does not disclose specific farm identifiers, locations, or ownership details.

Table 10 AgriBase FarmType Codes and descriptions.

FARM TYPE CODE	FARM TYPE DESCRIPTION
0TH	Enterprises not covered by other classifications
ALA	Alpaca and/or Llama Breeding
API	Beekeeping and hives
ARA	Arable cropping or seed production
BEF	Beef cattle farming
CAR	Calf Rearing
DAI	Dairy cattle farming
DEE	Deer farming
DOG	Dogs
DPL	Dairy Plant/Factory
DRY	Dairy dry stock
EMU	Emu bird farming
FIS	Fish, Marine fish farming, hatcheries
FLO	Flowers
FOR	Forestry
FRU	Fruit growing
GOA	Goat farming
GRA	Grazing other people's stock
HOP	Hop Growing
HOR	Horse farming and breeding
LIF	Lifestyle block
MPL	Manufacturing Plant
MTW	Meat Slaughter Premises
NAT	Native Bush
NEW	New Record - Unconfirmed Farm Type

FARM TYPE CODE	FARM TYPE DESCRIPTION
NOF	Not farmed (i.e. idle land or non-farm use)
NUR	Plant Nurseries
OAN	Other livestock (not covered by other types)
OPL	Other planted types (not covered by other types)
OST	Ostrich bird farming
OTH	Enterprises not covered by other classifications
PIG	Pig farming
PKH	Packhouse
POU	Poultry farming
RAB	Rabbit breeding and farming
RES	Residential livestock on property
RET	Retail
SAW	Sawmill
SHP	Sheep farming
SHW	Showgrounds
SLY	Saleyards
SNB	Mixed Sheep and Beef farming
SPO	Sport Grounds
TOU	Tourism (i.e. camping ground, motel)
TRD	Transport/ truck depot
UNS	Unspecified (i.e. farmer did not give indication)
VEG	Vegetable growing
VIT	Viticulture, grape growing and wine
ZOO	Zoological gardens

Key	Relevance
ABC	Value has been assigned to AgriBase features within the Region, but are not considered as these categories are either not well defined or are better represented by other data inputs (e.g. Property Valuations Database, LCDB)
ABC	Value has not been assigned to any AgriBase features within the Region. A different input dataset (e.g. Property Valuations Database) may have these identified instead.
ABC	Category used in WISE 2018 LU update and again in 2023
ABC	Class flagged as potentially "Other Agriculture" in WISE LU 2023 update.
ABC	Class flagged as potentially "Lifestyle" in WISE LU 2023 update.
ABC	Class flagged as potentially "Forestry" in WISE LU 2023 update.

The AgriBase data is used to identify several classes within the WISE Land Use (LU) polygon layer. From this, a 20m grid layer based on the WISE LU code is created, and then a 100m grid is derived by resampling. As a result, the boundary details and attributes from the original AgriBase data are not preserved in detailed form. The spatial features from AgriBase are grouped into broader WISE classifications and dissolved before being combined with other datasets, causing the original farm boundaries to be somewhat lost. This should remove some of the sensitivity around identification of individual farms if a user were to use the vector polygon layer. This is of lesser significance to the raster outputs as they only possess a single numeric WISE 2023 LU code value.

Valuations Database (VDB)

The Waikato Regional Council provided the CRS Property Valuations Database (VDB) for the entire region to support the WISE 2023 land use update. Several fields from the VDB (Table 11) are retained throughout the analysis and are frequently used in the classification logic. The documentation from the 2018 WISE Land Use update included a list of various VDB land use codes that corresponded to different WISE LU Classes, with a table in the appendices that detailed the Primary and Secondary level descriptions for each land use code. Early in the 2023 update process, a matrix was developed to help visualise how these codes in the VDB correspond to the indicated WISE LU classifications identified in the 2018 documentation (Table 12).

Table 11 Valuations Database (VDB) Input data fields used.

Field	Information
VALUATION_ID	A unique property ID – helpful to retain during the process just in case there is a need to join back to the source data at a later date.
LAND_USE_CODE	Numeric codes 00-99 which relate to a Secondary classification. First digit relates to the Primary classification. The associated classifications were pulled from the WISE 2018 documentation and are listed in the table below.
VNZ_CATEGORY_CODE	This is referred to in the classification with AgriBase Data, more specifically in regard to Dairying and Sheep and Beef
CAPITAL_VALUE	Capital value – this is only used in an initial equation (Capital Value – Land Value)
LAND_VALUE	Land value – this is only used in an initial equation (Capital Value – Land Value)
IMPROVEMENTS	Provides an indication of the improvements present on the property. This has been used in the process to identify properties with dwellings (e.g. DWG, Dwelling, Unit, Apartment) and to some extent how many, as well as other features which may align to other WISE LU classes e.g. Church as Community Services, Quarry where this may not have been covered in LINZ topo 1:50,000 data, etc.
AREA_SQM	Area used in WISE 2018 documentation, which has been applied up until first draft in this assessment. However, the rules around 0 values that were assigned to Medium to High Density Residential meant revisiting and re-assessing based on the geometric feature area (Shape_Area). So would not recommend relying on this field in the future.
Shape_Area	Would suggest next time a new field with the original feature Shape_Area is added and populated before any feature fracturing from overlaying various layers, and that this be used in the residential assessments of MHDR vs LDR vs Lifestyle instead of AREA_SQM.

Table 12 VDB Land Use Code and related Primary and Secondary descriptions with indicative potential WISE Land use classes per VDB land use code based on 2018 WISE LU documentation.

Valuations Database			WISE Indicative Class Options		
Primary	**Land Use Code**	**Secondary Name**	**Class 1**	**Class 2**	**Class 3**
0 - Multiuse at primary level	00	Vacant or intermediate	Further Assessment		
	01	Rural industry	Further Assessment		
	02	Lifestyle	Lifestyle	Further Assessment	
	03	Transport	Utilities	Further Assessment	
	04	Community Services	Community Services		
	05	Recreational	Urban Parks and Recreation	Further Assessment	
	06	Utility Services	Utilities	Further Assessment	
	07	Industrial	Manufacturing	Further Assessment	
	08	Commercial	Commercial	Further Assessment	
	09	Residential	Further Assessment		
1 – Rural Industry	10	Multi-use within rural industry			
	11	Dairy	Dairying	Further Assessment	
	12	Stock finishing	Dairying	Sheep and Beef	
	13	Arable farming			
	14	Store livestock	Dairying	Sheep and Beef	
	15	Market gardens and orchards	Vegetable Cropping	Horticulture	
	16	Specialist livestock	Other Agriculture		
	17	Forestry			
	18	Mineral extraction	Mines and Quarries		
	19	Vacant			
2 - Lifestyle	20	Multi-use within lifestyle	Lifestyle	Low Density Residential	Further Assessment
	21	Single unit 1	Lifestyle	Low Density Residential	Further Assessment
	22	Multi unit 2	Lifestyle	Low Density Residential	Further Assessment
	29	Vacant	Lifestyle	Vacant	Further Assessment
3 - Transport	30	Multi-use within transport	Utilities		
	31	Road transport	Utilities		
	32	Parking	Utilities		
	33	Rail transport	Utilities		
	34	Water transport	Utilities		
	35	Air transport	Airports		
	39	Vacant	Utilities		

Valuations Database			WISE Indicative Class Options		
Primary	Land Use Code	Secondary Name	Class 1	Class 2	Class 3
4 -Community Services	40	Multi-use within community services	Community Services		
	41	Educational	Community Services		
	42	Medical and allied	Community Services		
	43	Personal and property protection	Community Services		
	44	Religious	Community Services		
	45	Defence	Community Services		
	46	Halls	Community Services		
	47	Cemeteries and crematoria	Community Services		
	49	Vacant	Community Services		
5 - Recreational	50	Multi-use within recreational	Community Services		
	51	Entertainment	Community Services		
	52	Active indoor	Community Services		
	53	Active outdoor	Urban Parks and Recreation	Community Services	
	54	Passive indoor	Community Services		
	55	Passive outdoor	Urban Parks and Recreation	Community Services	
	59	Vacant	Urban Parks and Recreation	Community Services	
6 - Utility Services	60	Multi-use within utility services			
	61	Communications	Utilities		
	62	Electricity	Utilities		
	63	Gas	Utilities		
	64	Water Supply	Utilities		
	65	Sanitary	Utilities		
	66	Postboxes	Utilities		
	67	Other	Utilities		
	69	Vacant	Utilities		

Valuations Database			WISE Initial Indicative Class Options		
Primary	Land use Code	Secondary Name	Class 1	Class 2	Class 3
7 - Industrial	70	Multi-use within industrial	Manufacturing	Commercial	
	71	Food, drink, and tobacco	Manufacturing	Commercial	
	72	Textiles, leather, and fur	Manufacturing	Commercial	
	73	Timber products and furniture	Manufacturing	Commercial	
	74	Building materials other than timber	Manufacturing	Commercial	
	75	Engineering, metalworking, appliances, and machinery	Manufacturing	Commercial	
	76	Chemicals, plastics, rubber, and paper	Manufacturing	Commercial	
	77	Other industries, including storage	Manufacturing	Commercial	
	78	Depots and yards	Manufacturing	Commercial	
	79	Vacant	Manufacturing	Commercial	Vacant
8 - Commercial	80	Multi-use within commercial	Commercial		
	81	Retail	Commercial	Low Density Residential	Medium to High Density Residential
	82	Services	Commercial	Low Density Residential	Medium to High Density Residential
	83	Wholesale	Commercial	Low Density Residential	Medium to High Density Residential
	84	Offices	Commercial	Low Density Residential	Medium to High Density Residential
	85	Car parking	Commercial	Utilities	Medium to High Density Residential
	89	Vacant	Commercial	Utilities	Vacant
9 - Residential	90	Multi-use within residential	Low Density Residential	Medium to High Density Residential	Lifestyle
	91	Single unit excluding bach	Low Density Residential	Medium to High Density Residential	Lifestyle
	92	Multi-unit	Low Density Residential	Medium to High Density Residential	Lifestyle
	93	Public communal unlicensed			
	94	Public communal licensed			
	95	Special accommodation			
	96	Communal residence dependent on other use			
	97	Bach			
	98	Car parking			
	99	Vacant	Low Density Residential	Vacant	Further Assessment

WISE Land Use FME Models

FME – Feature Manipulation Engine

FME (Feature Manipulation Engine) is a powerful data integration platform designed to manipulate, transform, and automate data workflows across various formats and systems. Developed by Safe Software (https://fme.safe.com/), FME is widely used in geographic information systems (GIS) for its ability to handle spatial data with efficiency and precision.

Key functionalities of FME include:

- **Data Transformation:** FME supports converting data between hundreds of formats, allowing users to seamlessly integrate data from different sources.
- **Spatial Data Processing:** It excels at handling spatial data, enabling users to perform complex transformations, analyses, and validations on geographic datasets.
- **Automation:** FME enables the automation of repetitive data tasks, streamlining workflows and saving time for users.
- **Data Quality Improvement:** Through its diverse set of tools, FME helps in cleansing and enriching data to ensure high quality and consistency.
- **Integration Capabilities:** By connecting data across various platforms, FME acts as a bridge between different applications and systems, enhancing interoperability.

FME Form is a desktop application that allows users to design workbenches (models) for reading, transforming, translating, and writing data. Due to the large volume of data and the complexity of analyses in WISE, FME proved to be more efficient since it supports a broader range of data formats and operates faster than some desktop GIS alternatives.

1600m Buffered Regional Boundary.fmw

One of the first steps was to define the 1.6 km buffered Waikato Region extent which would serve as a basis for clipping many other input datasets. The regional council_2023_clipped__generalised_ layer was used for this purpose because it aligns with the coastline, unlike the unclipped version that includes the region's offshore extent. To streamline the process, a standalone model (Figure 11) was created to generate this layer once, avoiding the need to replicate the same steps across multiple models.

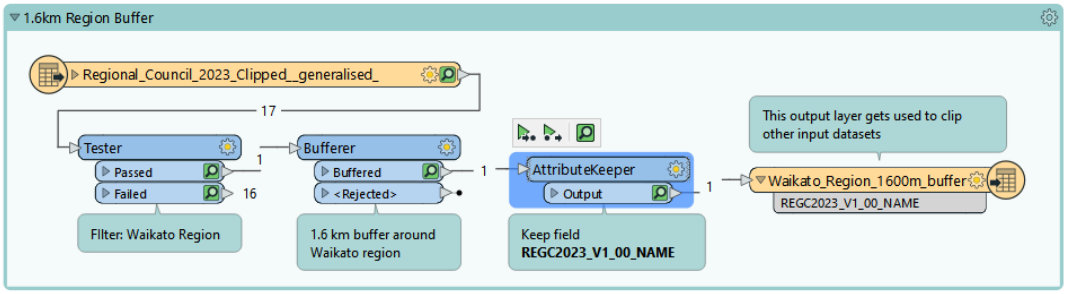


Figure 11 Buffer Waikato Region by 1.6km to use as a clip on other inputs.

Mines and Quarries.fmw

This model (Figure 12) clips and combines the LINZ topo 1:50k Mines and Quarry layers, then overlays these features with the Mines and Quarries features from the WISE 2018 LU layer. The resulting output was visually inspected against aerial imagery using the NZ imagery basemap to ensure accuracy before it was included in the mass compilation and classification model process (Figure 20)

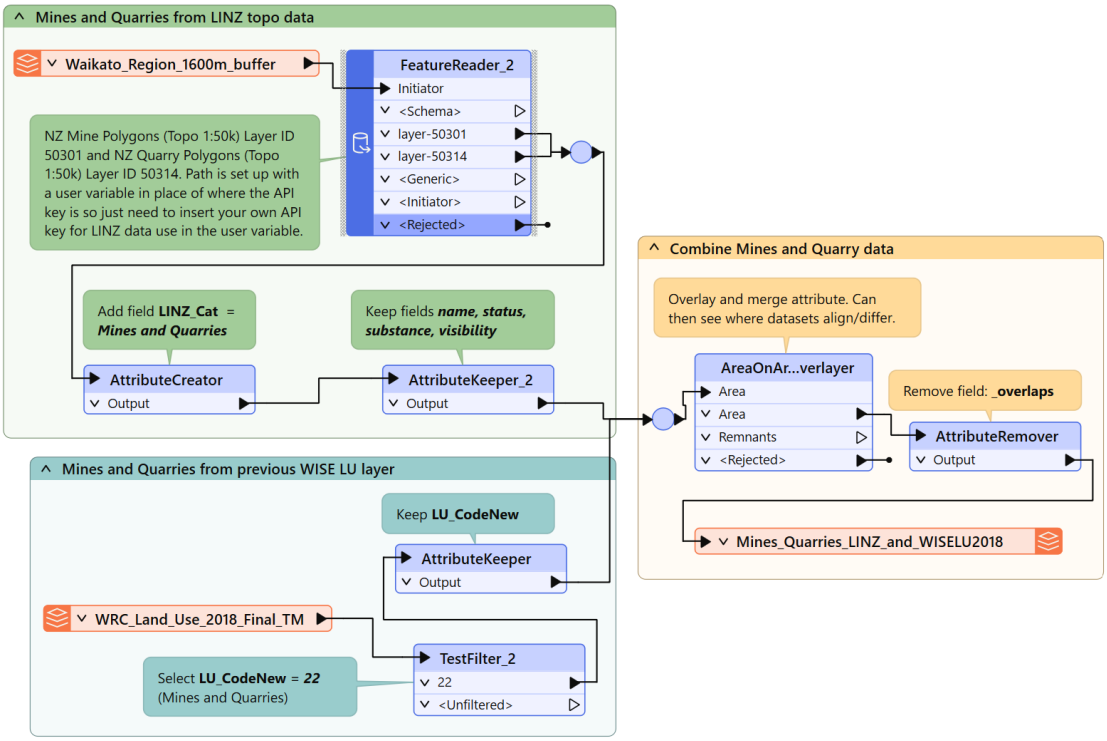


Figure 12 FME model for Mines & Quarries - Combine LINZ and WISE LU 2018 Mine classes for comparison.

WRC BioVege layer.fmw

This model (Figure 13) adds an intermediate WISE LU class (WRCBIO_WISE_LU_NAME) based on the LCDB2_Name field values noted in Table 2, removes all other fields and amalgamates adjoining features of the same WISE LU class into larger singular features. The output of this becomes an input in a later model (Figure 20) that compiles and classifies the inputs within the Waikato Region and its 1.6 km buffer.

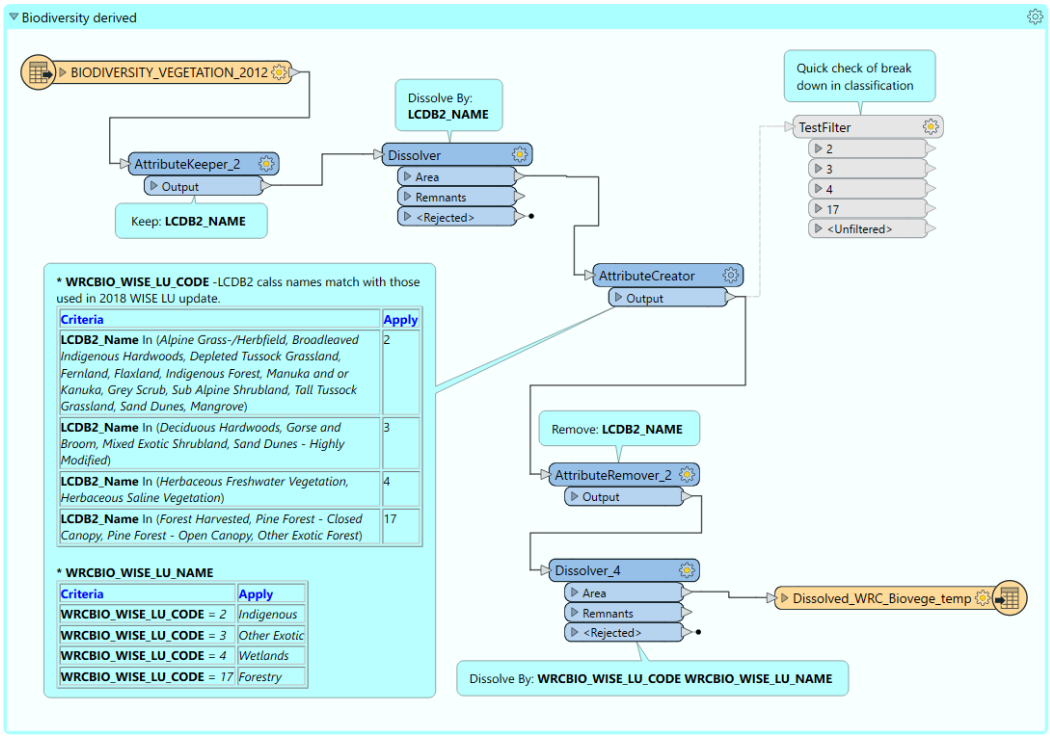
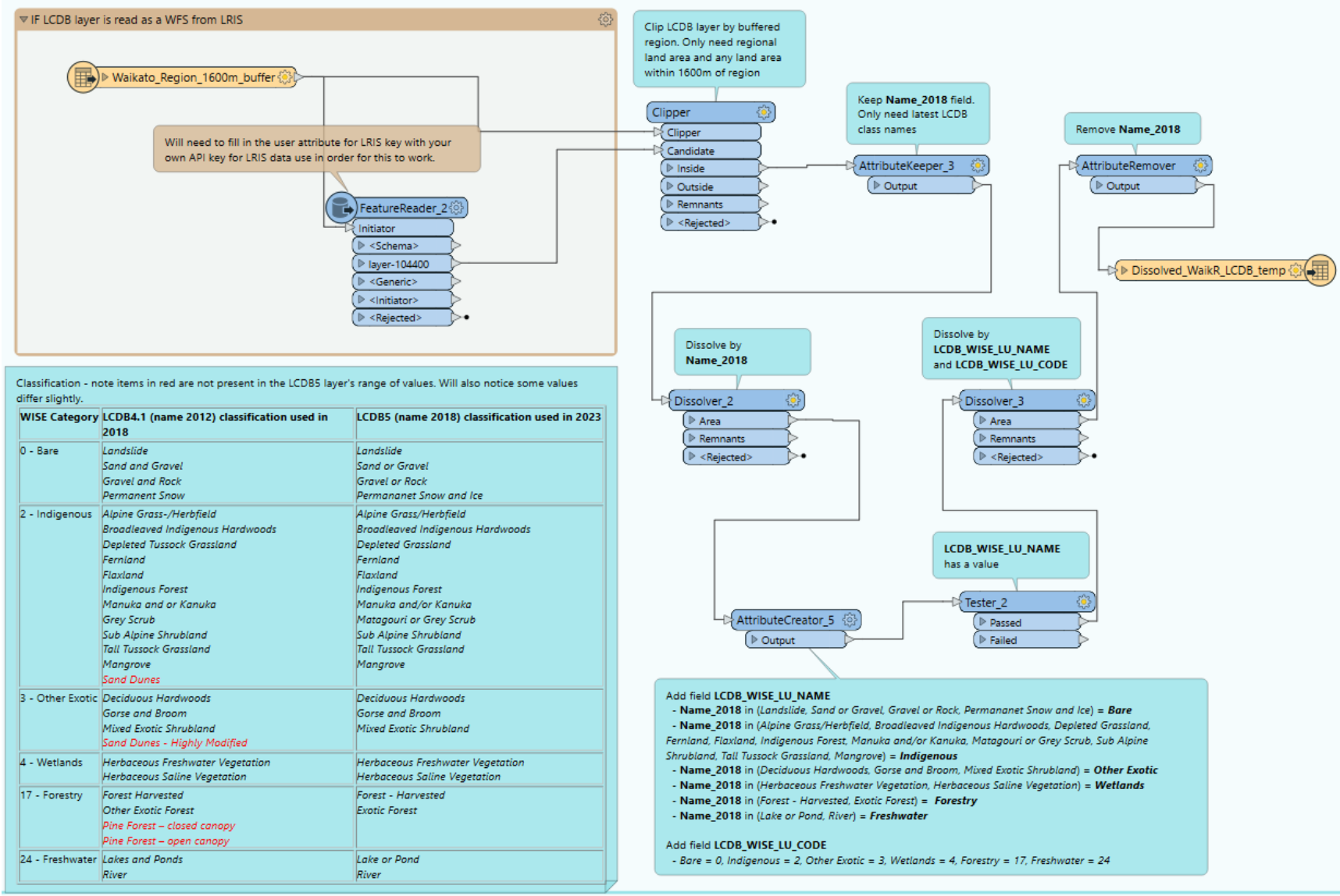


Figure 13 FME model to classify the Waikato Regional Council Biodiversity layer to WISE classification before dissolving to generate a simplified intermediate input layer for further analysis.

LCDB layer.fmw

This model (Figure 14) uses the 1.6 km buffered Waikato Region layer to clip the Landcare Research LCDB5 layer then assigns the WISE LU classes based on criteria outlined in Table 2. A new field was added to capture the WISE LU categories specifically for this layer (LCDB_WISE_LU_NAME). Features assigned a WISE LU class were dissolved to form a simplified intermediate input data source, which only contained the new LCDB_WISE_LU_NAME. A brief visual check was carried out on freshwater items, as some included wastewater ponds. This layer forms another input to the mass compilation and classification process (Figure 20).



Classification - note items in red are not present in the LCDB5 layer's range of values. Will also notice some values differ slightly.

WISE Category	LCDB4.1 (name 2012) classification used in 2018	LCDB5 (name 2018) classification used in 2023
0 - Bare	*Landslide* *Sand and Gravel* *Gravel and Rock* *Permanent Snow*	*Landslide* *Sand or Gravel* *Gravel or Rock* *Permananet Snow and Ice*
2 - Indigenous	*Alpine Grass-/Herbfield* *Broadleaved Indigenous Hardwoods* *Depleted Tussock Grassland* *Fernland* *Flaxland* *Indigenous Forest* *Manuka and or Kanuka* *Grey Scrub* *Sub Alpine Shrubland* *Tall Tussock Grassland* *Mangrove* *Sand Dunes*	*Alpine Grass/Herbfield* *Broadleaved Indigenous Hardwoods* *Depleted Grassland* *Fernland* *Flaxland* *Indigenous Forest* *Manuka and/or Kanuka* *Matagouri or Grey Scrub* *Sub Alpine Shrubland* *Tall Tussock Grassland* *Mangrove*
3 - Other Exotic	*Deciduous Hardwoods* *Gorse and Broom* *Mixed Exotic Shrubland* *Sand Dunes - Highly Modified*	*Deciduous Hardwoods* *Gorse and Broom* *Mixed Exotic Shrubland*
4 - Wetlands	*Herbaceous Freshwater Vegetation* *Herbaceous Saline Vegetation*	*Herbaceous Freshwater Vegetation* *Herbaceous Saline Vegetation*
17 - Forestry	*Forest Harvested* *Other Exotic Forest* *Pine Forest – closed canopy* *Pine Forest – open canopy*	*Forest - Harvested* *Exotic Forest*
24 - Freshwater	*Lakes and Ponds* *River*	*Lake or Pond* *River*

Figure 14 FME model to classify LCDB by WISE classification and dissolve by this new classification to generate a simplified intermedaite input layer for further analysis.

Roads.fmw

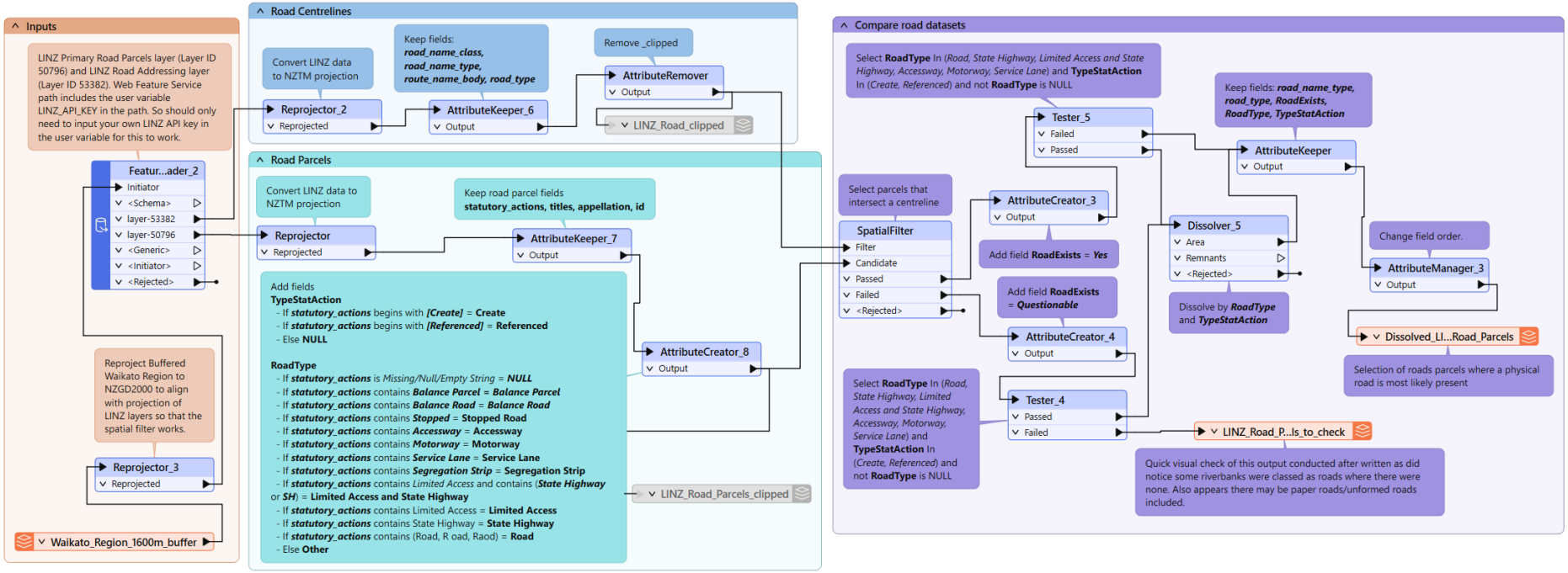


Figure 15 FME model to identify road parcels that intersect with the road centreline and those that do not which underwent a quick visual inspection.

Combine AgriBase and VDB.fmw

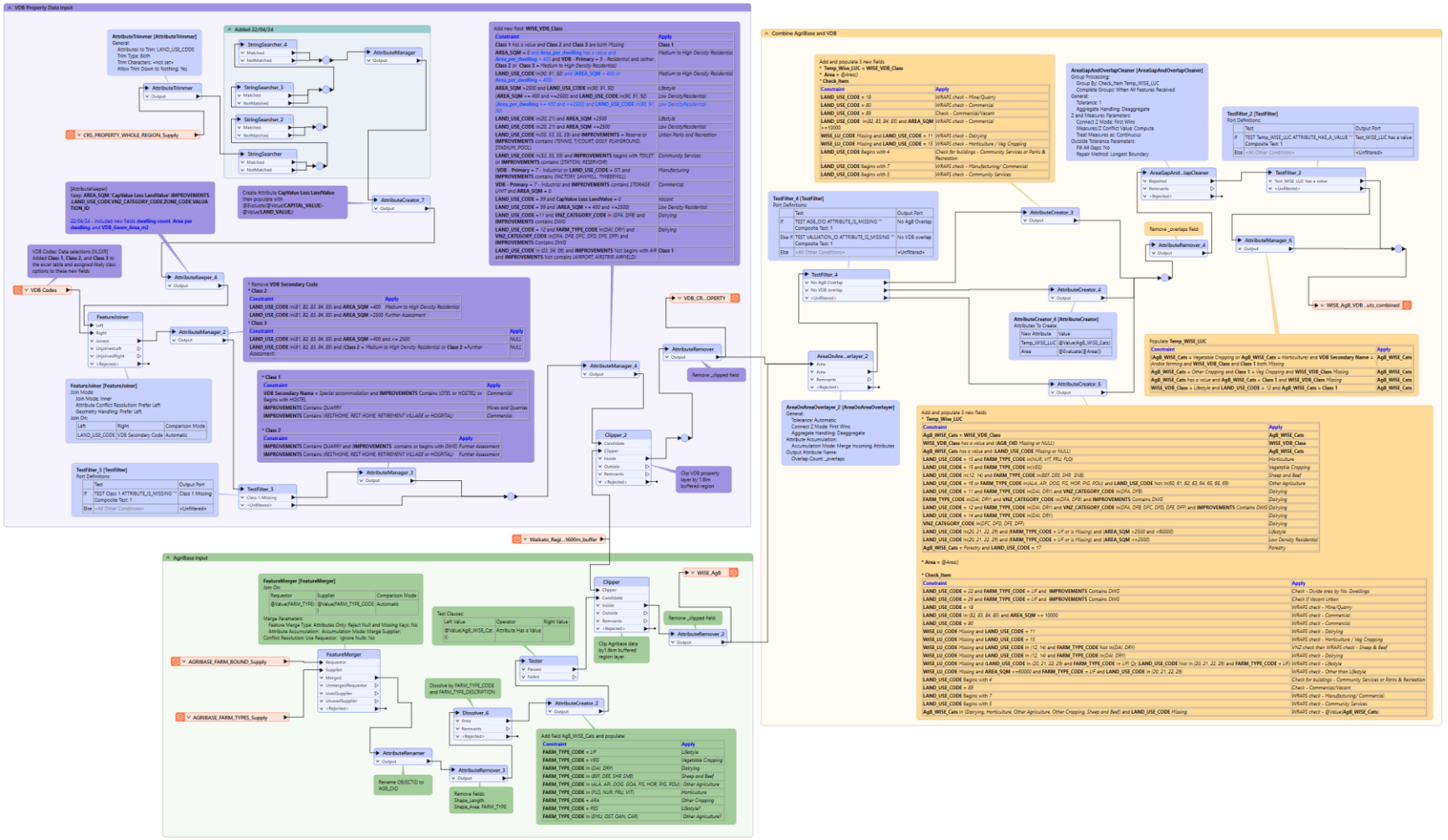


Figure 16 FME model to combine both the Property Valuations Database and AgriBase datasets and attempt to carry out intermediate WISE classification before generating a simplified dissolve intermediate layer for use in further analysis.

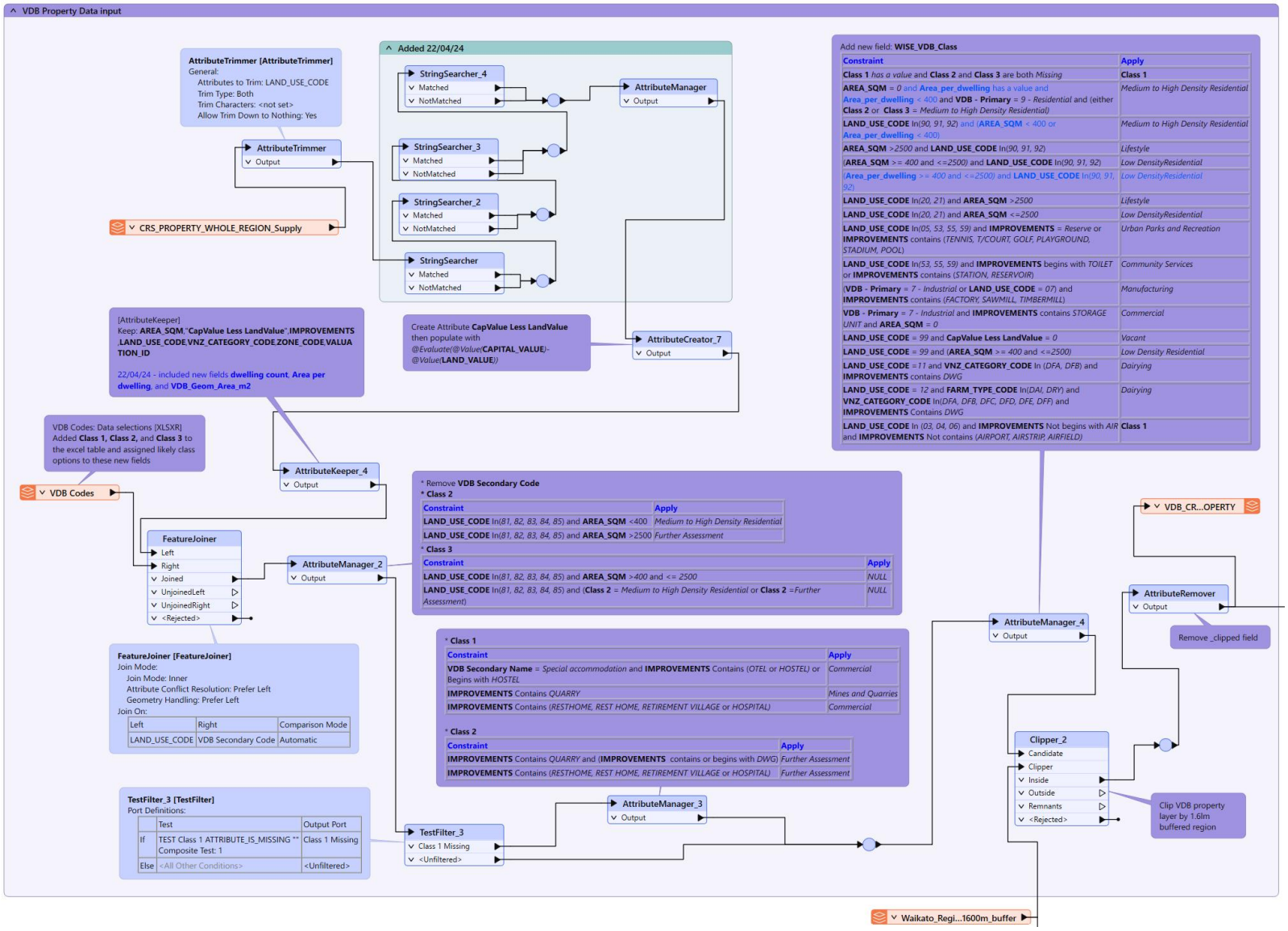


Figure 17 Preparation of the property valuations database before the FME model combines this with the prepared AgriBase data in the same FME mode.

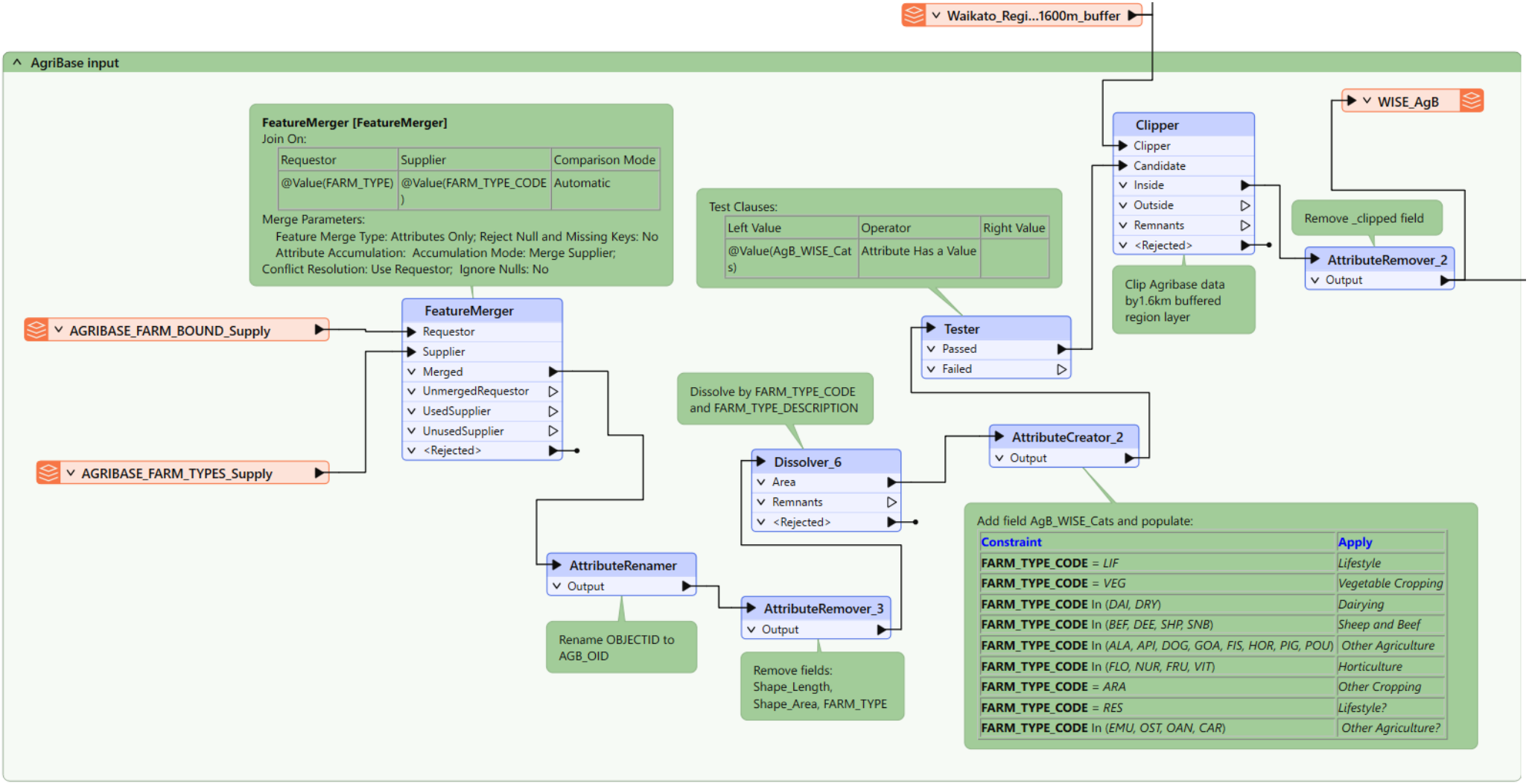


Figure 18 Preparation of the AgriBase data with initial WISE land use classifications based on farm type prior to combining with the prepared property valuations dataset in the same FME model.

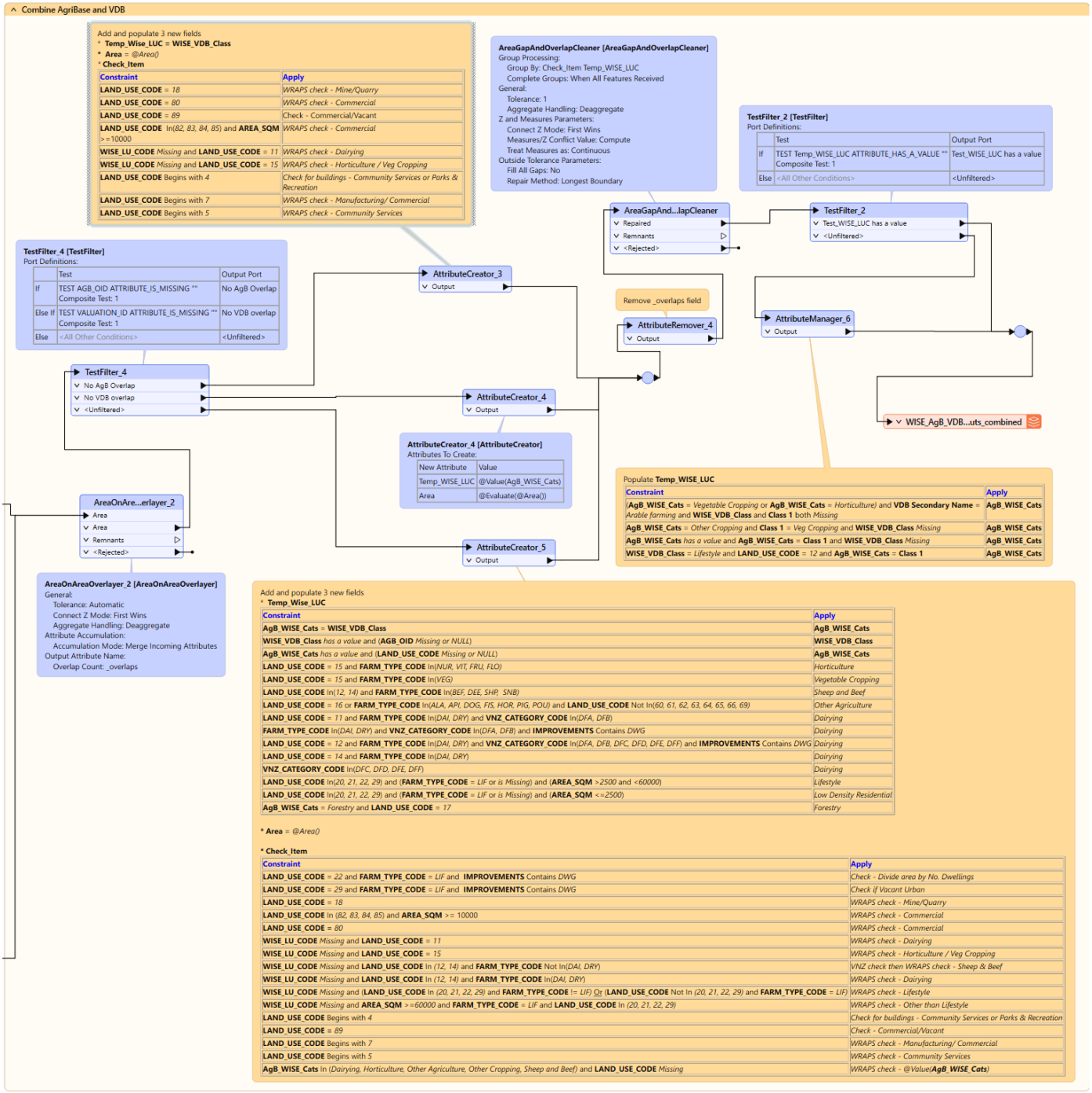


Figure 19 Overlay of both the AgriBase and Property Valuations Database followed by some intermediate WISE land use classification.

Compile Inputs and Classify.fmw

This is a complex model (Figure 20). It begins with preparing multiple input datasets (Figures 21 to 26), which are then combined into a single, highly fractured layer containing all fields from each input (Figure 27). Next, a series of majority rules classifications is applied, after which the data is split (Figure 28) and processed through separate classification pathways (Figures 29 to 40). These pathways use targeted logic to automate the majority of the classification process, minimising the need for manual classification. Eventually, all streams are merged back together (Figure 41), allowing for final checks to identify any unclassified data before producing the final output.

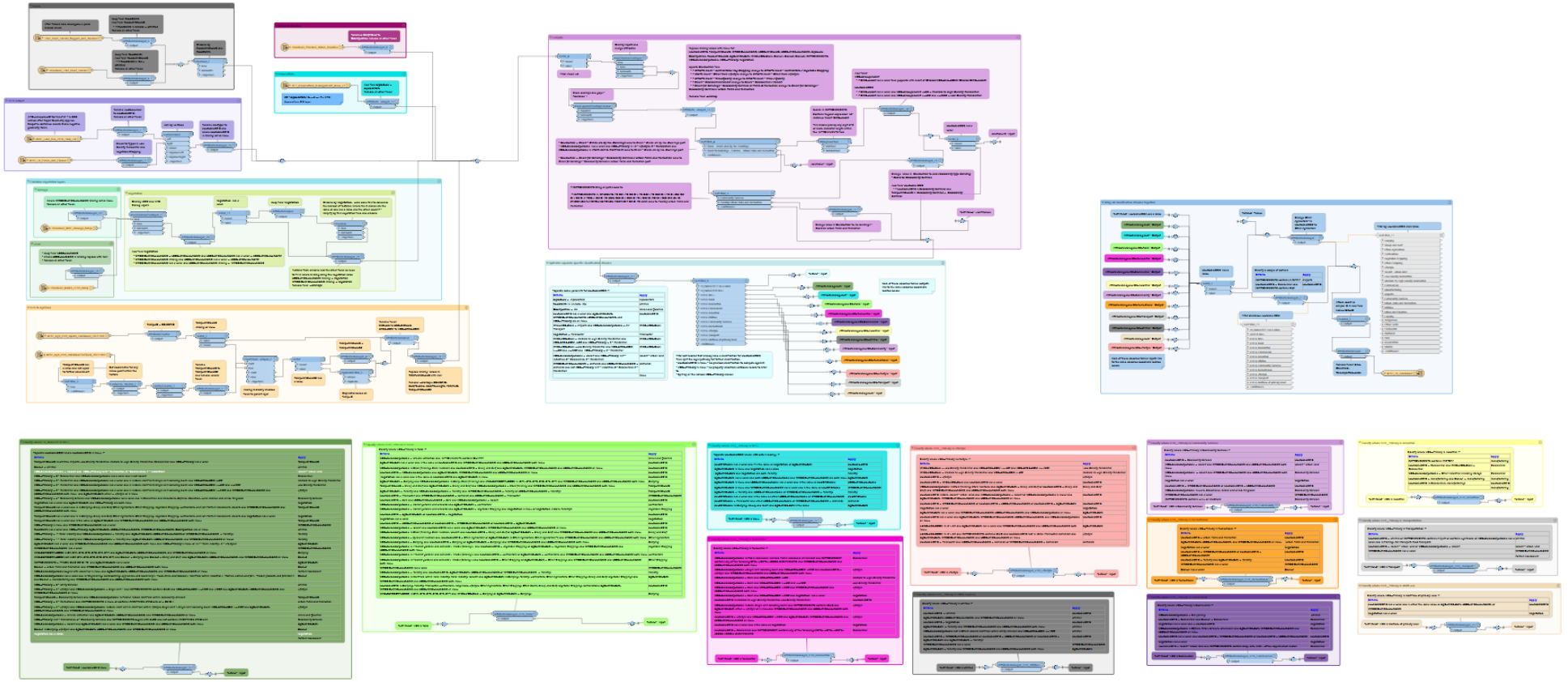


Figure 20 Combine multiple inputs together and carry out a series of classifications across the various intermediate WISE classification fields.

Mines and Quarries Input

In ArcGISPro, a field named "Confirmed" was added to the *Mines_Quarries_LINZ_and_WISELU2018* layer. A quick visual inspection of these polygon features was conducted using aerial imagery to verify if each polygon accurately represented a part of a mine or quarry. Features confirmed (*Yes* value) via visual aerial inspection were dissolved to generate the Dissolved_Checked_Mines_Quarries layer that has been used as input in this model (Figure).

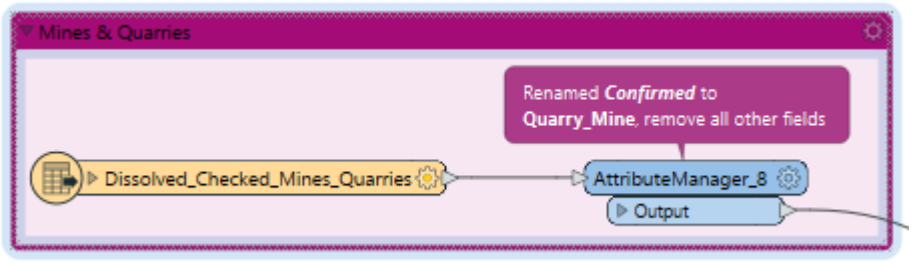


Figure 21 Close up of mines and quarry model component with field renaming prior to multi-overlay process with the other inputs.

Aquaculture

This is the easiest classification as it should not overlap with any other classifications other than the default marine area ones added later. As it has no useful fields, one is added to denote what its WISE LU class is (Figure).

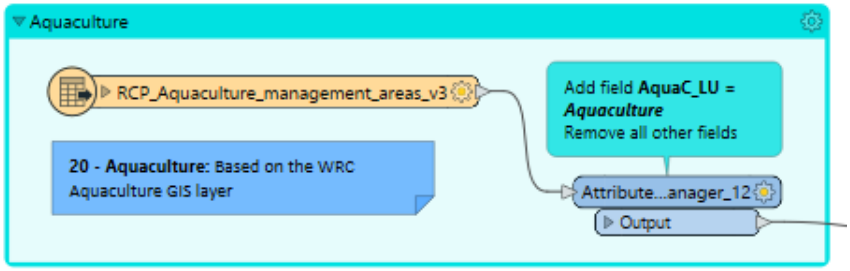


Figure 22 Close up on aquaculture model input, where a field to record the WISE LU as aquaculture before removing all other fields.

WISE 2018 LU output

The 2018 WISE Land Use layer included only numeric codes, lacking their corresponding descriptions. Therefore, the first step was to join a table containing these descriptions (Figure 23). This addition simplifies working with the layer by providing a clearer reference for the multiple codes involved.

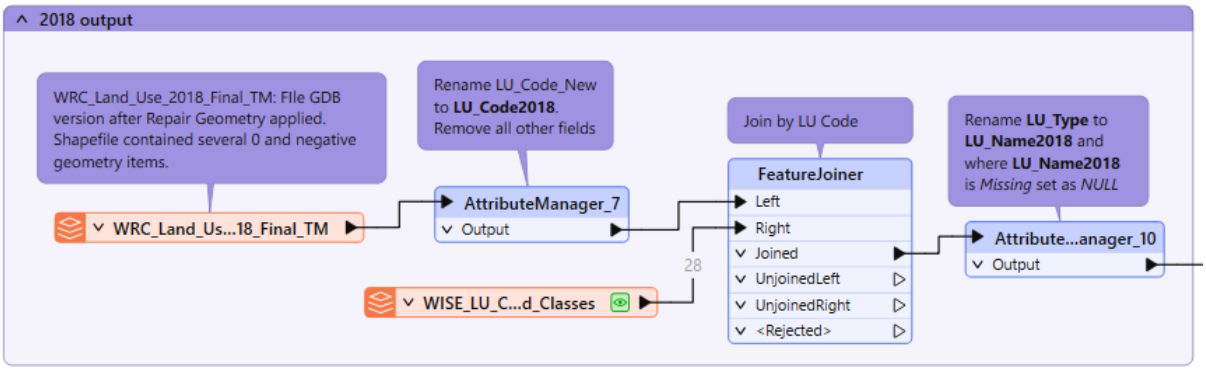


Figure 23 Part of the model that prepares the WISE 2018 LU input prior to combining with the other datasets.

Roads

The Roads model (run earlier in the process), generates two output polygon layers. One layer consists of parcels that have been dissolved, where the parcels had a higher confidence of representing actual roads. The other layer, which requires a brief manual review, includes features with less certainty. This review is necessary because some stream banks and beaches were mistakenly identified as roads, despite the absence of an actual road nearby. These misidentifications could include paper roads, forestry roads, or similar features. After the manual review, the two layers are merged back together (Figure 24).

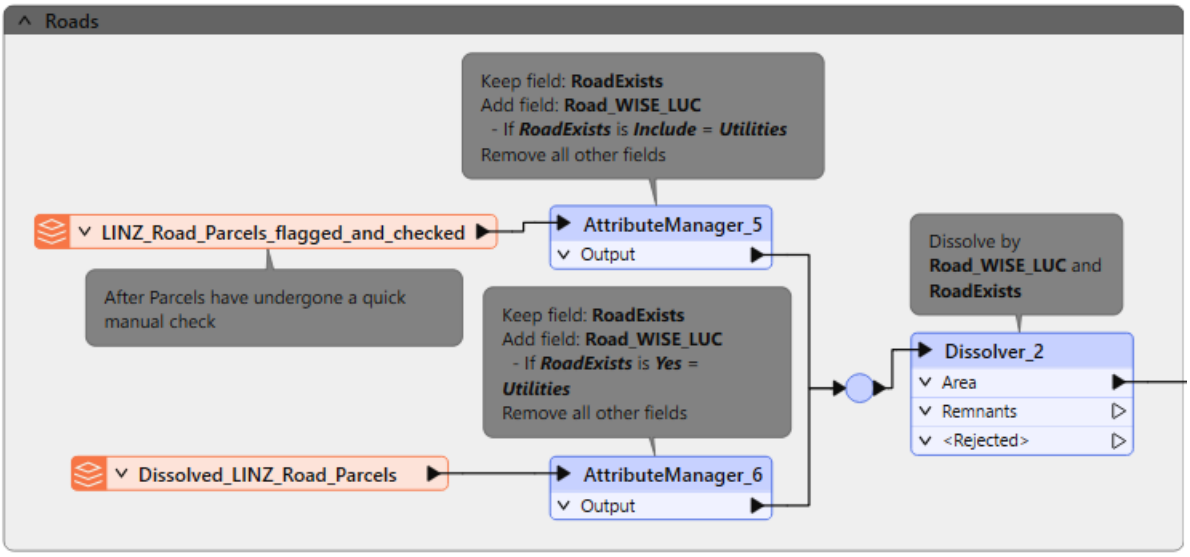


Figure 24 Prepare Roads input combining the features that were manually checked with those that aligned with road centrelines. Dissolve to simplify prior to combining with other inputs.

Vegetation inputs

If the values in these fields are the same, or if one field has a value while the other is marked as "Missing" (meaning one layer is present while the other is not, which is different from NULL), populate the "Vegetation" field with the available value. This approach aims to streamline the classification process (Table 13 and Figure 25).

Table 13 Logic applied in defining values to apply in new Vegetation field.

Scenario	Result
WRCBIO_WISE_LU_NAME = LCDB_LU_NAME	New Vegetation field populated with LCDB_LU_NAME
WRCBIO_WISE_LU_NAME *has no value and* LCDB_LU_NAME *has a value*	New Vegetation field populated with LCDB_LU_NAME
WRCBIO_WISE_LU_NAME *has a value and* LCDB_LU_NAME *has no value*	New Vegetation field populated with WRCBIO_WISE_LU_NAME
WRCBIO_WISE_LU_NAME and LCDB_LU_NAME both have values but differ	*No value assigned (Further assessment required.)*

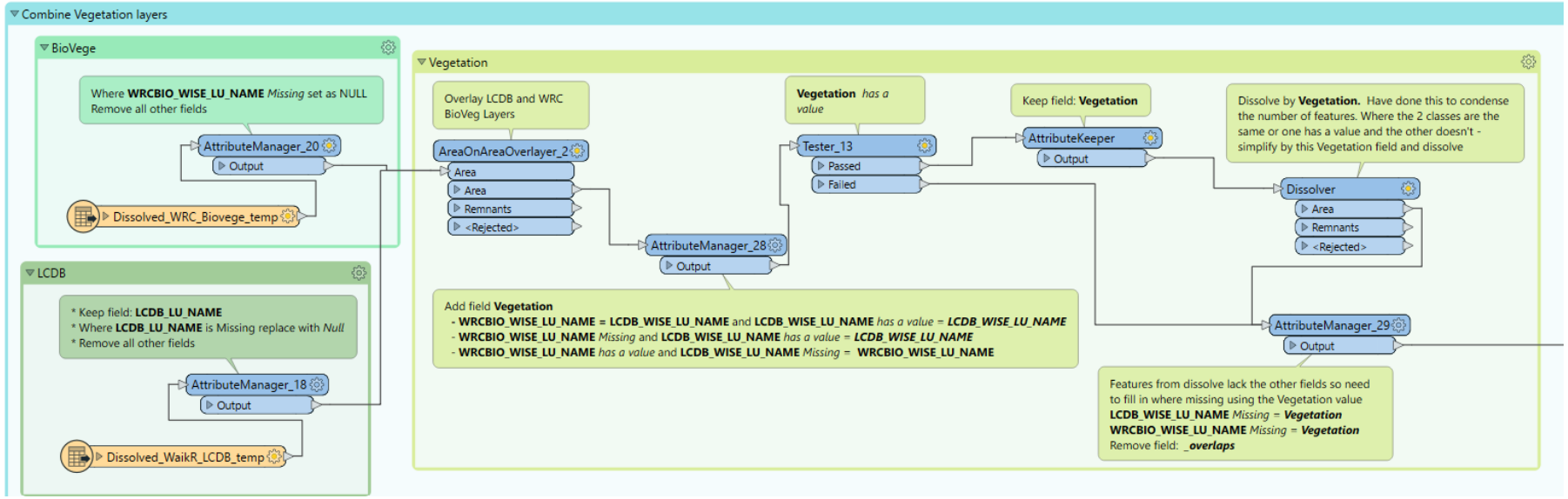


Figure 25 Overlay the LCDB and WRC Biodiversity intermediate classed layers and add field named Vegetation to record the overriding WISE LU class where the two inputs are identical, or one has a value, and the other does not. Introduced to cut down on logic statements downstream.

VDB and AgriBase

After running the model outlined under the heading Combine AgriBase and VDB, a brief manual review of certain flagged features was conducted using aerial imagery. The Temp_Wise_LUC field was updated for features where a quick decision could be made about their classification. Importantly, no feature geometry was modified during this inspection. To integrate these updates into the full dataset—comprising combined AgriBase and VDB inputs—without altering geometry or creating duplicate features, the reviewed subset was first converted to a central point within each polygon. This step ensured an accurate spatial relationship with the correct feature (Figure 26).

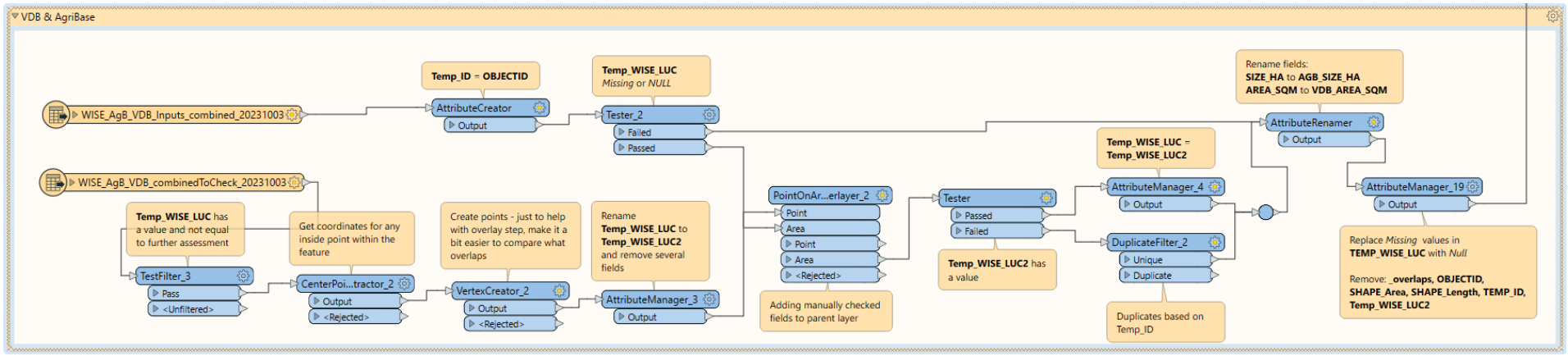


Figure 26 Preparation of combined AgriBase and Property VDB data after some early manual checks were carried out.

Initial group compilation

This is where Mines and Quarries, Aquaculture, WISE 2018 data, Roads, Vegetation, and VDB AgriBase inputs converge (Figure 27).

- Check geometry Area of all features is greater than 0 m^2
- Overlay (union) all polygon inputs to generate a more fragmented layer where the attributes for all inputs are merged into one layer.
- Run the area gap and overlap cleaner to help tidy up any overlaps, slithers, and small gaps within 1m tolerance.
- In the attribute manager,
    - Replace Missing string with Null values for several fields. Missing is the default value applied to a feature of a layer that didn't have that field going in to the overlay and hasn't overlapped with the layer that possesses a value for that field. Setting these to NULL for easier downstream analyses.
    - Make some minor changes to the *Check_Item* field – ensure any '/' has a space each side and that any '&' is replaced with 'and', also fix any typos.
    - Remove the _overlaps field that was added by default by the overlay process.
- Filter
    - Items flagged to check number of dwellings to divide property area by
    - Items flagged to check for buildings to help distinguish between Community Services and Urban Parks and Recreation
- For those filtered to check for dwellings, check if the *IMPROVEMENTS* field contains any digits (numbers). The value of the digit if present is recorded in a new *DWG_count* field, otherwise the value assigned is NULL.
    - Add a field *VDB_Area_per_unit* to record the resulting property area when equally divided by number of dwellings. Following this where *DWG_count* has a value populate *LU_Name2023* where it meets the criteria for either Medium to High Density Residential or Low Density Residential.
- Further filter those filtered to check for buildings to help differentiate between community services and urban parks and recreation.
    - If the *IMPROVEMENTS* are limited to some combination of BRIDGE, FG, OB, OI, OBS, POOL, ROAD, PLAYGROUND, PONDS, RESERVOIR, or XXX then filter as Possibly Urban Parks and Recreation as neither of these have a relevant building.
    - If IMPROVEMENTS contains (SCHOOL, CHURCH, HALL, TOILET, LIBRARY, LIBAR, CREMATORIUM, CEMET, SURGERY, KINDERGARTEN, KINDY, CLASS, COMMUNITY, MARAE, DAYCARE, THEATRE, COURT H, CLUB, GYM, PRISON, FIRE ST, FIREST, CLINIC, CHAPEL, CHILD CARE, CHILDCARE, REST HOM, RESTHOME, HOSPITAL, AMBULANCE, MED C, MEDICAL, POLICE ST, TEMPLE, MUSE, CENTRE, CTR) then filter as Community Services.
    - Update the *Check_Item* field for both paths to reflect the more likely option. For those filtered as Community Services, if the *LU_Name2018* and *Temp_Wise* field both state Community Services then assign this to the LU_Name2023 field.
- Filter to check if LU_Name2023 has a value, if so it can bypass the more refined classification assessments that follow. The remaining data is brought back into one path at a junction before progressing to the next set of steps as a means to visually check the count of features is correct and there is not any left behind.

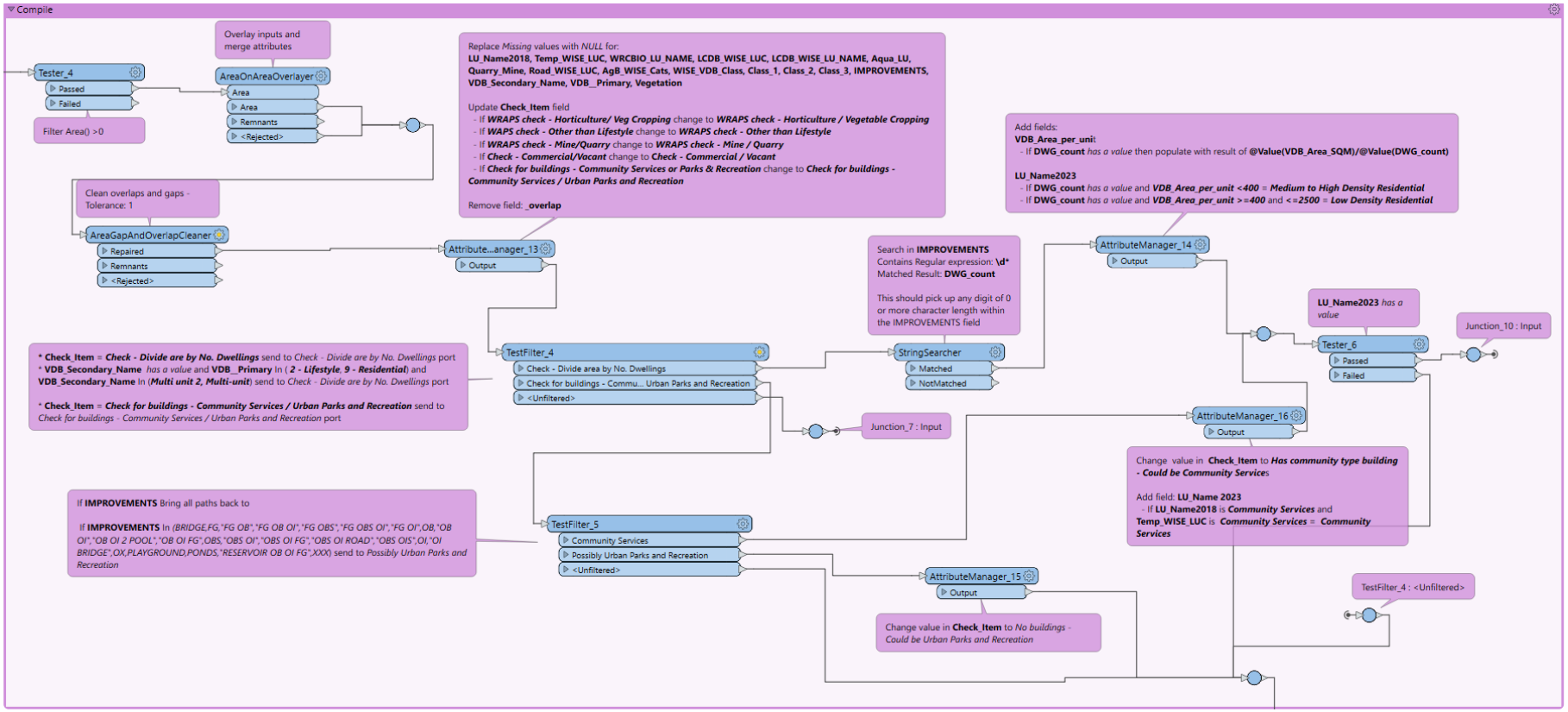


Figure 27 First round of bulk classifications across multiple inputs.

Split remainder of unclassed LU_Name2023 across specific classification streams

To refine the classification assessment process, filter the data to create more specific streams (Figure 28). First, isolate the features where *LU_Name2023* already has a value, so these can bypass further classification. Next, focus on the items where *LU_Name2018* is NULL, as these lack a default option for addressing uncertainty (Figure 29). Then, filter based on the *VDB_Primary* field, starting with NULL values (Figure 31) and progressing through its various classes (Figures 30, 32 to 40). This approach aims to streamline and target the classification process effectively.

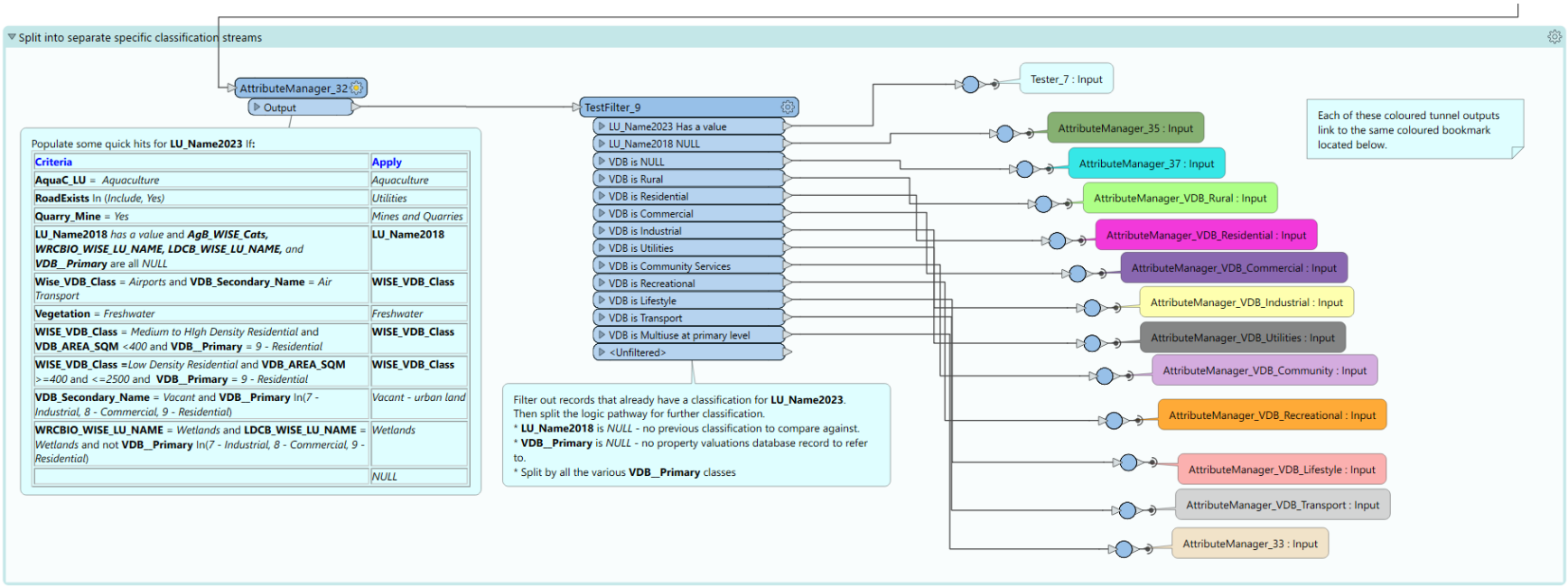


Figure 28 Split the data into separate paths for further analysis.

LU2018 is NULL

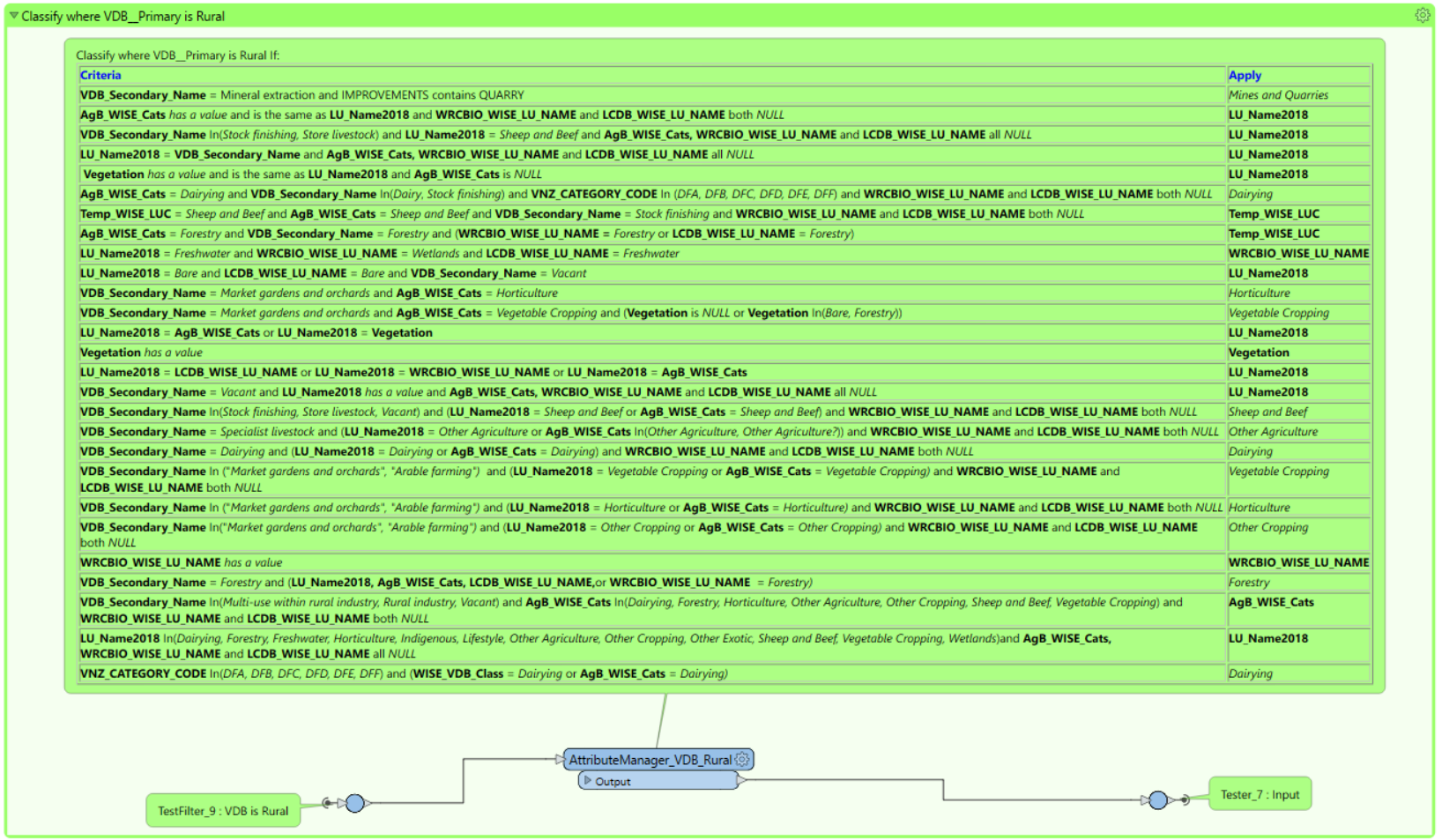
When the 2018 WISE Land Use (LU) is null, it indicates an absence of features in areas where other input layers might be present. This absence means there is no past reference for comparison or default option. In such cases, the classification relies on existing inputs and intermediate classifications within the filtered subset (as outlined in Table 14), aiming to determine the most likely classification. The process employs a top-down approach: if the first criteria are met, the corresponding value is assigned. If not, the process evaluates the next criteria, and continues in this manner (Figure 29).

Table 14 Fields used in logic and where they have come from.

Field Name/s	Source/derived from
VDB_AREA_SQM, VNZ_CATEGORY_CODE, IMPROVEMENTS	CRS Property Valuations Database.
VDB_Primary, VDB_Secondary_Name	Primary and Secondary descriptions per Land Use Code in the Property Valuations Database – have joined to make it easier to identify what the codes mean
Class_1, Class_2	For each Valuations Database Land Use Class have assigned based on the WISE 2018 Land use documentation what the likely classifications might be based purely on VDB Primary and Secondary descriptions
Temp_WISE_LUC	Intermediate WISE LU class based on earlier evaluation of just VDB and AgriBase as much of the WISE 2018 documentation indicated a greater overlap in criteria between these two input datasets
LCDB_WISE_LU_NAME	Intermediate WISE LU class based on grouping of Land Cover Database 5 classes
WRCBIO_WISE_LU_NAME	Intermediate WISE LU class based on grouping of Waikato Regional Council's Biodiversity classes
Vegetation	Intermediate WISE LU class based on LCDB_WISE_LU_NAME and WRCBIO_WISE_LU_NAME being the same or one having a value and the other not
AgB_WISE_Cats	Intermediate WISE LU class based on based on grouping of AgriBase FarmTypes
RoadExists	based on road parcels that overlap a road centreline
Quarry_Mine	Field added to indicate presence of Quarry or Mine from LINZ Topo 1:50,000 and quick comparison against WISE 2018 LU layer.

While efforts have been made to automate the classification of these features, it is advisable to verify them against aerial imagery. This "sense check" provides confidence they have been accurately classified, especially given the reliance on existing data and known information gaps.

Figure 29 Classification pathway where the 2018 WISE Land Use classification is missing so there is no past classification to compare against.



Criteria	Apply
VDB_Secondary_Name = Mineral extraction and IMPROVEMENTS contains QUARRY	*Mines and Quarries*
AgB_WISE_Cats *has a value* and is the same as **LU_Name2018** and **WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** both *NULL*	**LU_Name2018**
VDB_Secondary_Name In(*Stock finishing, Store livestock*) and **LU_Name2018** = *Sheep and Beef* and **AgB_WISE_Cats, WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** all *NULL*	**LU_Name2018**
LU_Name2018 = **VDB_Secondary_Name** and **AgB_WISE_Cats, WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** all *NULL*	**LU_Name2018**
Vegetation *has a value* and is the same as **LU_Name2018** and **AgB_WISE_Cats** is *NULL*	**LU_Name2018**
AgB_WISE_Cats = *Dairying* and **VDB_Secondary_Name** In(*Dairy, Stock finishing*) and **VNZ_CATEGORY_CODE** In (*DFA, DFB, DFC, DFD, DFE, DFF*) and **WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** both *NULL*	*Dairying*
Temp_WISE_LUC = *Sheep and Beef* and **AgB_WISE_Cats** = *Sheep and Beef* and **VDB_Secondary_Name** = *Stock finishing* and **WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** both *NULL*	**Temp_WISE_LUC**
AgB_WISE_Cats = *Forestry* and **VDB_Secondary_Name** = *Forestry* and (**WRCBIO_WISE_LU_NAME** = *Forestry* or **LCDB_WISE_LU_NAME** = *Forestry*)	**Temp_WISE_LUC**
LU_Name2018 = *Freshwater* and **WRCBIO_WISE_LU_NAME** = *Wetlands* and **LCDB_WISE_LU_NAME** = *Freshwater*	**WRCBIO_WISE_LU_NAME**
LU_Name2018 = *Bare* and **LCDB_WISE_LU_NAME** = *Bare* and **VDB_Secondary_Name** = *Vacant*	**LU_Name2018**
VDB_Secondary_Name = *Market gardens and orchards* and **AgB_WISE_Cats** = *Horticulture*	*Horticulture*
VDB_Secondary_Name = *Market gardens and orchards* and **AgB_WISE_Cats** = *Vegetable Cropping* and (**Vegetation** is *NULL* or **Vegetation** In(*Bare, Forestry*))	*Vegetable Cropping*
LU_Name2018 = **AgB_WISE_Cats** or **LU_Name2018** = **Vegetation**	**LU_Name2018**
Vegetation *has a value*	**Vegetation**
LU_Name2018 = **LCDB_WISE_LU_NAME** or **LU_Name2018** = **WRCBIO_WISE_LU_NAME** or **LU_Name2018** = **AgB_WISE_Cats**	**LU_Name2018**
VDB_Secondary_Name = *Vacant* and **LU_Name2018** *has a value* and **AgB_WISE_Cats, WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** all *NULL*	**LU_Name2018**
VDB_Secondary_Name In(*Stock finishing, Store livestock, Vacant*) and (**LU_Name2018** = *Sheep and Beef* or **AgB_WISE_Cats** = *Sheep and Beef*) and **WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** both *NULL*	*Sheep and Beef*
VDB_Secondary_Name = *Specialist livestock* and (**LU_Name2018** = *Other Agriculture* or **AgB_WISE_Cats** In(*Other Agriculture, Other Agriculture?*)) and **WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** both *NULL*	*Other Agriculture*
VDB_Secondary_Name = *Dairying* and (**LU_Name2018** = *Dairying* or **AgB_WISE_Cats** = *Dairying*) and **WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** both *NULL*	*Dairying*
VDB_Secondary_Name In ("*Market gardens and orchards*", "*Arable farming*") and (**LU_Name2018** = *Vegetable Cropping* or **AgB_WISE_Cats** = *Vegetable Cropping*) and **WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** both *NULL*	*Vegetable Cropping*
VDB_Secondary_Name In ("*Market gardens and orchards*", "*Arable farming*") and (**LU_Name2018** = *Horticulture* or **AgB_WISE_Cats** = *Horticulture*) and **WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** both *NULL*	*Horticulture*
VDB_Secondary_Name In("*Market gardens and orchards*", "*Arable farming*") and (**LU_Name2018** = *Other Cropping* or **AgB_WISE_Cats** = *Other Cropping*) and **WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** both *NULL*	*Other Cropping*
WRCBIO_WISE_LU_NAME *has a value*	**WRCBIO_WISE_LU_NAME**
VDB_Secondary_Name = *Forestry* and (**LU_Name2018, AgB_WISE_Cats, LCDB_WISE_LU_NAME,**or **WRCBIO_WISE_LU_NAME** = *Forestry*)	*Forestry*
VDB_Secondary_Name In(*Multi-use within rural industry, Rural industry, Vacant*) and **AgB_WISE_Cats** In(*Dairying, Forestry, Horticulture, Other Agriculture, Other Cropping, Sheep and Beef, Vegetable Cropping*) and **WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** both *NULL*	**AgB_WISE_Cats**
LU_Name2018 In(*Dairying, Forestry, Freshwater, Horticulture, Indigenous, Lifestyle, Other Agriculture, Other Cropping, Other Exotic, Sheep and Beef, Vegetable Cropping, Wetlands*)and **AgB_WISE_Cats, WRCBIO_WISE_LU_NAME** and **LCDB_WISE_LU_NAME** all *NULL*	**LU_Name2018**
VNZ_CATEGORY_CODE In(*DFA, DFB, DFC, DFD, DFE, DFF*) and (**WISE_VDB_Class** = *Dairying* or **AgB_WISE_Cats** = *Dairying*)	*Dairying*

Figure 30 Classification pathway where the VDB Primary level is Rural.

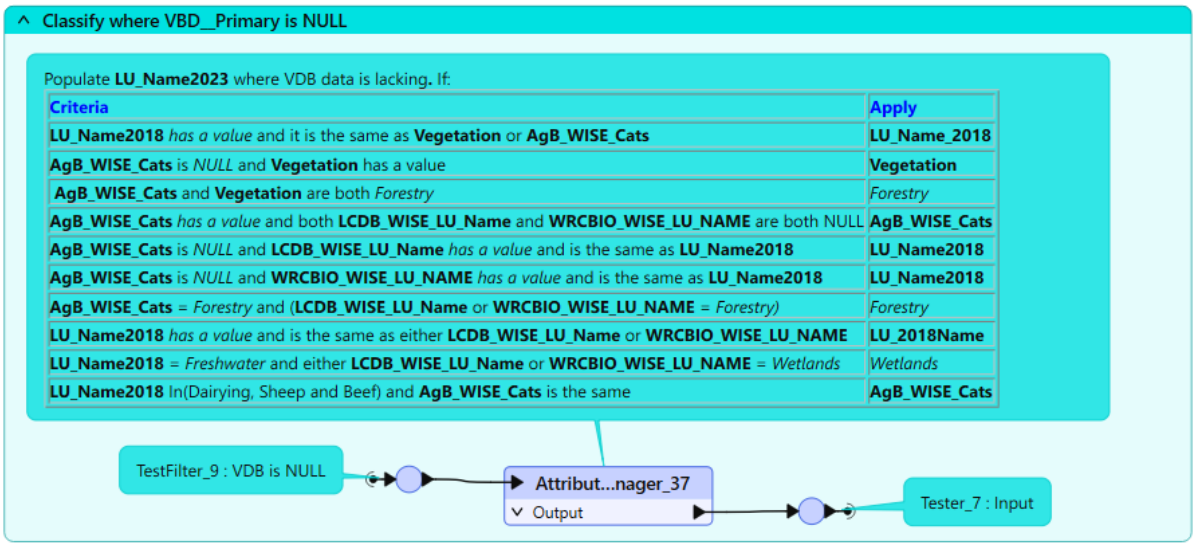


Figure 31 Classification pathway where the VDB Primary value is null (missing).

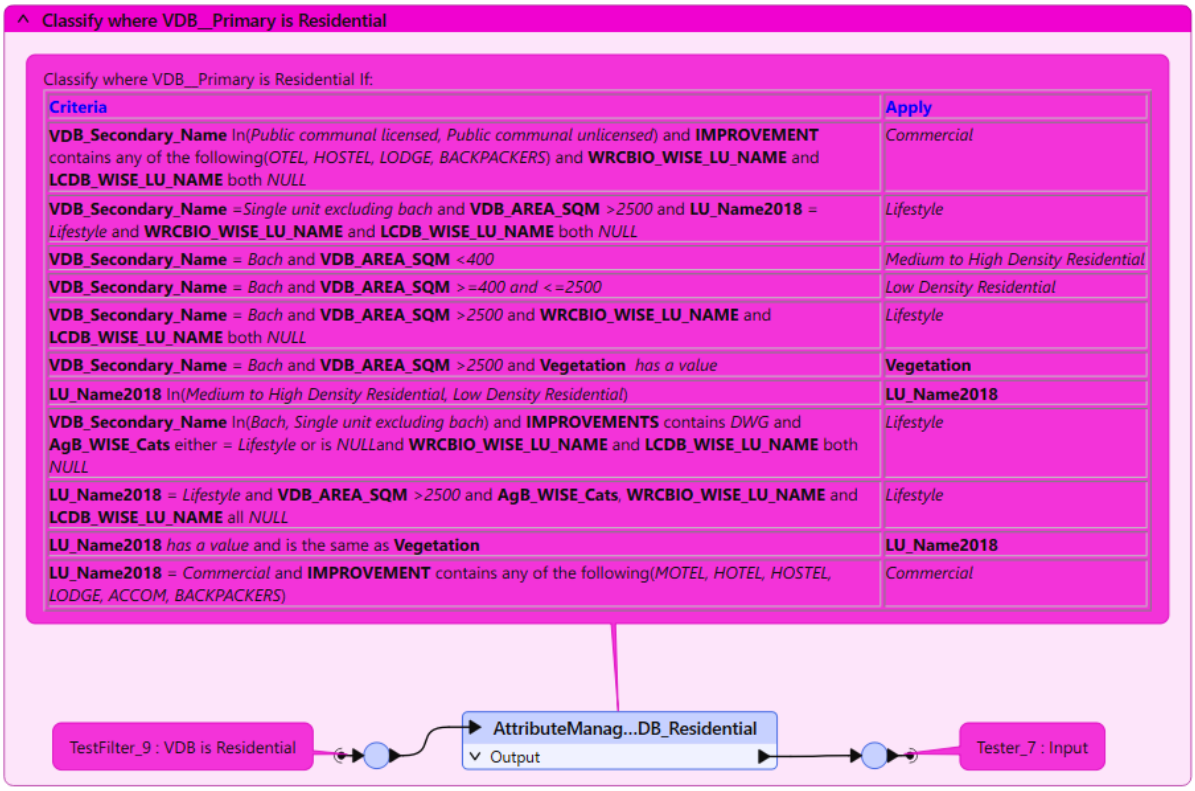


Figure 32 Classification pathway where the VDB Primary Level is Residential.

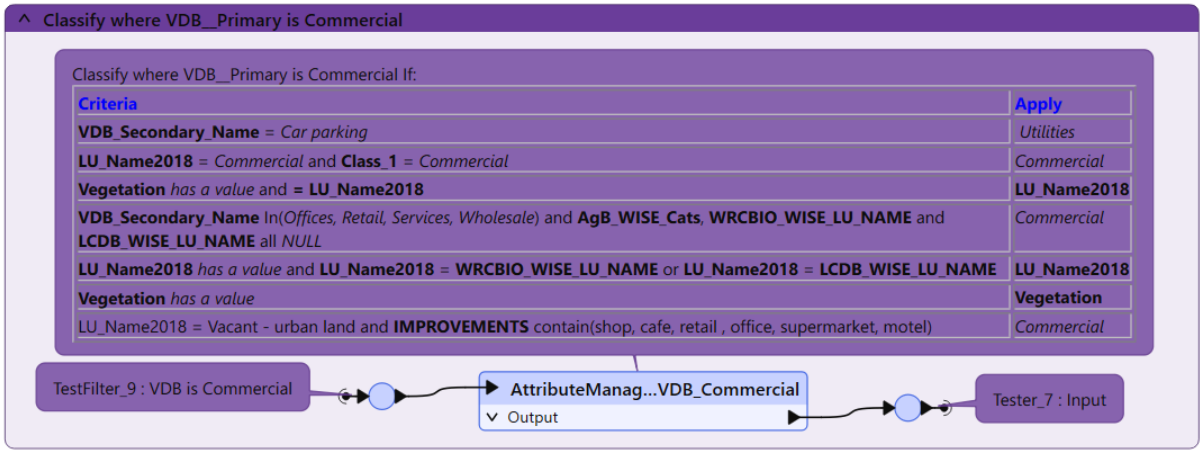


Figure 33 Classification pathway where the VDB Primary level is Commercial.

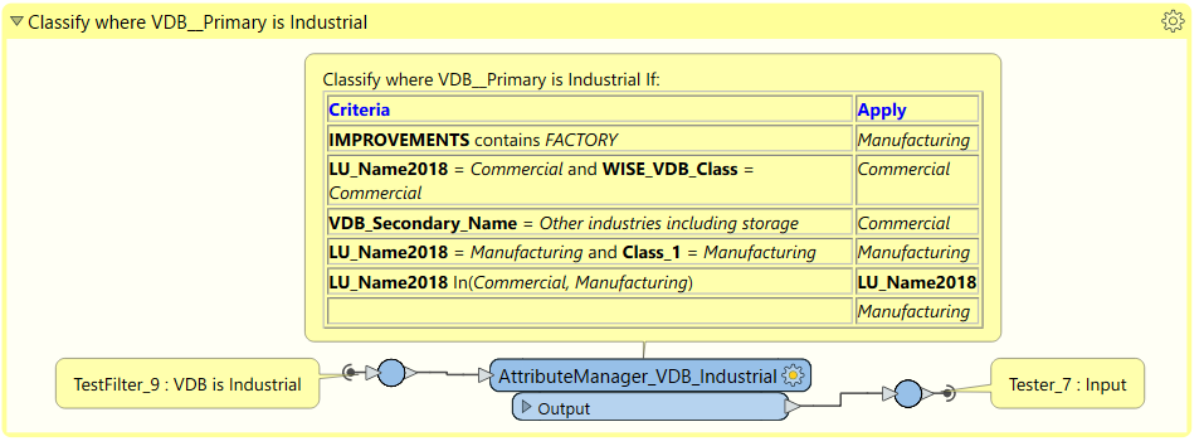


Figure 34 Classification pathway where the VDB Primary level is Industrial.

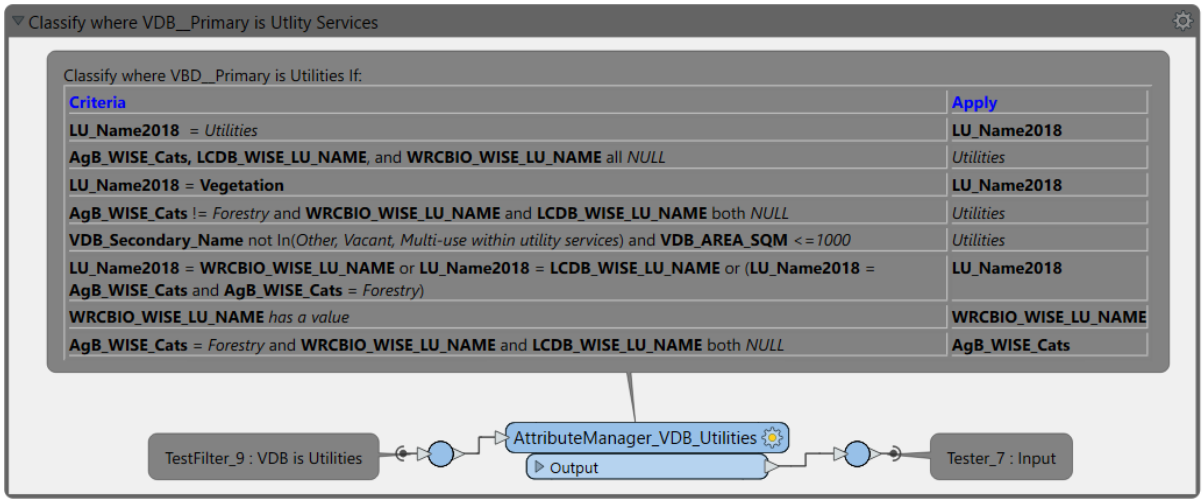


Figure 35 Classification pathway where the VDB Primary Level is Utilities.

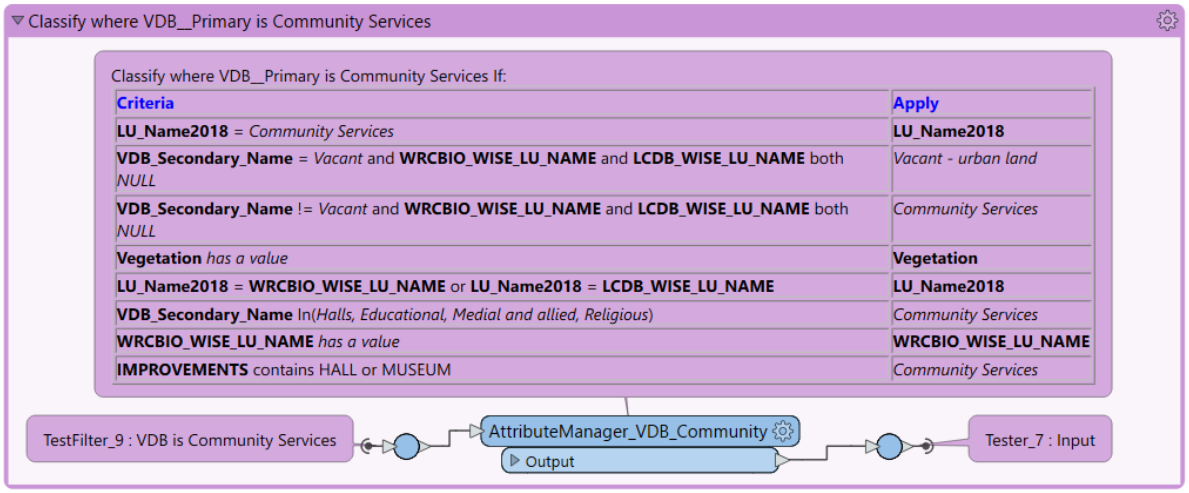


Figure 36 Classification pathway where the VDB Primary level is Community Services.

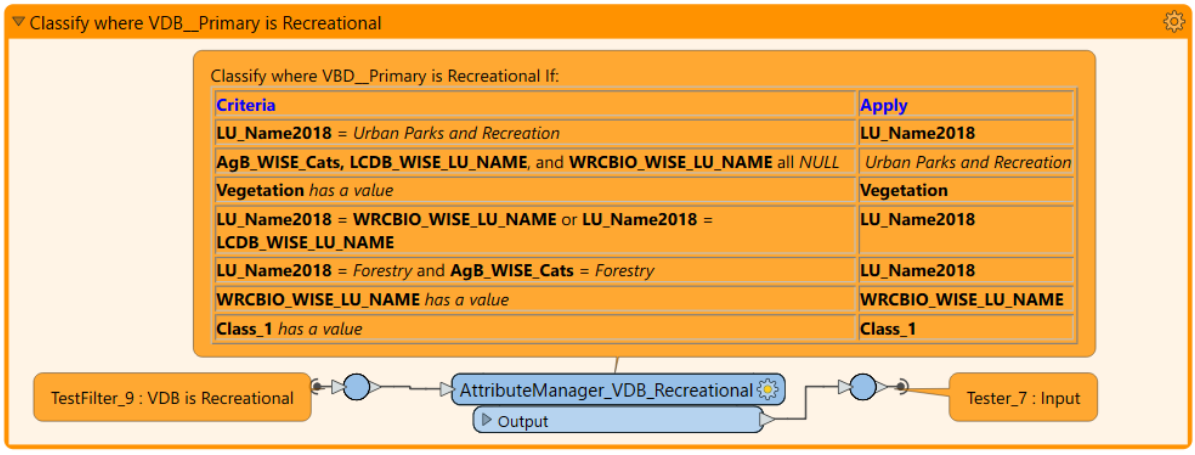


Figure 37 Classification pathway where the VDB Primary level is Recreational.

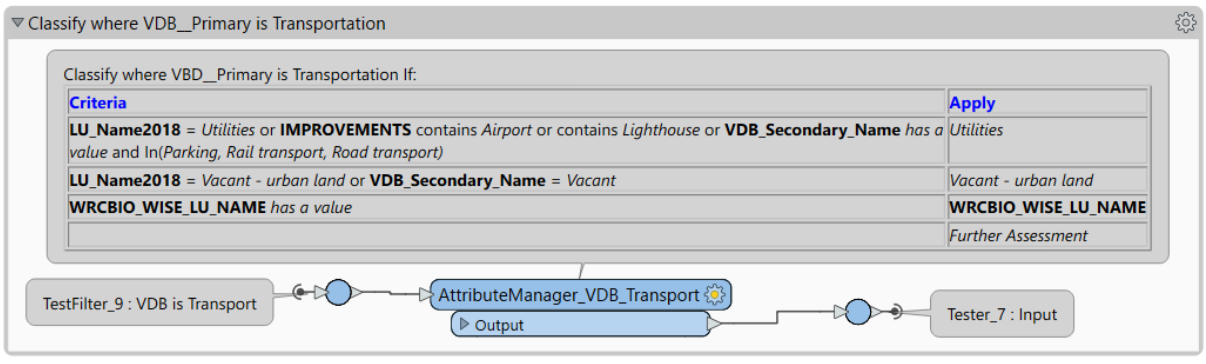


Figure 38 Classification pathway where the VDB Primary level is Transport.

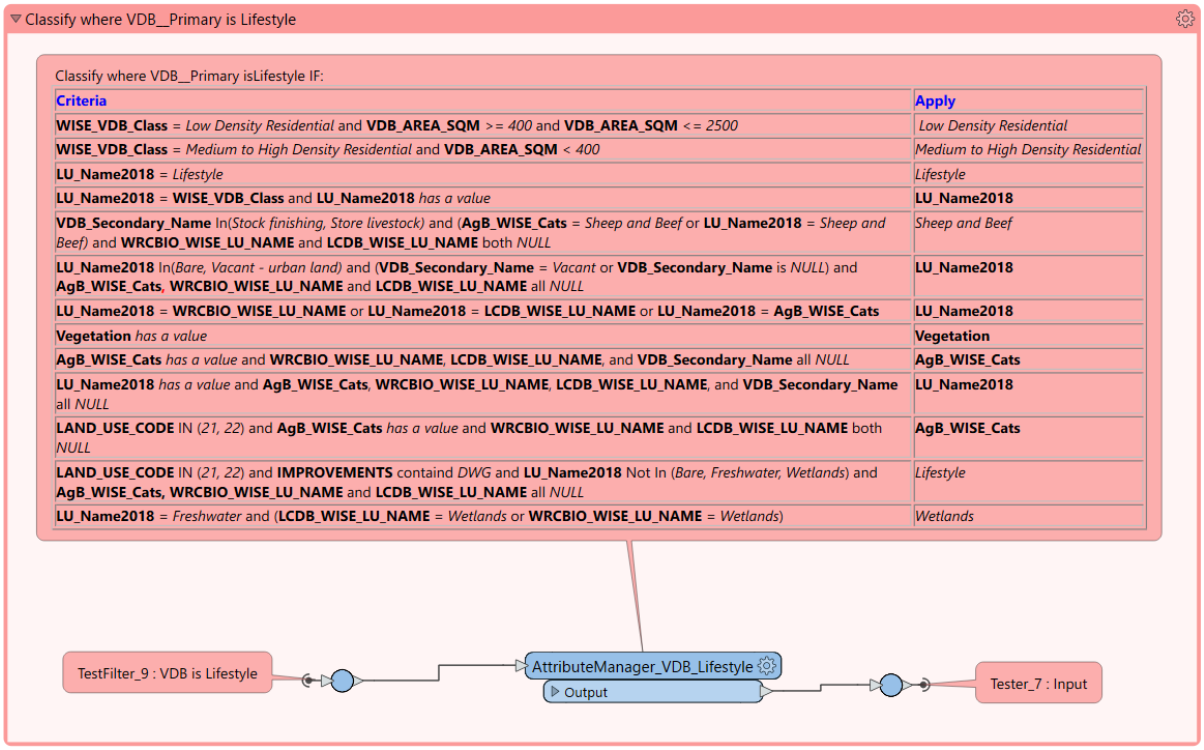


Figure 39 Classification pathway where the VDB Primary level is Lifestyle.

VDB__Primary is Multiuse at primary level

Where the VDB primary land use classification falls under multiuse (VDB__Primary = 0) the value assigned will either be the previous LU2018 classification where it aligns with one of the other fields (AgB_WISE_Cats, LCDB_WISE_LU, or WRCBIO_WISE_LU), or failing that the value held by the Vegetation intermediate field if it has one, otherwise it was left unassigned (Figure) for a later visual review.

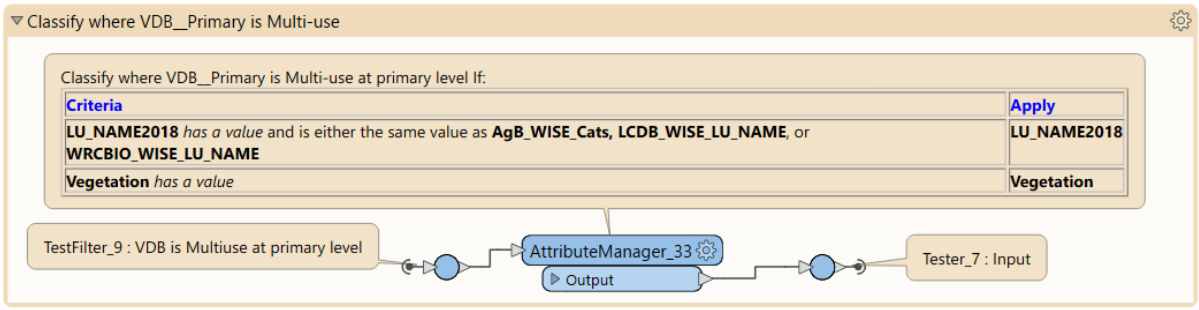


Figure 40 Classification stream based on Multiuse at a (VDB) Primary level.

Reunite all classification streams

At this stage the various paths reunite (Figure 41), and a greater proportion of features should now have a classification assigned to *LU_Name2023*

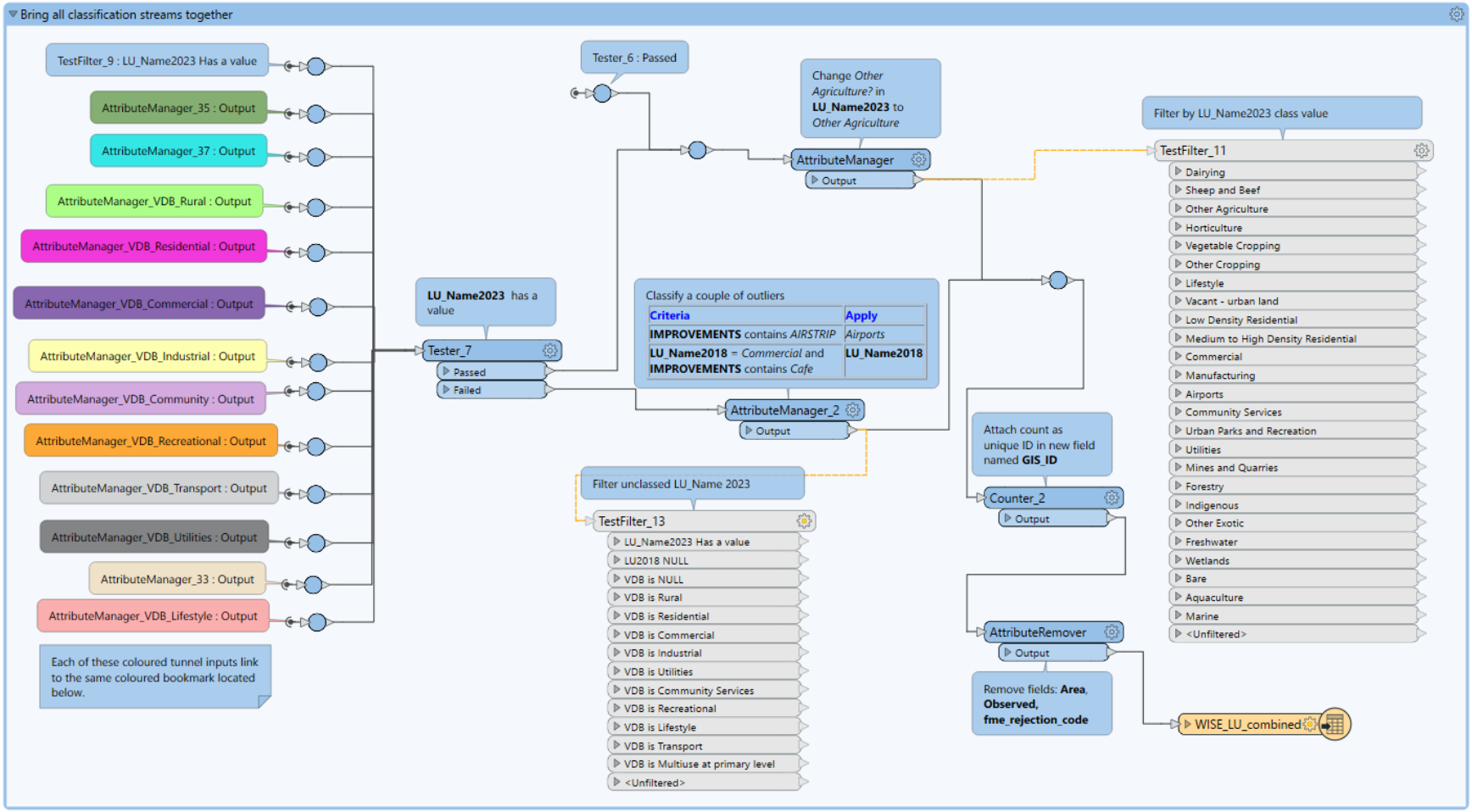


Figure 41 Part of the large classification model that brings all the separate classification pathways back together before writing an output.

Following reuniting of the various analysis streams and writing an output, unclassed features were visually assessed using aerial imagery, considering the classification options provided by each input dataset (where values were available). Where there was uncertainty, but a value available from *WISE_LU2018,* that value was assigned.

Additionally, a brief visual inspection was carried out in known areas of residential growth. As a result, some features were reclassified from rural to urban classifications.

Land and Marine extent.fmw

The final raster must match the previous raster's extent while also identifying and classifying (Figure 42) the following areas:

- *Marine* – the Waikato Region marine areas
- *Marine areas outside the region* - any other marine areas included within the raster extent but located outside the Waikato Region.
- *Area outside regio*n – all other land areas beyond the Waikato Region + 1.6 km buffer extent that are within the raster extent.

Overlay with dissolved extent of the classed land area to get a basic sense of both land and marine within and outside region.

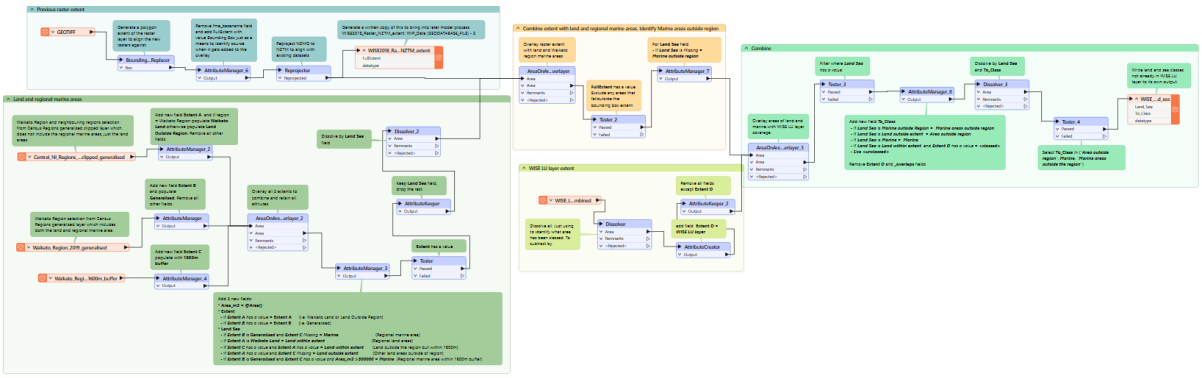


Figure 42 WISE land and marine extent FME model.

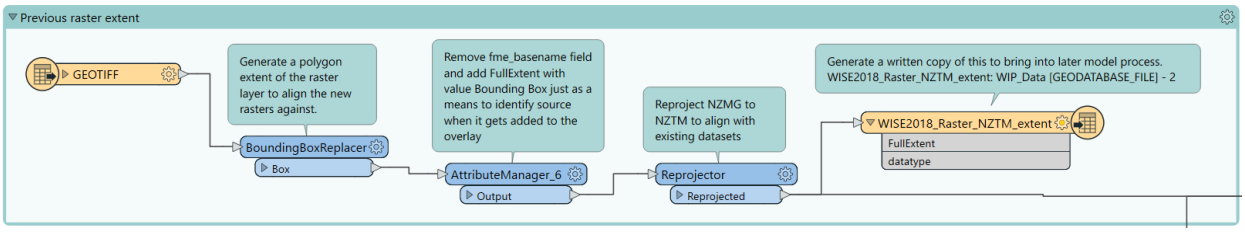


Figure 43 Part of the WISE land and marine extent model that generates the polygon extent from the raster extent.

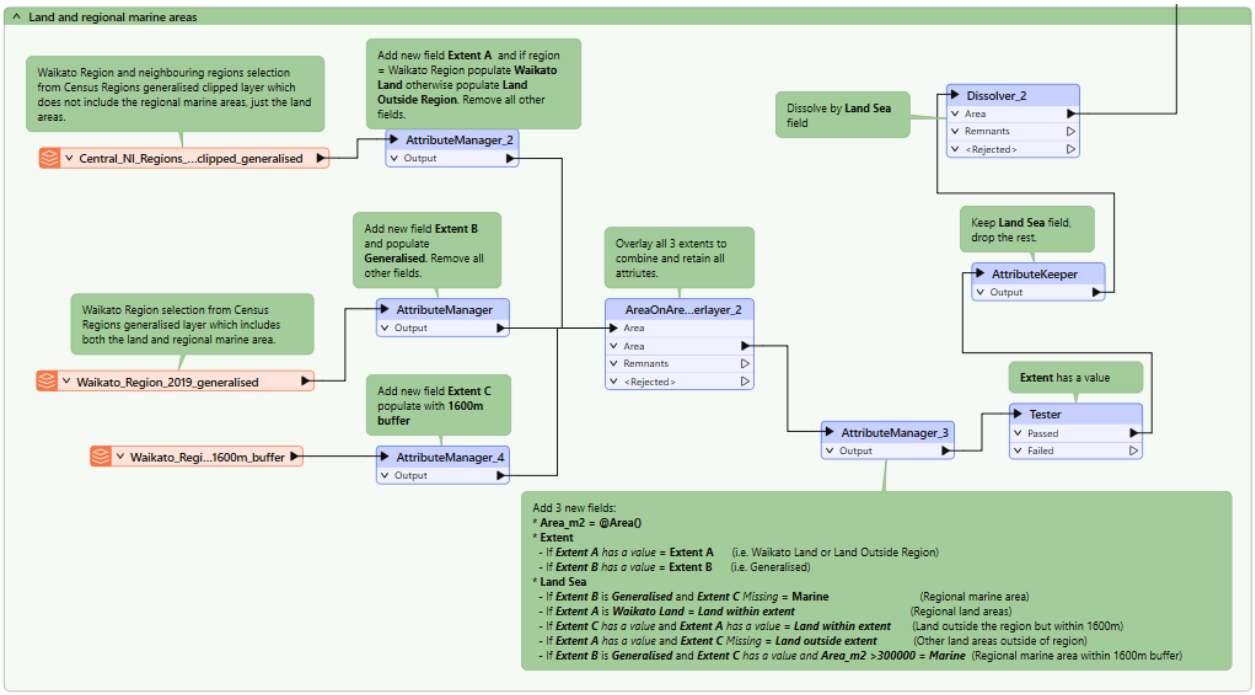


Figure 44 Define regional land and marine areas from the clipped and unclipped Statistics NZ regional boundary layers.

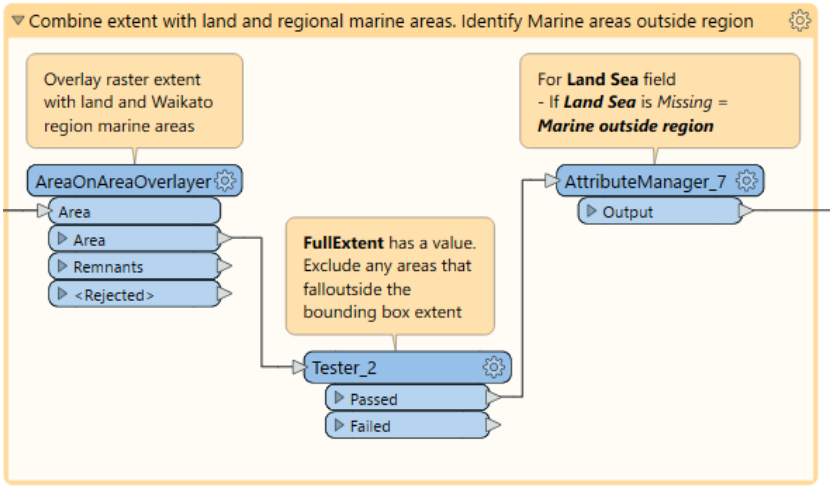


Figure 45 Part of the WISE land and marine extent model that combines the WISE model extent with the regional areas to identify marine areas outside region.

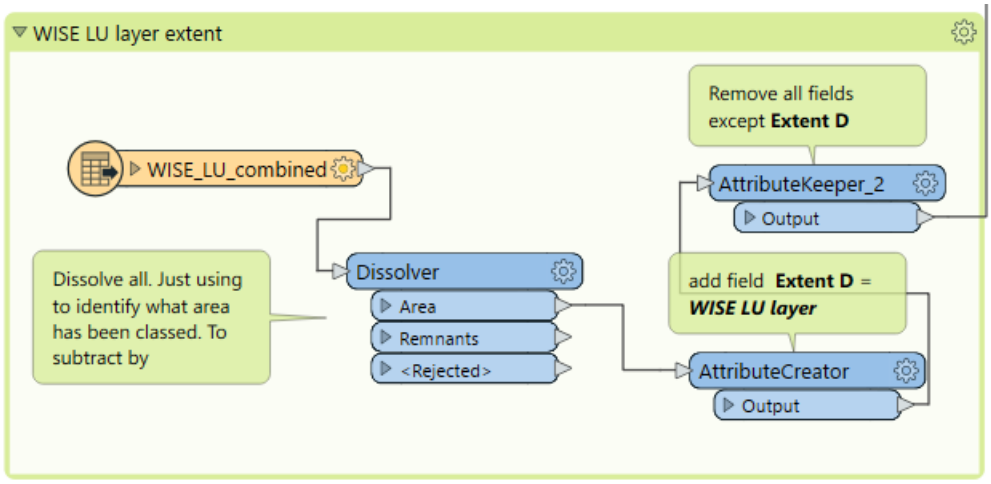


Figure 46 Add the intermediate results of the combined WISE land use classes and dissolve all just to represent what is covered by existing land use classes.

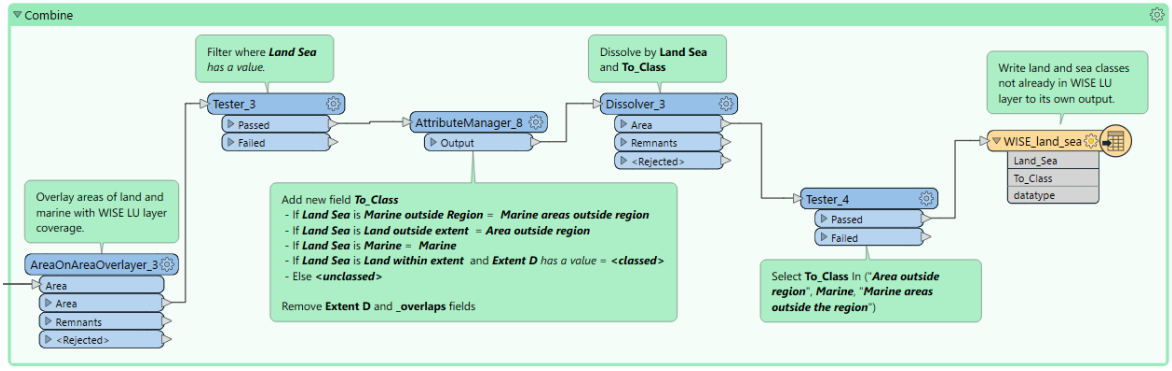


Figure 47 Part of the WISE land and marine extent model that combines and classifies the land and marine areas based on overlap rules. Note the <unclassed> areas within the Waikato region and 1.6 km buffer are not retained.

Classed WISE LU layer.fmw

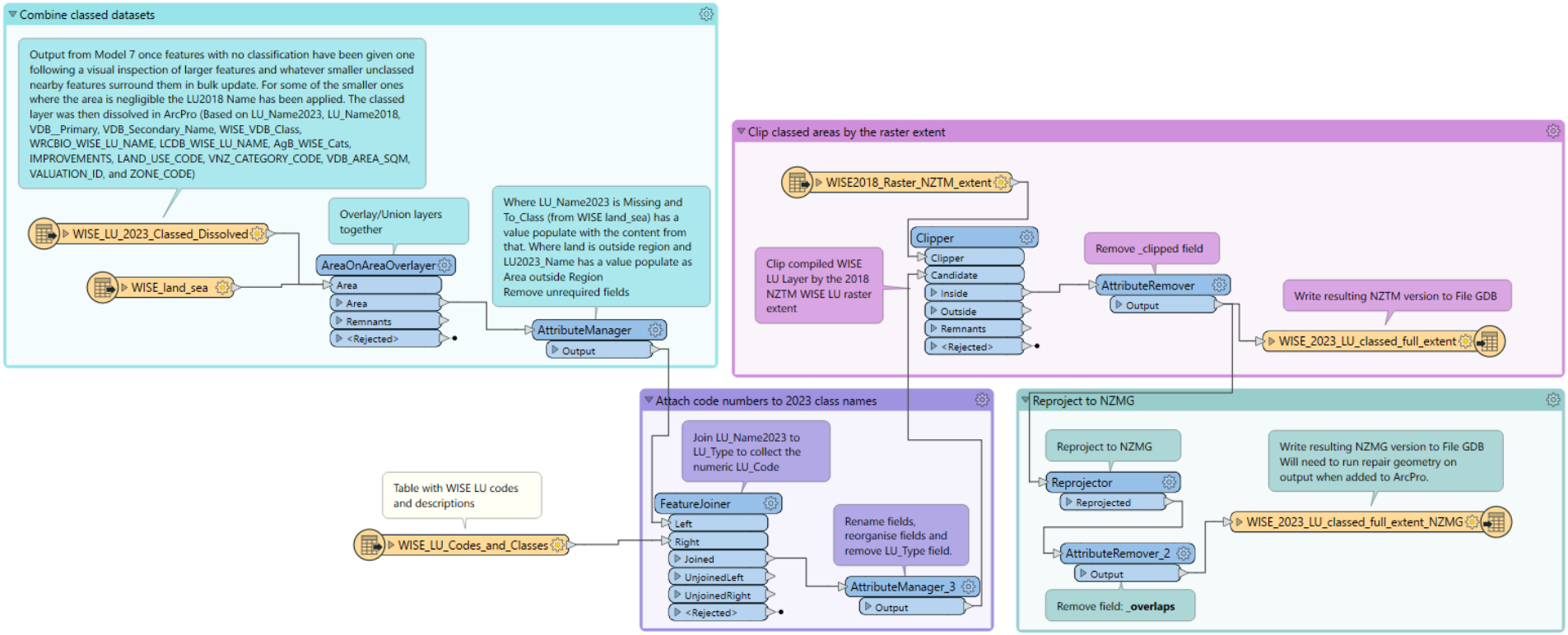


Figure 48 Add marine and areas outside region to rest of classed content.

Medium to High Density Residential Review

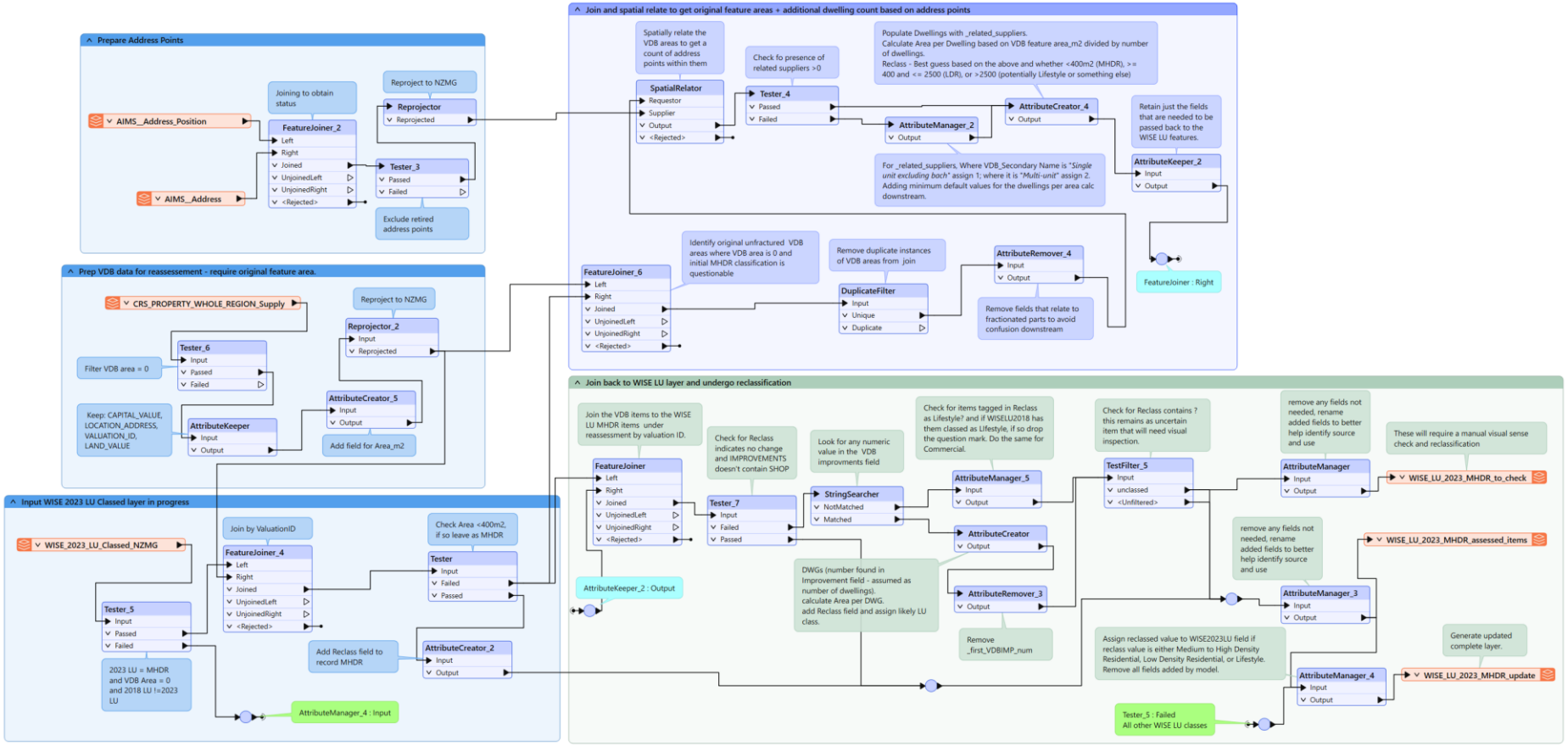


Figure 49 Review of Medium to High Density Residential, where the VDB Area = 0m2, obtain the geometric areas from the source (link by Valuation_ID). Carry out analysis of area per dwelling then reclass.

Lifestyle Review

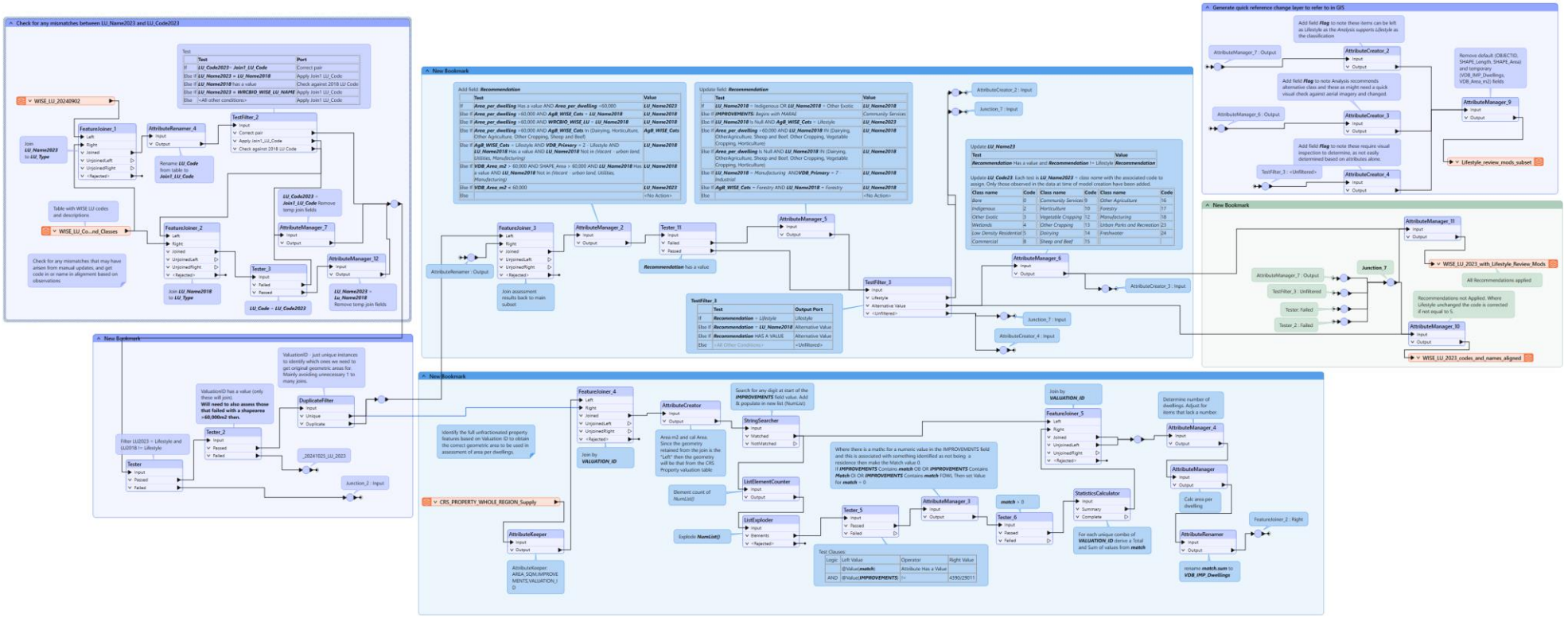


Figure 50 Lifestyle review - check features that are >6ha and what the most likely alternative classification might be.

Generate Raster Grid Layer

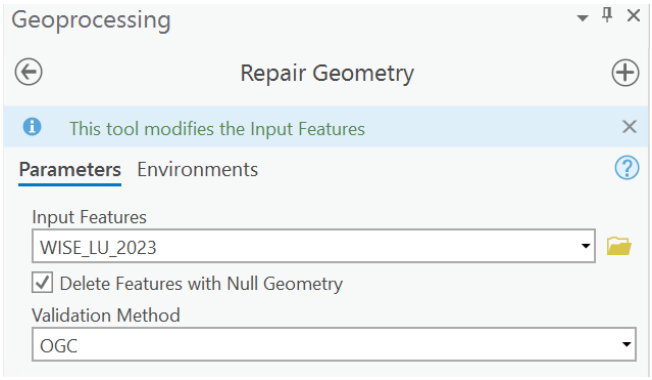


Figure 51 Repair Geometry - Fix any negative areas and remove any null geometries.

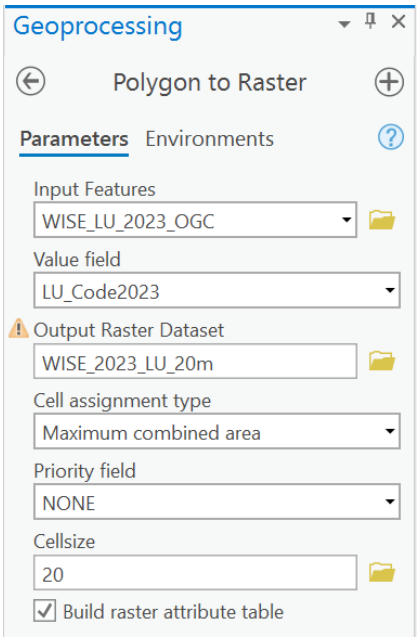


Figure 52 Polygon to Raster - Convert polygons to a 20m raster based on maximum combined area (total area of all features of the same LU_Code2023 in each 20m x 20m area within the extent.

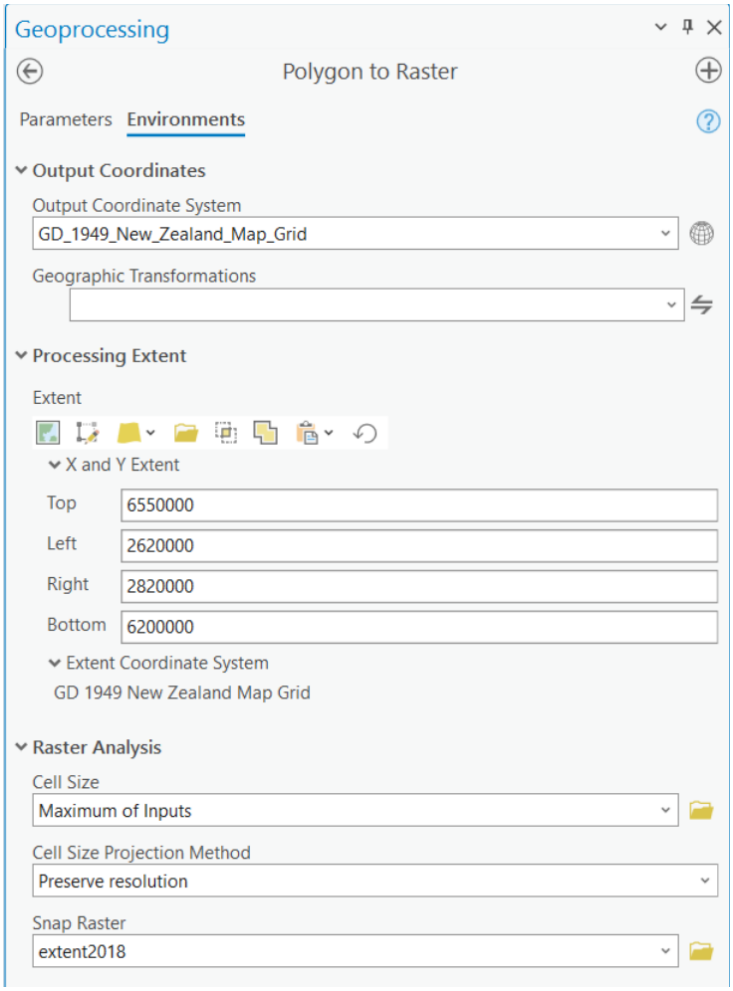


Figure 53 Polygon to Raster - Environment Settings that need to be set. Alignment based on Land_Use_Mask2018.tif (provided by Tony Fenton) which was replicated in extent2018 Esri grid layer.

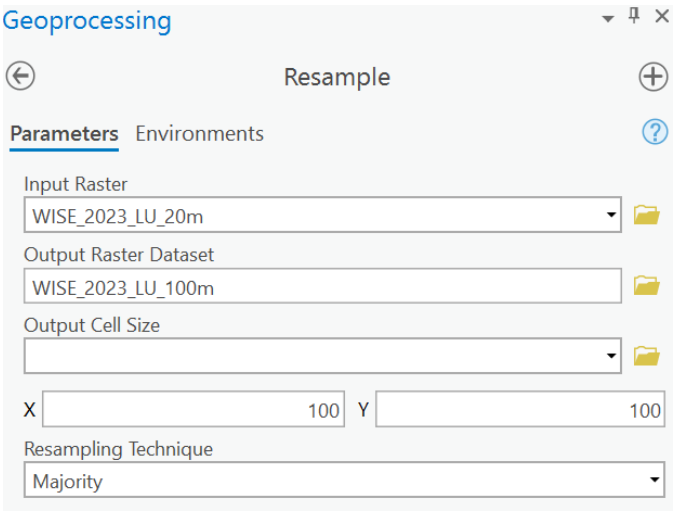


Figure 54 Resample - Output (as per 2018 process) needs to be 100m grid cell size. Use the same environment settings as per Figure 53. If the 20m grid size step is skipped, then some classifications will visibly differ from vector output and appear over or under- represented.

Review of Final 2023 LU from Beca for Waikato Regional Council

Tony Fenton - November 2024

Summary

- The final 2023 land use layer was compared with the 2018 WISE version to help identify where differences occurred. This allowed for a spatial crosscheck to identify any significant differences which could then be investigated to see if logic correct.

- The 2023 version has corrected some errors that were in the 2018 layer (i.e. Taupo and Tokoroa airports, and some quarries around Tuakau/Pokeno missing in 2018). These accounted for some of the differences.

- Most of the suggested changes are based on looking at areas of significant difference and then viewing the aerial imagery (WRAPS 23) to assess which land use is correct considering the data attribute. No attempt to specifically understand why the model logic did not 'correctly' identify the land use was made.

- For indigenous there appears to have been an error in CRS conversion for the WRCBioveg in 2018 which caused an over statement of Indigenous around the regional boundary. Also, it appears that the LCDB classification for Forestry was applied in preference to the WRCBioveg data in many cases. This was looked at but there appeared to be some anomalies both ways (i.e. areas classed as Forestry in LCDB, but Indigenous in WRCBioveg – but when check against WRAPS23 some were Forestry, and some were Indigenous). Outcome overall is ok but an aspect to maybe investigate further in next update.

- There was still a handful of lifestyle block areas over 6ha – these were checked and some recoded. A number were on the northern boundary within Auckland so were left as is.

- 2023 layer looks to provide a good assessment of the medium to high density residential – a few additional 'lifestyle' village areas were identified and added to this Class in recommended changes.

- In WISE manufacturing is seen as actually making something – producing a product- whereas commercial is seen as selling a product to the user or providing a service. Therefore, activities like electricians, auto shops tyre shops, storage facilities, industrial supplies would be classed as commercial. Overall, the 2023 layer looks to have done a good job with these two classes and defining the new growth areas. In developing the 2018 version time was spent using WRAPS and Google Maps to separate out these differences for Hamilton and Cambridge and some other urban areas. For Hamilton it is recommended that the 2018 LU classes for smaller parcels in the Frankton and Te Rapa area are applied.

- Utilities land use classification has picked up the new infrastructure well (motorways, geothermal power stations).

- For Dairy land use assessment of the differences between time steps a mixture of results. Working through the identified areas showed some of the 2023 code were more appropriate based on visual inspection compared to 2018 classification. However, the majority seemed to suit the 2018 assessment. A lot of time was spent visually working through the code "conflicts" in the 2018 version, so more weight could have been applied to them in final LU assessment process. Also, a lot of visual assessment was undertaken on forestry for 2018 land use so the areas that were in dairying in 2018 and "Forestry" in WRCBIO12 should have been classed as Dairying. A number of corrections are recommended based on review of the two layers.

- In considering the next repeat of land use layer development it is worth considering refinement of how some layer priorities are applied (i.e. do road parcels get applied over say indigenous vegetation or not, does indigenous vegetation get applied across low density residential or not). This may require some further advice to the process on where priority sits between 'land use' and 'land cover' for some classes. The way it has been applied in 2023 layer isn't a significant issue and overall outcome is considered OK.

It is noted that there is some variation in the logic (i.e. difference in how low density residential and Indigenous vegetation are applied between Coromandel township and Thames)

- The other land use classes not mentioned specifically were good outcomes from the analysis process and aligned with expects changes over time with land use.

- The recommended changes captured in the reviewed final 2023 land use layer attribute table are put forward for Waikato Regional Council staff to consider for adoption or not before the layer is 'corporatised' as the official version.

Background

This document is a collection of notes from the review process of Beca's final 2023 land use layer for the Waikato Region. It defines the review process undertaken and the reasoning behind any recommended changes in classes allocated to some of the land parcels in the final Land Use data layer that Beca provided.

Renée Schicker from Beca has done a very good job at creating this land use layer. The workflow and processes used has created a good fit for the WISE land use classes and the vast majority of land use classes allocated are well justified and "correct".

The word "correct" is put in quote marks as allocating land use can move from being very clear to somewhat subjective as the different input data is evaluated. Some land uses are easy to separate out when all the data sets agree (i.e. VDB and AgriBase), but as these are weeded out there is a lot more subjectivity needed when data inputs don't agree or conflict. At the more subjective end the logic used can be sound, but in some cases the outcome is incorrect and the only way to know is through visual checking against aerial imagery.

The quality of data inputs (VDB and AgriBase, LCDB) has been improving as successive land use layers have been developed and this has helped with the process and should make future land use layers using the developed FME model more robust.

The points raised in an earlier review of the draft land use layer created by Beca have been well picked up and added to the final map.

Data processing

The following data processing was used to assess the Final land use layer:

- The final vector layer from Beca for 2023 and the WISE 2018 land use vector layer were Rasterized into 20m grids, then resampled into 100m grids.

- The were converted these to .ASC files and put into Map Comparison Kit (a raster comparison tool) to assess overall differences and where the main differences occurred.

- Areas of difference were then assessed using the vector data for the 2023 and 2018 land use layers

- In the attribute table of the 2023 Land Use file 3 new columns were created - "RvwName23" for land use name, "RvwCode23" for WISE LU Code, and RV_Comment" to define why a change to Beca LU classification was recommended. Initially data for land use name (RvwName23) and code (RvwCode23) were copied in from the Beca classifications, and then edited if a changes was recommended.

Map Comparison Kit Outputs

The RIKs (http://www.riks.nl/) Map Comparison Kit (MCK) tool was used to do a quick comparison of total area by land use class between the 2018 land use and new Beca 2023 land use. The results are in Table 15 below.

MCK was used to identify key differences between the 2018 and 2023 land use data (Figure 55) so that the review could focus on major differences and not get bogged down into too much detail.

Table 15 Outputs from MCK comparing areas by land use class between different land use maps

	Area (ha)										
Land Use Layer Evaluation	Bare	Vacant	Indig Veg	Other Exotic	Wetlands	Lifestyle	LD Resid	MHD Resid	Commercial	Comm Serv	Hort
2018	18,505	3,005	717,758	37,468	20,135	35,464	12,811	314	1,884	24,13	3,397
Beca 2023	16,037	2,444	712,202	35,269	20,155	37,967	13,879	402	2,454	3,171	3,302
Reviewed 2023	15,821	2,679	712,123	35,541	20,170	37,358	13,712	429	2,473	2,781	3,268
Diff Beca23 -18	-2,468	-561	-5,556	-2,199	20	2,503	1,068	88	570	758	-95
Diff post Review23-18	-2,684	-326	-5,635	-1,927	35	1,894	901	115	589	368	-129

	Area (ha)										
Land Use Layer Evaluation	Veg Crop	Other Crop	Dairy	Sheep Beef	Other Agr	Forestry	Manufc	Utilities	Mine Quarries	Parks Rec	Airport
2018	8,329	8,257	695,943	566,717	14,127	326,633	2,415	11,109	3,127	6,462	360
Beca 2023	8,581	7,946	681,844	561,582	14,639	332,954	2,781	14,108	5,652	8,552	556
Reviewed 2023	8,597	8,353	686,358	564,841	14,608	328,260	2,715	13,937	4,403	7,053	559
Diff Beca23 -18	252	-311	-14,099	-5,135	512	6,321	366	2,999	2,525	2,090	196
Diff post Review23-18	268	96	-9,585	-1,876	481	1,627	300	2,828	12,76	591	199

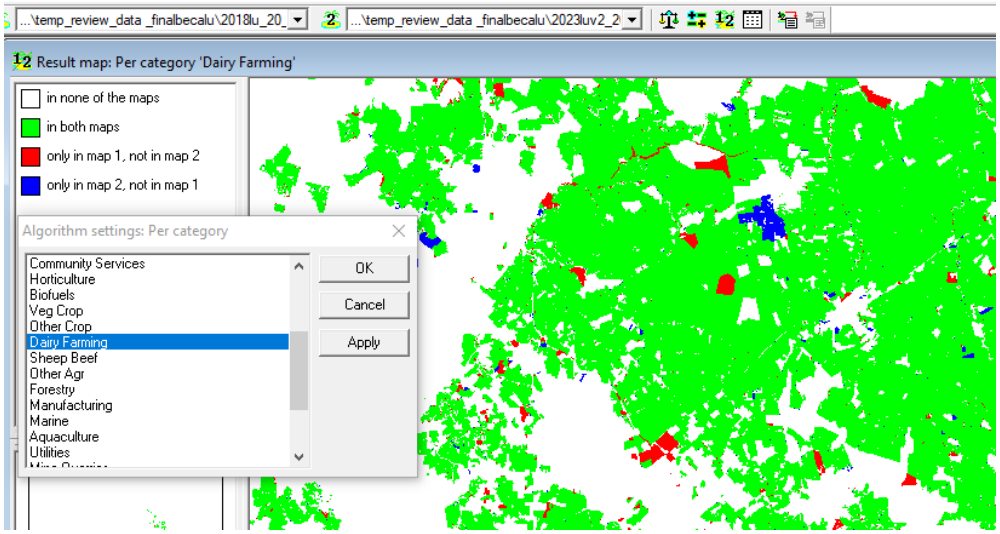


Figure 55 Example of outputs from MCK tool

Assessment by Land Use Class

Final output

After completing the review process outlined below the revised land use map was put back int MCK to compare degree of changes between the original 2023 Beca land use map and the reviewed version. This information is outlined in the table above and these changes are discussed by land use in the notes below.

Bare Land

Little change was made to this class as defined by Beca – this class was probably a bit overrepresented in the 2018 when looking at the areas defined in 2023 layer.

Vacant Urban Land

This class seems to have been well defined in the 2023 layer and corresponds well to activities on ground. Some additional vacant area were identified as part of looking over WRAPS23 images. It is a dynamic land use type over time and location.

Indigenous Vegetation

MCK comparison shows that 2023 has 5556 ha less indigenous (~1% of total) but in MCKit there are no large areas of discrepancy. From assessment there were several drivers found – individually these were not large. It was noted that the WRCBioveg polygons used in the 2018 LU analysis were offset about 1.5m to the 2023 polygons – this error seems to have occurred in 2018 process probably when changing CRS's. From the MCK maps this seems to have created more indigenous around the boundary in the 2018 LU layer (Figure 56).

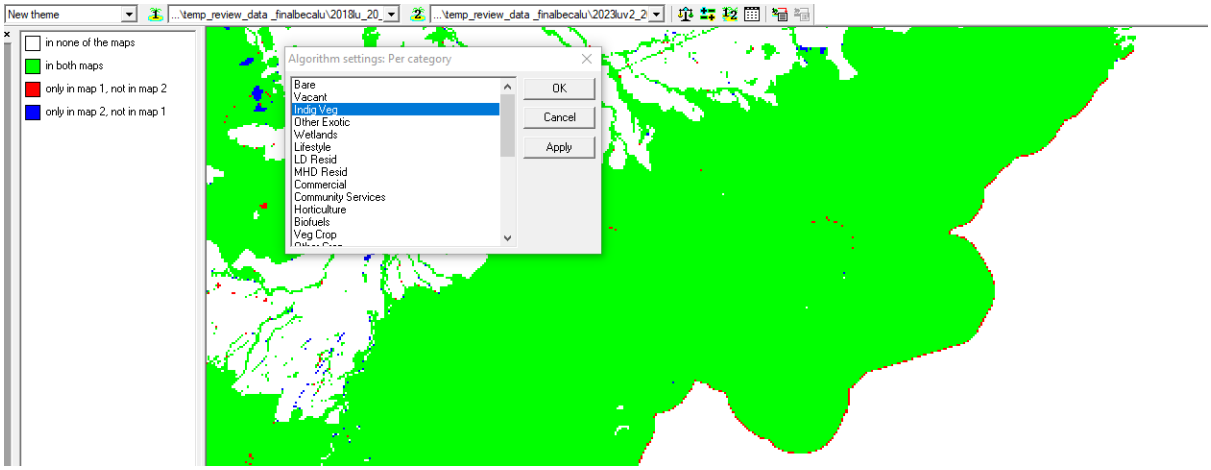


Figure 56 "Reduction" in indigenous around the boundary due to CRS conversion error in 2018

In terms of process it looks like for 2023 model logic has applied LD Residential last, or in preference to Indigenous vegetation in most places. Therefore, properties with some indigenous are all LD Residential – the 2018 was opposite order was used. Nothing was changed to address this in data file.

Also, it appears that the LCDB classification for Forestry was applied in preference to the WRCBioveg data in many cases. Investigated with a search of polygons where "LU_Name2023 doesn't equal WRCBio" then get 143,228 features – looking closely at these it seems that Forestry (LCDB) was overlaid onto Indigenous Veg as from WRCBio Layer. Initial checking of WRAPS would suggest that the WRCBioVeg – indigenous class could be more valid. On looking at this more there appeared to be some anomalies both ways (i.e. areas classed as Forestry in LCDB, but Indigenous in WRCBioveg – but when check against WRAPS23 some were Forestry, and some were Indigenous). Some visual corrections were made to large polygon areas during the investigation, and the majority left as classified. Outcome overall is good but an aspect to maybe investigate further in next update.

Also, in the 2023 process it appears 'Utilities' (Roads) are across Indigenous but this is probably OK for logic, but this was different in 2018 where indigenous was applied as the last layer.

Other Exotic

It appeared a similar issue in some areas between the LCDB classification for Forestry and "other Exotic" in WRCBioveg occurs with similar effect as outlined above for Indigenous. This was not seen to be too significant in scale, but the logic could be reassessed in future.

Overall though the 2023 provides a good representation of this class – it was probably a bit overrepresented in 2018.

Wetlands

Good representation from data sets – nothing changed.

Lifestyle

The Lifestyle land use was sorted by area and then looked at those over 6ha – 232 of them of which 171 where classed as lifestyle in 2018. Many of those classes in both 2018 and 2023 are on northern boundary and are now

subdivided – not sure if Beca accessed data from Auckland Council – but most on boundary are OK and were not changed

A number of lifestyle blocks are actually parts of farms that have been subdivided off but are still part of active farm – these can be seen in WRAPS where raceways etc cross boundaries.

Looked at most of those large ones down to 6 ha and checked – also looked at some of the ones just <2,500m^2 to check, most of very small parcels are segments created as part of the overlay process. Where it was thought classification was incorrect made a recommendation to change.

Low Density Residential

For LD Residential the major areas of change between timesteps seem to make sense when look where growth is and compare to WRAPS23. The 2023 layer provides good classification based on the data. Some anomalies were found when looking across other classes and some changes recommended. An in-depth analysis of applied logic was not undertaken as the extent and location of class matched well with scan of WRAPS23.

It was noted that LD residential seems to have been applied over top of Indigenous – making LD res area larger in areas like Coromandel township. But this has not been applied in all places – for example see Thames township properties. Probably not a big deal as bit of +/- in outcomes, but worth reviewing the logic of model that produced this in future updates.

In future an overlay logic of residential last is probably best for LD Residential, but good that a different logic has been applied for Lifestyle where large areas of block can be Indigenous.

Medium to High Density Residential

The 2023 has done a good job of picking up new areas of MH Density Residential.

A few additions were found for a few Lifestyle villages which parts of needed to be included into this land use class. Also, in a couple of locations the area calculation seemed to be a little out (see west side Matamata and Eastern side of Morrinsville – not sure what has driven this – probably the number of dwellings or number actual titles in parcel that has been used in calculation differs – I took data from NZ Primary Parcels of LINZ data portal. In most areas the overall logic applied is sound and happy with changes between timesteps and overall extent as corrected.

Commercial and Manufacturing

The process of distinguishing between commercial and manufacturing is not easy – in WISE manufacturing is seen as actually making something – producing a product- whereas commercial is seen as selling a product to the user or providing a service (so things like electricians, auto shops tyre shops, storage facilities, industrial supplies would be commercial) – the coding in VDB doesn't allow for an easy distinction between these two land uses.

Overall, the 2023 layer looks to have done a good job with these two classes and defining the new growth areas. There is a bit of 'swings and roundabouts' between the layers but overall quantum feels right.

In 2018 version I spent some time in using WRAPS and Google maps to separate out these differences for Hamilton and Cambridge and other urban areas – So for Hamilton I recommend that the 2018 LU class for smaller parcels in the Frankton and Te Rapa area is applied. Admittedly this division is not a perfect process to implement using data sets or even WRAPS and Google Maps.

Community Services

Community services was a bit overrepresented - this occurred in the 2018 as well as a facility (or cemetery) can be associated with a large parcel of land – this can be easily picked up using the VDB data. Some corrections were made where seen to be different from 2018 without good reason.

Utilities

Some of the utility facilities have large land areas associated with them – often this land is part of the "parcel" but is used for other land uses so best to split off and reclass. Most of these were picked up through the draft review process

Also, with roads in 2018 version the final land use layers laid down were forestry, then other exotic, then indigenous – this overlaid a number of road areas, the 2023 LU layer the roads (in most places it seems – maybe a function of private vs public roads? Where it doesn't occur with road parcels) seem to be laid over towards end – this creates more Utilities land use – also some of the land parcels associated with roads are much larger than the road themselves so 'exaggerate' the area of use (maybe a solution next time might be to buffer the road network centreline and then apply this over rather than the road parcels?)

Dairying and Sheep and Beef

Dairying was compared for 2023 and 2018 in MCKit and worked way across region looking at large areas of difference. These differences a mostly between classification of an area as Dairying or Sheep and Beef (with a little bit of forestry in mix).

This assessment provided a mixture of results as when working through identifies areas some showed the 2023 code was probably more appropriate based on visual inspection compared to 2018 classification. However, the majority seemed to suit the 2018 assessment, as a lot of time was spent visually working through the code "conflicts" in the 2018 version, so more weight could have been applied to them in final LU assessment process. Also, a lot of visual assessment was done on forestry for 2018 so the areas that were in dairying in 2018 and "Forestry" in WRCBIO12 should have been classed as Dairying. Corrections are recommended based on review of the two layers.

For Sheep and Beef most changes seem to be swaps between the classification of dairy vs S&B/stock finishing in data sets – haven't chased this down in detail as most of it seems to be OK – and sorted the main dairying LU changes first so rest are just smaller switches.

The distinction between dairying and sheep and beef is probably one of the harder to make for classifying land use as there is a large grey area in the middle. There can be a lot of conflict between VDB and AgriBase, and some farms are a mixture of both land uses and many block are runoff or dairy support units. So, it does get subjective in the middle ground and require either manual checking or wider assumptions.

Forestry

Forestry has been changing rapidly in the last decade or two in Waikato. For the 2018 layer a lot of manual checking was done in the south of the region to try and delineate some of this change which the datasets (LCDB, AgriBase and VDB) hadn't kept up with.

There were some large areas that were incorrectly classed as forestry in the 2023 layer. These have been identified and changes recommended.

Horticulture, Vegetable cropping, Other cropping, Other Agriculture

The methodology for identifying these is sound and there were no noticeable anomalies. The cropping land uses can be spatially variable between timesteps but overall, the extents identified are plausible

Mines and Quarries

The 2018 analysis missed three quarries in the Tuakau/Pokeno area from LU map. The other quarries in the region were reviewed – some of them had larger areas than the active quarry so changed additional areas to appropriate land cover/use. Some of this adjustment could have occurred in the creation process if WRCBio veg or LCDB were applied in a different order – looks like mines/quarries were applied after WRCBioveg in some places but not in others? Other mines have expanded their area.

Parks and Recreation

Parks and Recreation are well identified in the urban areas in 2023 map. The issue with this land class is that in rural landscape large areas are classed in VDB as this use. In WISE this is meant to be an urban class. In most cases the application of land cover or some specific use has predicted the right land use. Some anomalies were identified and suggestions for LU Class recommended.