Te Puke Stormwater Modelling Report

Project No. 44801858

15 August 2022

Prepared for Western Bay of Plenty District Council

The expert in **WATER ENVIRONMENTS**

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Prepared for: Western Bay of Plenty District Council
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Contents

1 Introduction

DHI was engaged by Western Bay of Plenty District Council (WBoPDC) to use the 2019 Te Puke model to simulate some future development scenarios. The scope of the work is detailed in the DHI proposal 44801858, dated 26th April 2022. Key points from the modelling are:

- Existing development scenario represents the year 2019. Which is referred to as the 2019 model.
- Maximum Probable Development (MPD) scenario is 70% imperviousness for existing residential with no change in imperviousness for any Greenfield development (any development in these areas will need to mitigate any increases in runoff)
- Future Intensification (Plan Change 2021/22) scenario is also 70% imperviousness for existing residential with no change in imperviousness for any Greenfield development (any development in these areas will need to mitigate any increases in runoff). Please note that there is a different extent for this scenario compared to the MPD scenario, which includes the Washer Road Industrial Zone and Seddon Street Medium Density Residential Zone
- DHI subcontracted Peter West to use the Non Linear Reservoir (NLR), rainfall-runoff model, to generate the climate change inflows
- The existing MOU between WBoPDC and Bay of Plenty Regional Council (BoPRC) allows the 2019 model to be used
- WBoPDC will use results from this modelling exercise to:
    - Update their website (including the online natural hazard maps).
    - Refer to in Land Information Memoranda (LIMs).
    - Process resource consents and building consents (including the use of flood levels to set minimum floor levels).
    - Support / inform changes to the District Plan for Te Puke (including for existing and new areas of development).

2 Scenarios

Twelve scenarios have been modelled as described in Table 1. The scenarios differ in the level of development which varies the land use and imperviousness within the catchment. The design rainfall varies between scenarios from 2% to 0.2 % AEP, with a constant sea level rise of 1.25m. Figure 1 to Figure 3, shows the extent of the development scenarios.

Scenarios 1-3 are the 2019 model setup from the previous study, /1/ DHI 2021, but have been rerun with climate change adjusted rainfall and a sea level rise of 1.25 metres. Also the surface roughness was modified as described in Section 3.2.4.

Scenarios 4-6 have the same rainfall and sea level rise allowances applied as for Scenarios 1-3, but have a larger extent of "developed" area as shown in Figure 1. These scenarios have a 70% impervious area applied for the residential areas and 90% impervious for the industrial/commercial areas.

Scenarios 7-9 are very similar to scenarios 4-6 in all ways apart from they have a very slightly larger potential "developed" area as shown in Figure 2.

Scenario 10 is very similar to scenario 8 in all ways except it has a 50% impervious area applied for the residential area rather than 70% impervious. This event is using the climate change adjusted 1% AEP design rainfall.

Scenarios 11-12 have a modified development extent as shown in Figure 3 and have a 50% impervious applied to the residential area or 70% impervious applied, respectively. Both events are using the climate change adjusted 1% AEP design rainfall.

Table 1 - Scenarios Modelled

No.	Development Scenario	Design Rainfall	Imperviousness (%)	Sea Level Rise (m)
1	Existing	2% AEP 2130 RCP 8.5	2019 Model Setup	1.25
2	Existing	1% AEP 2130 RCP 8.5	2019 Model Setup	1.25
3	Existing	0.2% AEP 2130 RCP 8.5	2019 Model Setup	1.25
4	Maximum Probable Development	2% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25
5	Maximum Probable Development	1% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25
6	Maximum Probable Development	0.2% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25

No.	Development Scenario	Design Rainfall	Imperviousness (%)	Sea Level Rise (m)
7	Future Intensification (Plan Change 2021/22)	2% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25
8	Future Intensification (Plan Change 2021/22)	1% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25
9	Future Intensification (Plan Change 2021/22)	0.2% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25
10	Future Intensification (Plan Change 2021/22)	1% AEP 2130 RCP 8.5	50 Residential /90 Industrial/Commercial	1.25
11	Alternative 1 Development (50% Imp)	1% AEP 2130 RCP 8.5	50 Residential /90 Industrial/Commercial	1.25
12	Alternative 1 Development (70% Imp)	1% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25

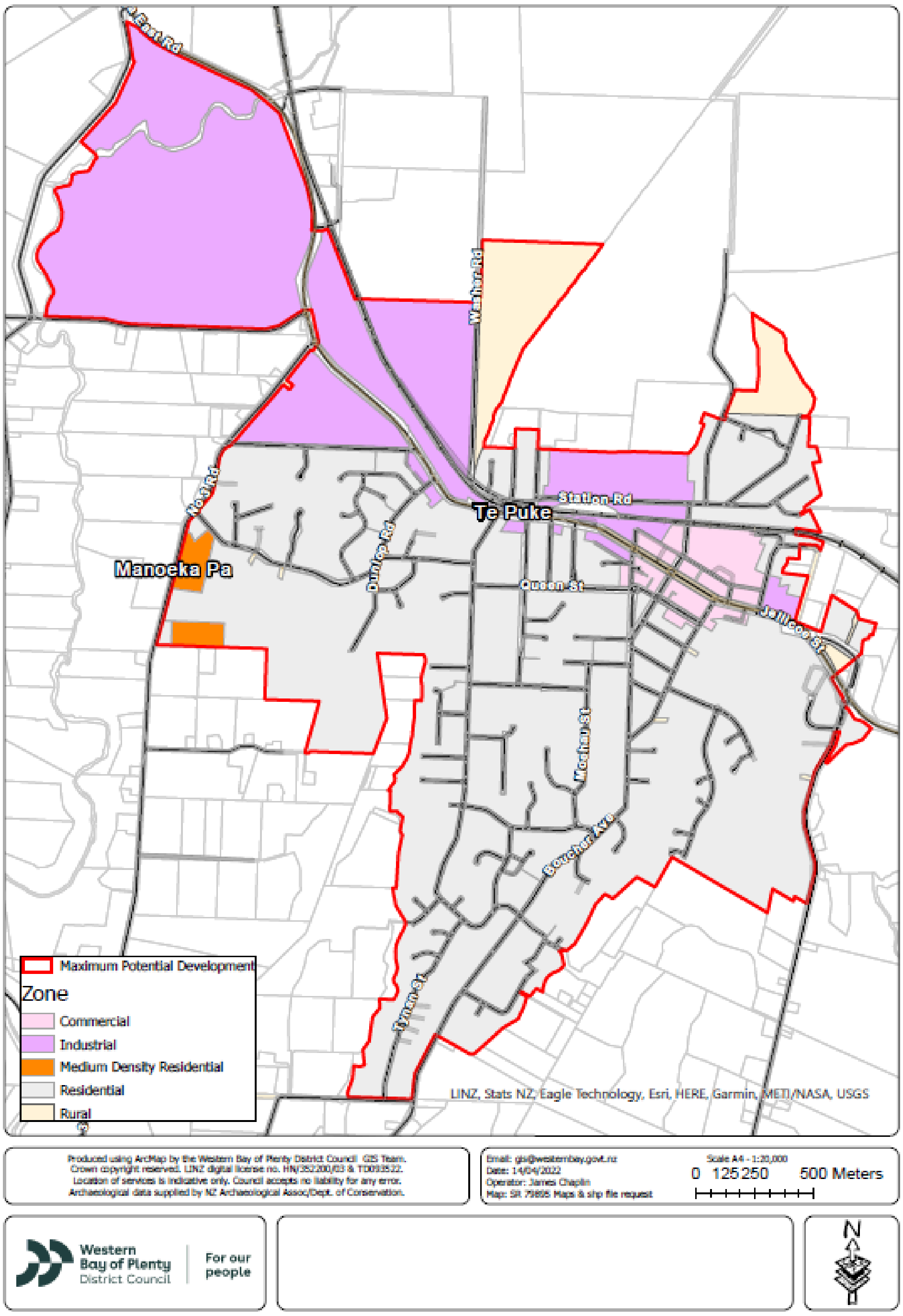

Figure 1 – MPDv3 supplied by WBoPDC

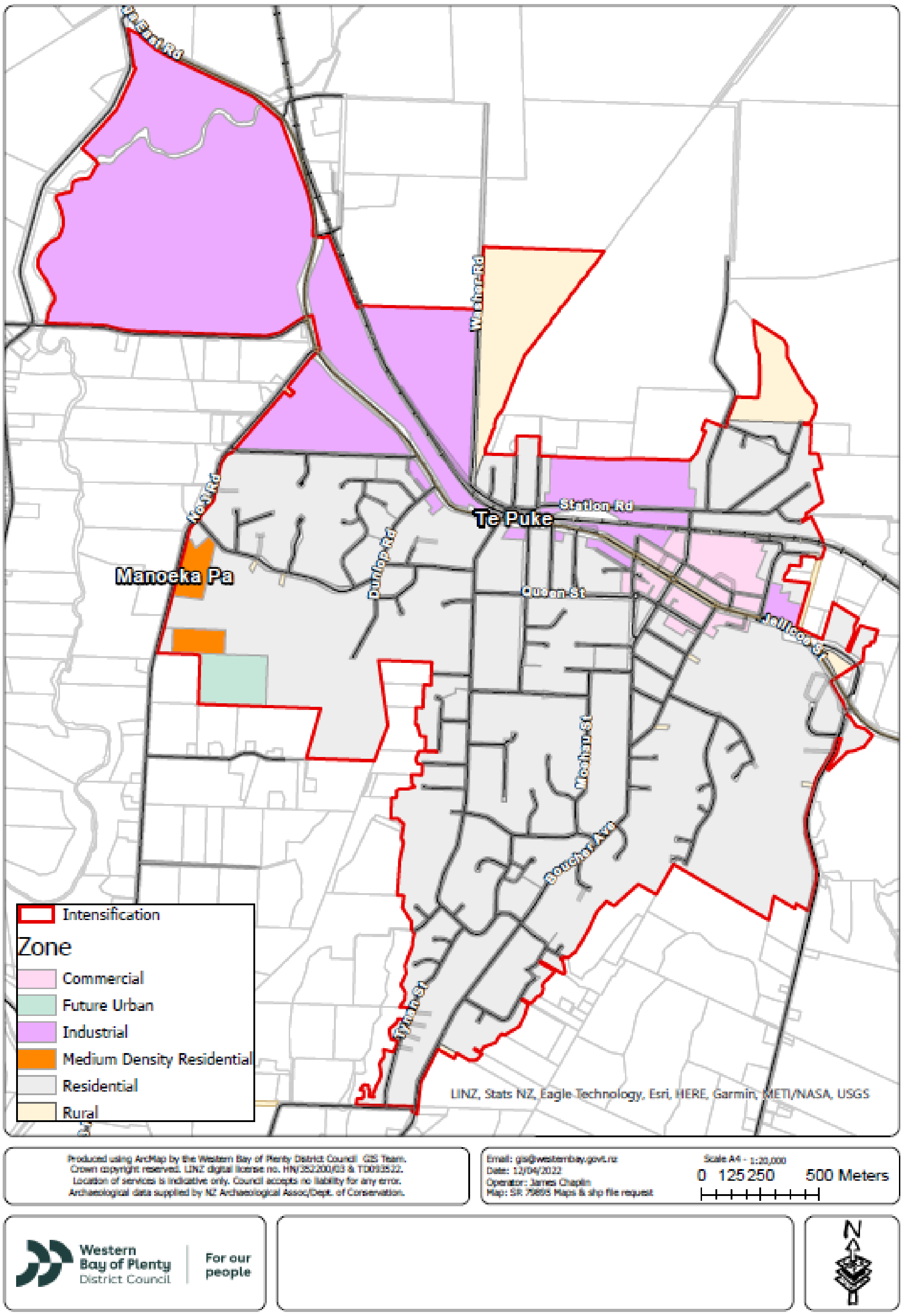

Figure 2 – Intensification map v2 supplied by WBoPDC

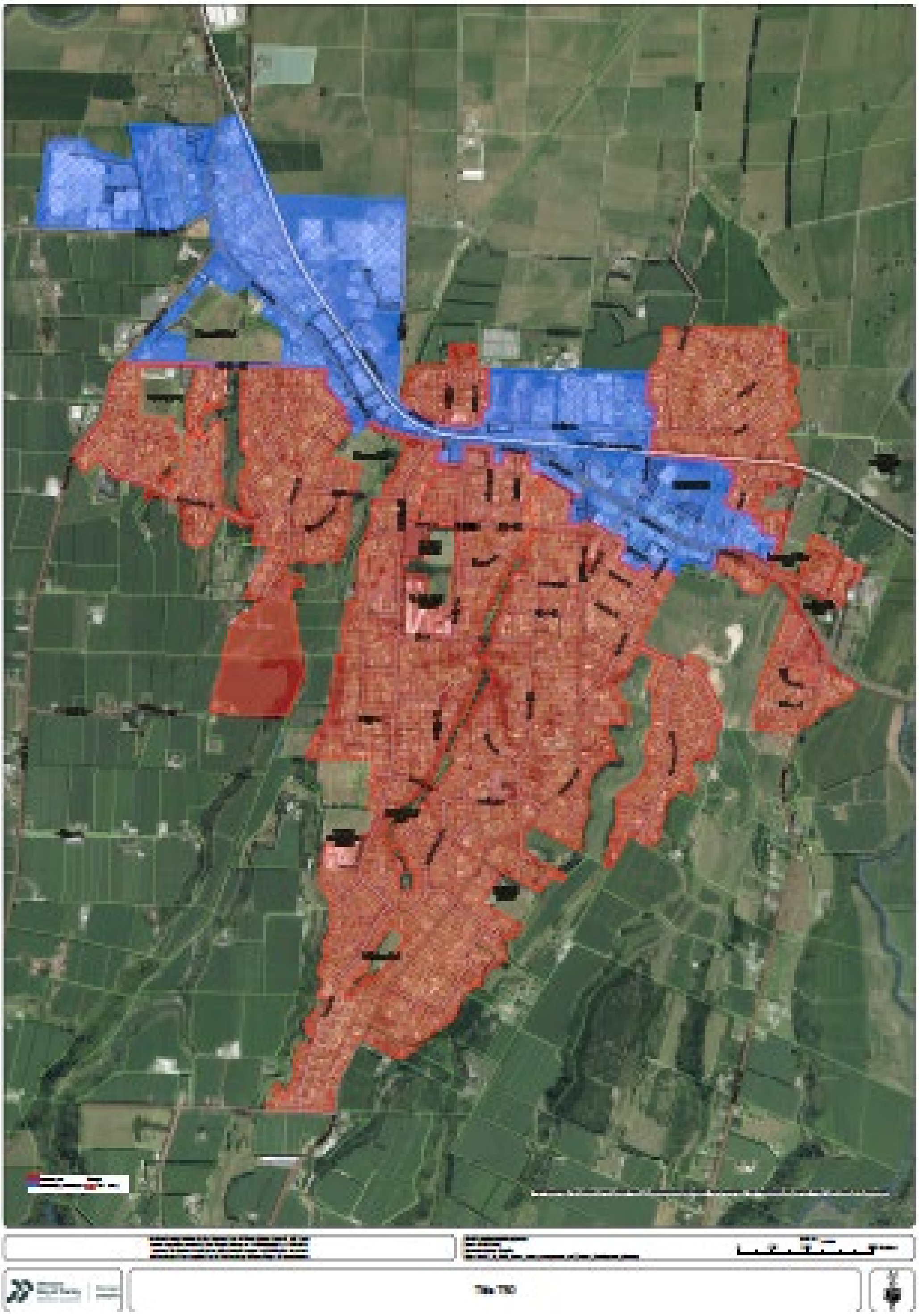

Figure 3 – Alternative 1 development scenario supplied by WBoPDC

3 Methodology

3.1 Previous Modelling

DHI previously completed a study for BoPRC and WBoPDC to build a flood model focussing on the Te Puke township and downstream floodplain. The purpose of the modelling was to assess the impact of development in the catchment over the last 20 years, to assess the effectiveness of the Kaituna flood scheme built pre 1999 and to have a model capable of assessing flood mitigation options completed at a later stage.

The model (known as the 2019 model) was created using the MIKE FLOOD software. The model setup was derived from previous model setups of the Kaituna River catchment, pipe and manhole asset data and LiDAR (2018 and 2011) survey. This model was calibrated to the June 2014 flood event and was found to match well where validation data was available.

Input rainfall and runoff were all derived by Blue Duck Consulting, using a Non Linear Reservoir (NLR) rainfall-runoff model that has been used as inputs to other hydraulic models of the Kaituna River catchment. Three different sized storm events were modelled the 1%, 10% and 20% AEP, with three storm shapes used; Te Puke centred, Mangorewa centred and a heavy-ended storm (Te Puke centred). The design events allowed for analysing the various levels of service required in the area and the impacts of different storm shapes on the local flood hazard. The heavy-ended storm shape proved to be the most critical of the three storm events modelled, and it is a recommendation to consider using this in future modelling.

A comprehensive modelling report was produced for this work, and the reader should refer to this report for further details, /1/ DHI 2021

3.2 Current Study

The 2019 model was modified for this study to extend the area that has rain on mesh hydrology applied. Other changes included land use, imperviousness, roughness, runoff inflow boundaries, and rain on mesh design rainfall (the last two provided by Blue Duck Consulting). Each of these changes to the 2019 model is detailed below:

3.2.1 Rain on Grid Extension

Part of the current catchment within the NLR rainfall runoff model was converted to using rain on grid hydrology so we could understand flood extents for the existing development scenario and other development scenarios, see Figure 4. The runoff inflow boundary at this location was removed from the model so as to not double count any runoff.

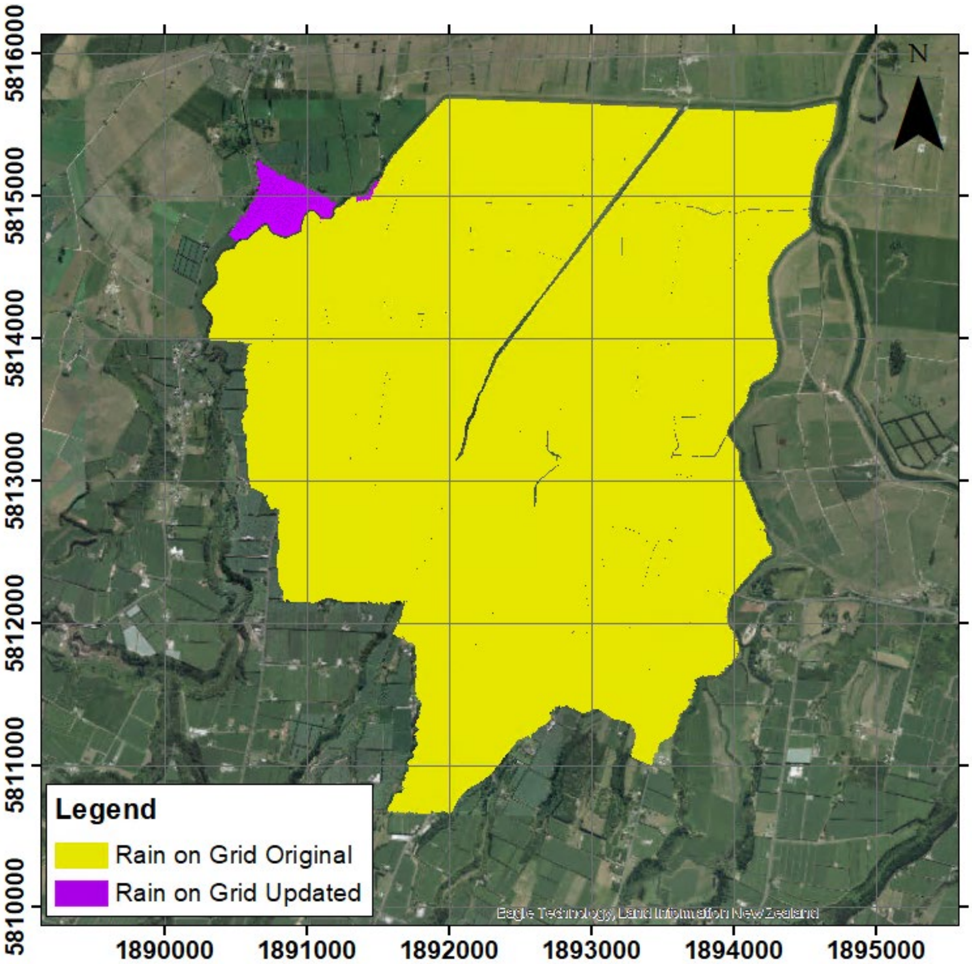

Figure 4 - Rain on Grid Extension

3.2.2 Land Use Changes

Land use and associated soil types are used in the model to apply varying infiltration as detailed in /1/ DHI 2021, Section 3.2.4.

The Land Resource Information Systems Portal (LRIS) gives access to the New Zealand Land Cover Database (LCDB). For the 2019 Te Puke model, soil types fall into three main drainage types, Very well Drained, Poorly Drained and Very Poorly Drained. Each soil type has an associated leakage rate calibrated for the 2019 model. See Leakage Rates and distribution in Appendix A, Figure 5 to Figure 10.

3.2.3 Imperviousness Changes

Imperviousness within the model is also accounted for, so the right balance of infiltration and runoff occurs during a rainfall event. It was assumed in the previous study, /1/ DHI 2021, and the 2019 model that all roads were entirely impervious, the residential areas were 50% impervious, and the industrial areas were 90% impervious. Where an area was impervious, the leakage rates were scaled, i.e. for the residential areas; the leakage rates were reduced by 50%. The scaling was done in-lieu, including individual detail of driveways, grassed/vegetated areas and roof areas.

3.2.4 Roughness

The roughness of the land surface is represented in the 2D part of the model and has been simplified compared to the 2019 model setup. The 2019 model setup has a detailed roughness definition with property level information represented. The new areas to be developed do not have this level of detail, so we needed to simplify how the roughness is characterised so we can compare between scenarios. The roughness is assigned based on land use in combination with the impervious percentages.

Figure 11 to Figure 15, in Appendix B, show the different roughness applied for each development scenario.

3.2.5 Runoff Inflow Boundaries & Rain on Grid Design Rainfall

Blue Duck Consulting have provided all required runoff inflow boundaries for the “Heavy Ended” design storm shape for the 2%, 1% and 0.2% AEP events. These design storm scenarios include increased rainfall intensities from 3.68 degrees of atmospheric warming (the year 2130 RCP 8.5) applied per NIWA's 2018 HIRDS v4 guidelines. Rain on grid design rainfall was also provided for the same events with the same allowance for atmospheric warming used.

The most upstream point of the Kaituna River in the 2019 model is at Te Matai bridge, where a synthetic hydrograph is applied. This is detailed in /1/ DHI 2021, Section 3.2.3. For this study, we have used the 100-year synthetic hydrograph for all model simulations. This synthetic hydrograph was produced for the previous study, /1/ DHI 2021, by Blue Duck Consulting.

4 Results

All twelve scenarios have been modelled, and results have been provided to WBoPDC. Results have been post-processed for maximum water level, depth, velocity and duration of inundation, provided as raster files in several geodatabases. Results contain full maximum results and a filtered version with 50 millimetres of water depth removed. The basis of removing 50 millimetres of depth is that a 50-millimetre depth is only a minor nuisance and not flooding of any significance. Also very shallow flood water could be regarded as outside the accuracy of the model.

1D and 2D model result files have also been provided.

A number of water level difference maps have been generated to compare the results between scenarios. Difference maps are a very good way to understand the impact of different scenarios on water levels. Nine key difference maps are included in Appendix C, Figure 16 - Figure 24, with a summary at selected locations in Table 2 to Table 4. These are the same reporting locations as for the previous study, /1/ DHI 2021, and Figure 5 below is a copy of Figure 5.2 from that study. It should be noted that a positive value in Table 2 to Table 4 means an increase in water level and a negative value mean a decreased in water level when compared to the existing 2019 base scenario.

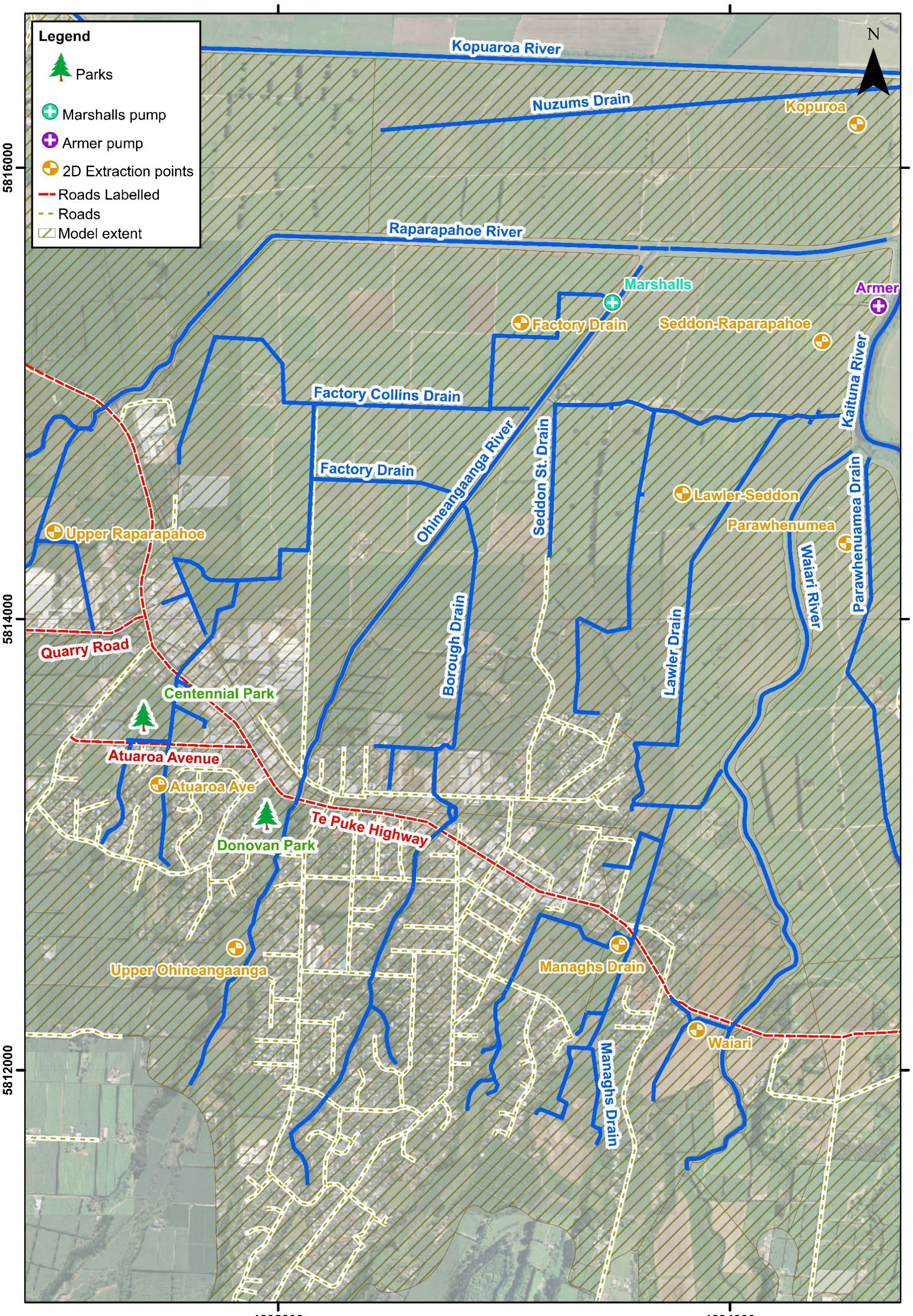

Figure 5 – Copy of Figure 5.2 from /1/ DHI 2021, showing selected 2D results extraction locations

Table 2 – Water Level Difference Summary for 2% AEP 2130 RCP 8.5

Water Level Difference to Existing (mm)		2% AEP 2130 RCP 8.5	
ID	Location	Maximum Probable Development	Future Intensification (Plan Change 2021/22)
0	Kopuaroa	3	3
1	Seddon-Raparapahoe	21	21
2	Factory Drain	54	57
3	Lawler-Seddon	11	11
4	Upper Raparapahoe	133	133
5	Upper Ohineangaanga	17	16
6	Managh's Drain	0	0
7	Waiari	9	9
8	Parawhenumea	1	1
9	Atuaroa Ave	48	58

Table 3 - Water Level Difference Summary for 1% AEP 2130 RCP 8.5

Water Level Difference to Existing (mm)		1% AEP 2130 RCP 8.5				
ID	Location	Maximum Probable Development	Future Intensification (Plan Change 2021/22)	Future Intensification Alternative 1	Alternative 1 Development (50% Imp)	Alternative 2 Development (70% Imp)
0	Kopuaroa	6	6	6	2	3
1	Seddon-Raparapahoe	28	28	3	-9	8
2	Factory Drain	47	50	36	20	26
3	Lawler-Seddon	13	13	1	-4	4
4	Upper Raparapahoe	144	143	143	1	1
5	Upper Ohineangaanga	29	27	23	2	4
6	Managh's Drain	0	0	0	0	0
7	Waiari	3	3	-4	4	7
8	Parawhenumea	0	0	-1	-2	-1
9	Atuaroa Ave	22	27	23	-9	3

Table 4 - Water Level Difference Summary for 0.2% AEP 2130 RCP 8.5

Water Level Difference to Existing (mm)		0.2% AEP 2130 RCP 8.5	
ID	Location	Maximum Probable Development	Future Intensification (Plan Change 2021/22)
0	Kopuaroa	7	7
1	Seddon-Raparapahoe	33	32
2	Factory Drain	36	38
3	Lawler-Seddon	33	32
4	Upper Raparapahoe	159	159
5	Upper Ohineangaanga	48	42
6	Managh's Drain	1	1
7	Waiari	1	1
8	Parawhenumea	0	0
9	Atuaroa Ave	23	17

5 References

/1/ DHI, November 2021, Te Puke Stormwater Investigation Stage 1 & 2

Appendix A Leakage Rates

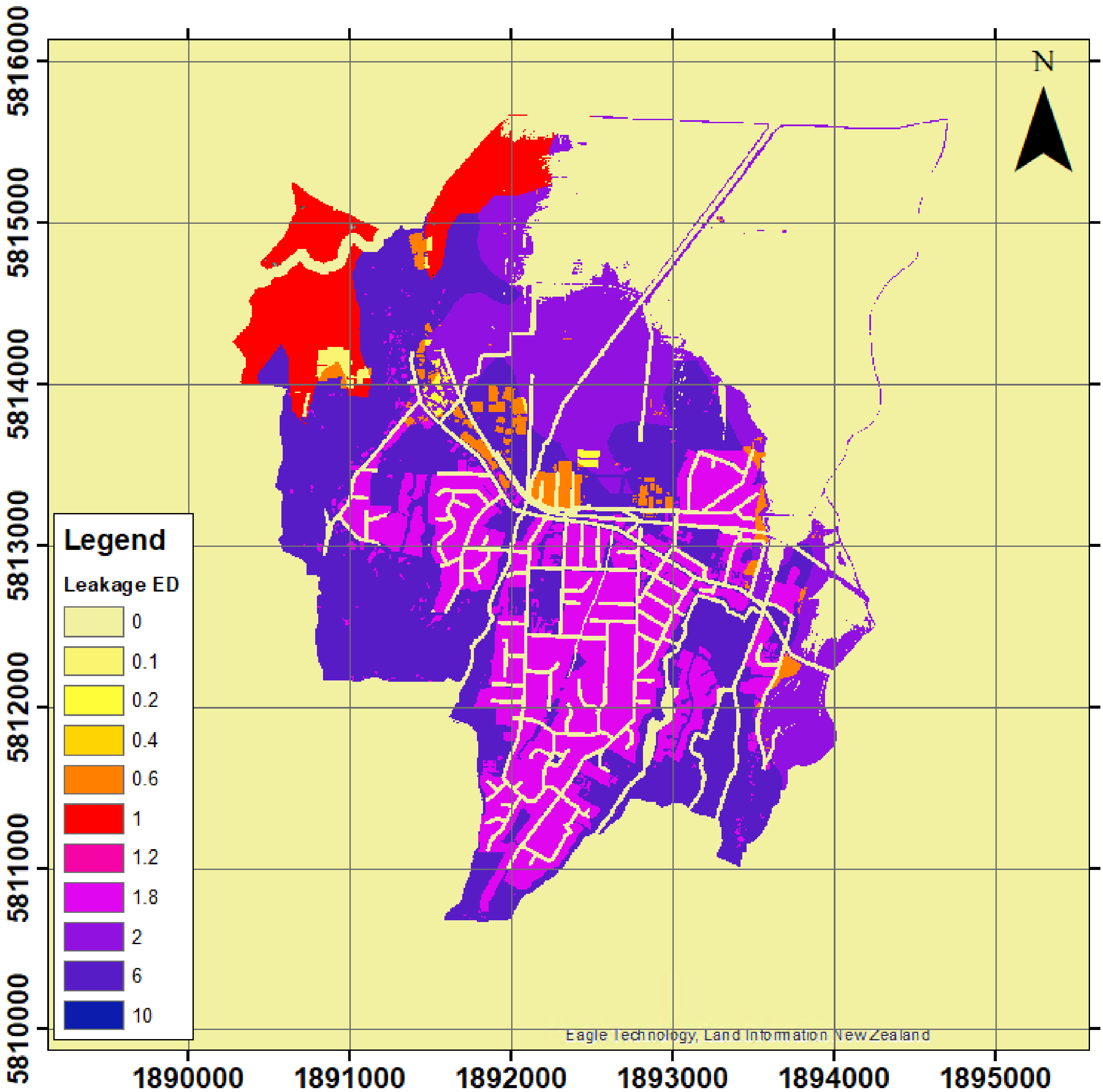

Figure 6 - Leakage Rates Existing 2019 Scenario

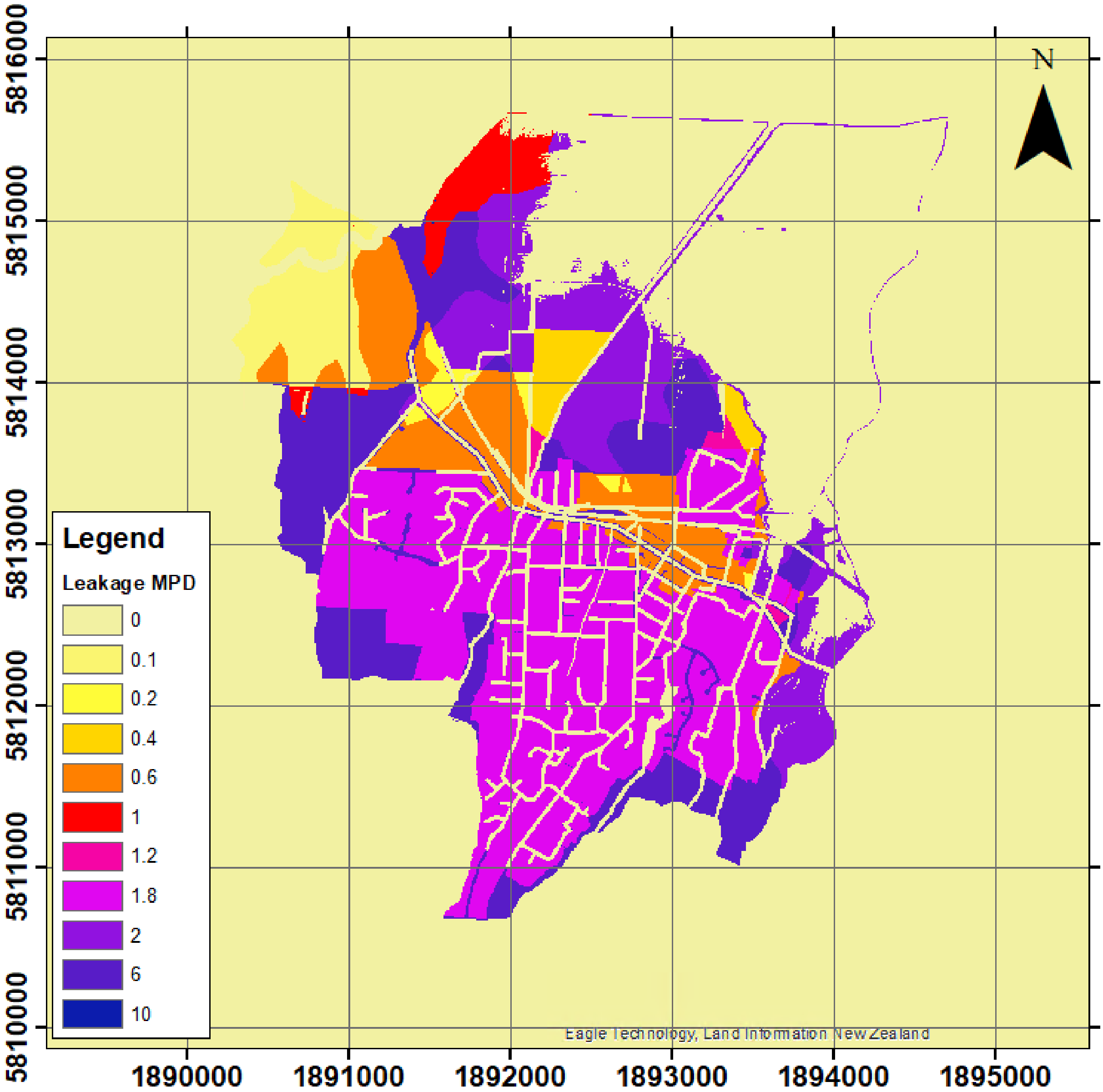

Figure 7 – Leakage Rates MPD Scenario

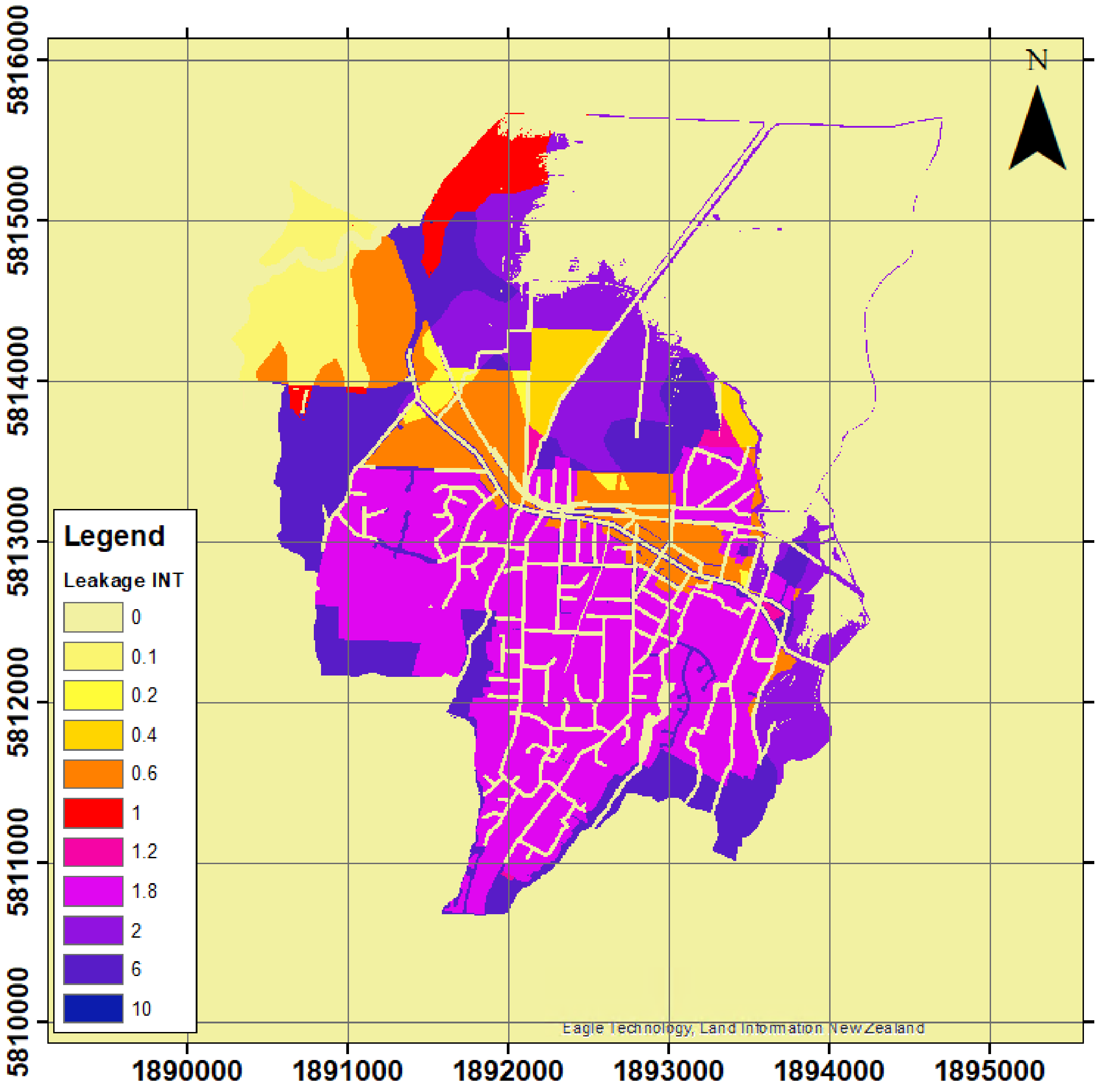

Figure 8 - Leakage Rates Intensification Scenario 70% Imperviousness

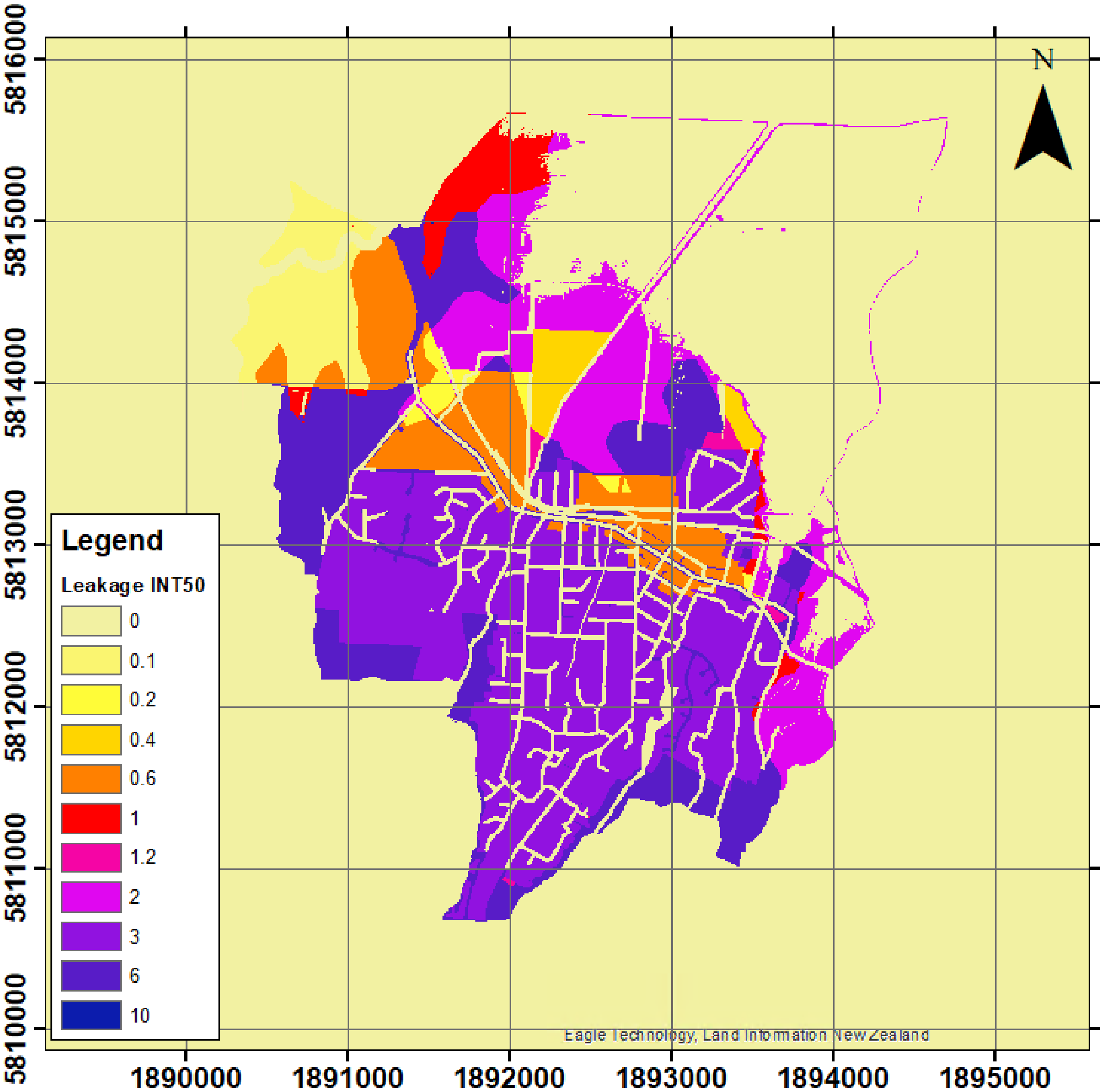

Figure 9 - Leakage Rates Intensification Scenario 50% Imperviousness

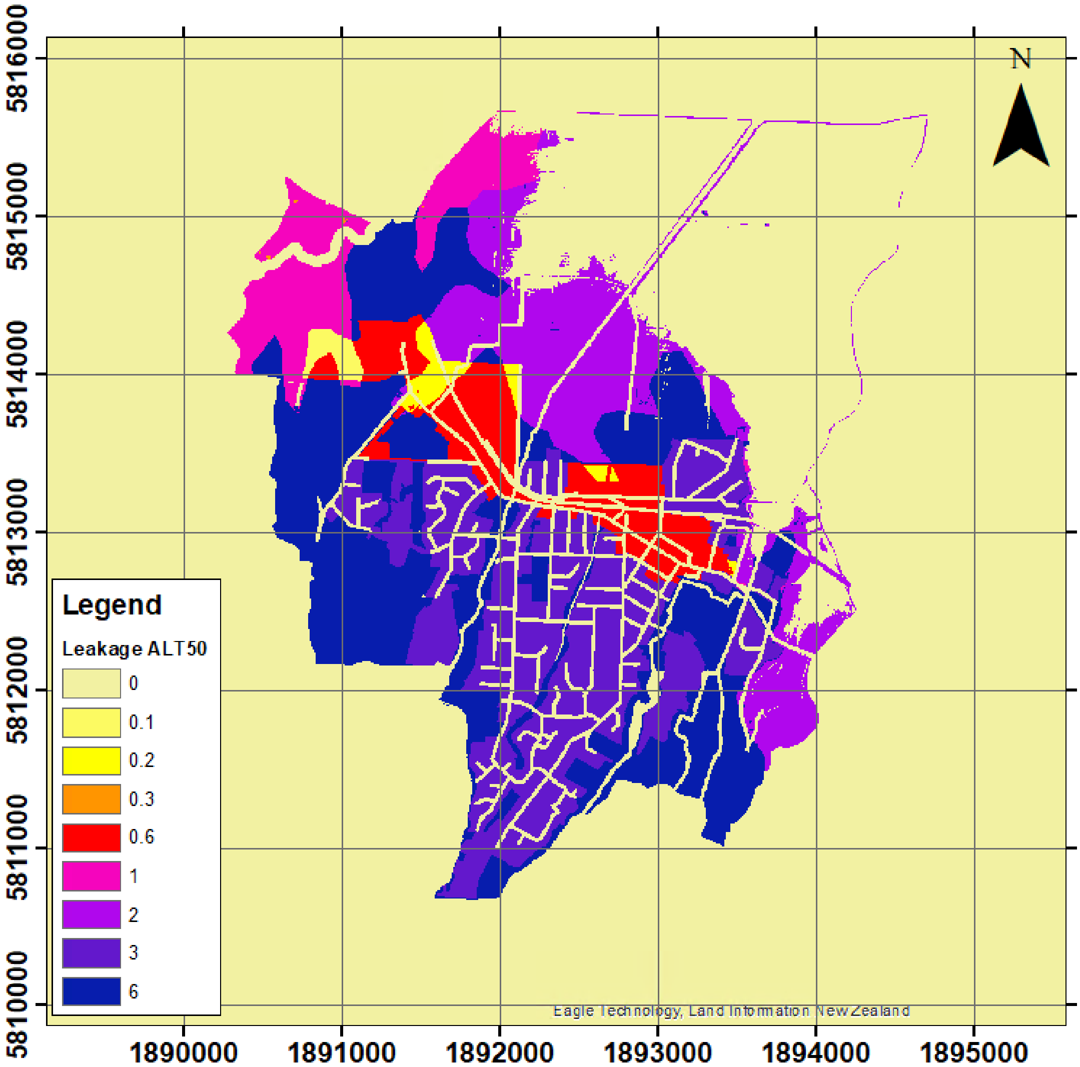

Figure 10 - Leakage Rates Alternative 1 Scenario with 50% residential

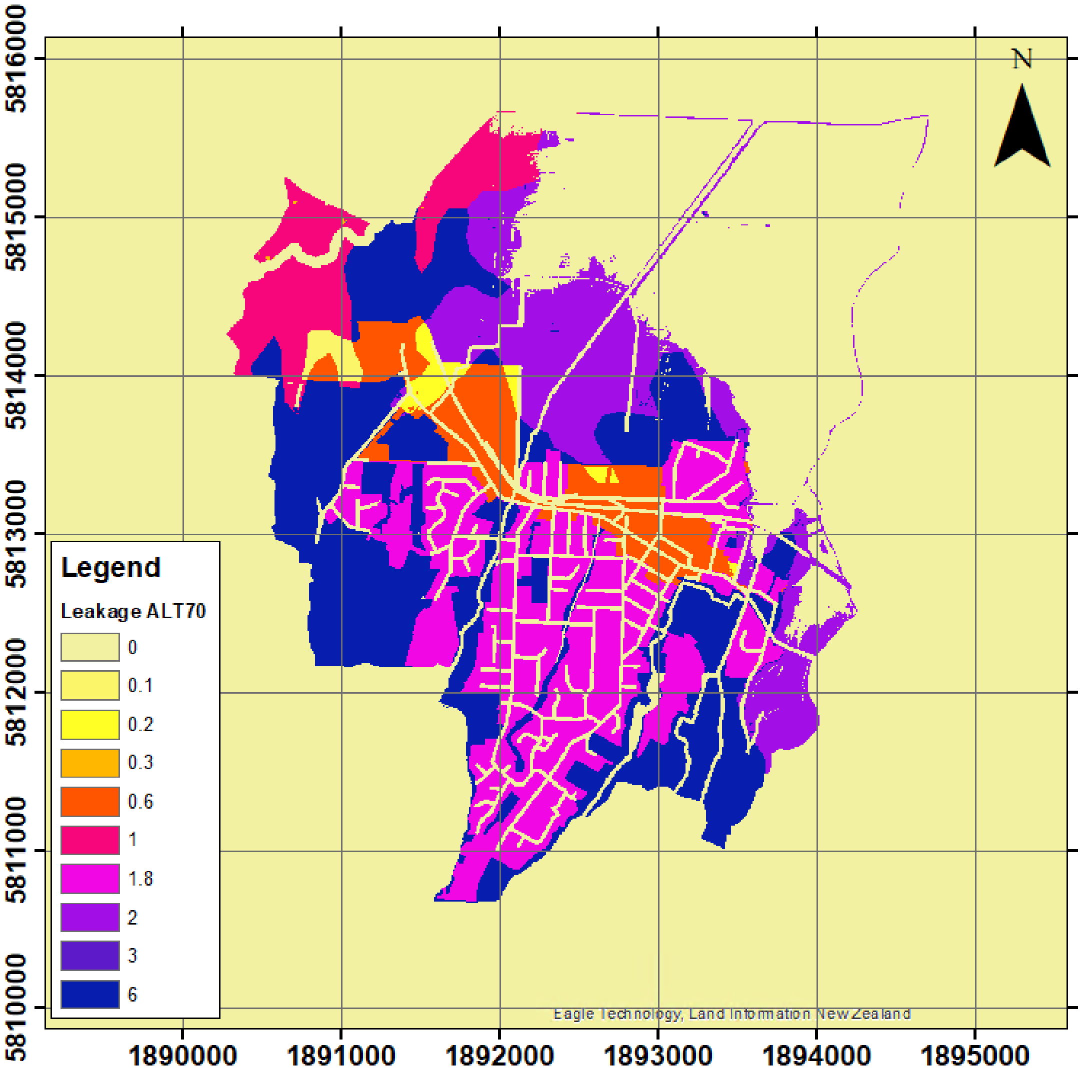

Figure 11 - Leakage Rates Alternative 1 Scenario with 70% residential

Appendix B Surface Roughness

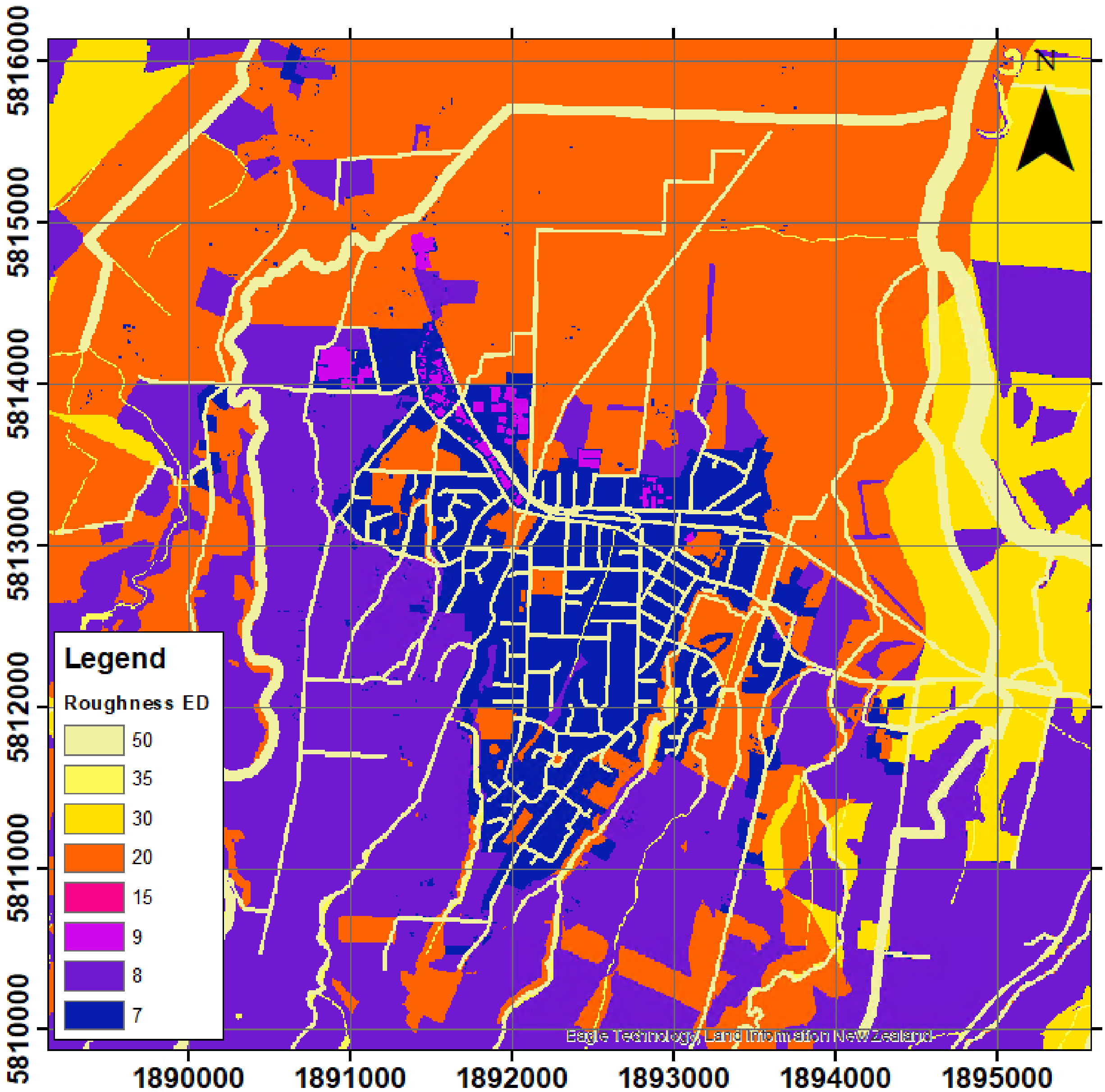

Figure 12 – Existing (2019) Scenario Manning's Roughness

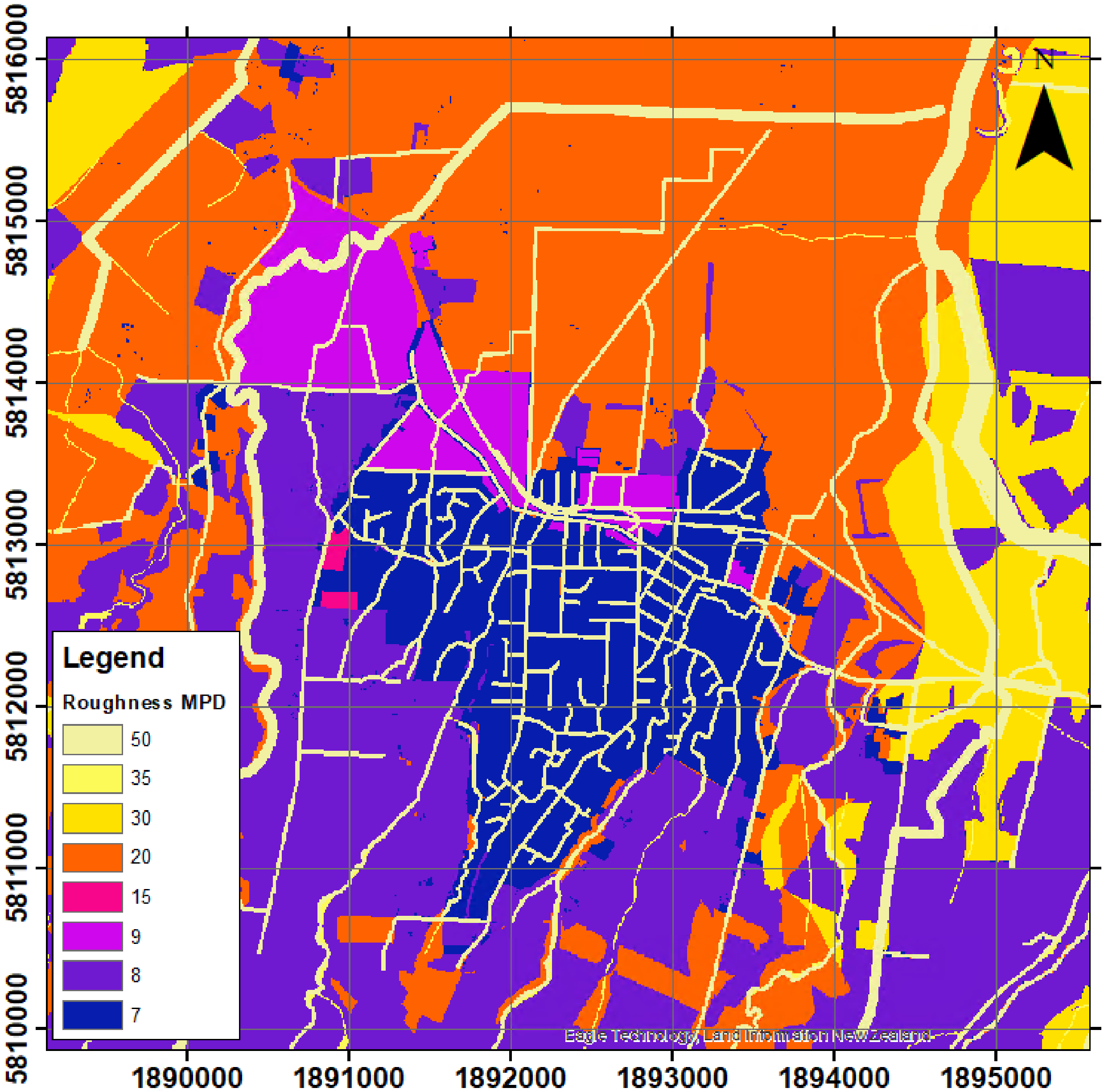

Figure 13 - MPD Scenario Manning's Roughness

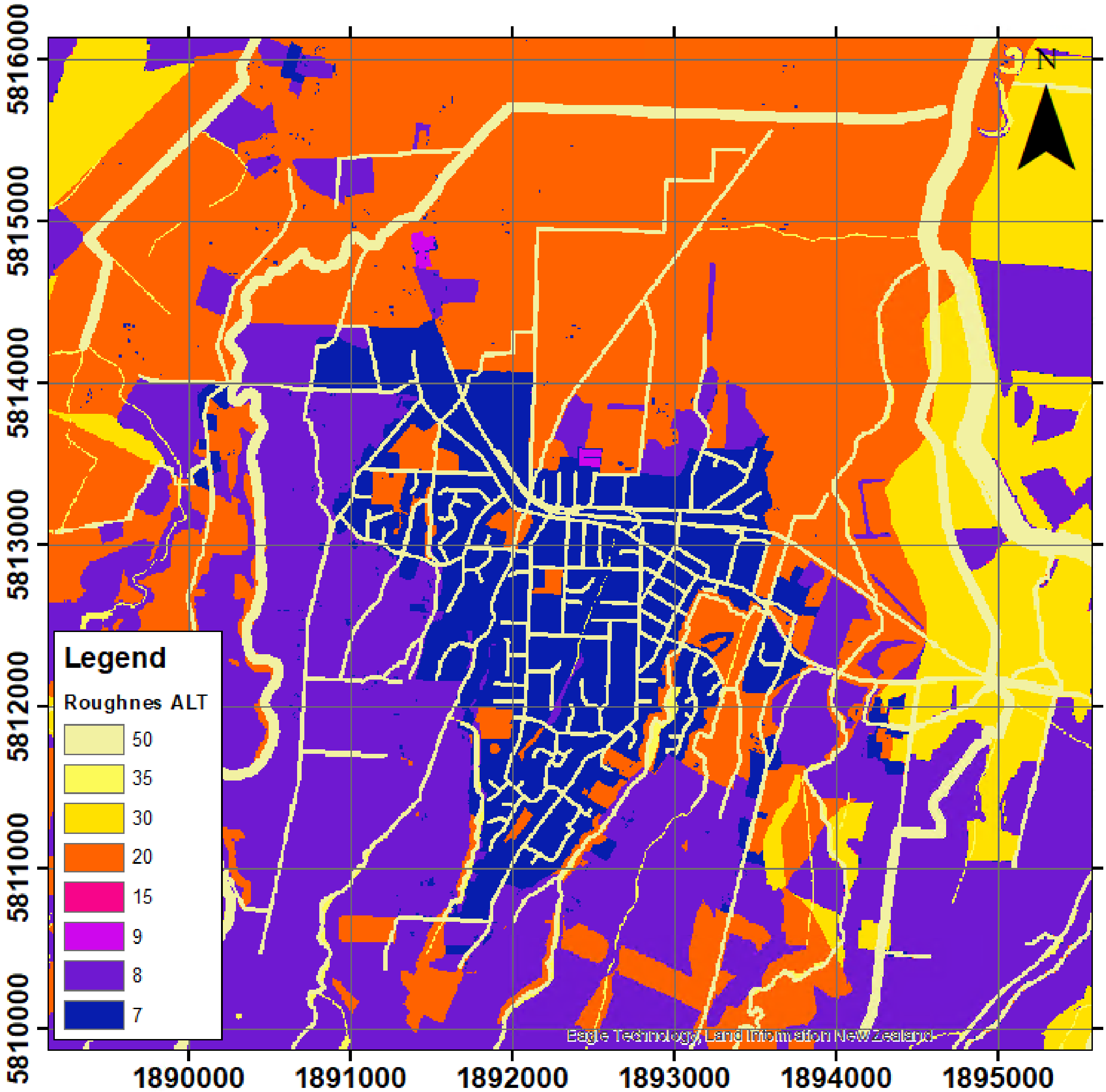

Figure 14 – Alternative 1 Development Scenario Manning's Roughness

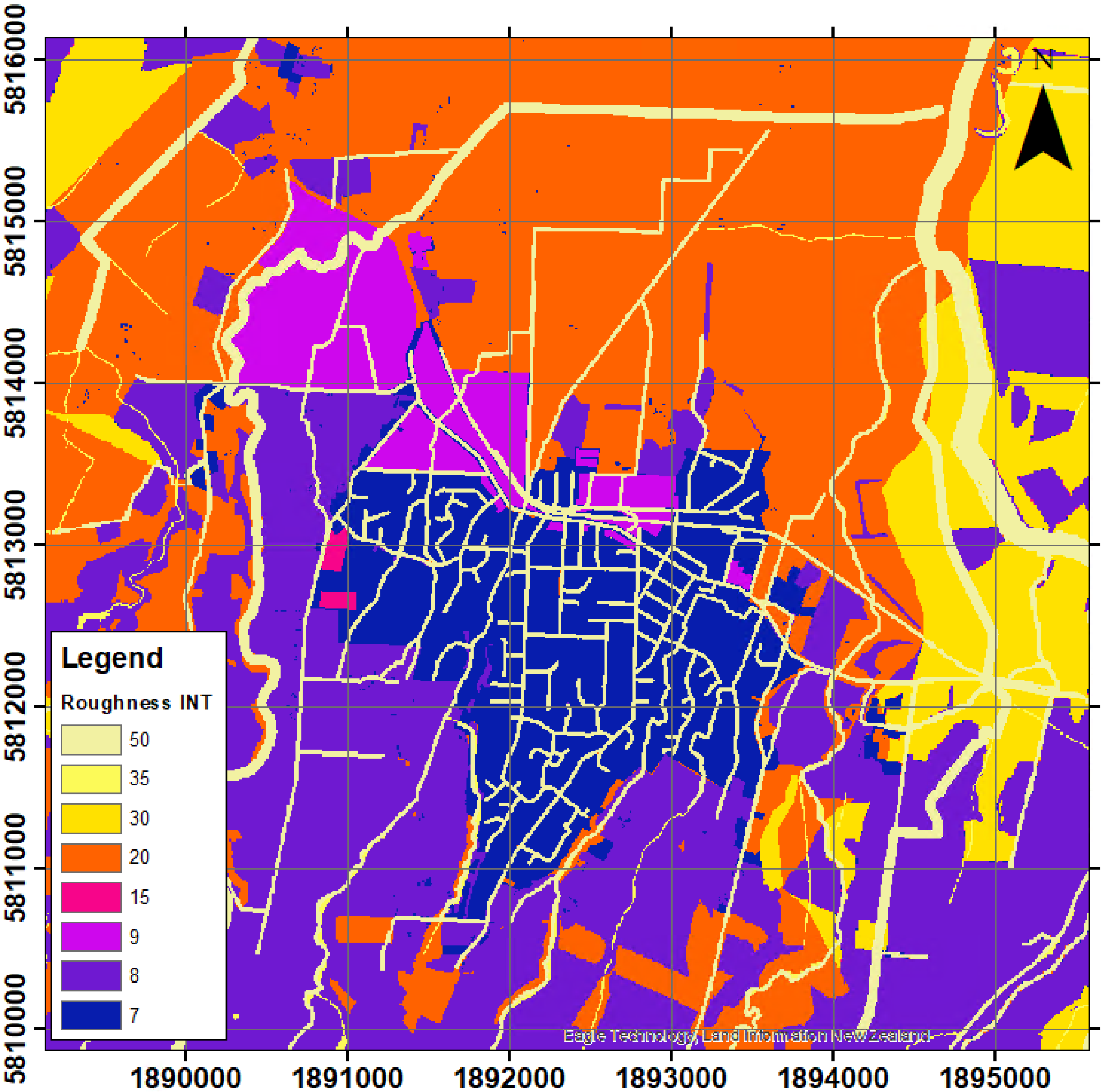

Figure 15 - Intensification Scenario Manning's Roughness

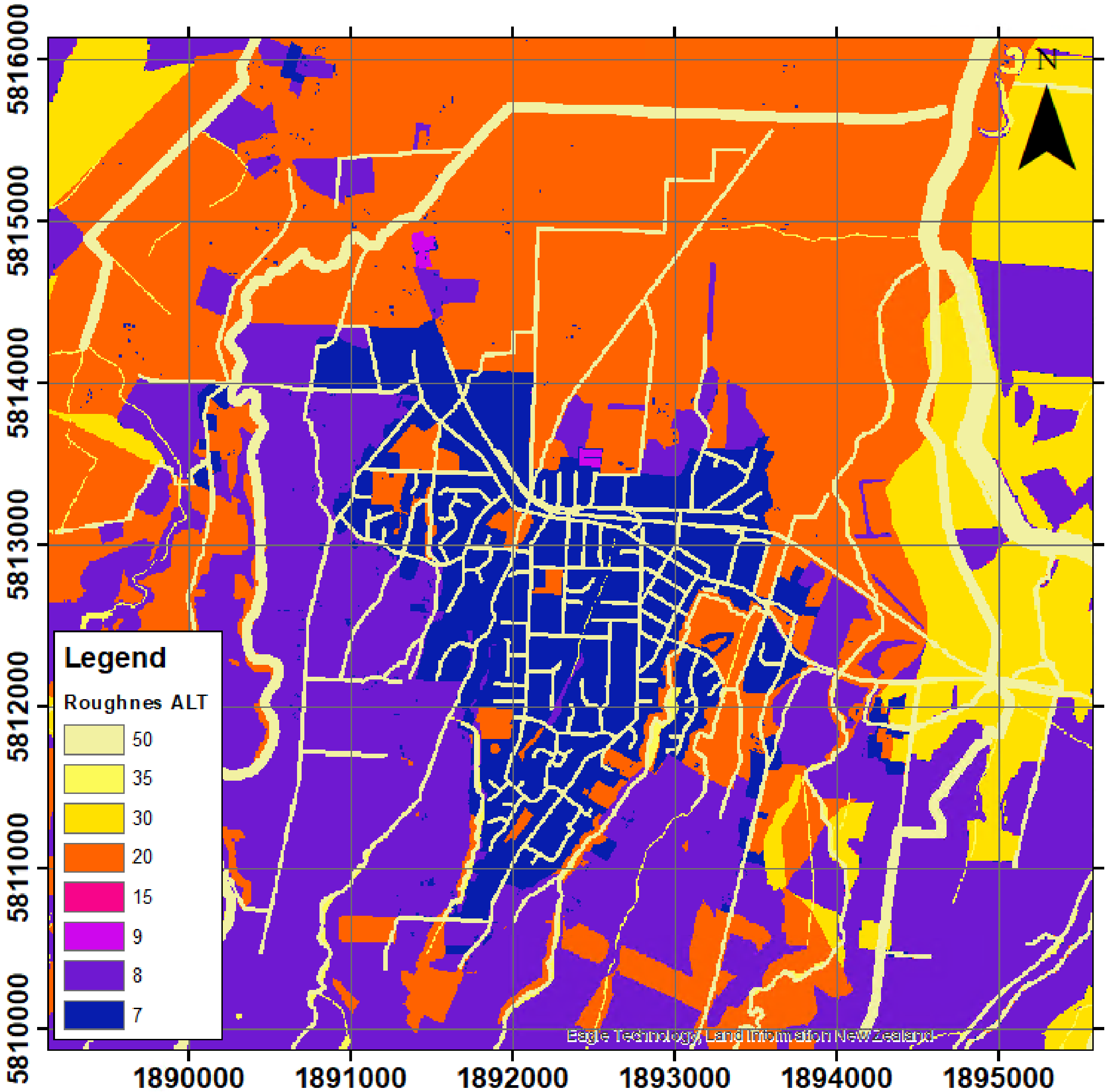

Figure 16 - Alternative 1 Scenario Manning's Roughness

Appendix C Water Level Difference Maps

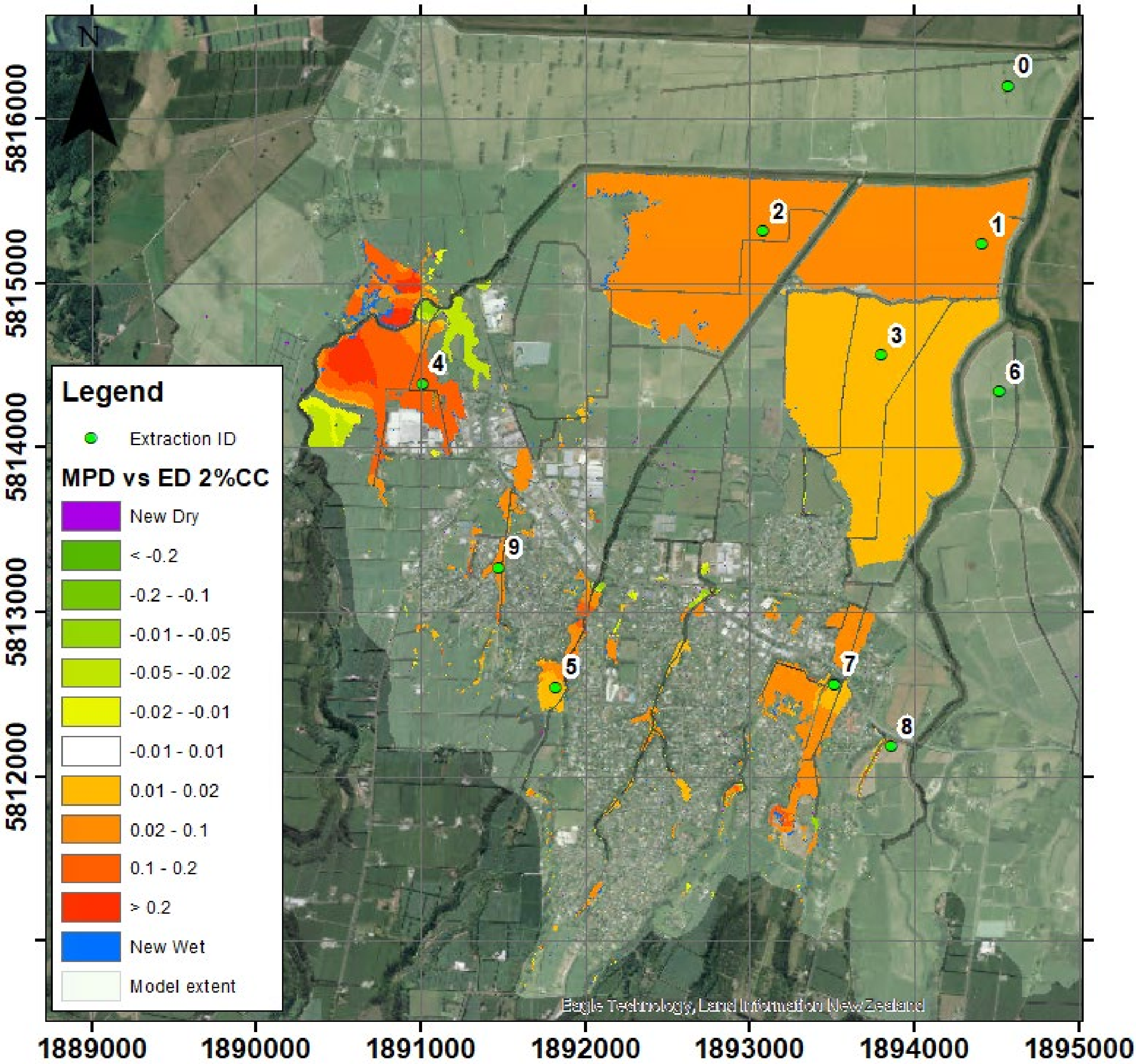

Figure 17 - Difference map between Maximum Probable Development vs Existing Development for the 50-year 2130 RCP 8.5 event

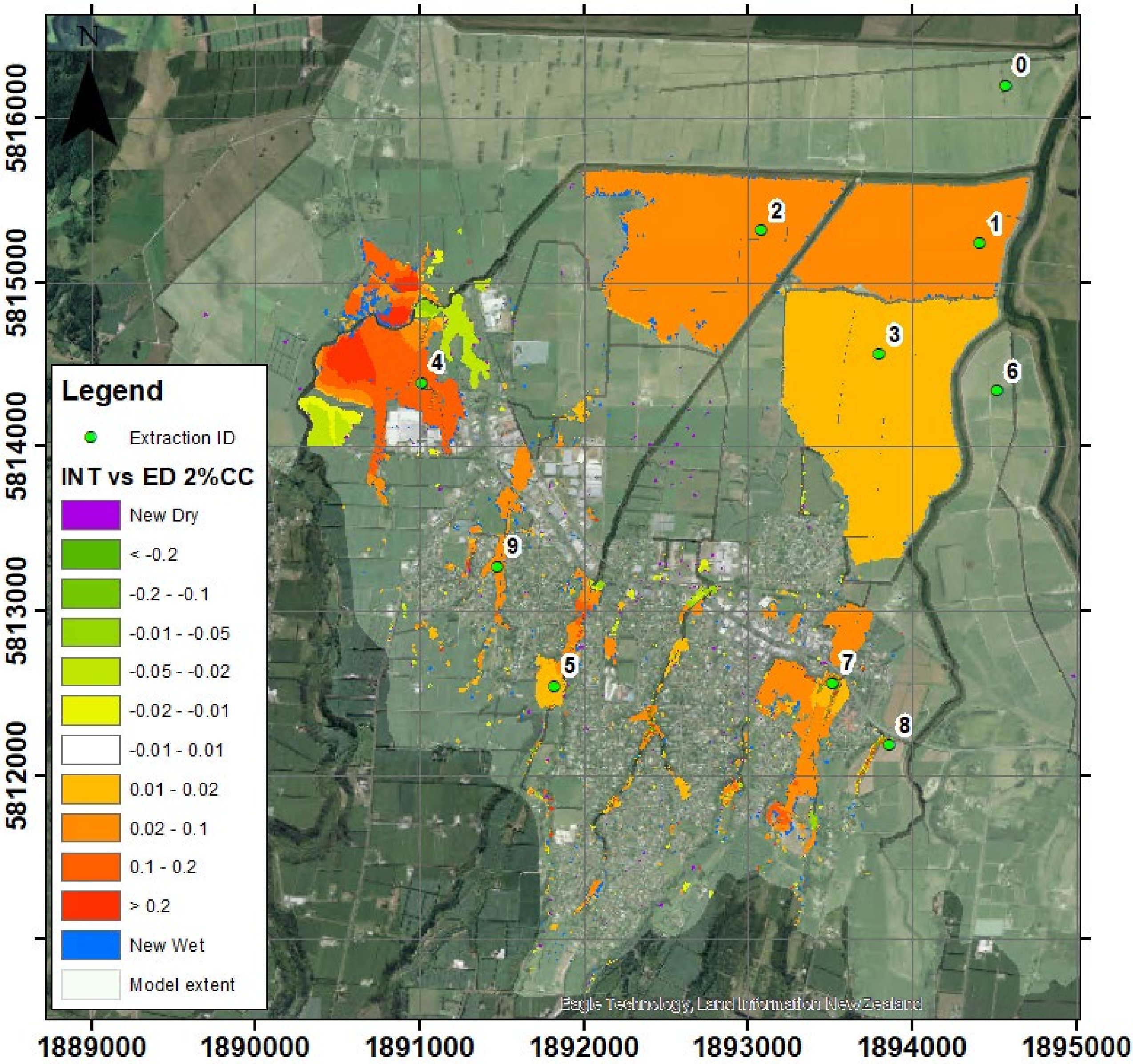

Figure 18 - Difference map between Future Intensification (Plan Change 2021/22) vs Existing Development for the 50-year 2130 RCP 8.5 event

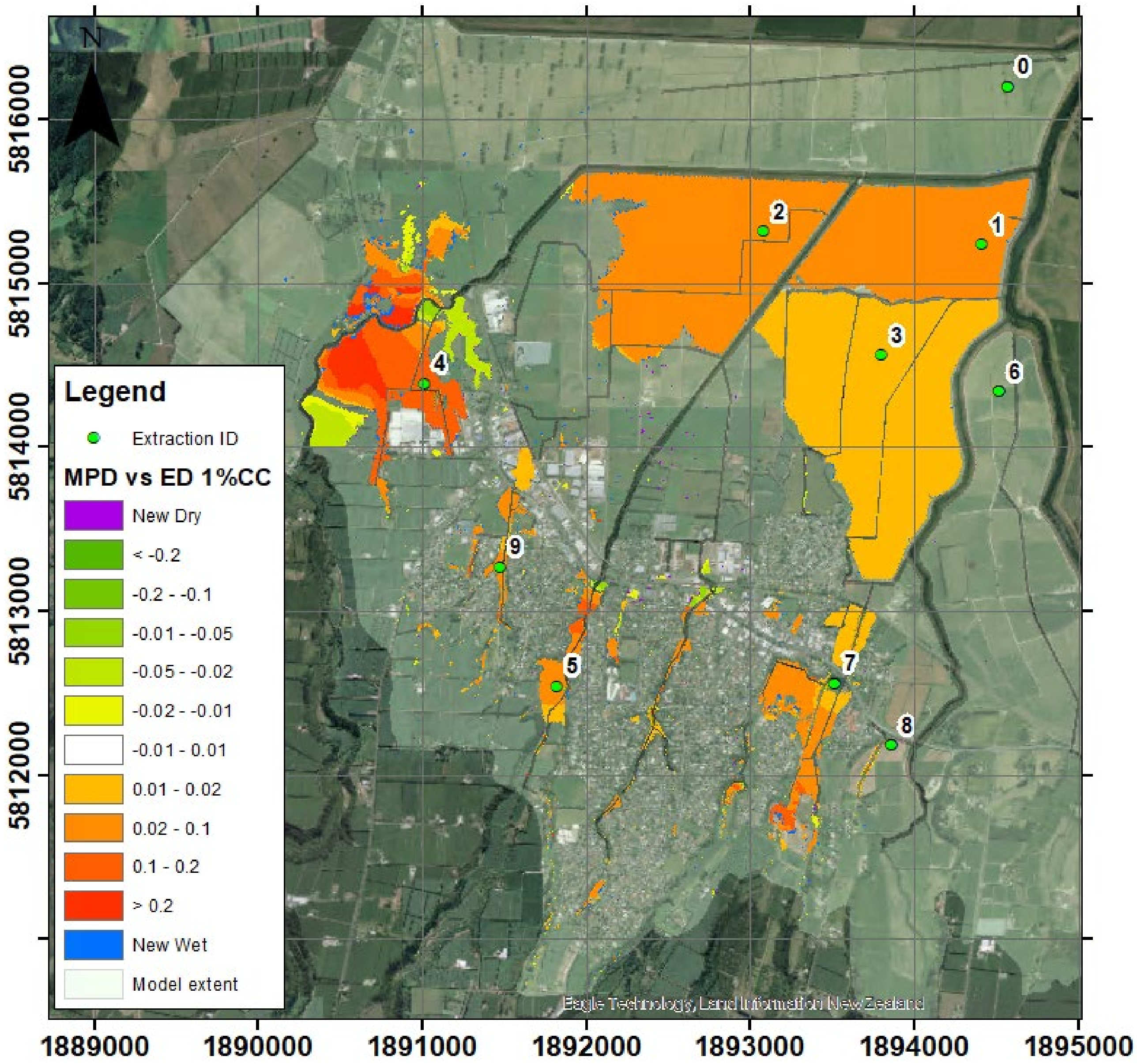

Figure 19 - Difference map between Maximum Probable Development vs Existing Development for the 100-year 2130 RCP 8.5 event

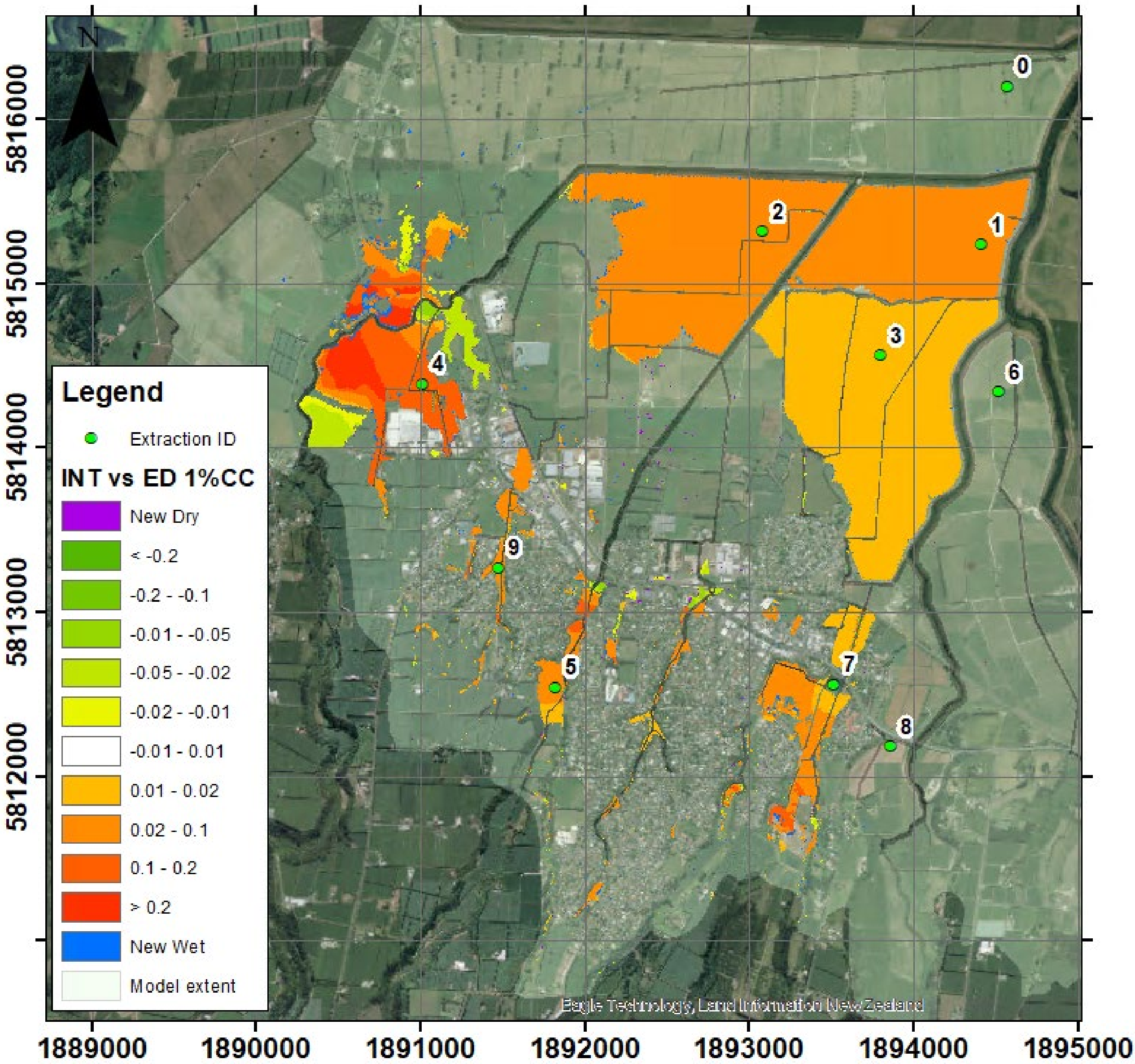

Figure 20 - Difference map between Future Intensification (Plan Change 2021/22) vs Existing Development for the 100-year 2130 RCP 8.5 event

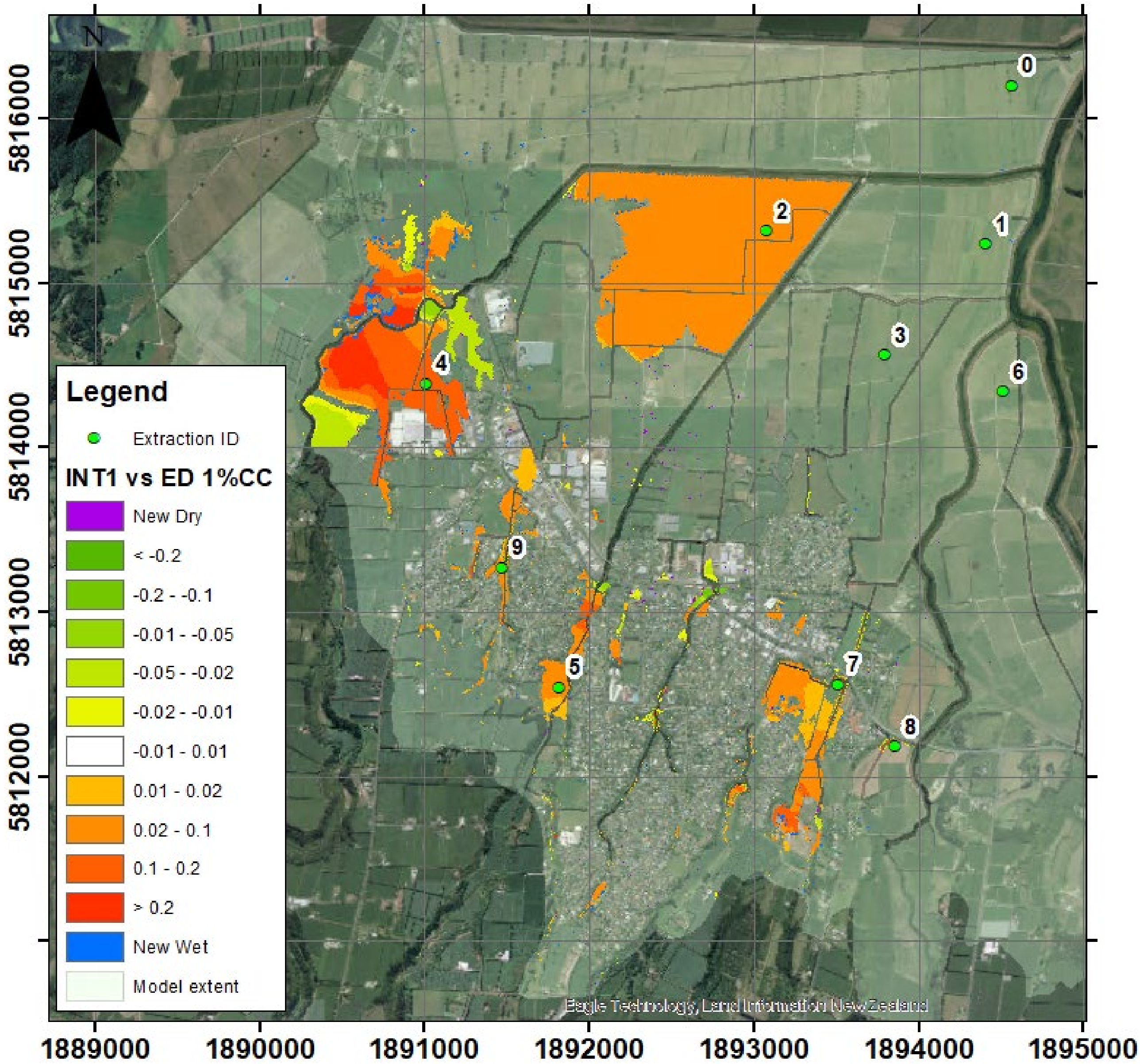

Figure 21 - Difference map between Future Intensification (Plan Change 2021/22) Alternative 1 vs Existing Development for the 100-year 2130 RCP 8.5 event

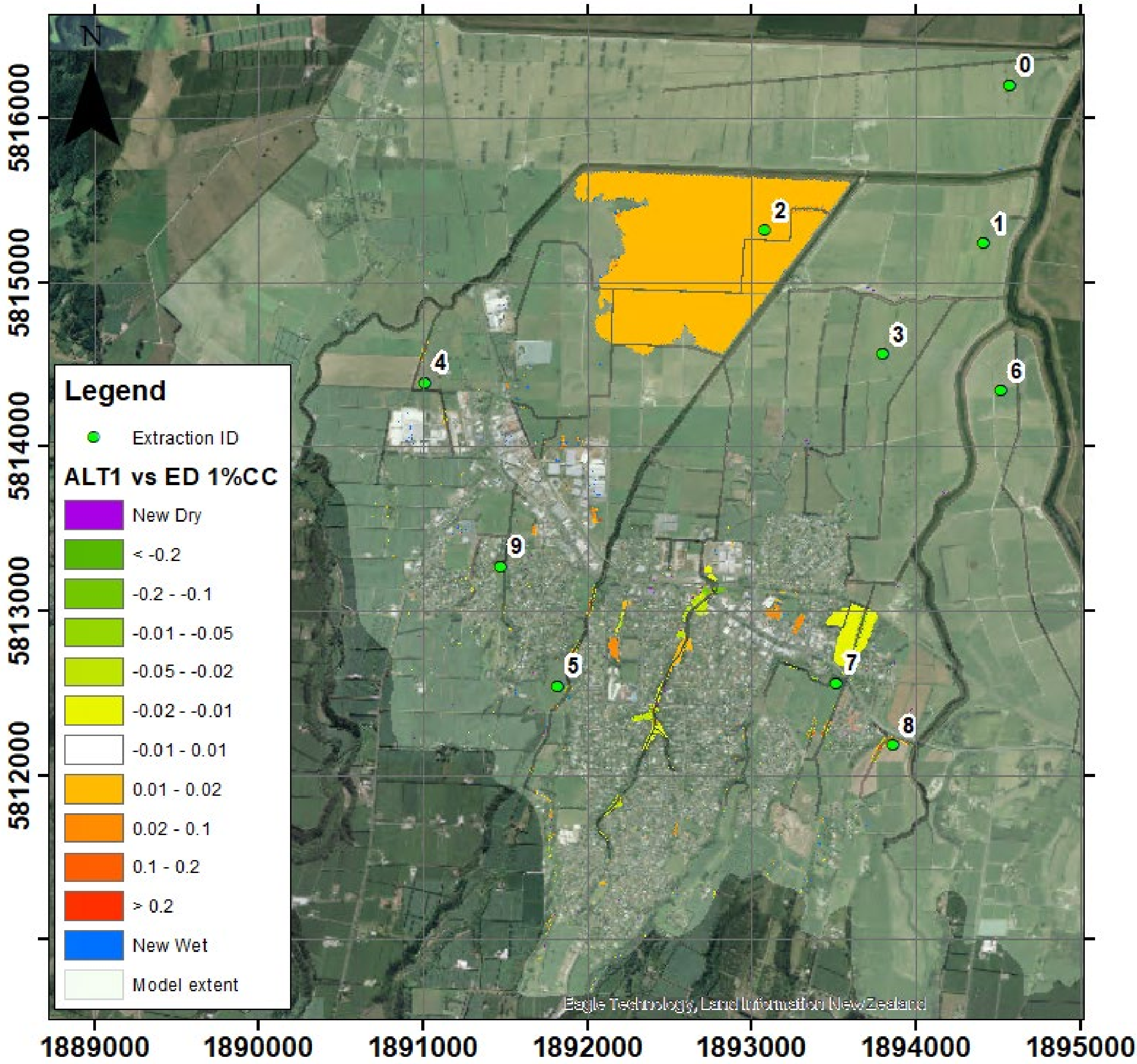

Figure 22 - Difference map between Alternative Future 1 (Imperviousness) vs Existing Development for the 100-year 2130 RCP 8.5 event

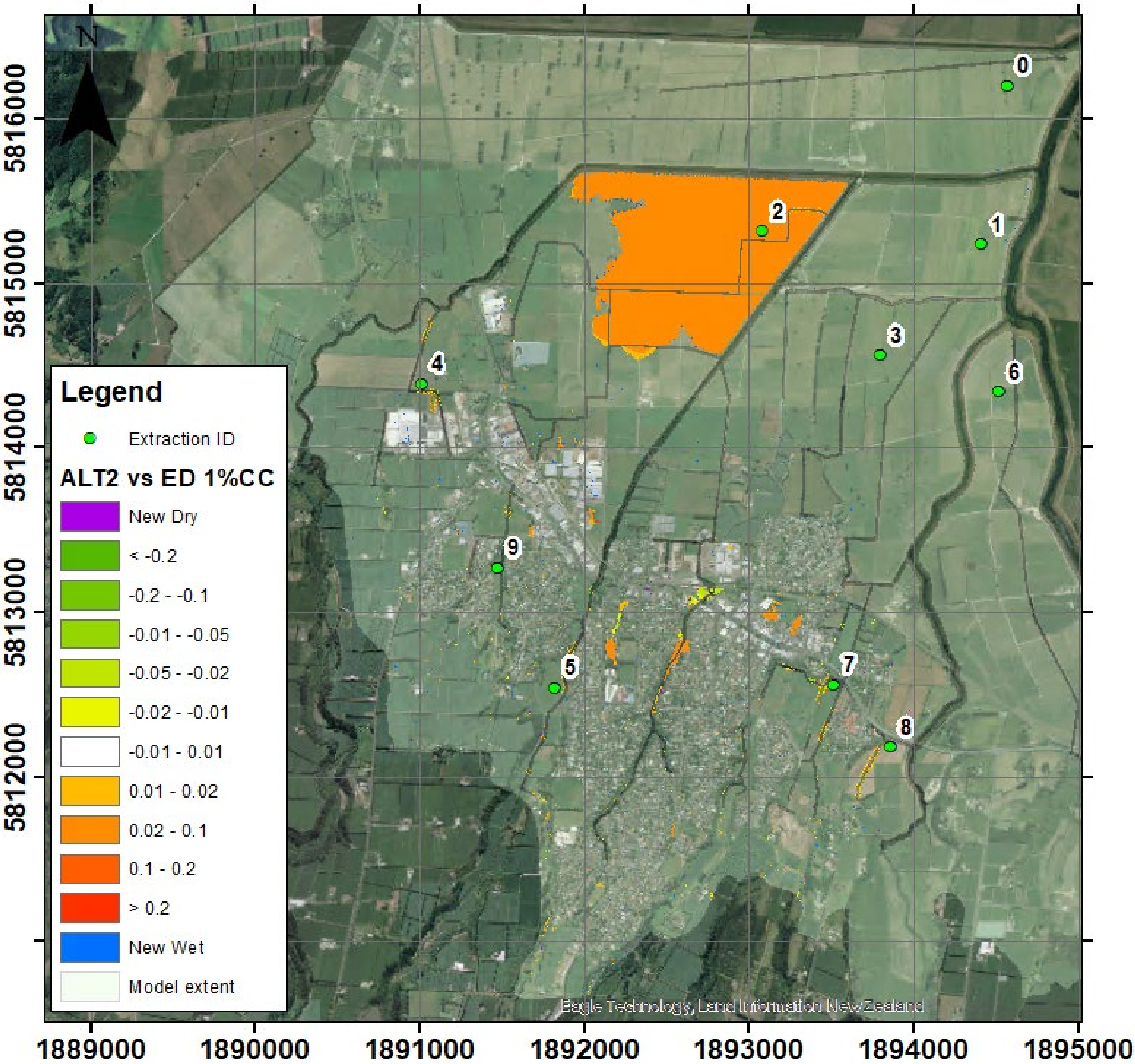

Figure 23 - Difference map between Alternative Future 2 (Imperviousness) vs Existing Development for the 100-year 2130 RCP 8.5 event

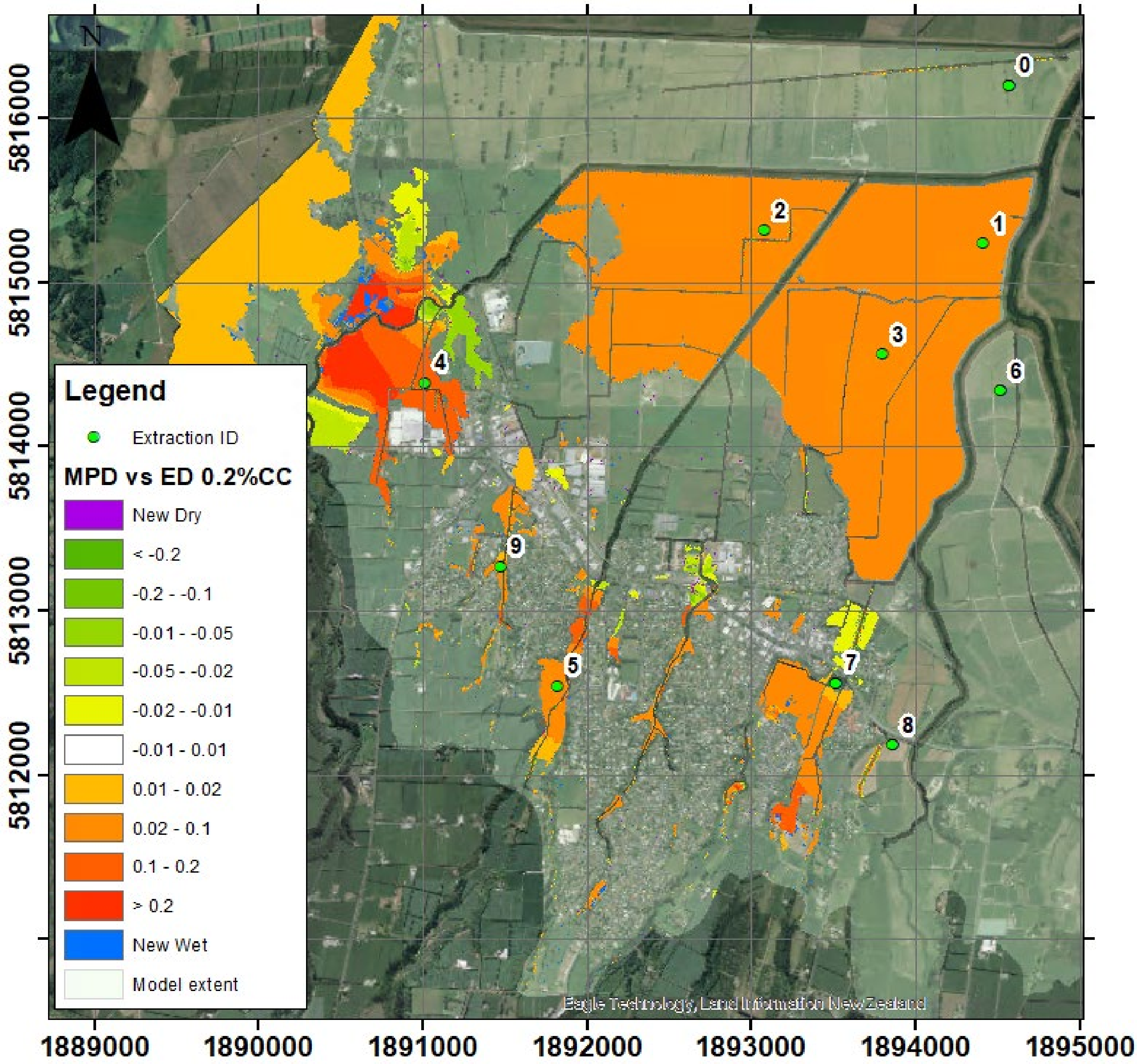

Figure 24 - Difference map between Maximum Probable Development vs Existing Development for the 500-year 2130 RCP 8.5 event

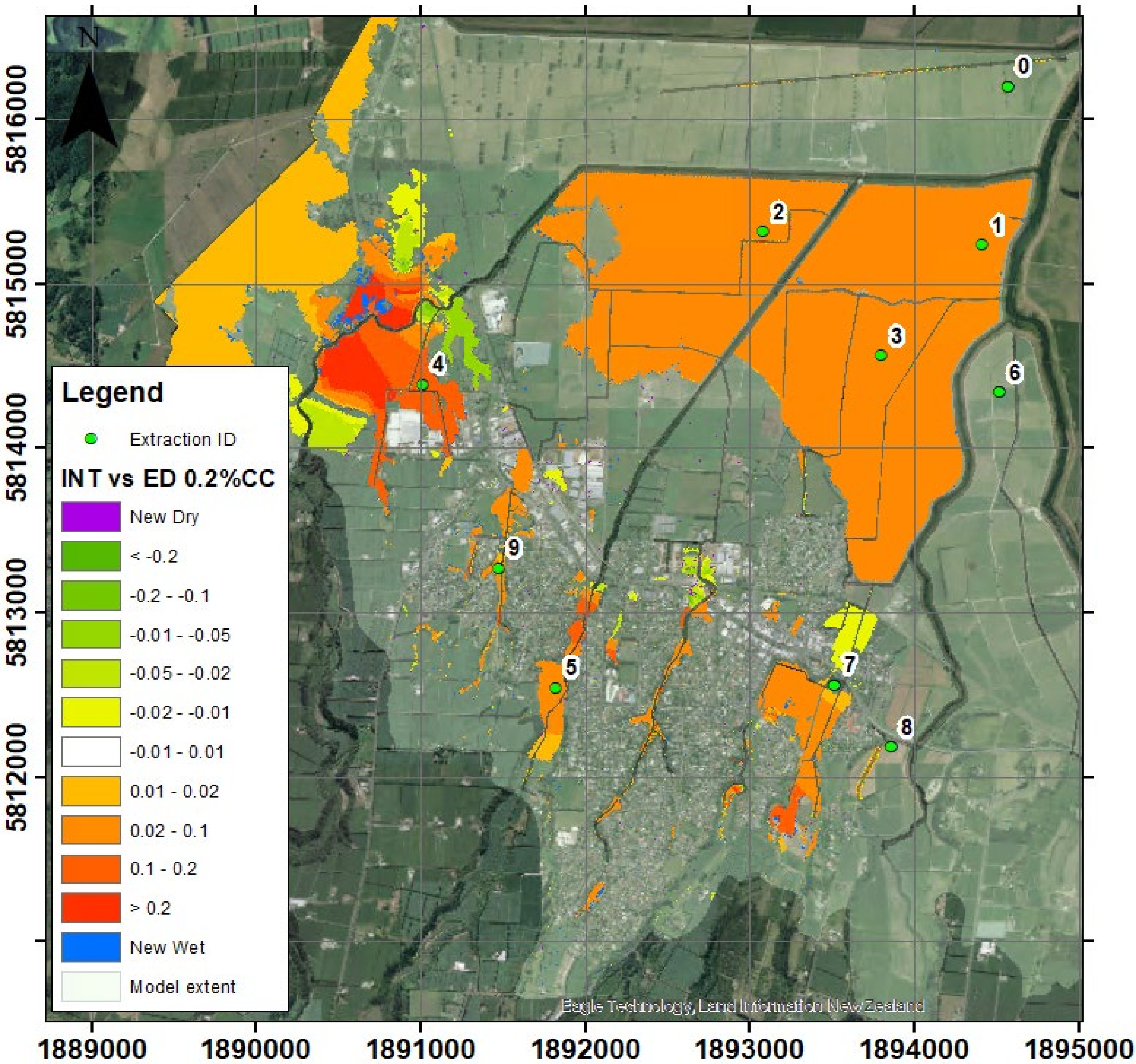

Figure 25 - Difference map between Future Intensification (Plan Change 2021/22) vs Existing Development for the 500-year 2130 RCP 8.5 event