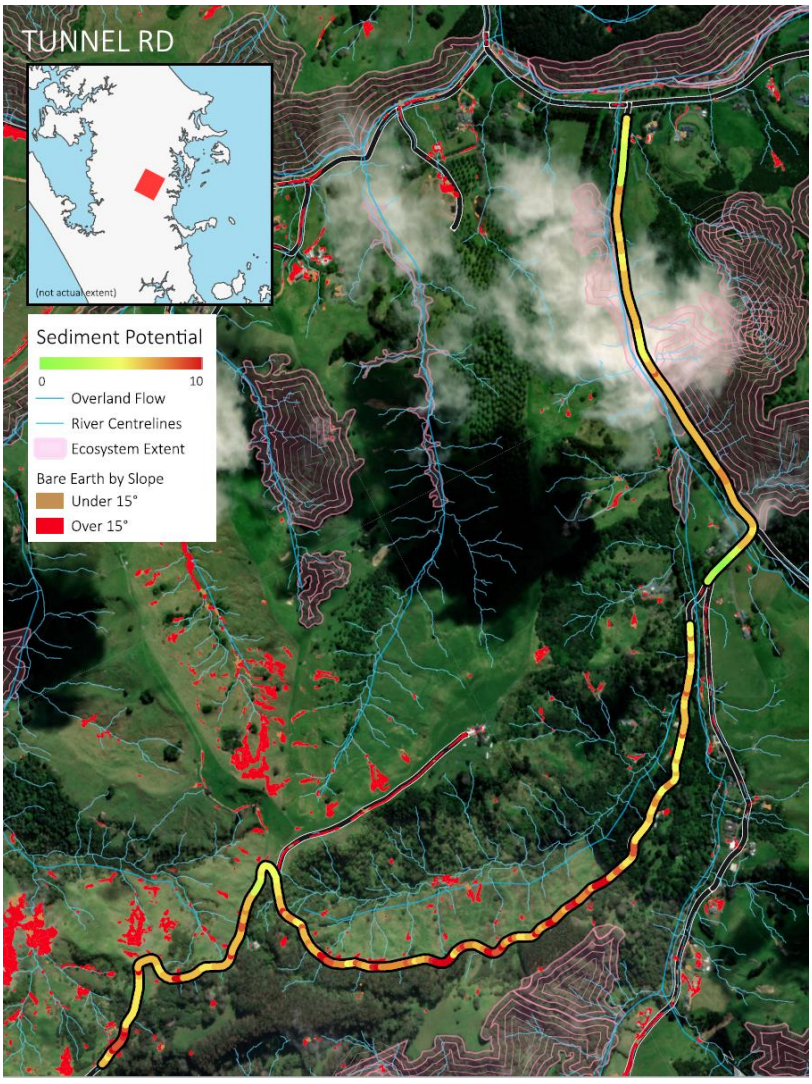
Auckland Council Unsealed Roads



Data Quality, Accuracy and Summary Report

11 March 2024

Contents

Figures

Tables

STATUS	DATE ISSUED	AUTHORS	REVIEWED AND RELEASED BY
DRAFT	08/03/2024	DAMIAN YOUNG, DAN BULL	RELEASED FOR COMMENT 04032024
FINAL	11/03/2024	DAMIAN YOUNG, DAN BULL, HANNAH CURRIE	RELEASED TO CLIENT

Prepared in Collaboration with ZEALANDIA Consulting

Executive Summary

This project uses high spatial and temporal resolution satellite imagery alongside machine learning techniques to identify “bare earth” and unsealed roads across the Auckland region, specifically using Maxar 0.3m RGBI imagery from March/April 2023 (post cyclone Gabrielle). The model analysis defines areas of bare earth as gravel, exposed soil, and sand.

GIS (Geographic Information System) processing techniques were used to consider key features, in conjunction with bare earth and unsealed roads, including intersections with overland flow pathways, river networks, and steep slopes.

The recently developed Sediment Sources Rapid Identification and Management System (SSRIMS) method, piloted on the Rodney region in 2023 (this is basically a set of scripts and GIS tools customised for Auckland Council), was used to score and rank unsealed roads for purposes of management. This has the potential to inform compliance, management, and monitoring across Auckland, utilising near real-time satellite imagery.

These resulting datasets can be used to provide further understanding and monitor the complex interactions of sediment within sensitive receiving environments and waterways. Additionally, the identification of unsealed roads, within high-risk environments, can be used to prioritise sealing works and road improvement works, such as through the Unsealed Roads Improvement Framework that Auckland Transport leads or to support the strategic management of potential sediment generating areas, across the entire Auckland region.

The 778 kilometres of unsealed roads, in the sample data set for the Auckland Region, are represented by 79,205 segments. Each segment has its own score and contributes to the overall score of the road. The total of this score is referred to as the High Sediment Potential (HSP) score. This is composed of weighted values for road slope, overland flow path proximity, distance to bare earth, proximity to Ecosystem Current Extent, and intersection with rivers.

The geospatial scoring method identified all roads (made up of segments) considered to have an HSP score of eight or more. Of the 809 unsealed roads, 267 (sub samples) had lengths/ segments that were scored eight or more, this represents approximately 33% of all the unsealed roads in the region.

Auckland Council requested that a defined list of the 20 highest ranked roads. These roads are listed in the table following.

TOP 20 AUCKLAND REGION ROADS RANKED FOR HIGH SEDIMENT POTENTIAL AND POTENTIAL REMEDIAL ACTION.

Roads Ranked 1-10	
MOUMOUKAI_HILL_RD	AHUROA_RD
WHATIPU_RD	MCNICOL_RD
NOAKES_HILL_RD	JONKERS_RD
ANAWHATA_RD	TUNNEL_RD
OLD_FOREST_HILL_RD	BROKEN_BRIDGE_RD
OTAU_MOUNTAIN_RD	KANOHI_RD
OPANUKU_RD	UPPER_WAIWERA_RD
BURKE_RD	KAIPARA_HILLS_RD
MOUMOUKAI_RD	BETHELLS_RD_WCC
SOUTH_HEAD_RD	JAMES_ST_SANDSPIT

To check for representativeness, the top 20 list has 15.3 kilometres of HSP in total, which is approximately 71% preliminary list of the top 40 roads. In summary, the top 20 list represents 43% HSP road lengths identified in the analysis.

When looking across the Region by the Local Board, as shown in the table following, Rodney has 59.8% of HSP length, Waitakere 19.3%, and Franklin 14.2%.

HIGH SEDIMENT POTENTIAL LENGTHS BY THE LOCAL BOARD

Board Name	Length Unsealed (m)	Length High Sediment Potential (m)	% of Total High Potential Length
Albert - Eden	3259.7	176.7	0.5%
Maungakiekie - Tamaki	276.8	0	0.0%
Papakura	2977.1	48.7	0.1%
Whau	1331	20	0.1%
Henderson - Massey	4583.2	140	0.4%
Ōrākei	3976.3	187.2	0.5%
Waitakere Ranges	38085.7	6788.8	19.3%
Devonport - Takapuna	1097.1	70	0.2%
Hibiscus and Bays	1474.7	71.8	0.2%
Māngere - Otahuhu	14274.6	100	0.3%
Waitematā	4157.6	30	0.1%
Howick	15404	523.7	1.5%
Upper Harbour	2603.1	107.6	0.3%
Ōtara - Papatoetoe	10493	30	0.1%
Manurewa	7446.1	861.1	2.4%
Franklin	59256.3	5001.4	14.2%
Rodney	607068.8	21040.8	59.8%
Outside Board Extent	482	0	0.0%
Totals (m)	778247.1	35197.8	100

It is worth noting that because each road segment has its own score and contributes to the overall score of the road, locations along a road can be highlighted and considered to inform management actions or maintenance methodologies.

This analysis can be modified and customised, to consider alternate or additional informational variables.

1 Introduction

There is a pressing need for the development of new rapid techniques to identify 'bare earth potential sediment generating areas', to support Council in meeting the 2020 National Policy Statement for Freshwater Management objectives, community expectations, and consent compliance requirements.

Overall, sediment has become a persistent and highly deleterious physical contaminant, in all receiving environments, across the Auckland region. Discharges can be influenced by human activities (e.g. deforestation, agriculture, urbanisation, increase in overland flow paths).

Catchment slope, hydrology/hydraulics, and soil/geology all play important roles in determining the rate, distribution, and extent of erosion in natural and modified catchments. Because roads form part of the runoff drainage network, which includes the road carriageway, culverts, pipes, and roadside drains, roads are also a significant potential contributor to surface erosion and the transport of that material into receiving environments such as streams, wetlands, and lakes.

In recent years, high resolution surface relief data have become readily available to practitioners and Councils. These data have been used to derive overland flow paths, slope classifications, sediment discharge potential (based on road length slope, proximity to mapped overland flow paths, including rivers and streams), and proximity to significant indigenous vegetation or significant habitats of indigenous fauna, located either on land or in freshwater environments.

This project has utilised high resolution digital imagery, to define areas of bare earth (model refined to express Bare Earth as gravel, exposed soil, sand) and this was then used to generate a "Bare Earth Potential" area in the classification of unsealed roads. It follows a pilot project completed on the Rodney area (Auckland Council Rodney Sediment Project Data Quality and Accuracy Report, Lynker Analytics 2023). The Rodney area has 78% of the unsealed roads in Auckland.

The scripts and tools used are based on the Sediment Sources Rapid Identification and Management System (SSRIMS) developed by Lynker Analytics during the 2023 Rodney Pilot. The overall objectives and process are described following:

(1) Create a hierarchy of roads based on sediment potential of those roads; and
(2) Find areas of high sediment potential.

This work was conducted using three major workstreams:

(1) Generation of the Bare Earth Model;
(2) Generation of input data via geospatial queries; and
(3) Applying this data to score unsealed roads by sedimentation potential.

A total of 809 unsealed roads are included in the analysis. These roads are included in the current RAMM database. This amounts to a total of 778 kilometres of unsealed roads in the sample data set for the Auckland region.

The outputs can be used to prioritise road improvement works, such as through the Unsealed Roads Improvement Framework (URIF) that Auckland Transport leads or to support the strategic management, of potential sediment generating areas, across the entire Auckland region.

2 Generation of Bare Earth model

2.1 Study Area

The study area encompasses Auckland Council territory, excluding offshore islands, as shown by the blue catchment boundaries in Figure 1.

FIGURE 1: STUDY AREA WITHIN AUCKLAND COUNCIL BOUNDARIES.

2.2 Input Imagery

Within the study region described above, Maxar 0.3m RGBI imagery from March/April 2023 (post cyclone Gabrielle) was obtained from Auckland Council. A cloud mask for the imagery was manually created to remove cloud and cloud shadow areas from the output datasets.

2.3 Bare Earth layer creation via Machine Learning

A Random Forest model was built to capture bare earth from the satellite data (source). Training data were captured in six specific areas (Figure 2).

FIGURE 2: TRAINING AREAS FOR ML MODEL WITHIN THE AUCKLAND REGION.

A training round was conducted using all four bands from the imagery. Feature importance (shown in Table 1 below) shows the relative contribution of each band towards assessing whether a pixel was bare earth or not. In this case, reflectance in the blue spectrum was most important.

TABLE 1. FEATURE IMPORTANCE OF TRAINING BANDS.

Band	Feature importance
Band 1 importance (red)	0.182
Band 2 importance (green)	0.059
Band 3 importance (blue)	0.617
Band 4 importance (near infra-red)	0.141

Inference of the whole Auckland region took place over 28 hours using 10 SPOT instances on Amazon Web Services (AWS). As part of this process, data were vectorised, and small polygons (≤10m2) removed from the data set.

Following inference, a cloud mask was used to remove cloudy areas.

During data processing, a further step was taken to remove false positives such as impervious surfaces (e.g. roads, buildings, and concreated areas), from the bare earth layer (Refer Figure 3).

FIGURE 3: INFERENCE OUTPUT EXAMPLES.

It should be noted that the bare earth layer created could more correctly be titled ‘bare earth and near bare earth’. Indeed, at times, areas on road edges, paddocks with thin brown grass, driveways, etc., were captured as “bare earth”. Further refinement of the bare earth geometry is possible (the data considered sufficient to use for aggregate statistics and general analysis), and as new aerial imagery becomes available, updated bare earth mapping can be conducted.

2.4 Geospatial Processing

The following section includes the details of the geospatial analysis conducted. This includes use of the established methods developed in the Sediment Sources Rapid Identification and Management System (SSRIMS), developed during the 2023 Rodney Pilot.

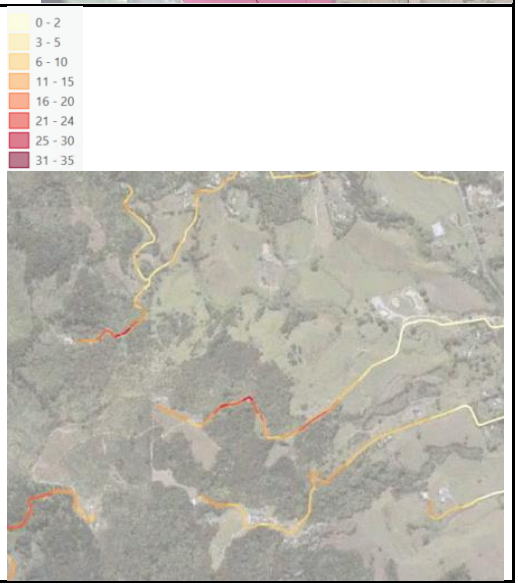
The unsealed roads data set, used for the project, is an Auckland Transport extract from the RAMM database of unsealed roads. It should be noted that in an earlier version of this

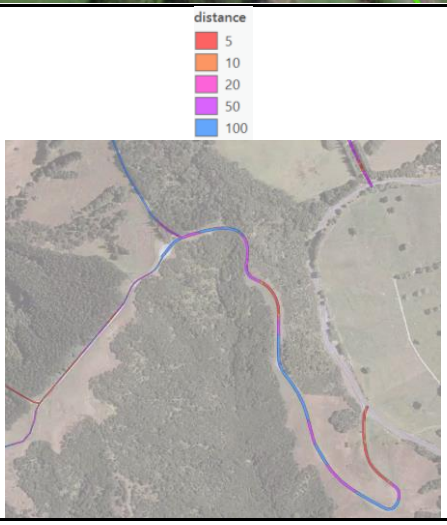
work, unsealed roads from LINZ and Open Street Map were included, however because of data quality and geometry issues, these layers were not used in this analysis.

2.5 Geospatial Analysis

Data pertaining to sediment potential from roads were created using inputs such as Overland Flow Paths (OLFP), bare earth (from Maxar inference), slope data (from Auckland 1m DEM), and rivers (from LINZ). Data processing occurred at the catchment level, and as a post-processing step, catchments were merged. Table 2 below outlines the methodology used for this to create the road score inputs.

TABLE 2: HIGHLIGHTS THE PROJECT QUERIES USED TO CREATE SEDIMENT POTENTIAL INPUT LAYERS OF UNSEALED ROADS.

Query	Method	Output	Geometries
*Unsealed roads in Current Ecosystem Extents *This generally includes SEA (Significant Ecological Areas) and/or BFA (Biological Focused Areas)*.	Any road within 50m of an SEA	A feature layer was created identifying, where unsealed roads intersect with Ecosystem Extents (in pink).	
Unsealed roads gradients.	Spatial queries, thresholds and intersections on the unsealed road network and slope layer.	A feature layer called **Unsealed Roads_Slope** was created where unsealed roads interact with slope. Intersections using slope ranges of 0-2º, 3-5º, 6-10º, 11-15º, 16-20º, 21-24º, 25-30º, 31-35º was carried out. These slope ranges were chosen to identify slight changes in slope gradient along the unsealed road network and exclude anything that is not too steep for the 0-2º range.	

Query	Method	Output	Geometries
Sections of unsealed roads that cross rivers.	Spatial queries, buffers and intersections on the unsealed road network and rivers layer (1:50,000).	A feature class showing points where unsealed roads cross rivers. (NB- these are actively managed assets by AT).	
Sections of unsealed roads that cross overland flow pathways and are within a defined proximity of overland flow pathways.	Spatial queries, buffers and intersections on the unsealed road network and overland flow paths layer.	A buffered feature layer called **Unsealed Roads_Overland Flow Paths** was created where unsealed roads intersect with OLFP (Overland Flow Paths) at 5m, 10m, 20m, 50m and 100m.	
Roads proximity to steep bare earth (bare earth greater than 15 degrees slope)	Spatial queries, thresholds and intersections on the bare earth and slope layer (LENZ 20m).	A feature layer called **Bare Earth_Slope** was created where bare earth and slope intersect. Intersections using slope ranges of 0-2º, 3-5º, 6-10º, 11-15º, 16-20º, 21-24º, 25-30º, 31-35º was carried out. These slope ranges were chosen to identify slight changes in slope gradient in the bare earth areas and exclude anything that is not too steep for the 0-2º range.	

3 Road Score Methodology

GIS (Geographic Information System) processing techniques were used to consider key features such bare earth and unsealed roads, intersections with overland flow pathways, river networks, and steep slopes. (Figure 4 outlines the potential process).

This followed Sediment Sources Rapid Identification and Management System (SSRIMS), piloted on the Rodney region used to rank unsealed roads for purposes of management, which could be utilised as a compliance, management, and monitoring tool, across Auckland, utilising near real time satellite imagery.

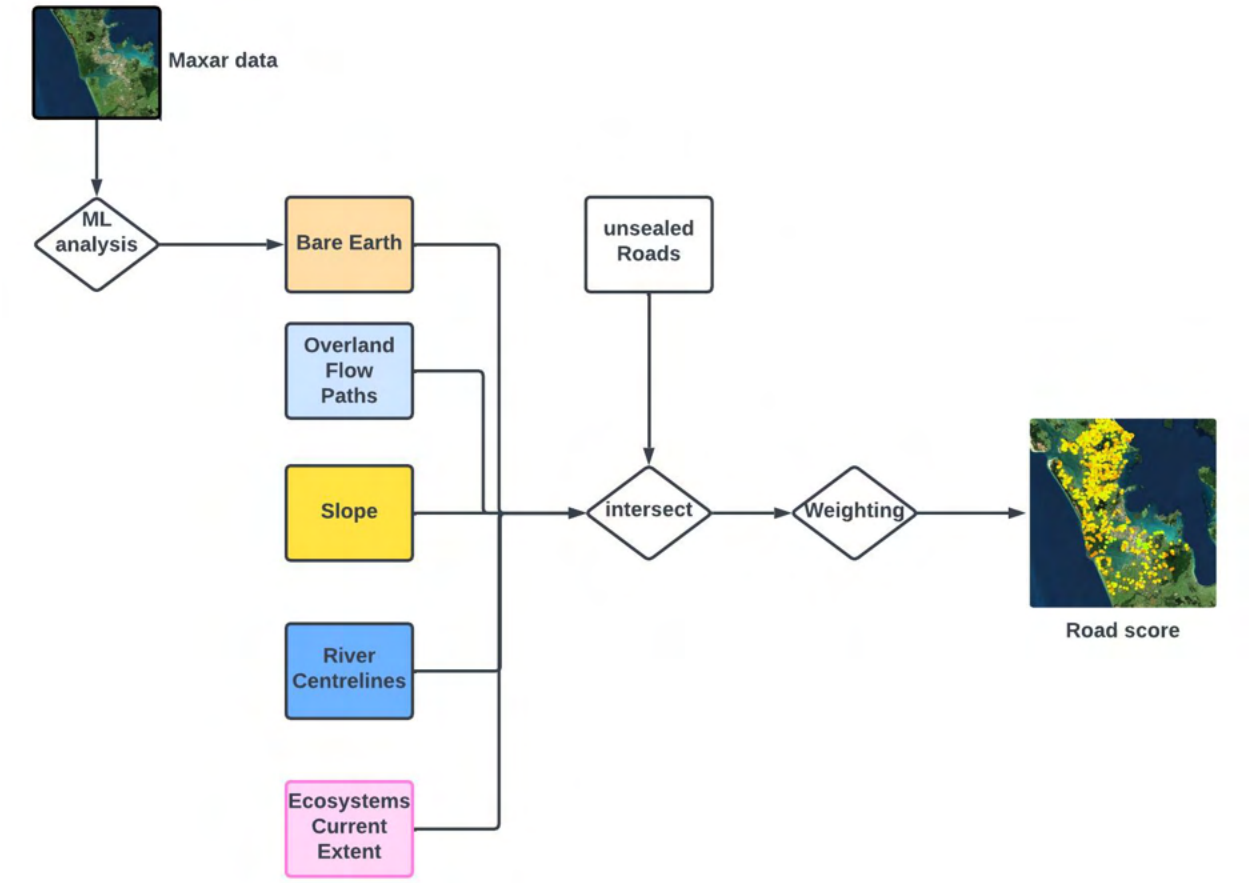


FIGURE 4. FLOWCHART HIGHLIGHTING THE GIS INPUTS AND PROCESSING.

3.1 Roads Hierarchy and HSP Score

For the purposes of this analysis, High Sediment Potential (HSP) is considered to represent the potential based proximity of existing and derived feature classes. For example, if an overland flow path intersects with a road, then the intersected road segment is assigned a numerical value, that contributes to the HSP score. It should be noted that the HSP score is not a rate, unit, or measure.

The HSP road score was created using the following process and values assigned to each segment:

1. Roads were divided into 10m segments.
2. These segments were scored based on:
    - Slope (scale of 0 – 10): Using the derived slope data (see above data sources) steep areas of road (i.e. >15°) were given a high score, flat areas were given a score of 0. In between values were given suitable scores between 2 and 8.
    - Distance from overland flow path (OLFP) (scale of 0 – 10): Closer than 5m from overland flow path was given a high score, further than 100 m from OLFP given a score of 0, and intermediate values scored as per above.
    - Distance to steep bare earth (scale of 0-5): Close to steep bare earth given a high score, and intermediate values scored as per above.
    - Within Ecosystem_Current_Extent (scale of 0 – 5): If the road segment was within 50m of an ecological zone it was given a score of 5, otherwise score was 0.
    - River crossing (scale of 0-5): If a river crossed the road, that segment was given a score of 5, otherwise the score was 0.
3. These scores were summed up and rescaled to create a 0 (low) – 10 (high) final score for each segment. Note that it is possible in this schema for a road to score above 10. However, when this occurred the score was rounded down to 10 indicating high sedimentation potential.
4. Statistics for each road were created including:
    - Mean road score.
    - *Length of high potential road score* i.e. any road scoring above 8; and
    - *Percentage high potential road score* i.e. Length of high potential road score/total road length.
5. A road hierarchy was created based on *Length of high potential road score*.
6. Human review of these data was used.

For each segment in the road, an attribute value is calculated for slope, OLFP proximity, distance to bare earth, (includes SEA area) Ecosystem Current Extent proximity, and presence of river crossing.

The mathematical equation for working out unsealed roads sediment potential score (x) is as follows:

$$score = (s + o + b + e + r)/2.5$$

Where road slope (*s*) (in degrees) is mapped as follows:

$$f(s) \rightarrow x: (0 \leq s < 2) \rightarrow 0, (2 \leq s < 5) \rightarrow 2, (5 \leq s < 10) \rightarrow 4, (10 \leq s < 15) \rightarrow 6, (15 \leq s < 20) \rightarrow 8, (20 \leq s < 25) \rightarrow 10, (25 \leq s < 30) \rightarrow 10, (s > 30) \rightarrow 10$$

And overland flow path proximity in metres (o) is mapped as follows:

$$f(o) \rightarrow x: (0 \leq o < 5) \rightarrow 10, (5 \leq o < 10) \rightarrow 8, (10 \leq o < 20) \rightarrow 6, (20 \leq o < 50) \rightarrow 4, (50 \leq s < 100) \rightarrow 2, (s > 100) \rightarrow 0$$

And distance to steep bare earth in metres (b) is mapped as follows:

$$f(b) \rightarrow x: (0 \leq b < 5) \rightarrow 5, (5 \leq b < 10) \rightarrow 4, (10 \leq b < 20) \rightarrow 3, (20 \leq b < 50) \rightarrow 2, (50 \leq s < 100) \rightarrow 1, (s > 100) \rightarrow 0$$

And proximity to Ecosystem Current Extent (e) is mapped as:

$$f(e) \rightarrow x: (0 \leq e \leq 50) \rightarrow 5, (e > 50) \rightarrow 0$$

And whether or not a river crosses the road (r) is mapped as:

$$f(r) \rightarrow x: (r) \rightarrow 5, (e > 50) \rightarrow 0$$

3.2 Roads Hierarchy and HSP Score Feature Class

The 778 kilometres of unsealed roads, in the sample data set for the Auckland Region, are represented by 79,205 segments. The total of this score is referred to as the High Sediment Potential score. This is composed of weighted values for road slope, overland flow path proximity, distance to bare earth, proximity to Ecosystem Current Extent, and intersection with rivers.

Each segment has its own score and contributes to the overall score of the road (Refer Figure 5). The benefit of this is that locations along a road can be observed and considered to inform management actions or maintenance methodologies. This analysis can be modified and customised, to consider alternate or additional informational variables.

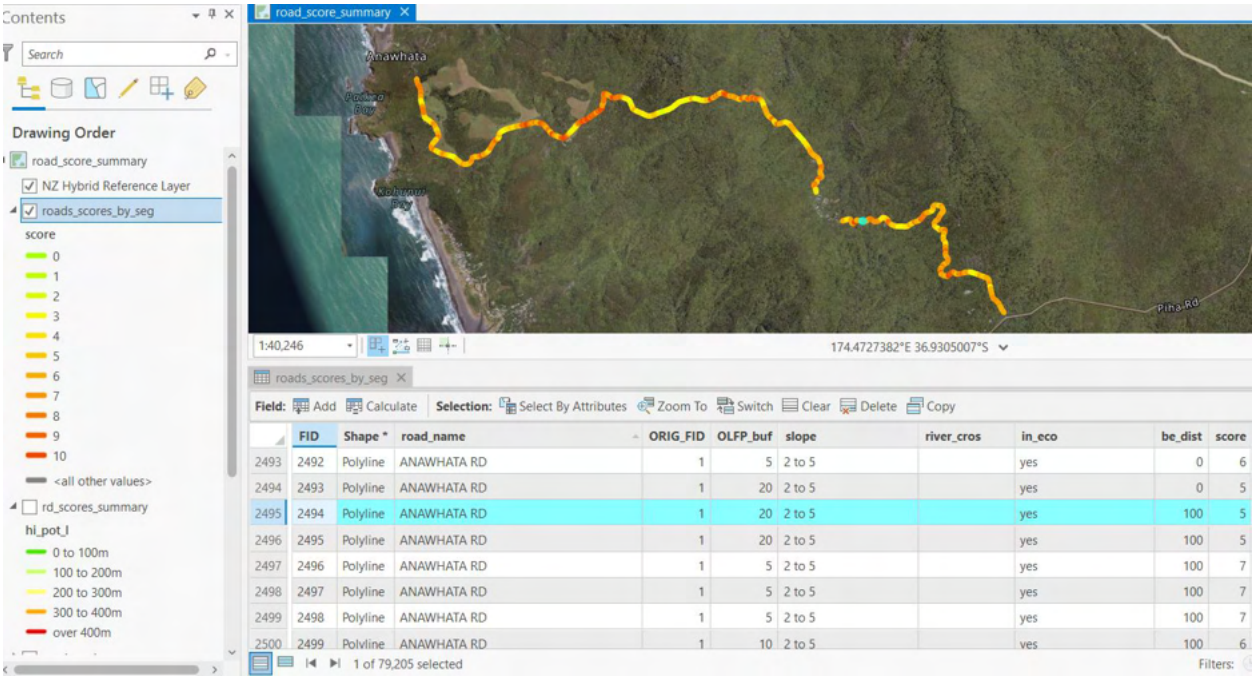


FIGURE 5: ANAWHATA ROAD SEGMENTS AND FEATURE CLASS RESULTS TABLE EXAMPLE.

4 Results and Analysis

A total of 809 unsealed roads are included in the analysis. These roads are included in the current RAMM database. Roads were scored in order of length of road with High Sediment Potential. This amounts to a total of 778 kilometres of unsealed roads in the data set.

The geospatial scoring method identified all roads considered to have a score of eight or more. Of the 809 unsealed roads, 267 (sub samples) had lengths/segments that were scored eight or more. This represents approximately 33% of all the unsealed roads in the region being considered to have lengths with High Sediment Potential ratings, at a total of approximately 49.3 kilometres.

4.1 Top 20 Unsealed Rural Roads Priority List

Auckland Council have requested that a list of 20 roads be compiled as part of this study. To do this, all roads in the sub sample data set were filtered and ranked by HSP length, with the longest lengths ranking highest, in this case Whatipu Road at 2,100 m HSP (Ranked 1), to the least, being Irvine Road at 1 m HSP (Ranked 267).

The top 40 (Refer Appendix 1) in the data set were then ranked by the percentage of lengths having a score of 8 or more, by the total road length, given a HSP length % ranking. These ranking scores were then combined to provide a weighted score for each road based on total length and total percentage of those lengths, being a score 8 or more. This combined score was then ranked and filtered to provide a top 40 list.

A sensitivity check was undertaken to see if shorter roads, that might have been pushed down the rankings because of the total length of other roads being greater, still made it into the preliminary list of 40 roads. This resulted in 3 of the top 10 roads, based only on % HSP score 8 or more, being included in the preliminary top 40 list; the intention being to provide a final list of 20 roads.

To check for representativeness, the top 20 list has 15.3 kilometres of HSP in total, which is approximately 71% preliminary list of 40 roads. In summary, the top 20 list represents 43% HSP length in total.

Each road identified, in the top 20, was reviewed in GIS to check the current status of the unsealed roadway, to make sure that the road, for example, was not a cycleway or an abandoned paper road, or have highly infrequent vehicle use if at all. These were then tagged out* for the purpose of reporting on the top 20 roads. This included one road only, being Redoubt Road/Marwan Cresc Cycleway.

Maps of each of the top 20 roads selected are provided in Appendix 3, with and overview map in Appendix 1.

Appendix 1 – Top 40 Roads Ranked by HSP Length

Road Name	road length	mean score	max score	high sediment potential length	HSP Length Rank	high sediment potential percentage	HSP % Rank	Combined Score	Priority
MOUMOUKAI_HILL_RD	2727	7.1	12	1220	3	45	4	7	1
WHATIPU_RD	5439	7.1	12	2100	1	39	6	7	2
NOAKES_HILL_RD	2476	6.2	11	840	7	34	9	16	3
ANAWHATA_RD	9244	6.0	12	1980	2	21	16	18	4
OLD_FOREST_HILL_RD	600	7.8	10	390	19	65	2	21	5
OTAU_MOUNTAIN_RD	2262	6.9	12	633	9	28	12	21	6
OPANUKU_RD	1538	6.9	11	528	14	34	8	22	7
BURKE_RD	1294	5.9	10	464	16	36	7	23	8
MOUMOUKAI_RD	2202	6.8	10	590	11	27	14	25	9
SOUTH_HEAD_RD	5334	5.3	12	898	6	17	19	25	10
AHUROA_RD	6237	5.1	12	900	5	14	21	26	11
MCNICOL_RD	1299	6.1	11	400	17	31	10	27	12
JONKERS_RD	1415	6.1	11	400	18	28	11	29	13
TUNNEL_RD	3634	6.0	10	560	12	15	20	32	14
BROKEN_BRIDGE_RD	319	8.0	11	249	34	78	1	35	15
KANOHI_RD	4303	5.8	10	550	13	13	22	35	16
UPPER_WAIWERA_RD	7723	5.1	12	652	8	8	28	36	17
KAIPARA_HILLS_RD	16307	4.6	10	916	4	6	32	36	18
BETHELLS_RD_WCC	557	7.1	10	246	35	44	5	40	19
JAMES_ST_SANDSPIT **	433	6.9	8	240	38	55	3	41	20
FITZPATRICK_RD	1262	5.4	9	280	28	22	15	43	21
MT_DONALD_MCLEAN_RD	931	7.1	10	260	31	28	13	44	22
WAIWHIU_RD	3743	5.2	10	380	20	10	24	44	23
LAKE_RD_TE_ARAI	2952	4.5	11	320	22	11	23	45	24
PAKIRI_BLOCK_RD	13604	4.3	10	592	10	4	36	46	25
J_MASON_RD	1451	4.9	10	278	29	19	18	47	26
RODNEY_RD_PAKIRI	4353	4.8	9	370	21	8	27	48	27
TAUHOA_RD	8541	4.8	13	470	15	6	33	48	28
SMITH_RD	1170	6.2	9	250	33	21	17	50	29
HAMILTON_RD_WARKWORTH	3733	5.0	11	302	23	8	29	52	30
WITHEFORD_RD	2605	2.9	9	260	30	10	25	55	31
SMYTH_RD	4038	4.7	10	298	24	7	31	55	32
GOVAN_WILSON_RD	3564	4.7	10	286	27	8	30	57	33
RYAN_RD_TOMARATA	6353	4.4	10	296	25	5	34	59	34
CONICAL_PEAK_RD	2690	5.2	10	240	37	9	26	63	35
BURMA_RD	12798	4.0	9	290	26	2	40	66	36
OCEAN_VIEW_RD_TE_ARAI	8073	3.8	11	260	32	3	38	70	37
RUN_RD	6952	5.1	9	240	36	3	37	73	38
WHAREHINE_RD	5068	4.8	10	230	40	5	35	75	39
TAHEKEROA_RD	7578	4.9	9	230	39	3	39	78	40

Appendix 2 – Overview Map


Roadway with High Sediment Potential (m)
0 - 100
100 - 200
200 - 300
300- 400
>400

Appendix 3 – Top 20 Roads Maps

MOUMOUKAI HILL RD

Sediment Potential

0 10

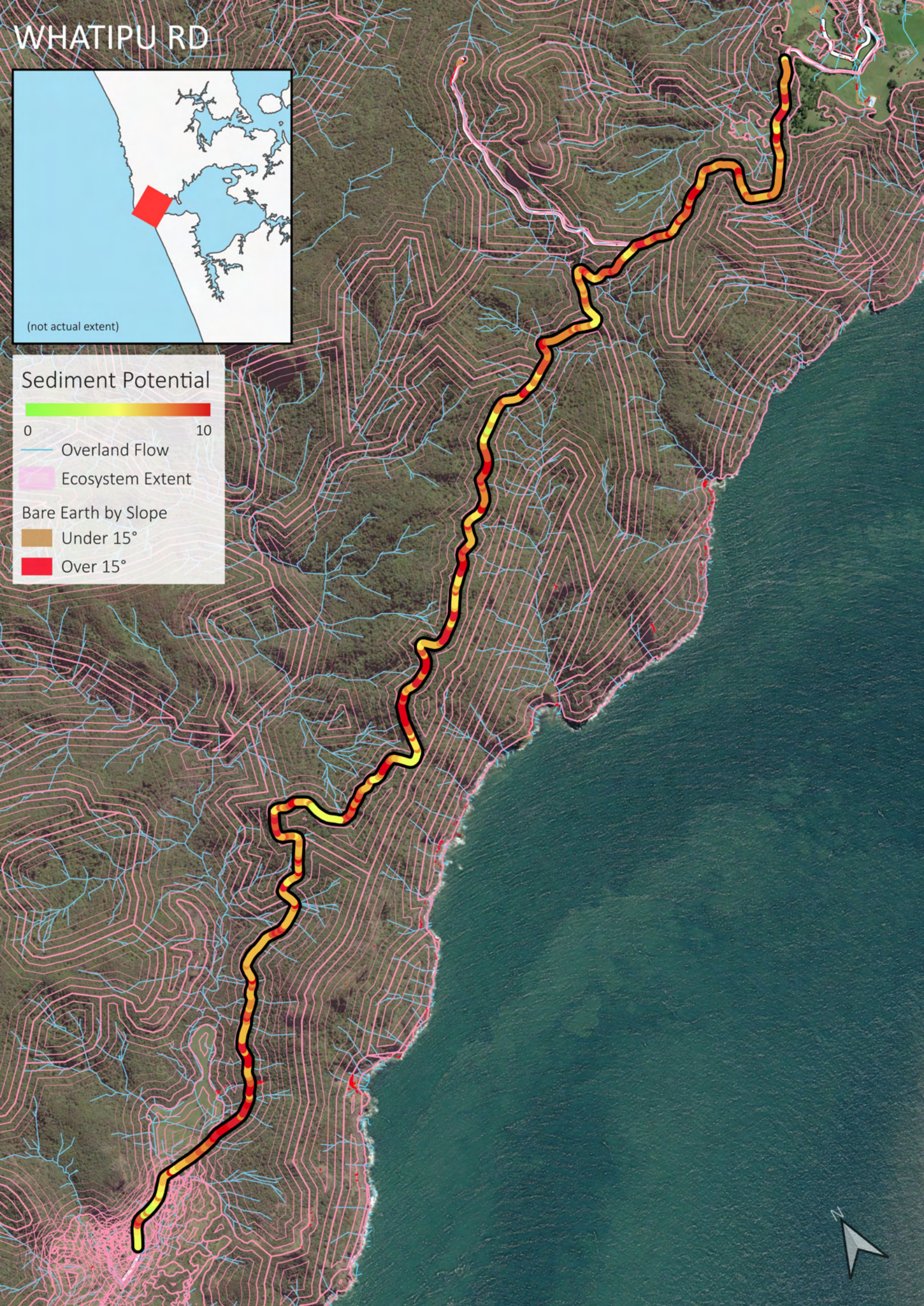
Overland Flow

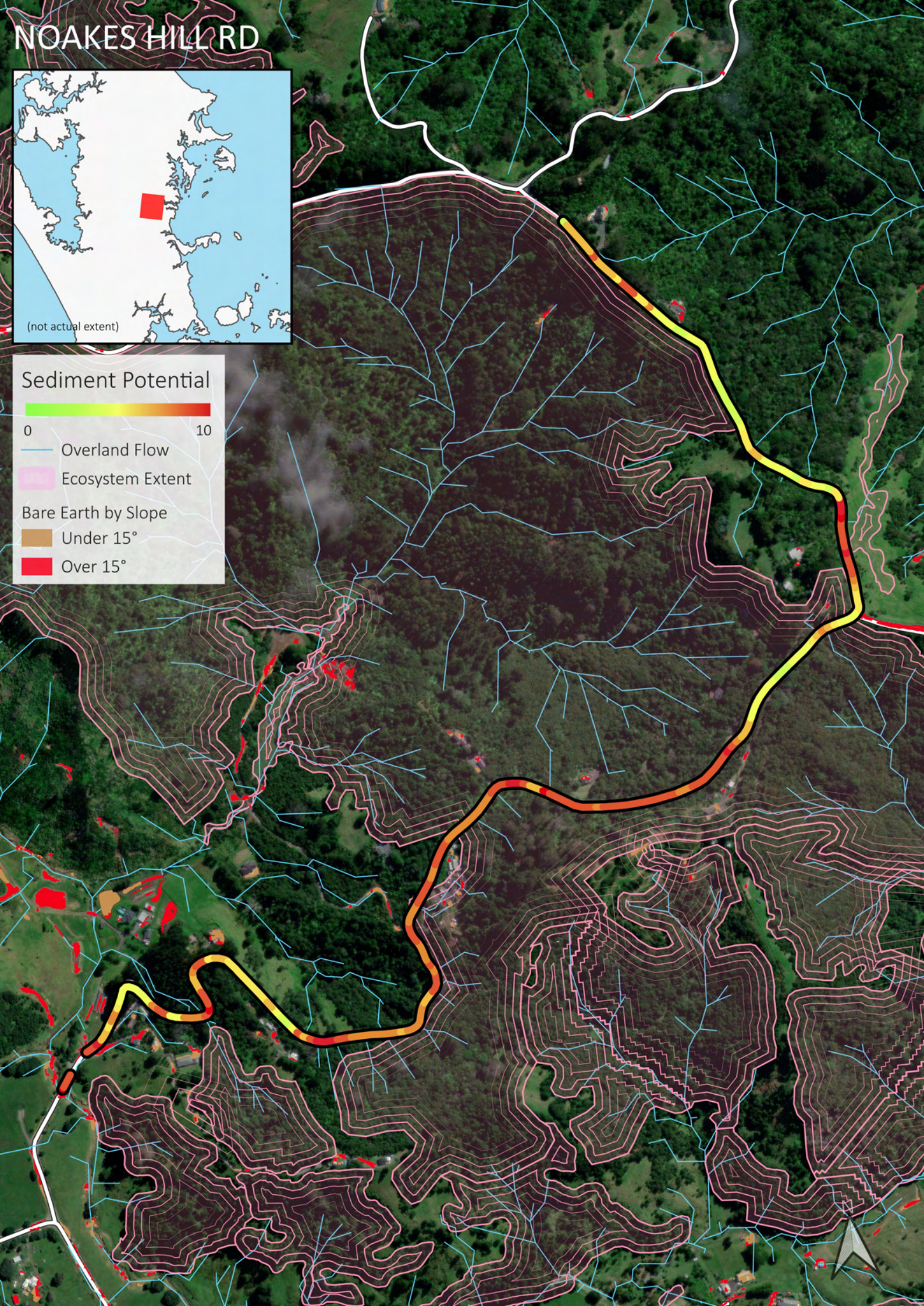
Ecosystem Extent

Bare Earth by Slope

Under 15°

Over 15°


WHATIPU RD
(not actual extent)
Sediment Potential
0
10
Overland Flow
Ecosystem Extent
Bare Earth by Slope
Under 15°
Over 15°
N


NOAKES HILL RD
(not actual extent)
Sediment Potential
0
10
Overland Flow
Ecosystem Extent
Bare Earth by Slope
Under 15°
Over 15°

ANAWHATA RD

Sediment Potential

0 — 10

Overland Flow

Ecosystem Extent

Bare Earth by Slope

Under 15°

Over 15°

OTAU MOUNTAIN RD

Sediment Potential

0 10

Overland Flow

Ecosystem Extent

Bare Earth by Slope

Under 15°

Over 15°

OLD FOREST HILL RD

Sediment Potential

0 10

Overland Flow

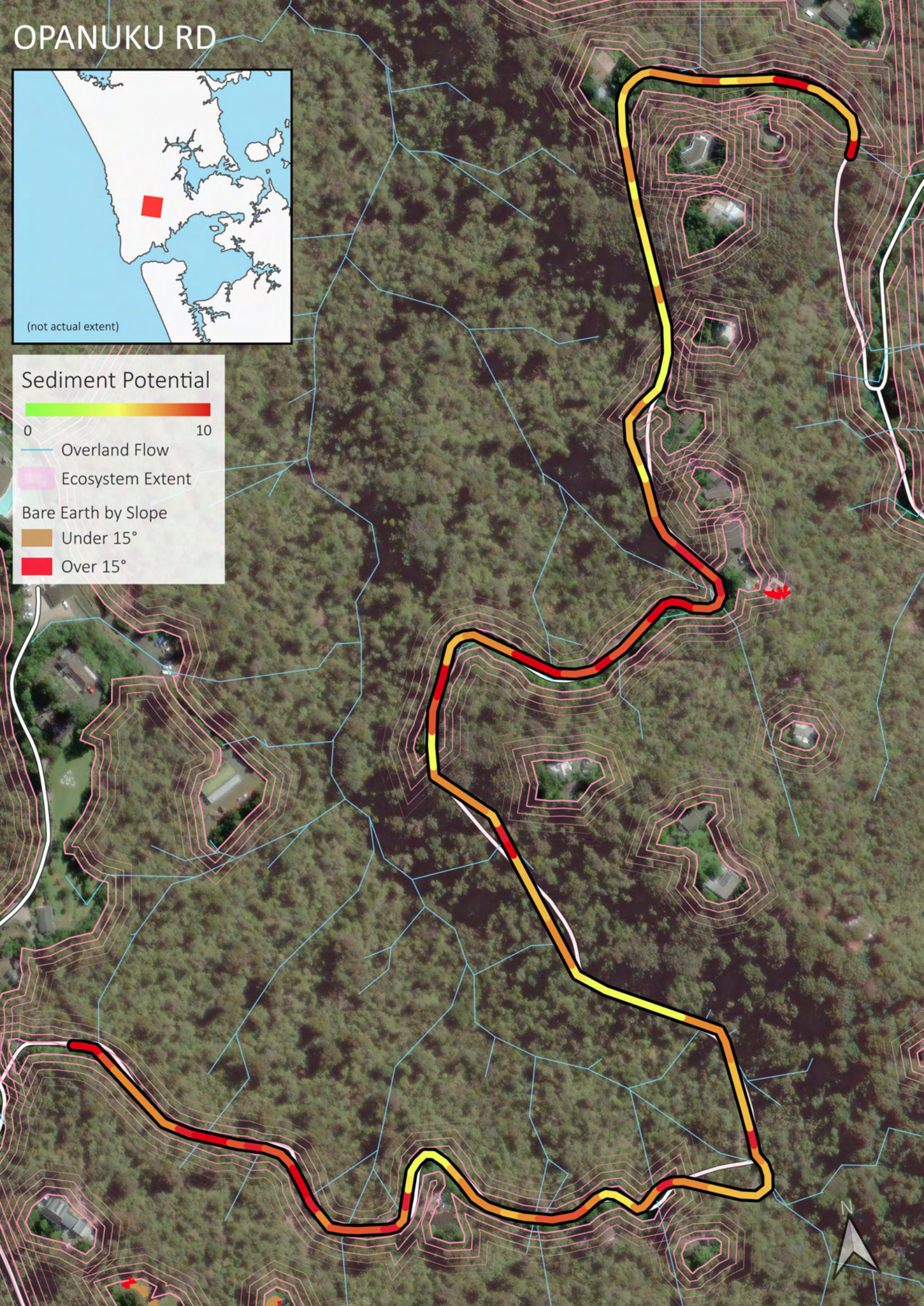
Ecosystem Extent

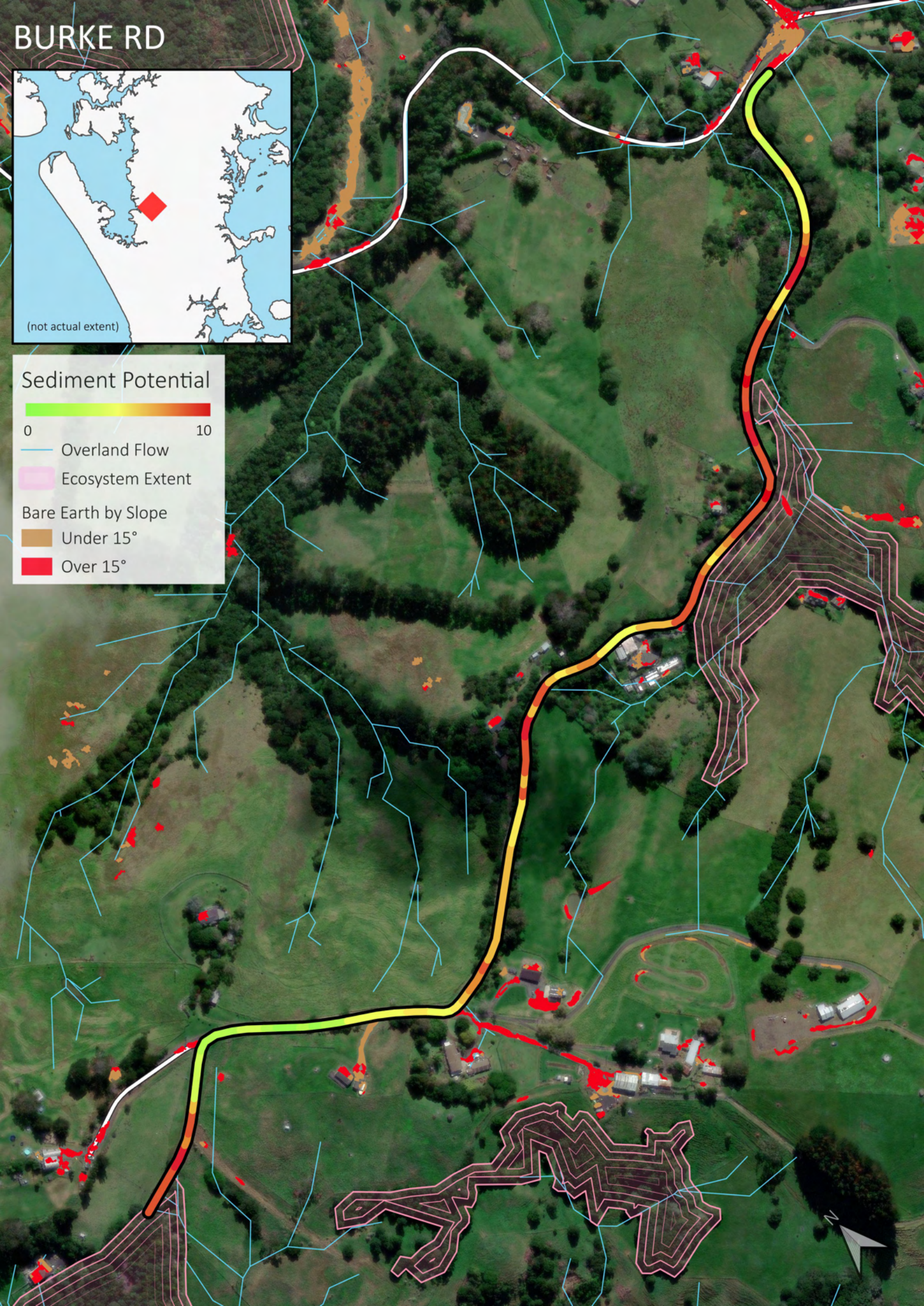
Bare Earth by Slope

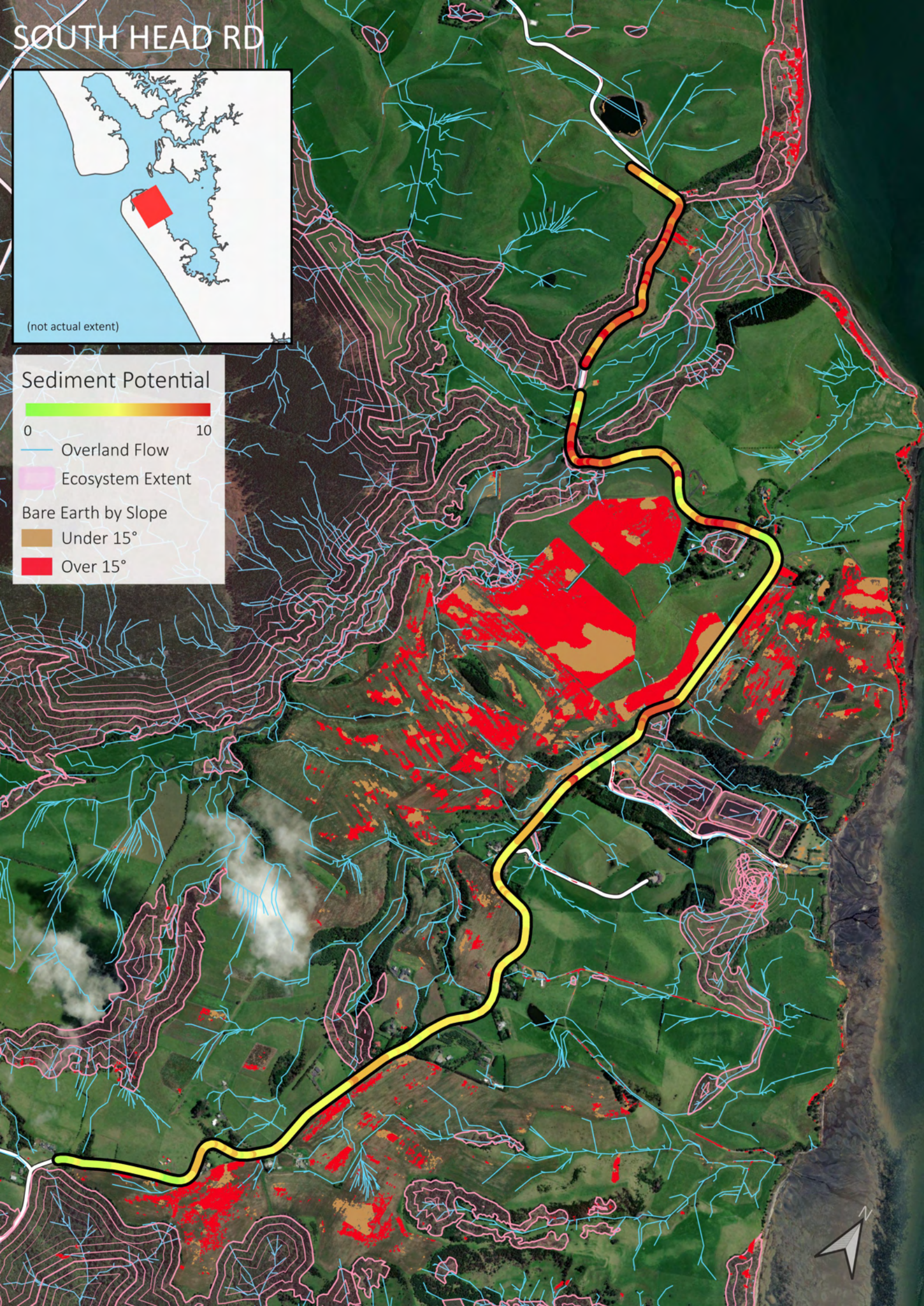
Under 15°

Over 15°

N


OPANUKU RD
(not actual extent)
Sediment Potential
0
10
Overland Flow
Ecosystem Extent
Bare Earth by Slope
Under 15°
Over 15°
N


BURKE RD
(not actual extent)
Sediment Potential
0
10
Overland Flow
Ecosystem Extent
Bare Earth by Slope
Under 15°
Over 15°
N


SOUTH HEAD RD
(not actual extent)
Sediment Potential
0
10
Overland Flow
Ecosystem Extent
Bare Earth by Slope
Under 15°
Over 15°

MOUMOUKAI RD

Sediment Potential

0 — 10

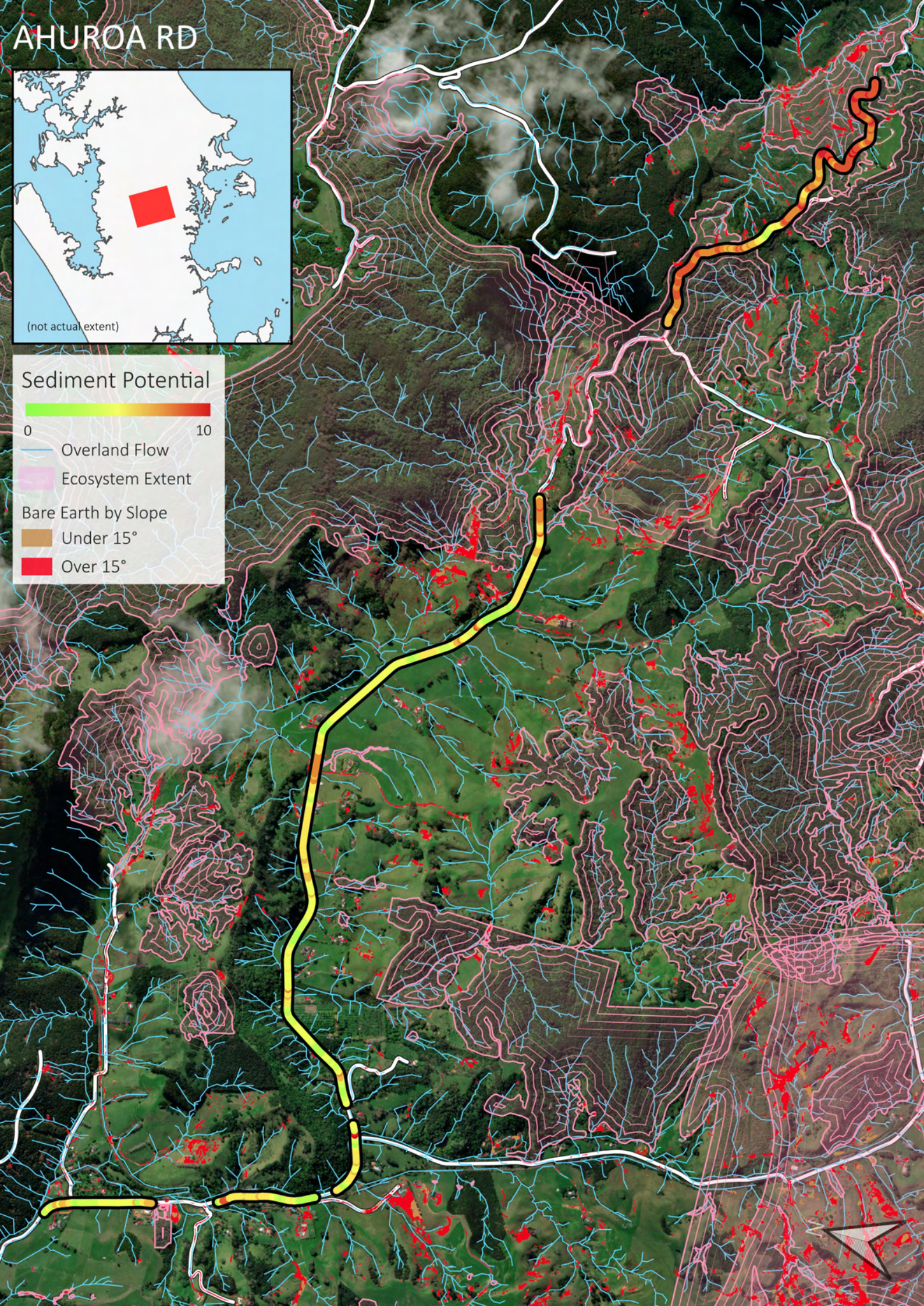
Overland Flow

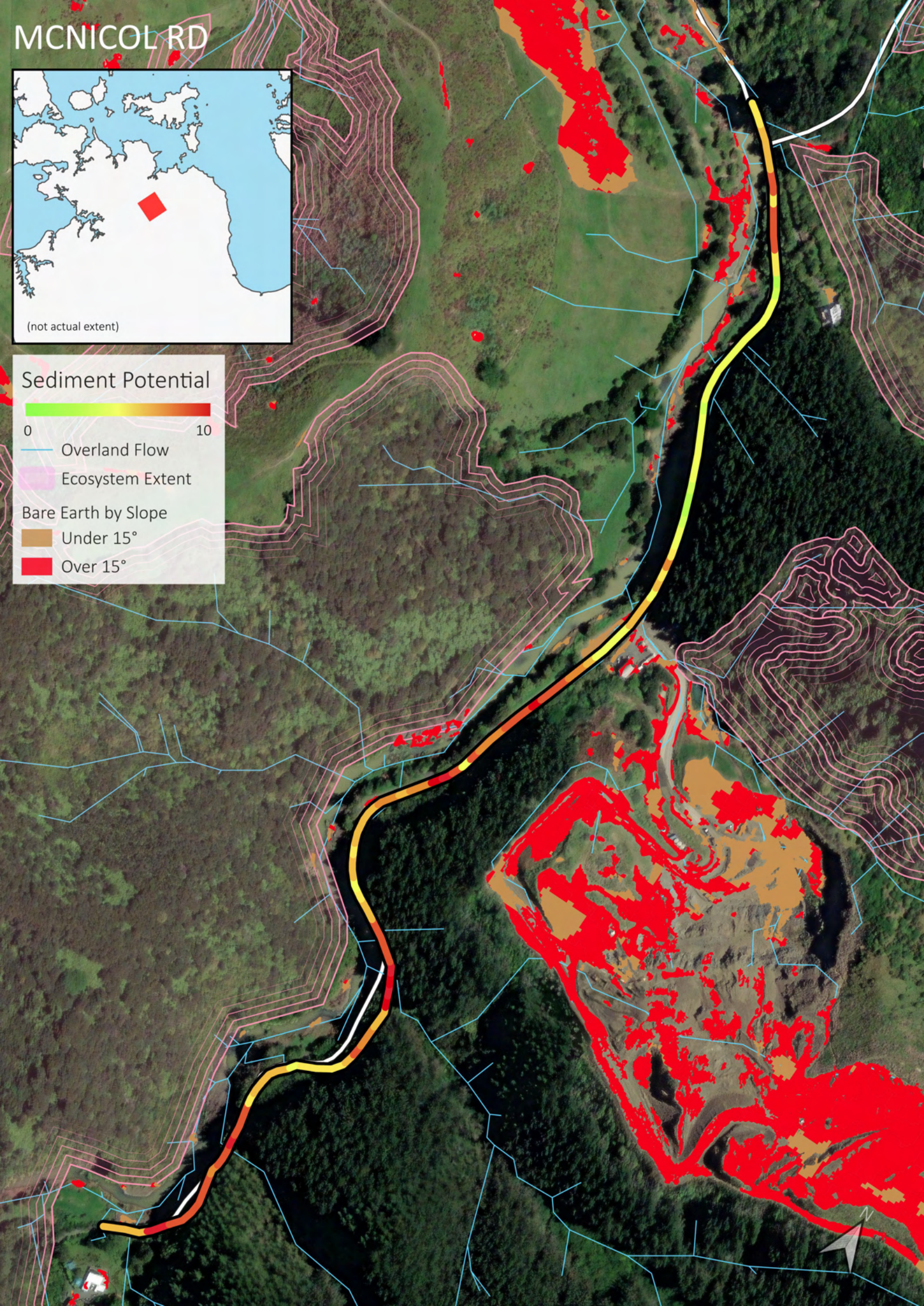
Ecosystem Extent

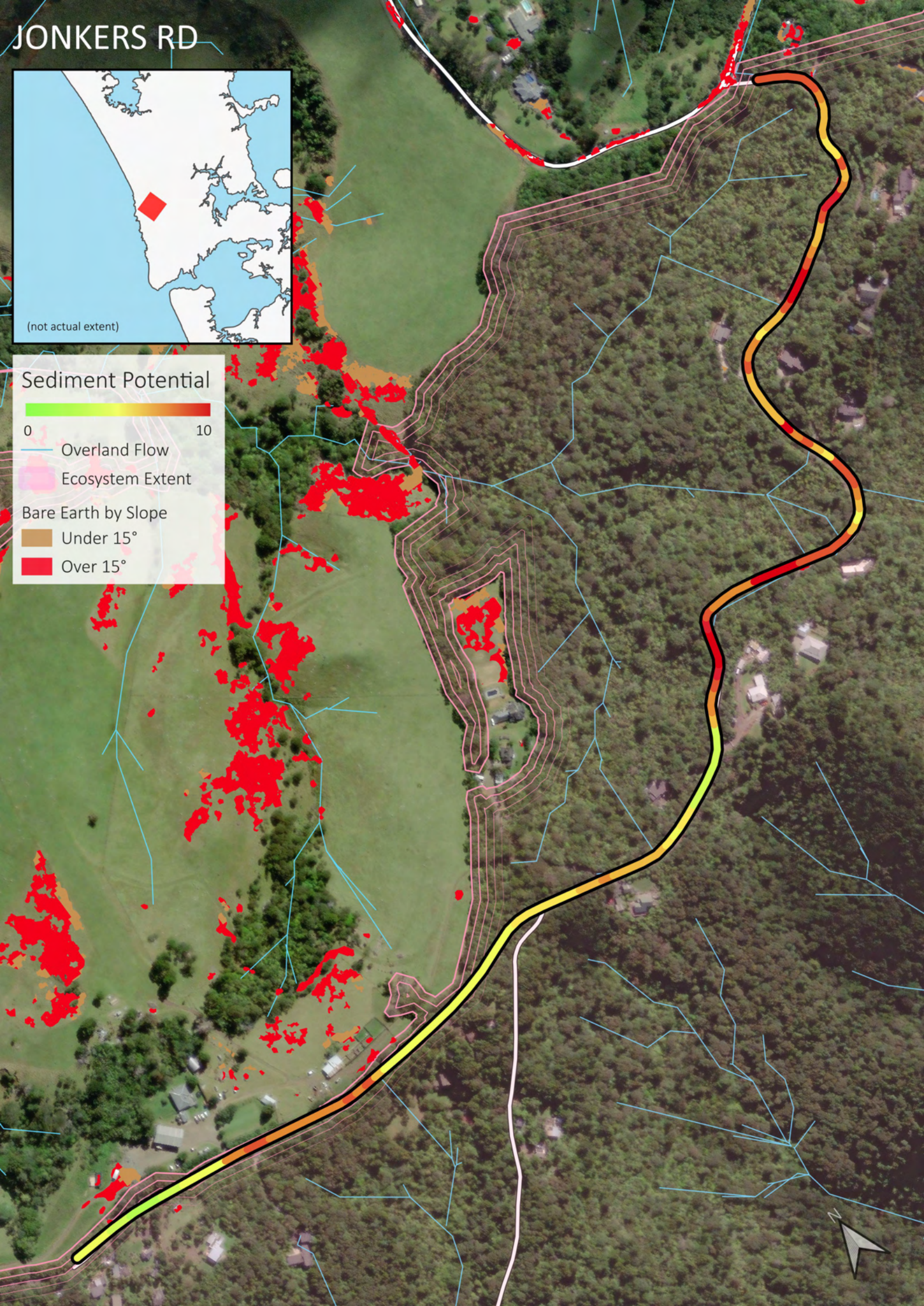
Bare Earth by Slope

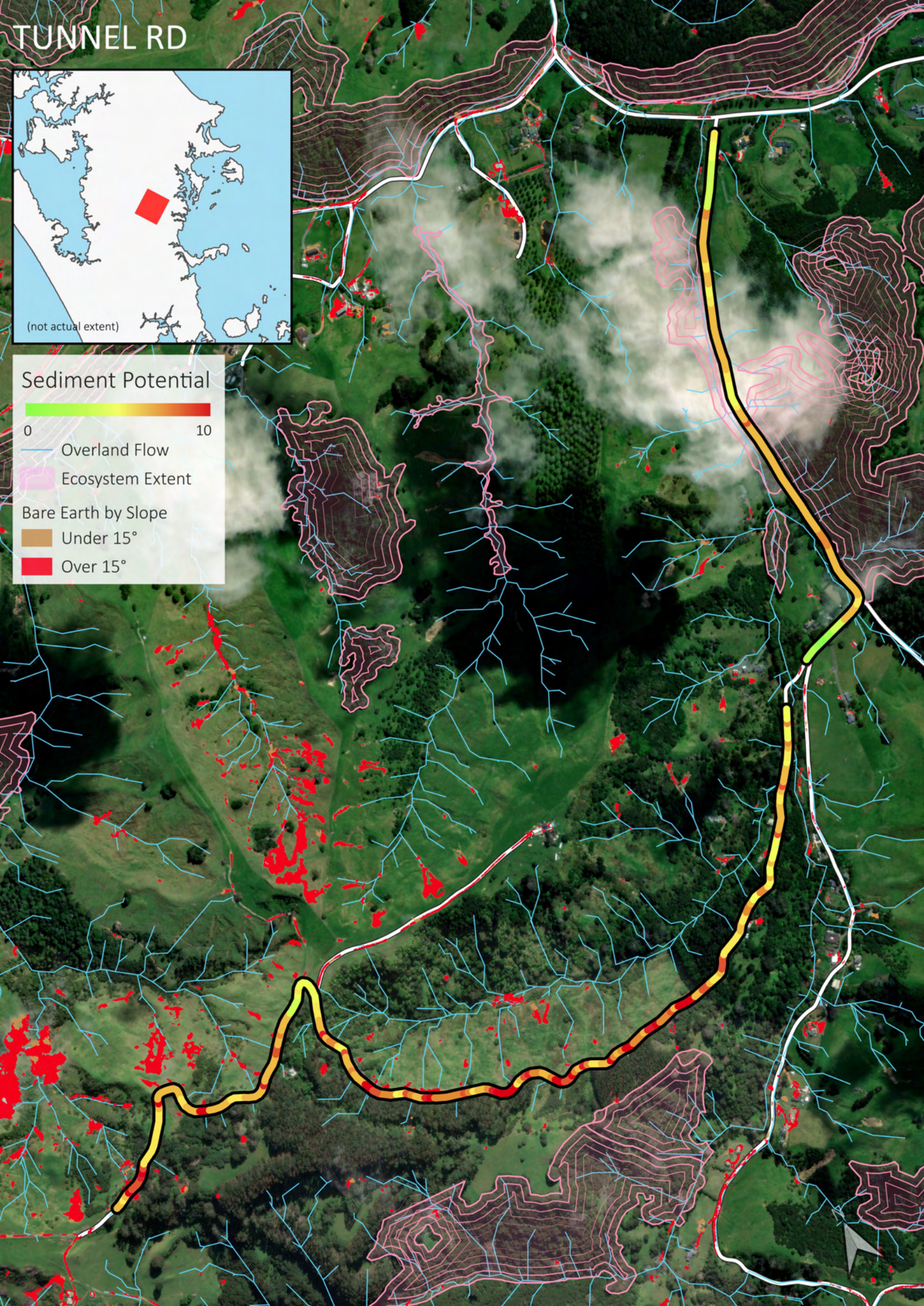
Under 15°

Over 15°


AHUROA RD
(not actual extent)
Sediment Potential
0
10
Overland Flow
Ecosystem Extent
Bare Earth by Slope
Under 15°
Over 15°


MCNICOL RD
(not actual extent)
Sediment Potential
0
10
Overland Flow
Ecosystem Extent
Bare Earth by Slope
Under 15°
Over 15°


JONKERS RD
(not actual extent)
Sediment Potential
0
10
Overland Flow
Ecosystem Extent
Bare Earth by Slope
Under 15°
Over 15°
N


TUNNEL RD
(not actual extent)
Sediment Potential
0
10
Overland Flow
Ecosystem Extent
Bare Earth by Slope
Under 15°
Over 15°

BROKEN BRIDGE RD

Sediment Potential

0 10

Overland Flow

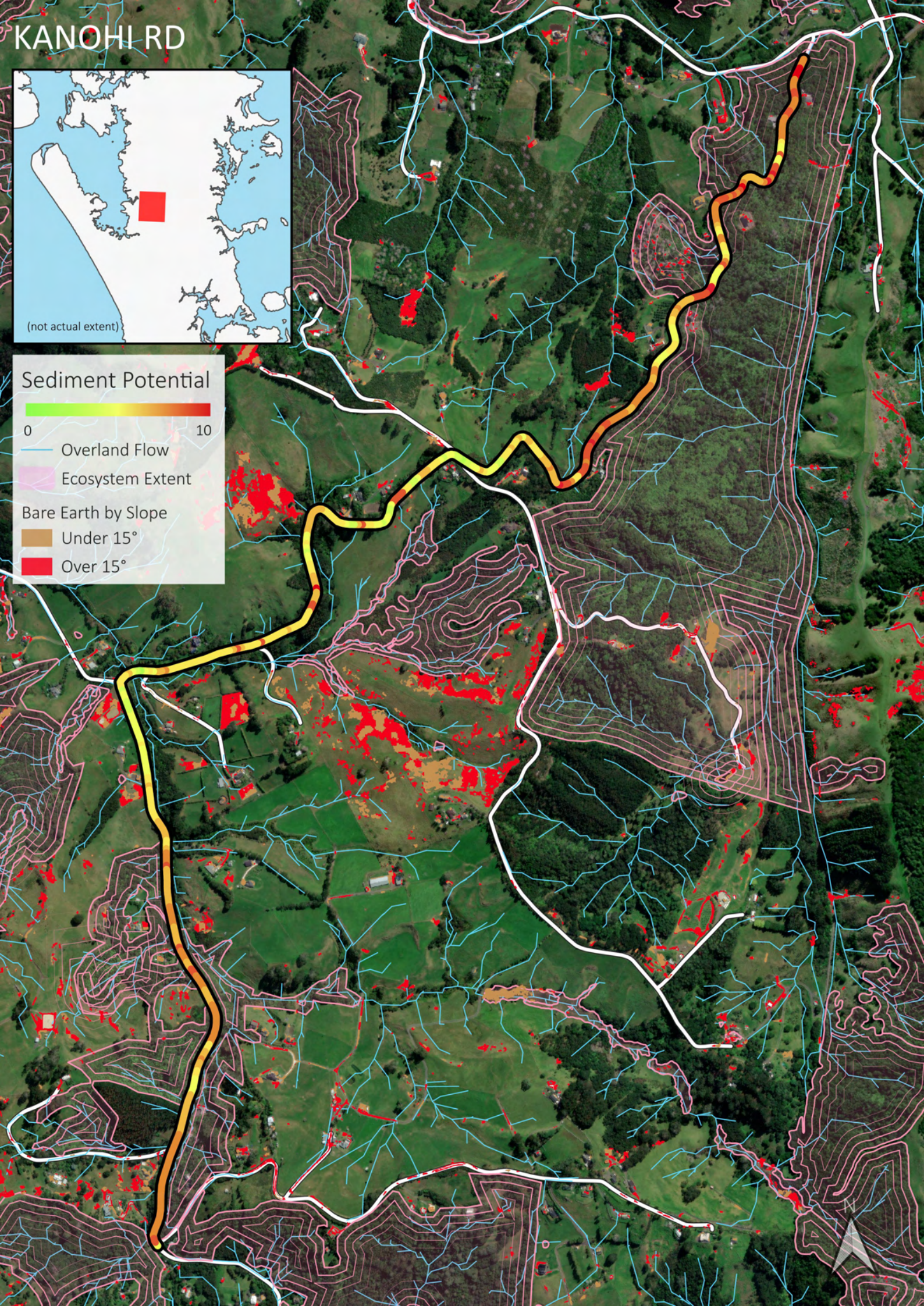
Ecosystem Extent

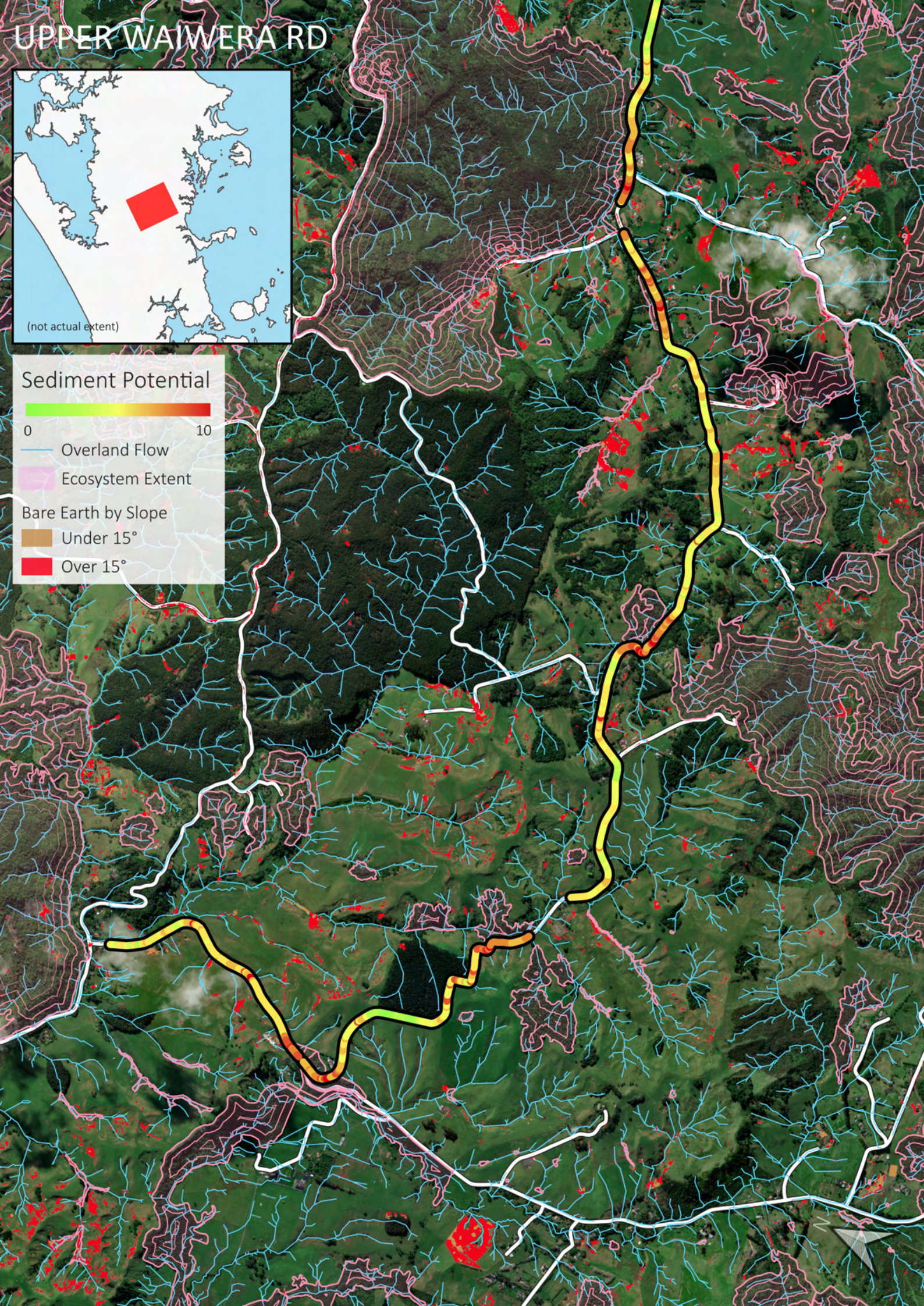
Bare Earth by Slope

Under 15°

Over 15°

N


KANOHI RD
(not actual extent)
Sediment Potential
0
10
Overland Flow
Ecosystem Extent
Bare Earth by Slope
Under 15°
Over 15°
N


UPPER WAIWERA RD
(not actual extent)
Sediment Potential
0
10
Overland Flow
Ecosystem Extent
Bare Earth by Slope
Under 15°
Over 15°

KAIPARA HILLS RD

Sediment Potential

0 10

Overland Flow

Ecosystem Extent

Bare Earth by Slope

Under 15°

Over 15°

BETHELLS RD (WCC)

Sediment Potential

0 10

Overland Flow

Ecosystem Extent

Bare Earth by Slope

Under 15°

Over 15°

JAMES ST (SANDSPIT)

Sediment Potential

0 10

Overland Flow

Ecosystem Extent

Bare Earth by Slope

Under 15°

Over 15°