Regional Aggregate Opportunity Modelling

Using spatial modelling to identify our future hard rock, gravel and sand critical minerals.

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& Mike Chilton – AGGREtech

18 July 2024

QUARRYNZ IOQ/AQA ANNUAL CONFERENCE

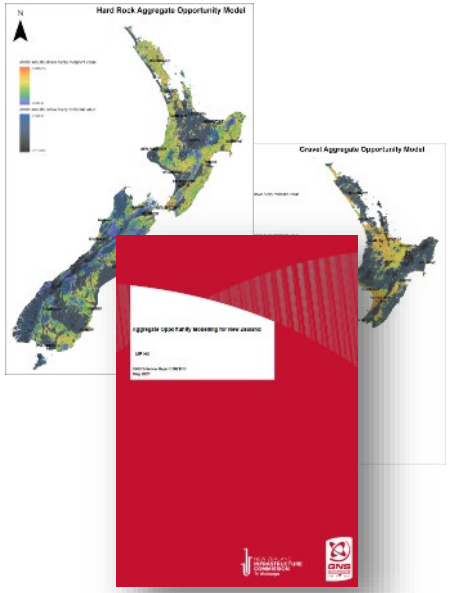
NEW ZEALAND INFRASTRUCTURE COMMISSION *Te Waihanga*

aqa

AGGREtech

The New Zealand Aggregate Opportunity Model

- Aggregate opportunity modelling was started by GNS Science in 2018 and refined over several years with input from industry experts.
- Initially designed to provide a national-scale overview of where aggregate opportunities existed and first published in 2021.
- Now undertaken at a more detailed resolution with a local geological and feasibility approach.
- Tasman District research due out next week.
- Aims to provide regional information about aggregate opportunity.



Hill MP. 2021. Aggregate Opportunity Modelling for New Zealand. GNS Science Report 2021/10.

Hill & Chilton 2024. GNS Science Report 2024/09; GNS Science Report 2024/10; GNS Science Report 2024/11; GNS Science Report 2024/12; & GNS Science Report 2024/13

All the reports, data, links to web maps and the webinar about the project are available on the Infrastructure Commission website →

We created models for the three main aggregate material groups.

HARD ROCK

- Sandstone, limestone, volcanic and intrusive rocks, schist, & granite.
- Must be hard and with consistent mineralogy and not altered or too fractured.
- Can be under cover material.

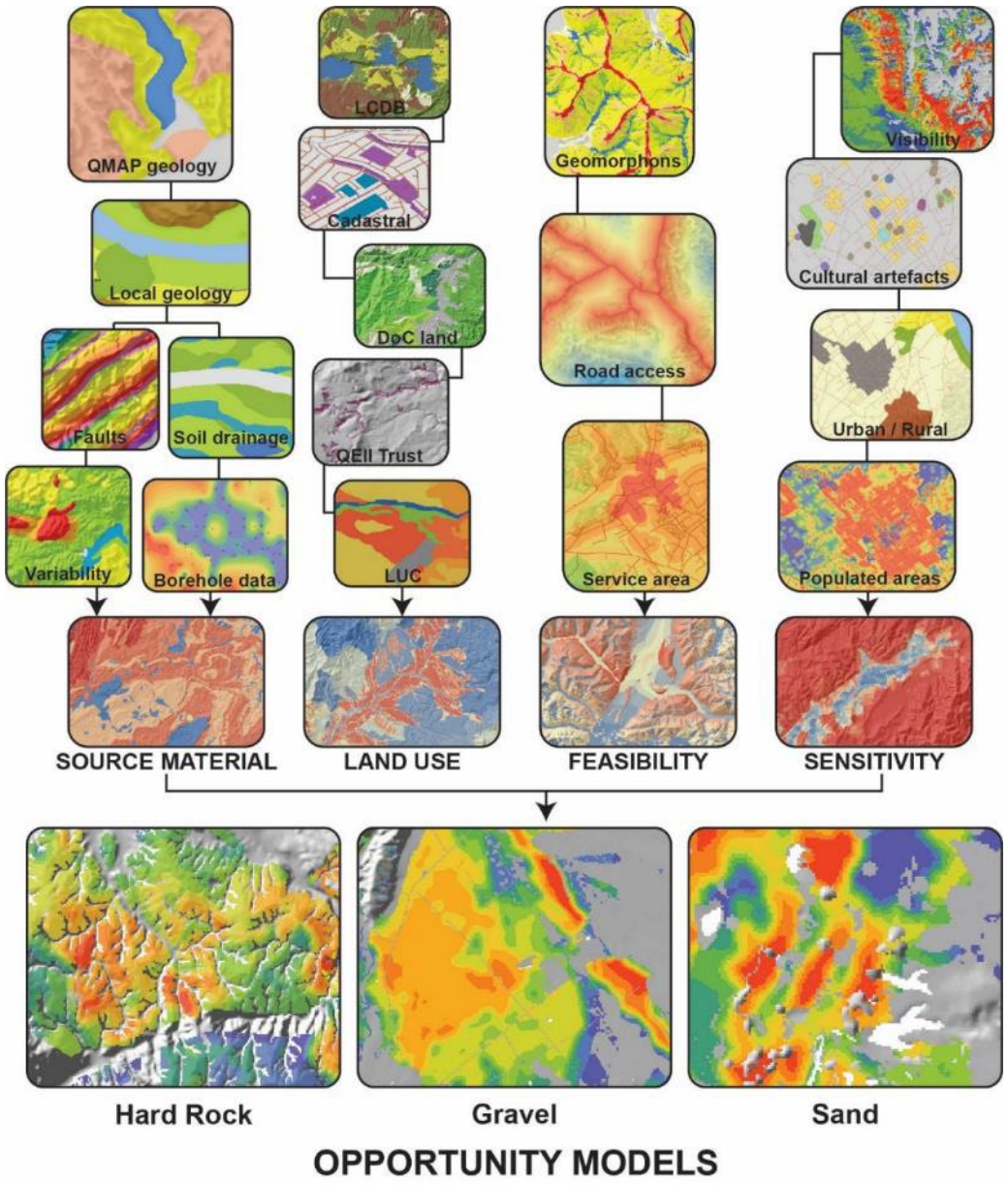
GRAVEL

- Rocks deposited by river systems.
- Best if of consistent rock type and not containing too many silts, clays and organic material.

SAND

- Critical for concrete as it fills gaps, increase surface area, and adds density.
- Sources such as rivers, dunes, beaches, offshore, and can even be manufactured.
- Best if angular, a variety of sizes, and chemically inert.

Aggregate Opportunity Concept and Model Method



LEVEL 1:
Mappable criteria layers

These are maps of source data that are classified and weighted.

LEVEL 2:
Predictive model components

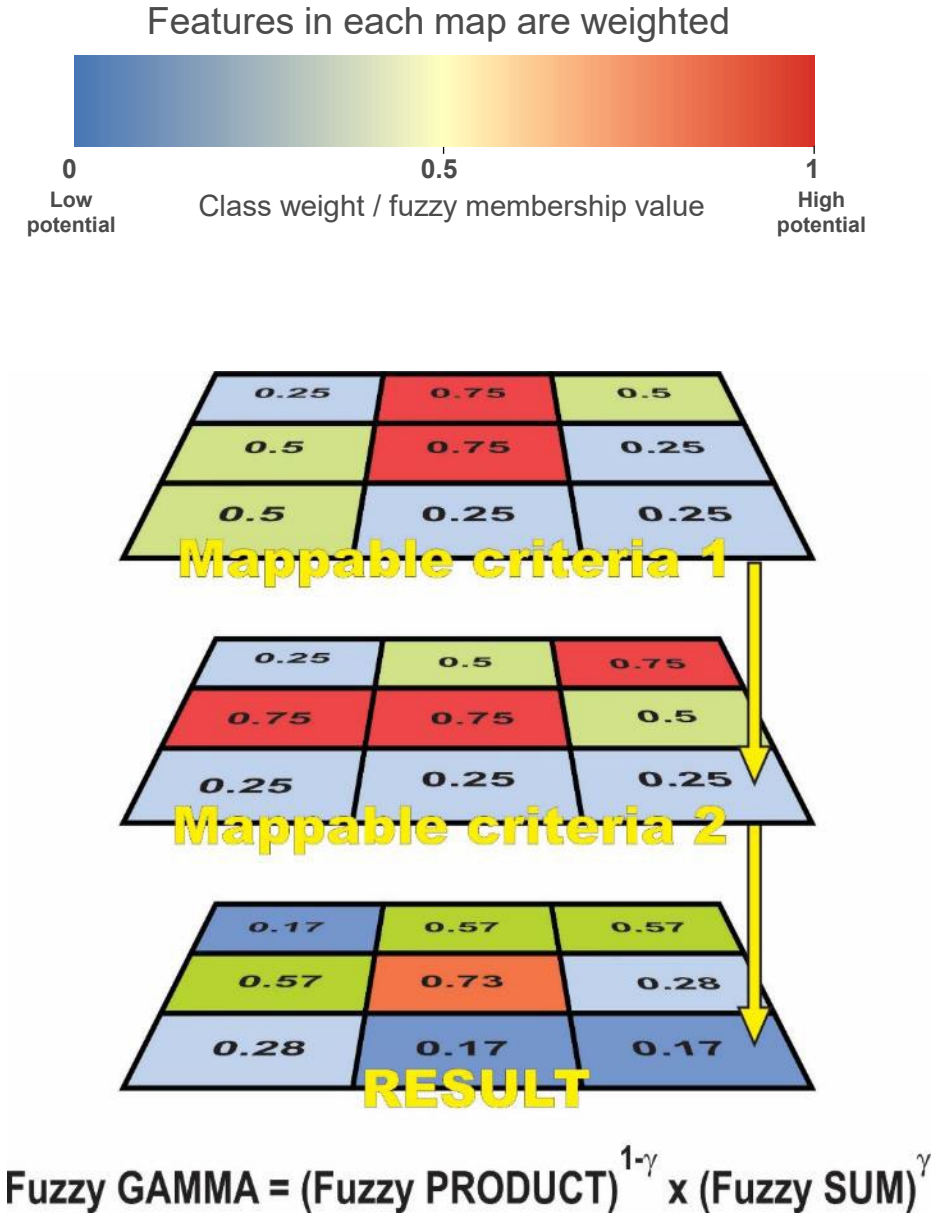
The four components of aggregate opportunity in this model.

LEVEL 3:
Final models for aggregate

Combining the Predictive Maps

- ***Knowledge-driven*** rather than data-driven method.
- Features in each map layer of the model are assigned a ***class weight***.
- They represent the importance of a feature or a map area to possible quarrying opportunities.
- Weight values are assigned by expert opinion and guided by spatial statistics.
- They are therefore ***subjective***.
- The maps are combined using ‘fuzzy operators’ which is very simple mathematics and easily understood.

- We have tested some machine learning methods, but these techniques produced poor results.



OPPORTUNITY

"a situation that makes it a possibility"

It **DOES NOT** map locations where quarrying will occur.

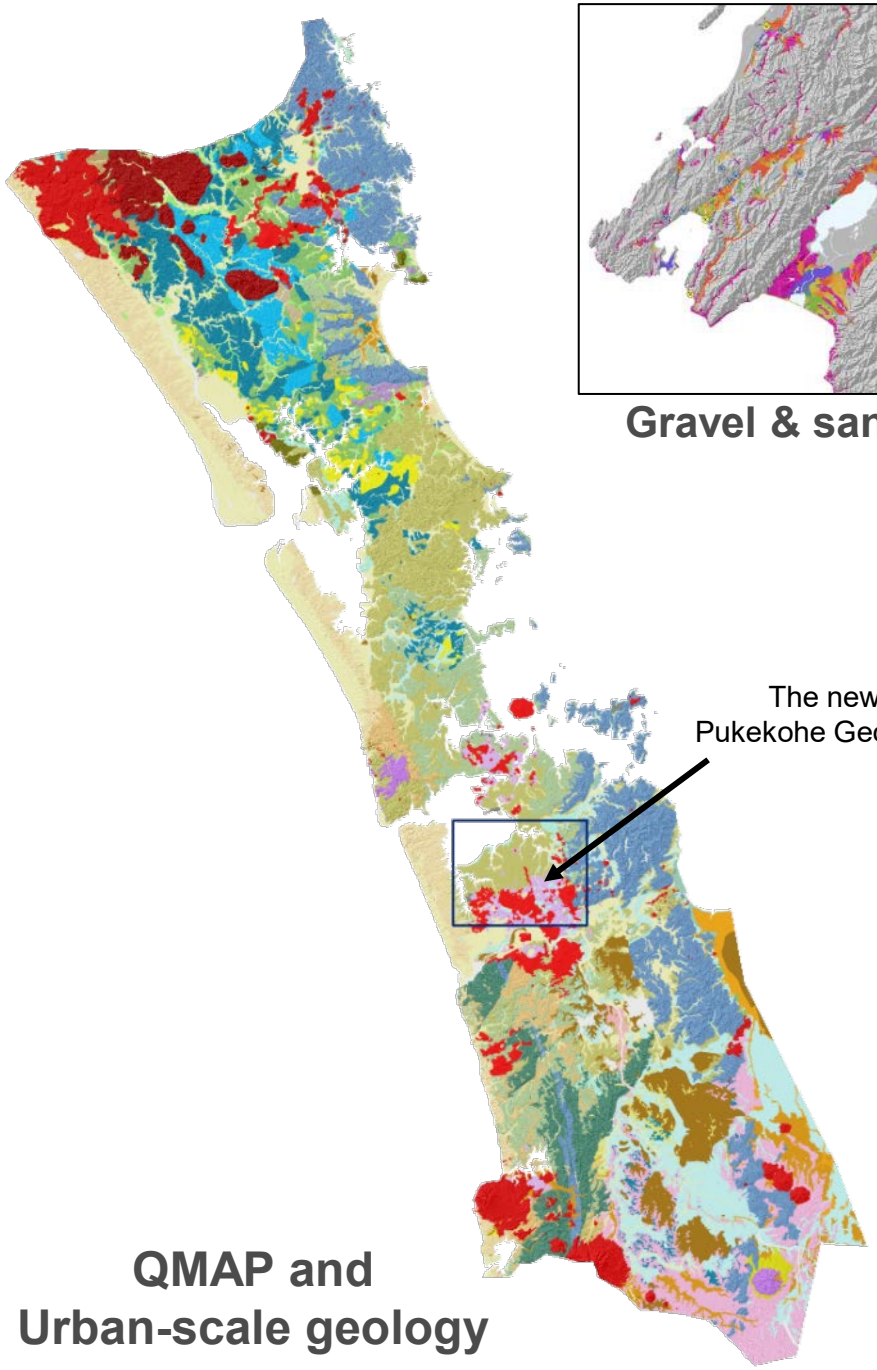
Results show where data indicates that there is an opportunity to consider the site for aggregate exploration.

A lot of additional testing and community engagement is required for any site to be considered a resource and for quarrying to start.

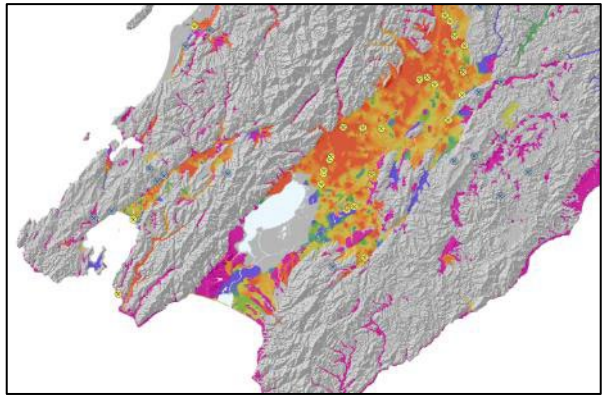
The modelling can only use mapped data and cannot include non-spatial information.

Source Material

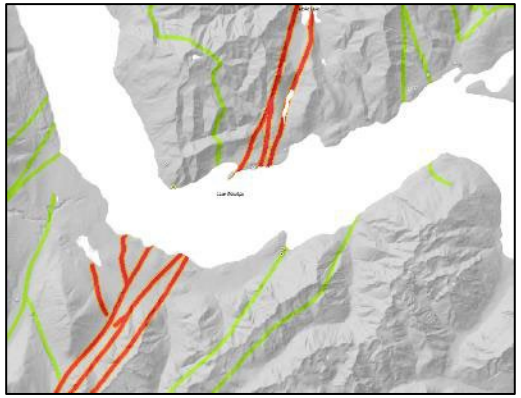
- We have used maps of geology to locate potential source material.
    1. QMAP 1:250 000 geological map combined with any local urban-scale geology.
    2. Rock unit variability
    3. Proximity to faults
    4. Regional soil permeability
    5. Borehole thickness of sand and gravel
- These maps have been classified to highlight areas where hard rock, gravel or sand material is most likely to have accumulated / outcrop.



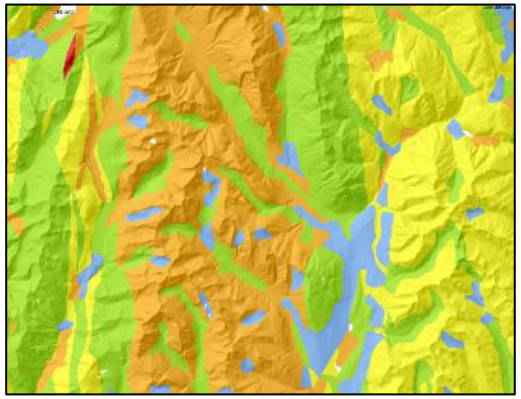
QMAP and Urban-scale geology



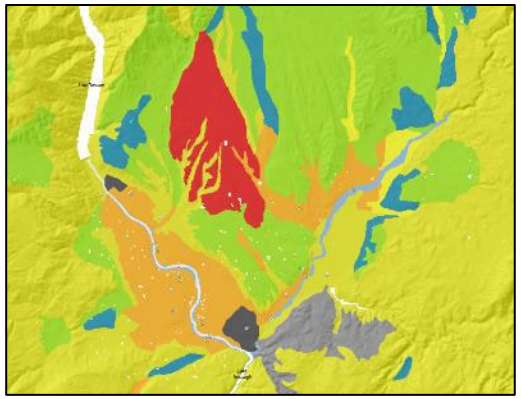
Gravel & sand thickness



Faults



Rock unit variability

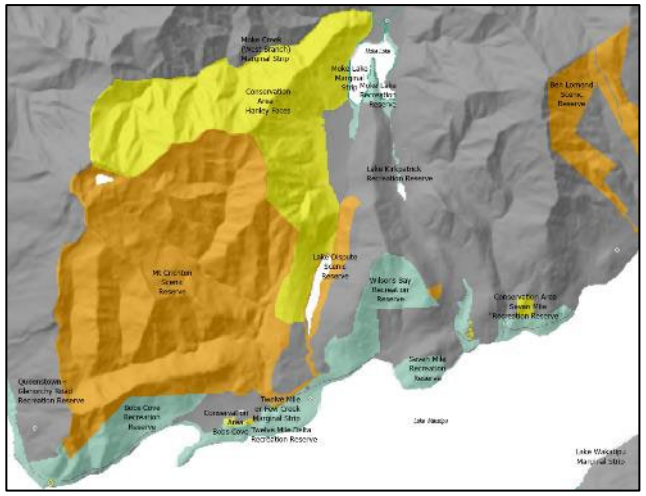


Soil permeability

Land Use

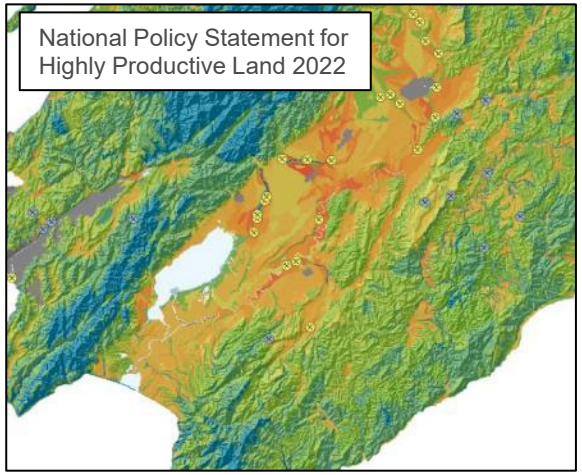
- Our model uses maps of land use to locate areas most suitable for quarrying activities.
- In particular, those that map areas that are restricted for mining activities.
- Data from maps of:
  1. DoC public conservation areas
  2. QEII Trust land
  3. Parks and reserves (in cadastral data)
  4. Land use capability (LUC) classes
  5. Land use classification database (LCDB)
- The model considers the different land access restrictions with appropriate weights in the model.

DOC

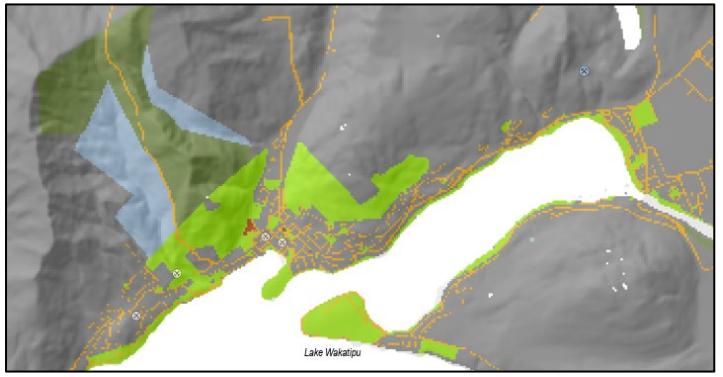


LCDB

LUC

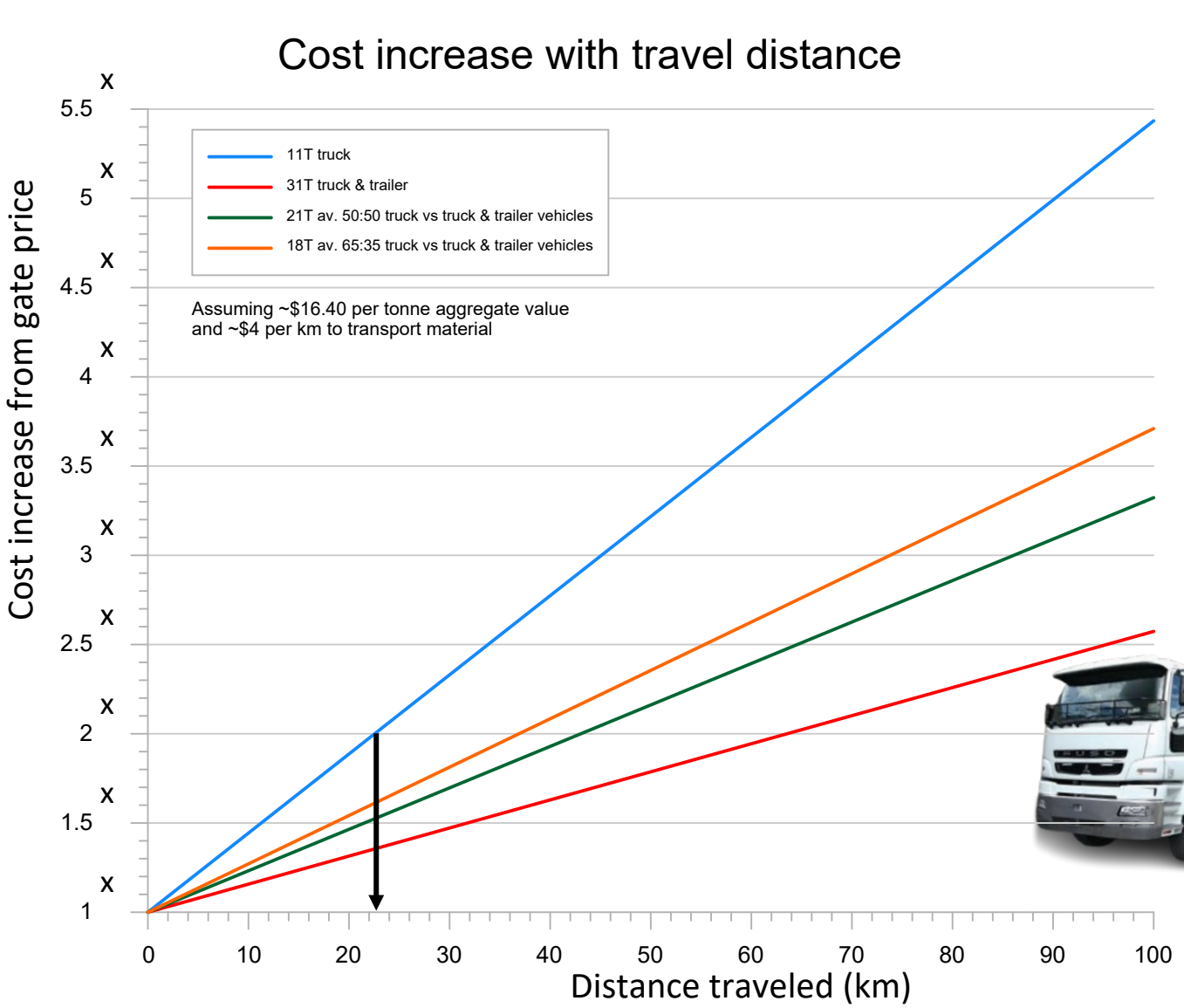


Parks



QEII

Feasibility



11t truck

50:50

65:35

T:T&T

31t truck & trailer

- Known as the "Tyranny of Distance"
- Aggregate is:
  - a bulk commodity;
  - Is high density;
  - is low value;
  - used in large quantities.
- Aggregate is almost exclusively transported by truck.
- For some transport options, the cost doubles after 23 km.
- This will only continue to worsen in the future with increasing fuel costs.
  (already a ~30% inc. since 2021)

After data within: "Infrastructure Resources Study" by NZ Infrastructure Commission (2021)

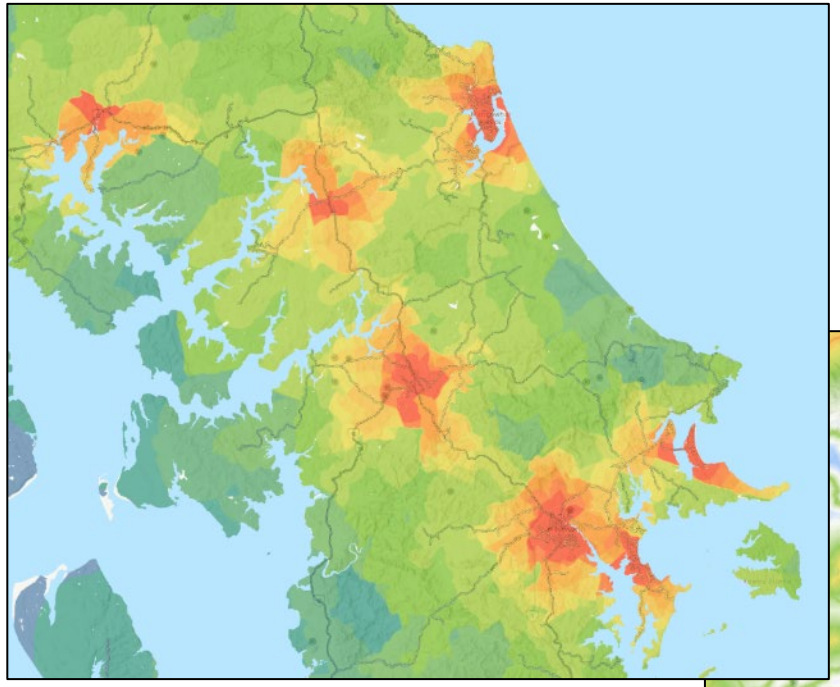
Feasibility

The feasibility of a new quarry is related to the distance from the market, the site, and access to that site.

1. We have mapped the driving distance to major populated areas as the cost of transport is critical to the profitability of a quarry.

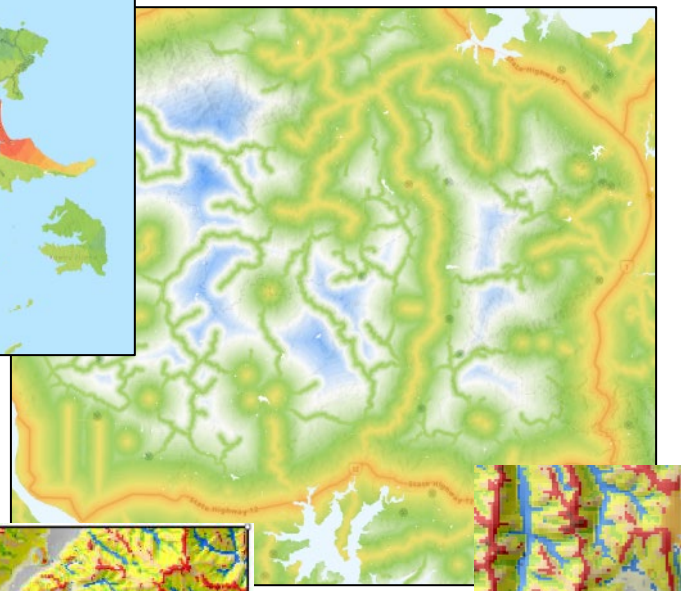
2. The nature of a site's terrain affects the style of extraction at specific sites.
   E.g. Steeper sites are better for accessing hard rock and flatter sites are where gravel and sand has accumulated.

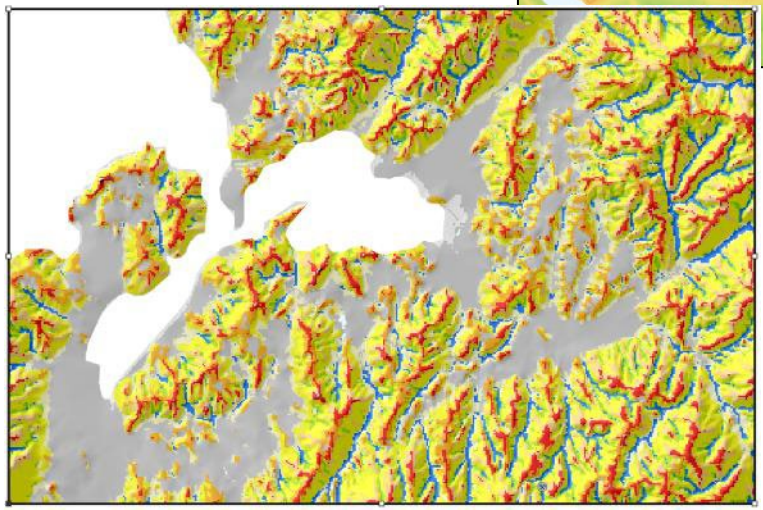
3. Being close to the existing road network is important for the establishment of a new quarry.

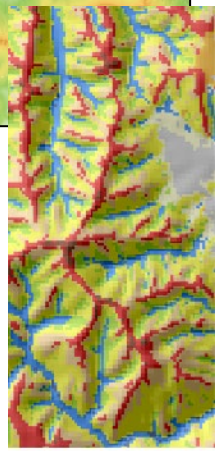


Driving distance

Road Access



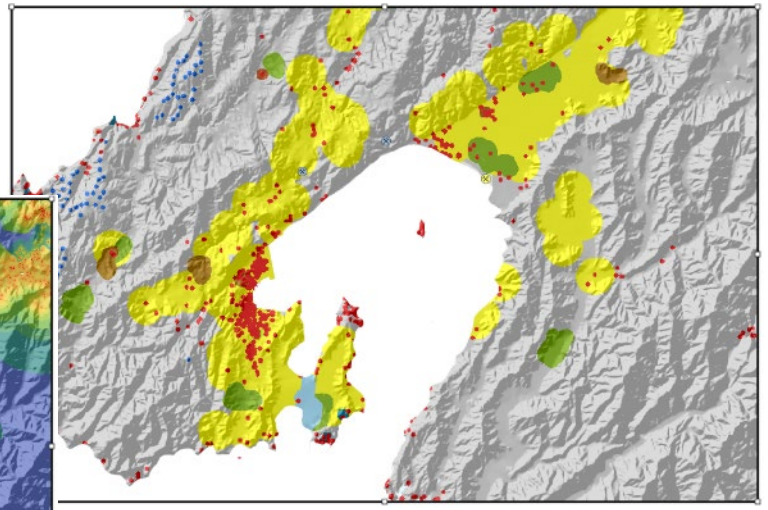




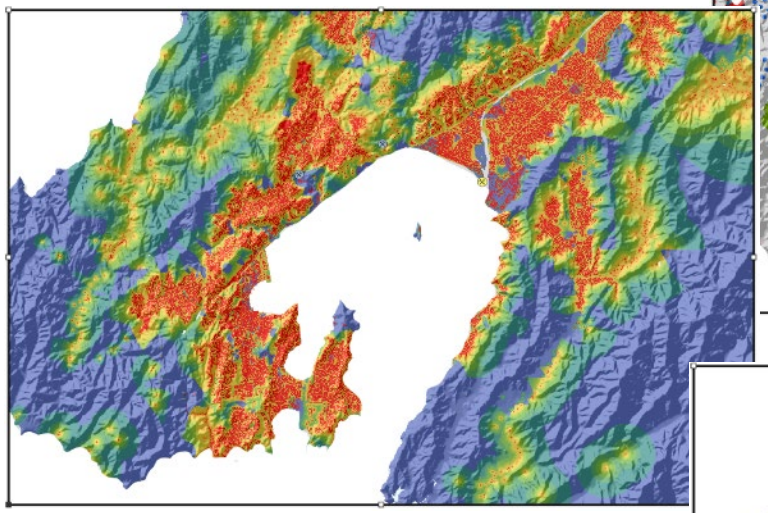
Terrain

Community Sensitivity

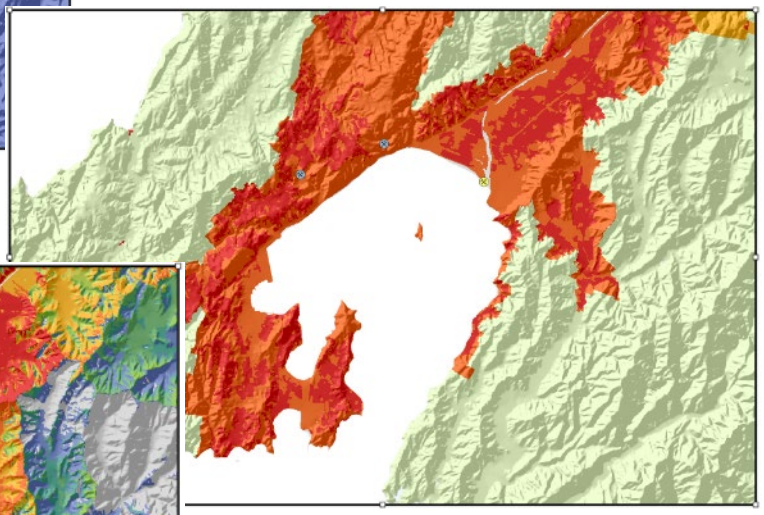
- As with all extractive activities consideration for the local community is important.
- Sensitivity to mining often places limitations on operators.
- Maps included in the model are:
    1. Proximity to cultural sites and features (e.g. marae, wind turbines, golf courses, cemeteries, airport, archaeological and historic sites, sports fields, schools, hospitals, etc.)
    2. Proximity to populated buildings.
    3. City, urban and rural areas.
    4. And a visibility analysis - what can be seen from buildings, homes and main roads.



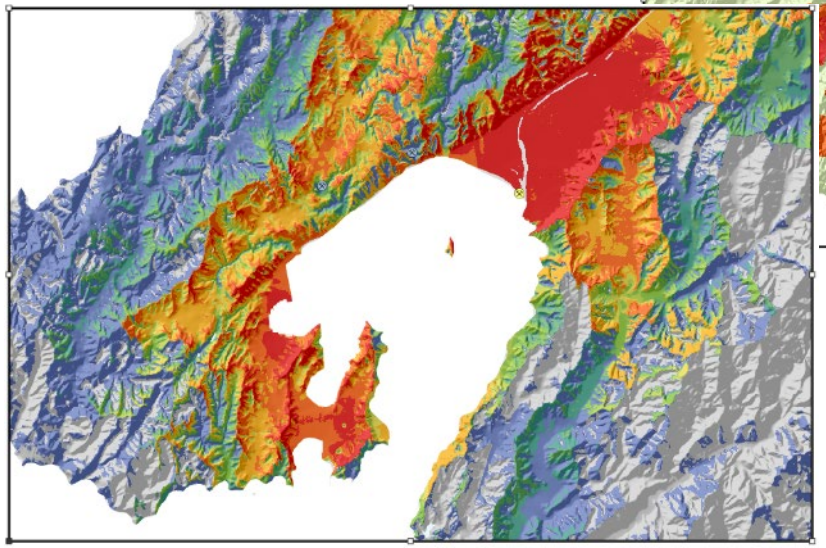
Cultural sites and features



Populated buildings



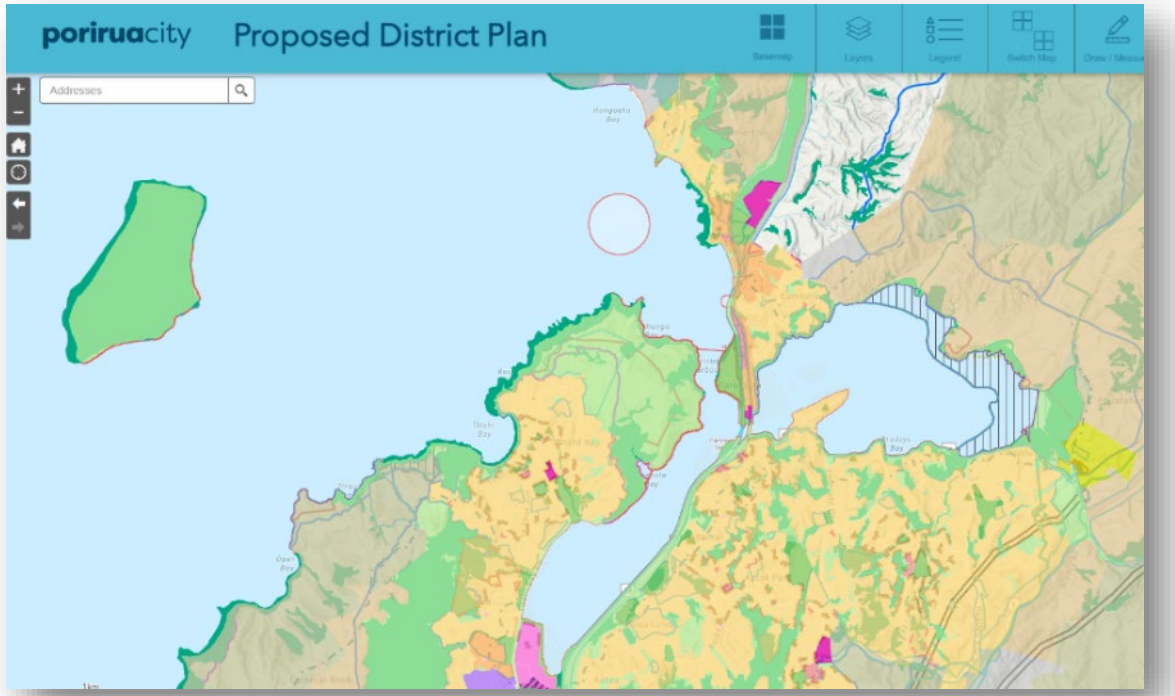
City, urban and rural



Visibility

Data Gaps

- There is still a lot of data that is not mappable or not available.
- For example:
  - Council zoning data is hard to compile across districts due to formatting, variable interpretations, or that it is undergoing a review.
  - Geotechnical data on rock properties (density, impurity, weathering, fracturing, etc.) are site-specific so not suitable for region-scale modelling.
  - And importantly, we can't map the perceived importance of sites to local communities and the Māori custodians of land areas.
- These geotechnical, regulatory and cultural influences are not included in this modelling so need to be considered as part of follow-up investigation.



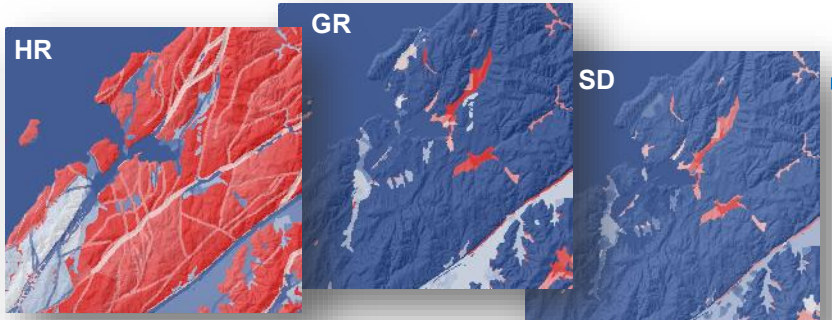
Combining the Predictive Component Maps

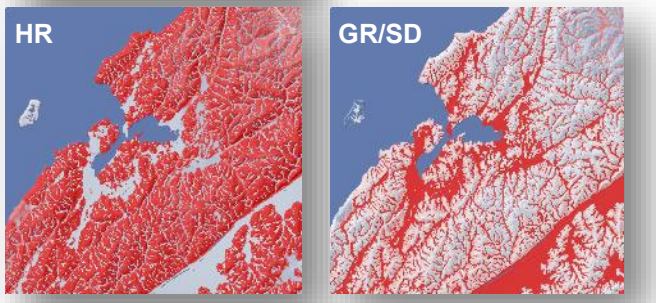
Source material

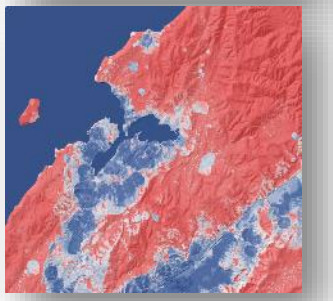
Land use

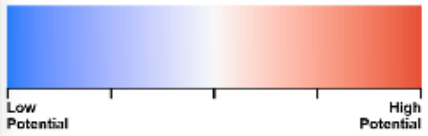
Feasibility

Sensitivity

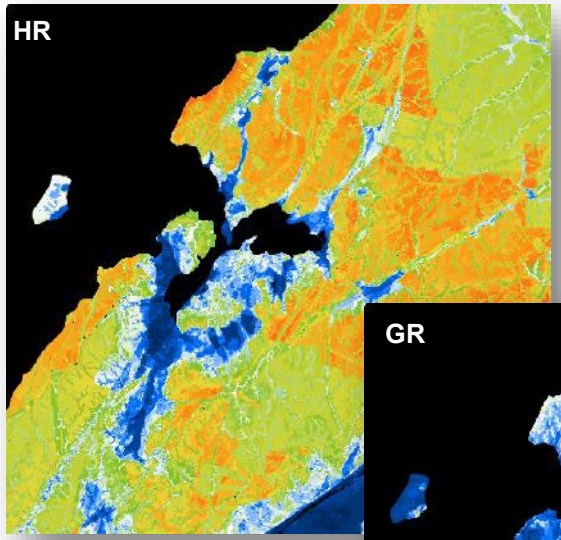


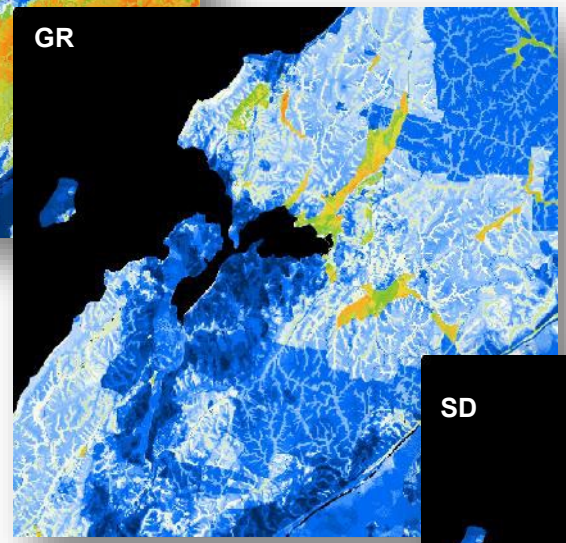


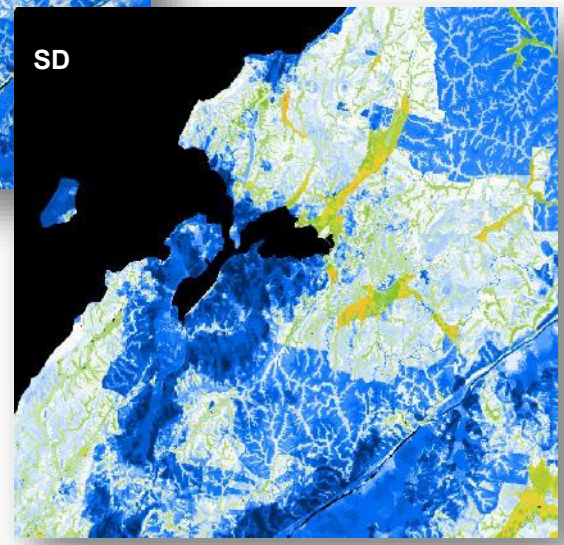


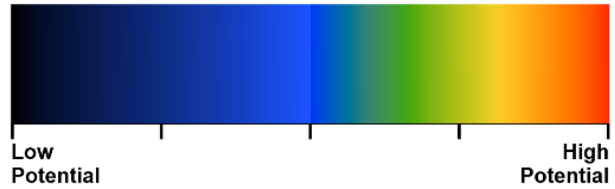


Final model



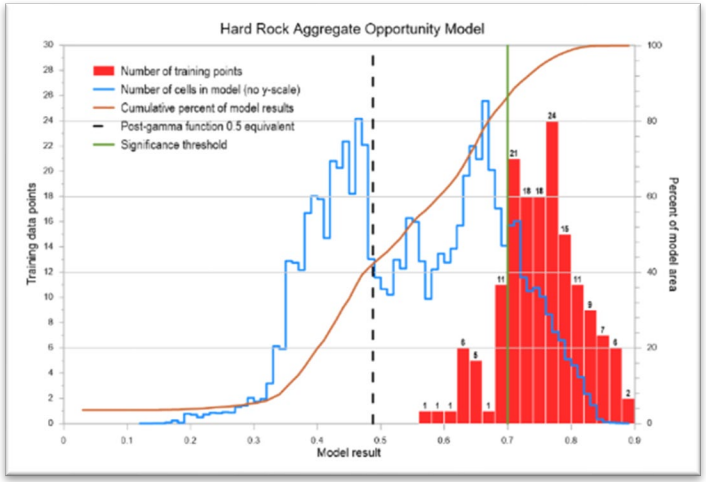




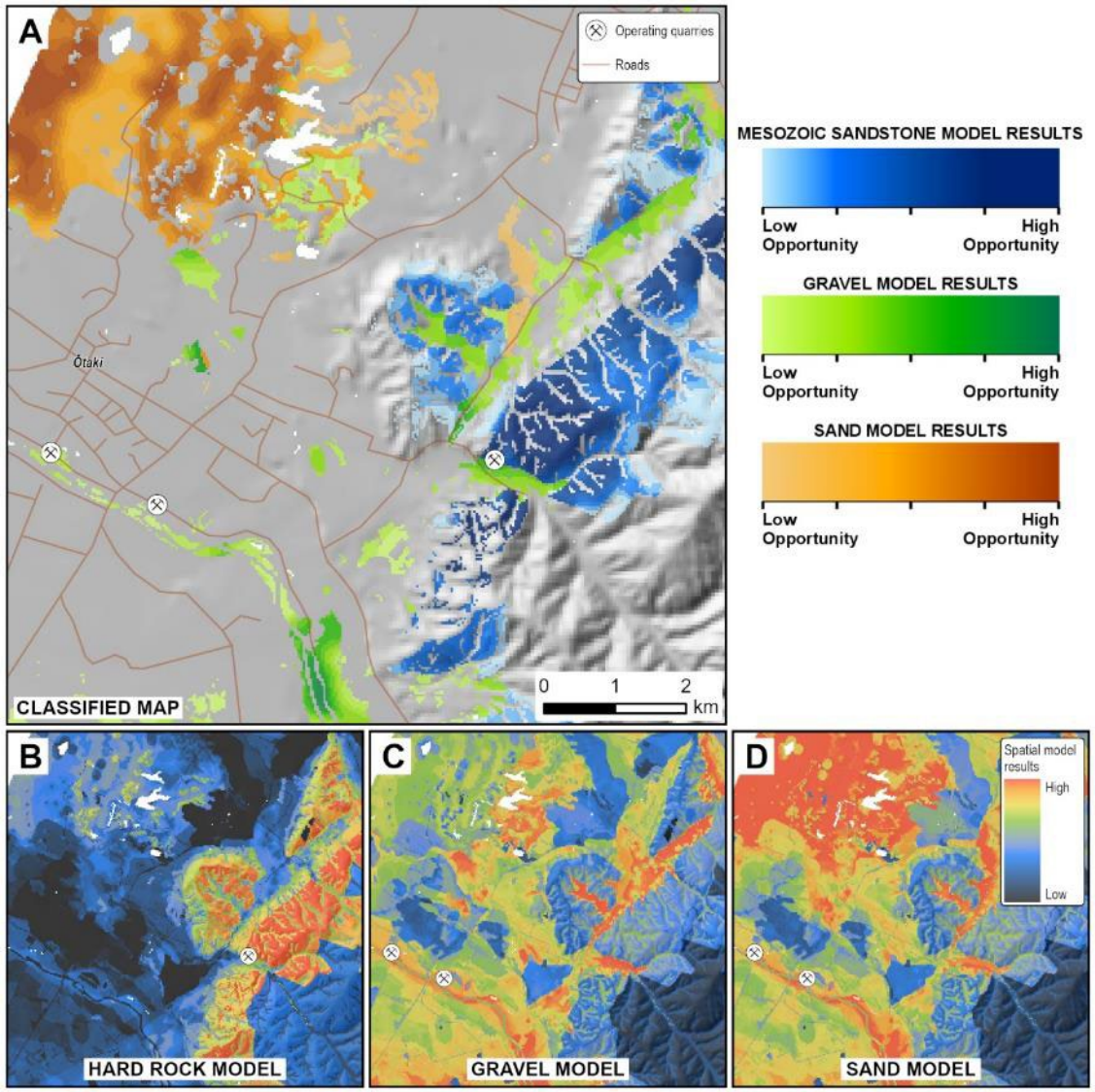


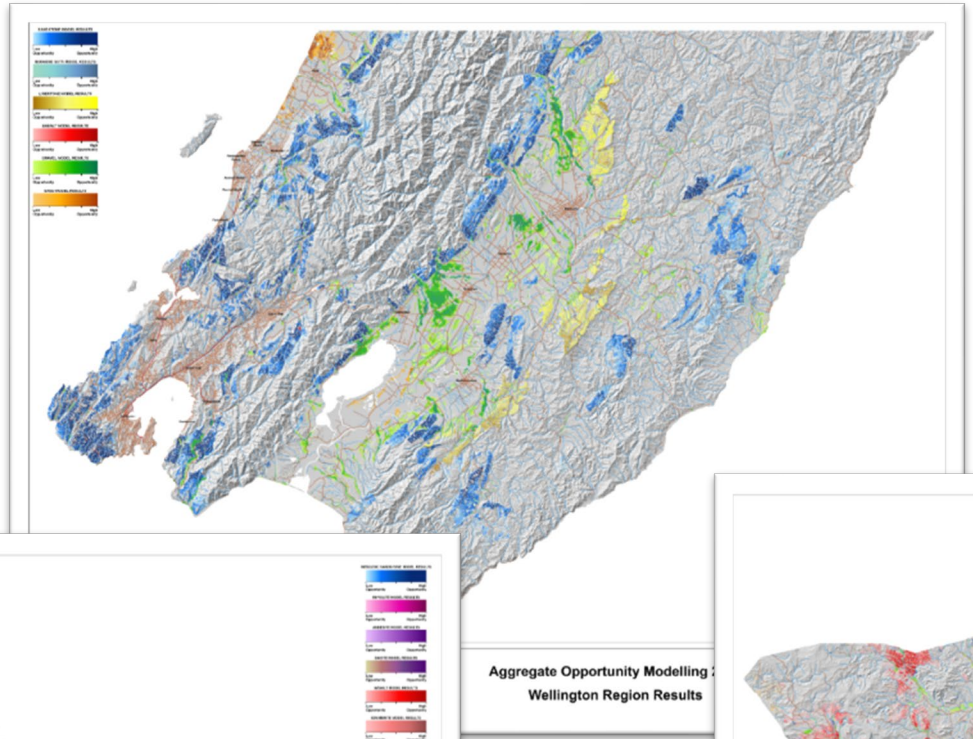
Aggregate Opportunity Model Results

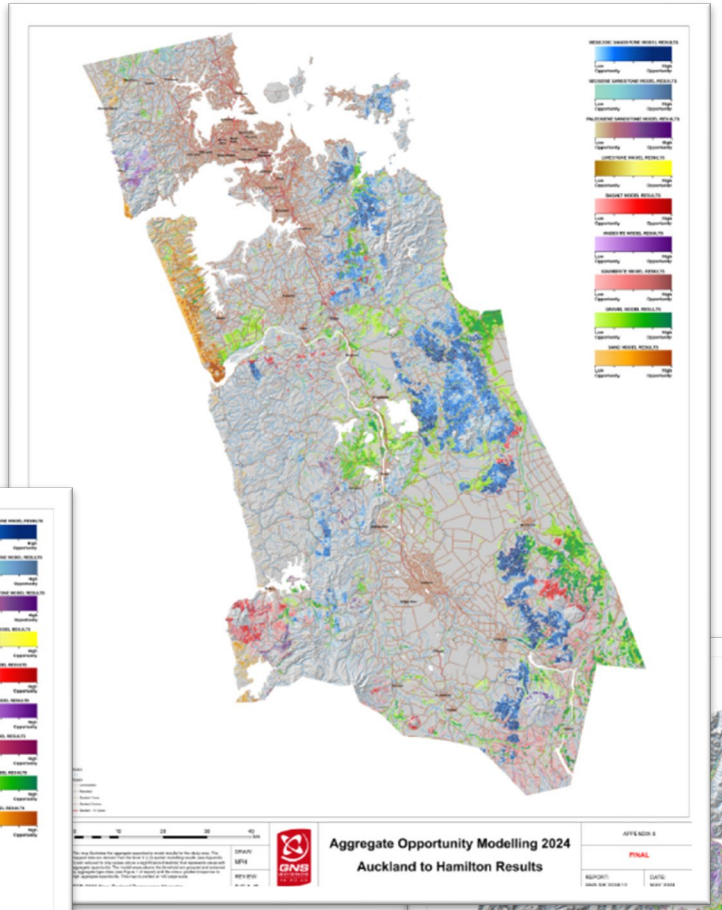
- The model results have been filtered to remove relatively low values.
- Opportunity model results show areas where the model is above a significance threshold.
- Colours represent the different aggregate commodity groups and are graduated by opportunity.

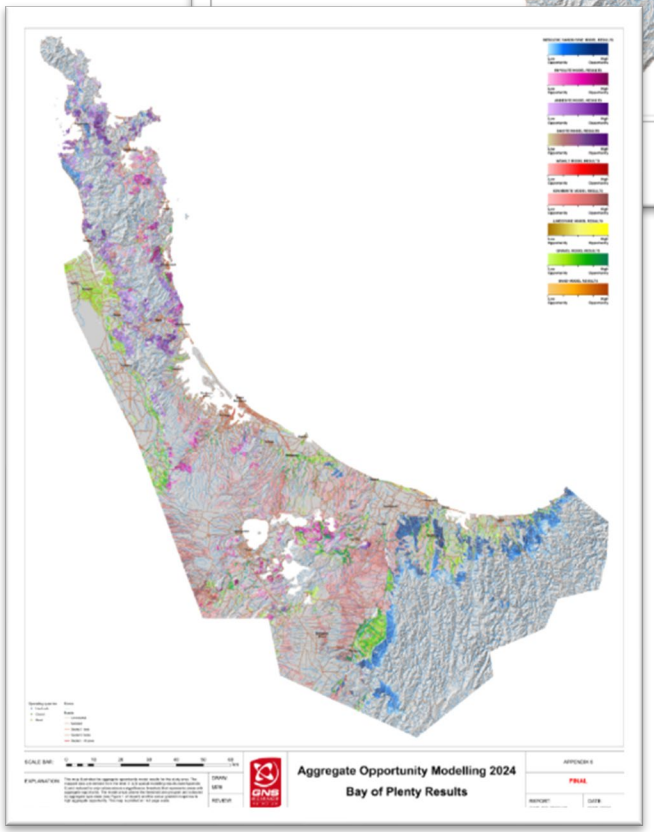


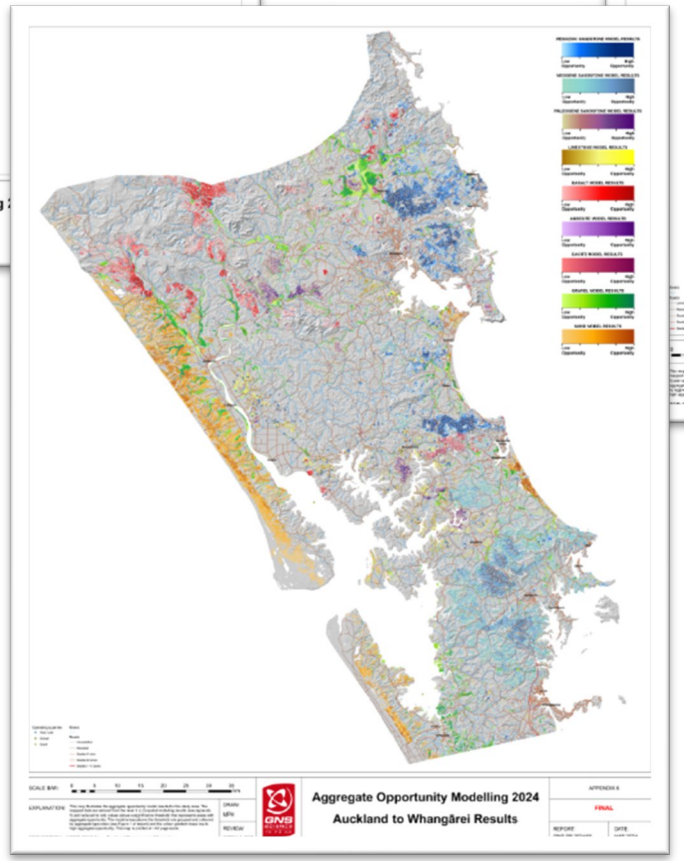
Statistical analysis to determine threshold

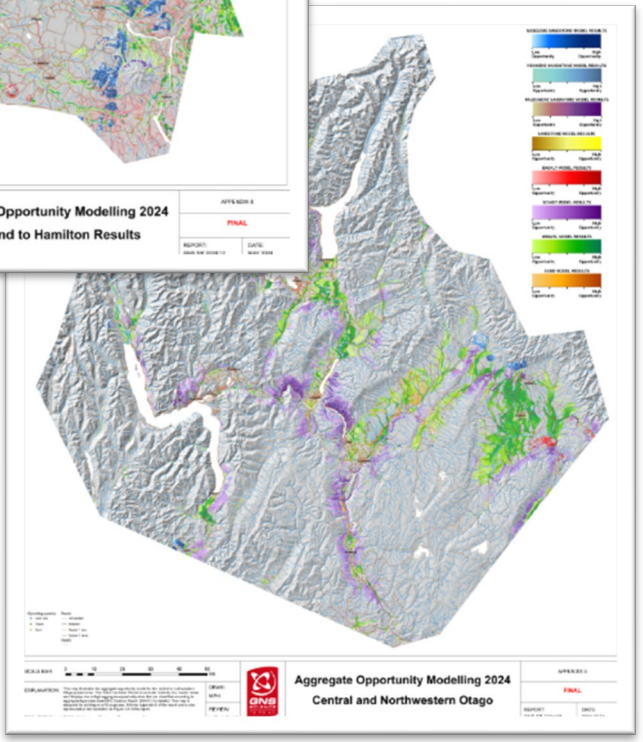



Aggregate Opportunity Modelling
Wellington Region Results

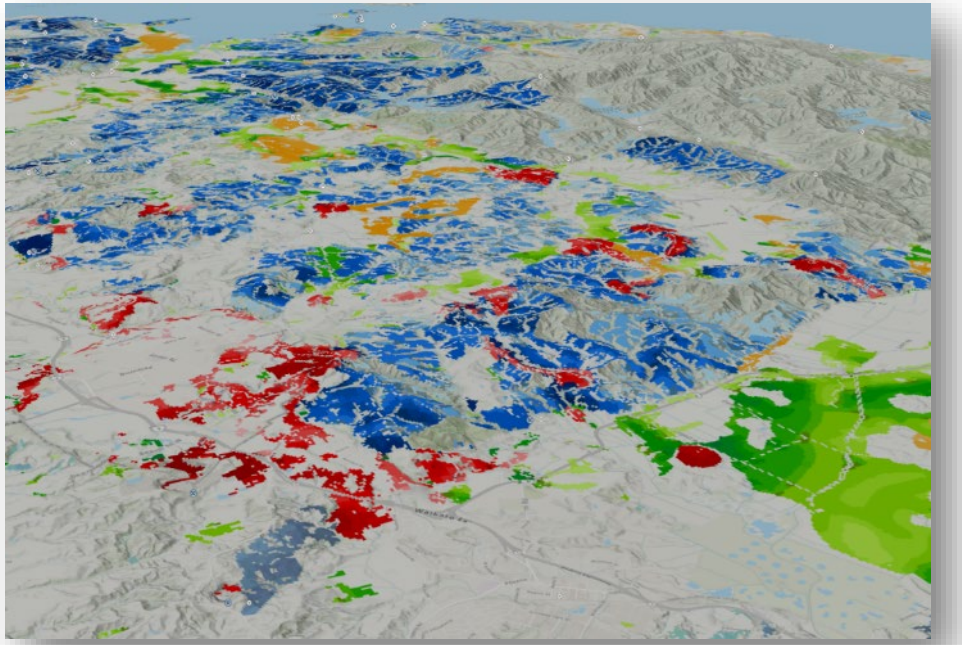

Aggregate Opportunity Modelling 2024
Auckland to Hamilton Results

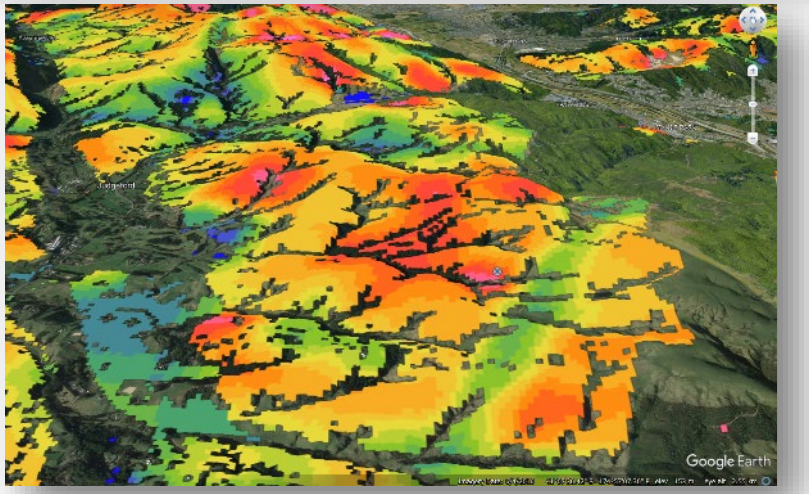

Aggregate Opportunity Modelling 2024
Bay of Plenty Results

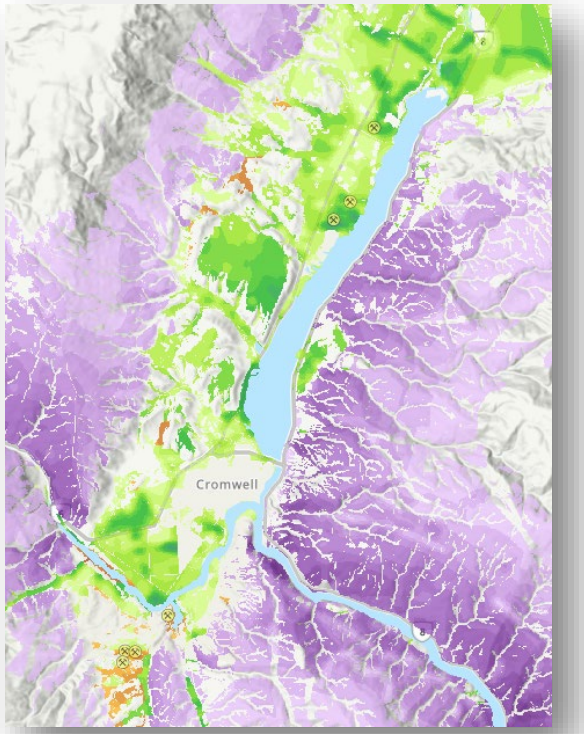

Aggregate Opportunity Modelling 2024
Auckland to Whangārei Results

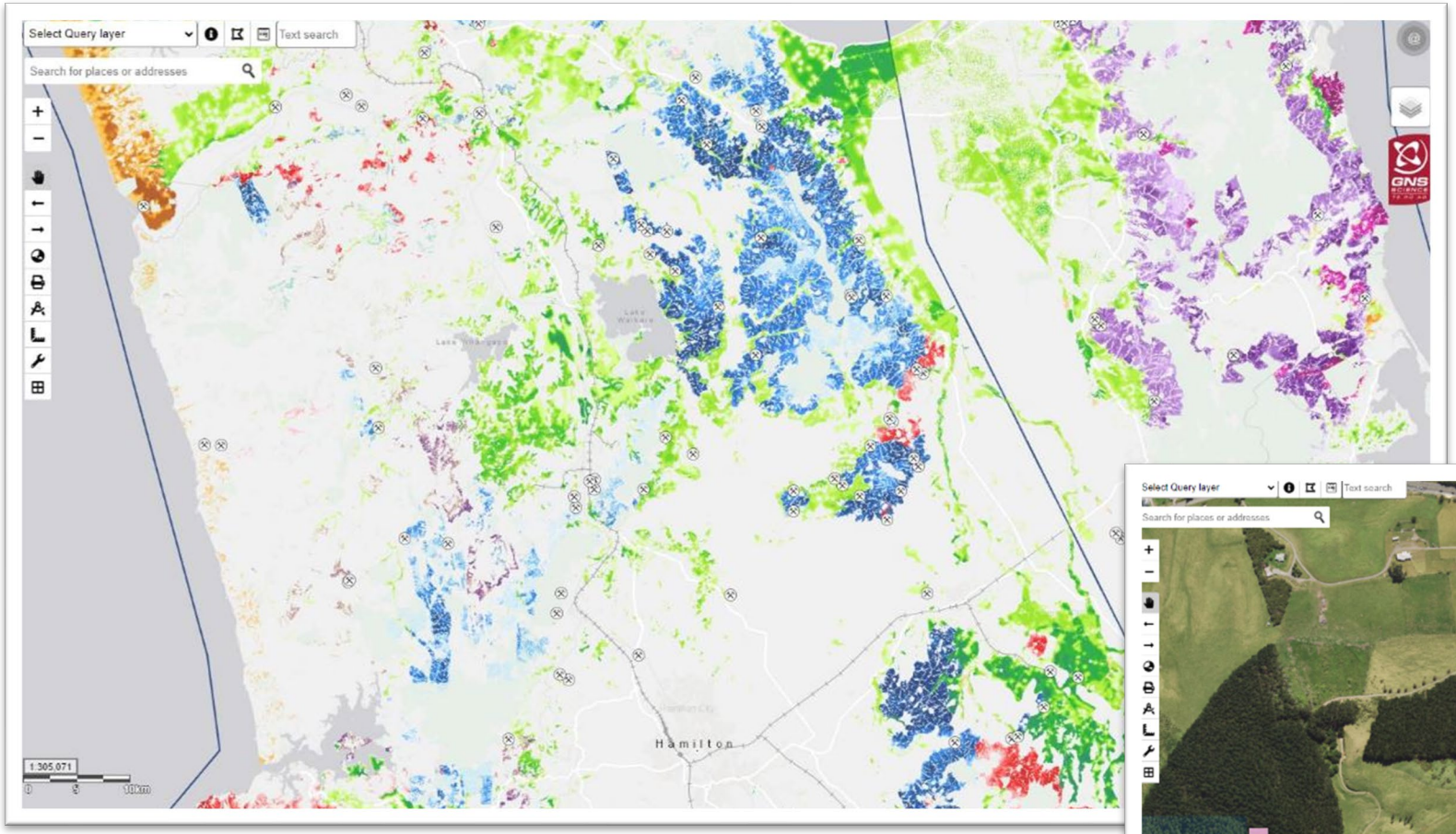

Aggregate Opportunity Modelling 2024
Central and Northwestern Otago

- Data is digital so it can be viewed at any scale* and integrated in existing mapping systems with other data.
- The results can also be viewed on dedicated web maps or in software such as Google Earth.
- These data and web-based maps make the results accessible to anyone investigating for our future resources.









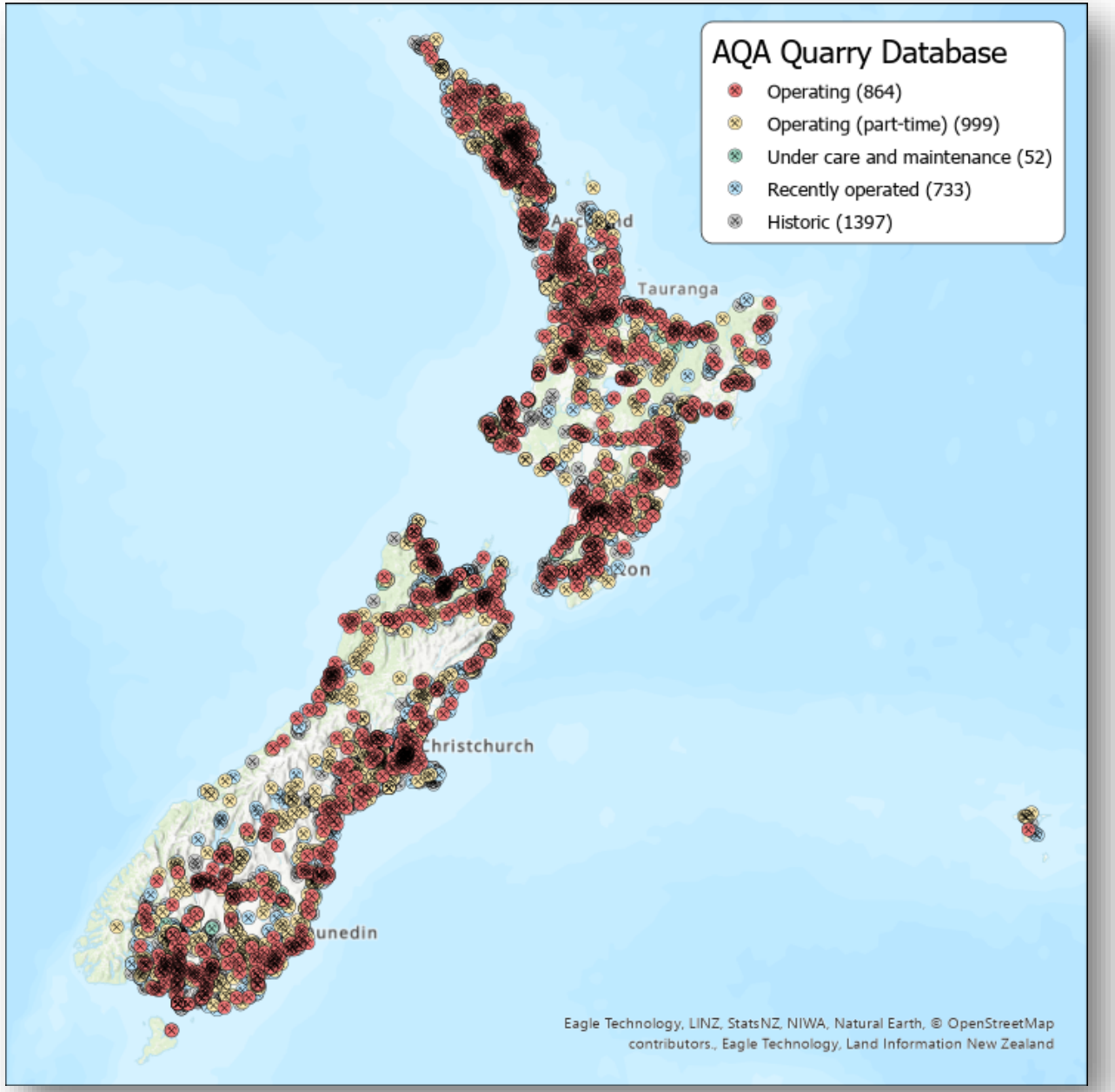
Available through our
E Tūhura - Explore Zealandia
geoscience web map portal.

https://data.gns.cri.nz/tez/index.html?map=Aggregate%20Opportunity

AQA Quarry Database

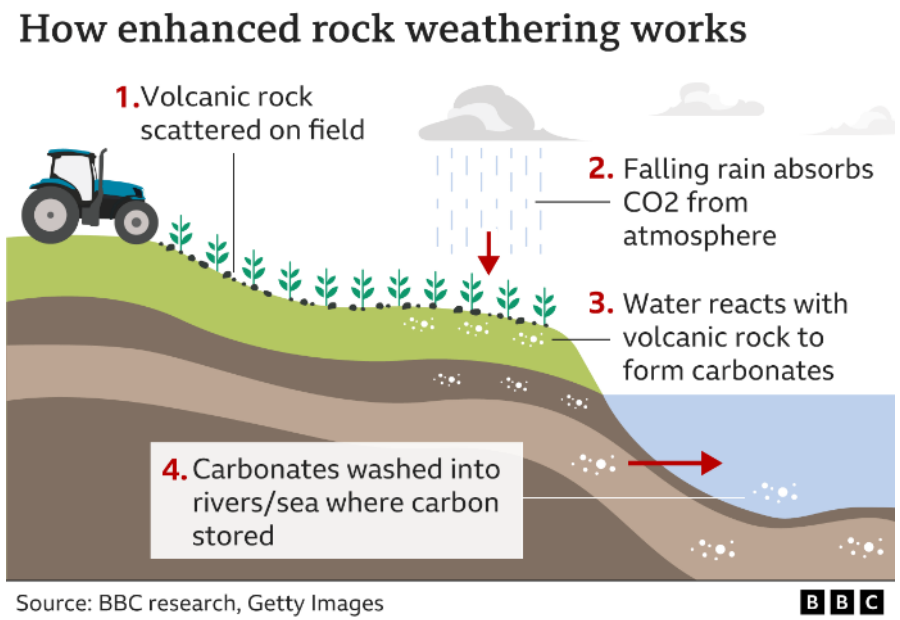
- The AQA and GNS Science have been working on a database of operating and historic quarry locations in New Zealand.
- So far, we've compiled >4,000 extraction sites and more than 1,800 of those are operating.
- The database is freely available online from the AQA.
- We can use this database of quarries to review our modelling results and for other analyses.

NZ Quarry Database



Enhanced Rock Weathering (ERW)

- Enhanced silicate rock weathering (ERW) relies on a natural geological process with a billion-year long track record of atmospheric carbon dioxide removal.
- ERW accelerates this process using finely ground basalt or peridotite that are rich in silicate minerals.
- The crushed rock is spread on a pastureland and natural processes transfer the CO_2 into our water networks.
- The material has the added benefit of naturally reducing soil acidity, providing nutrients to support crop growth and soil health, and aiding soil water retention.
- It's also an opportunity to use the finely crushed basalt that is frequently a biproduct at quarries.
- But we don't want to generate more CO_2 transporting the rock than we're going to capture!

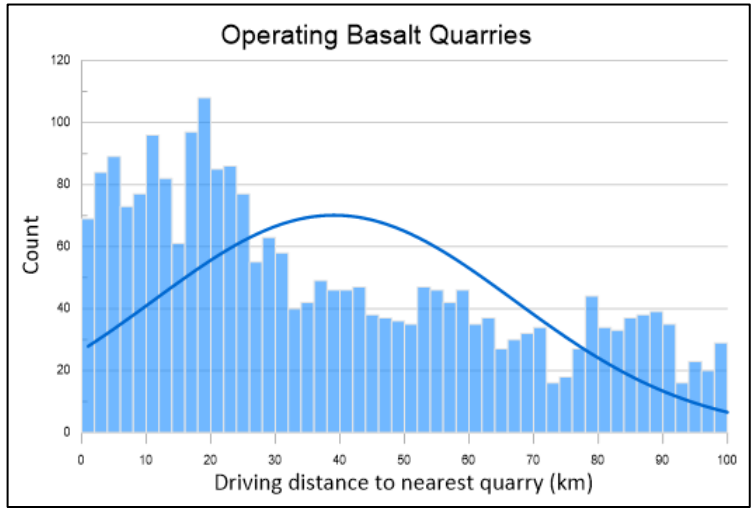


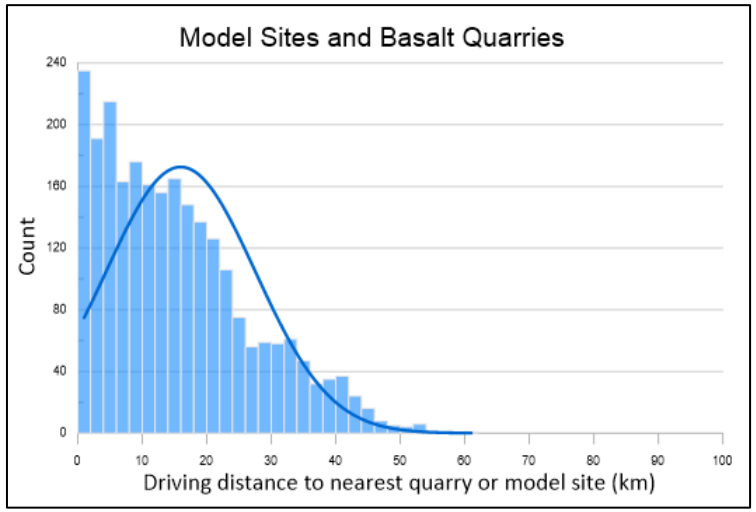
Dr Terry Isson
(Uni. of Waikato)

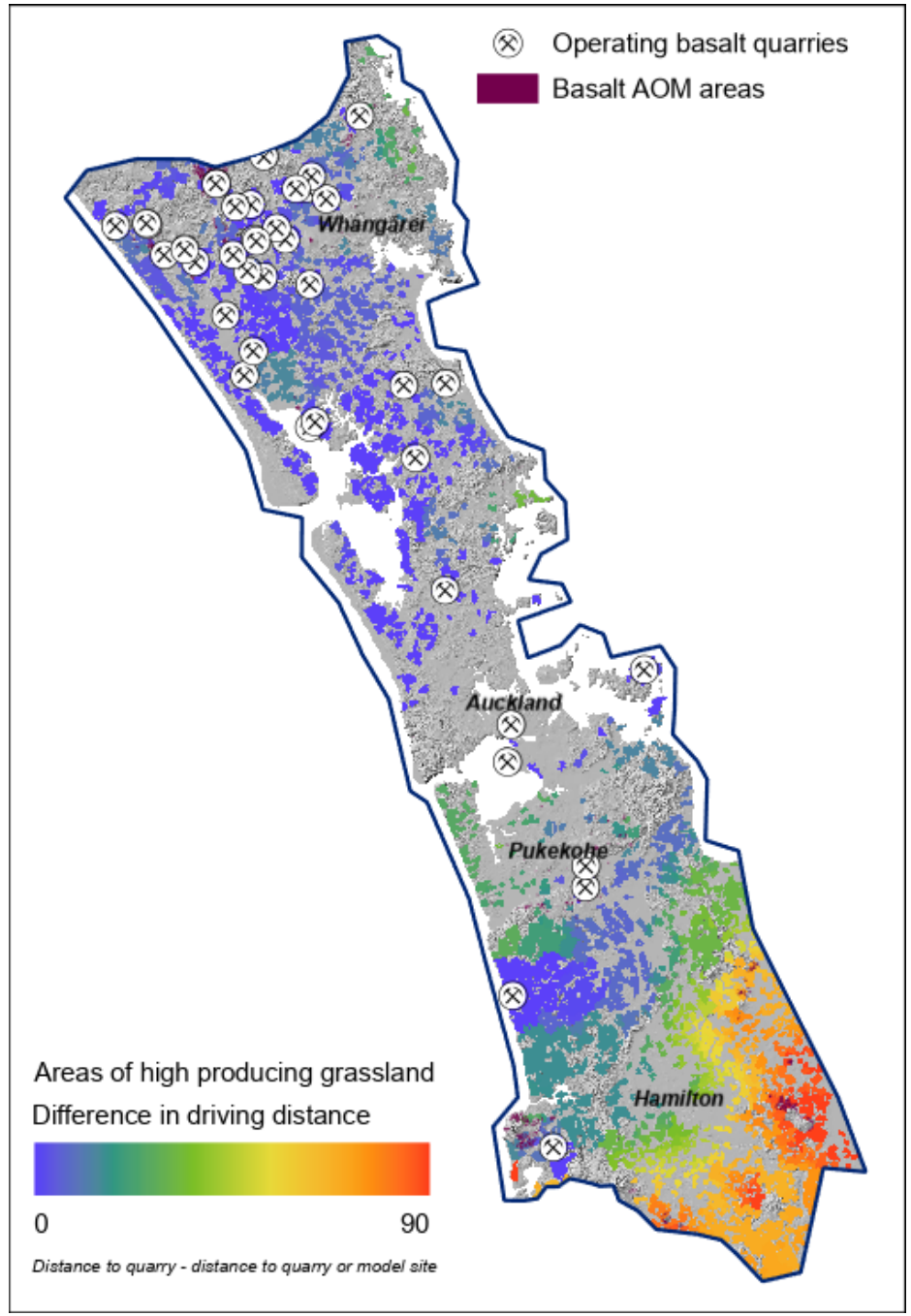
Enhanced Rock Weathering

What is the driving distance from pastureland to the nearest quarry or model site?

1. Map out all the high producing grassland for each farm >10 ha in the wider Auckland region.
2. Calculate the driving distance from that farm to the nearest basalt quarry.
3. Calculate the driving distance to the nearest quarry or >1 ha model site.
4. Compare the distances.

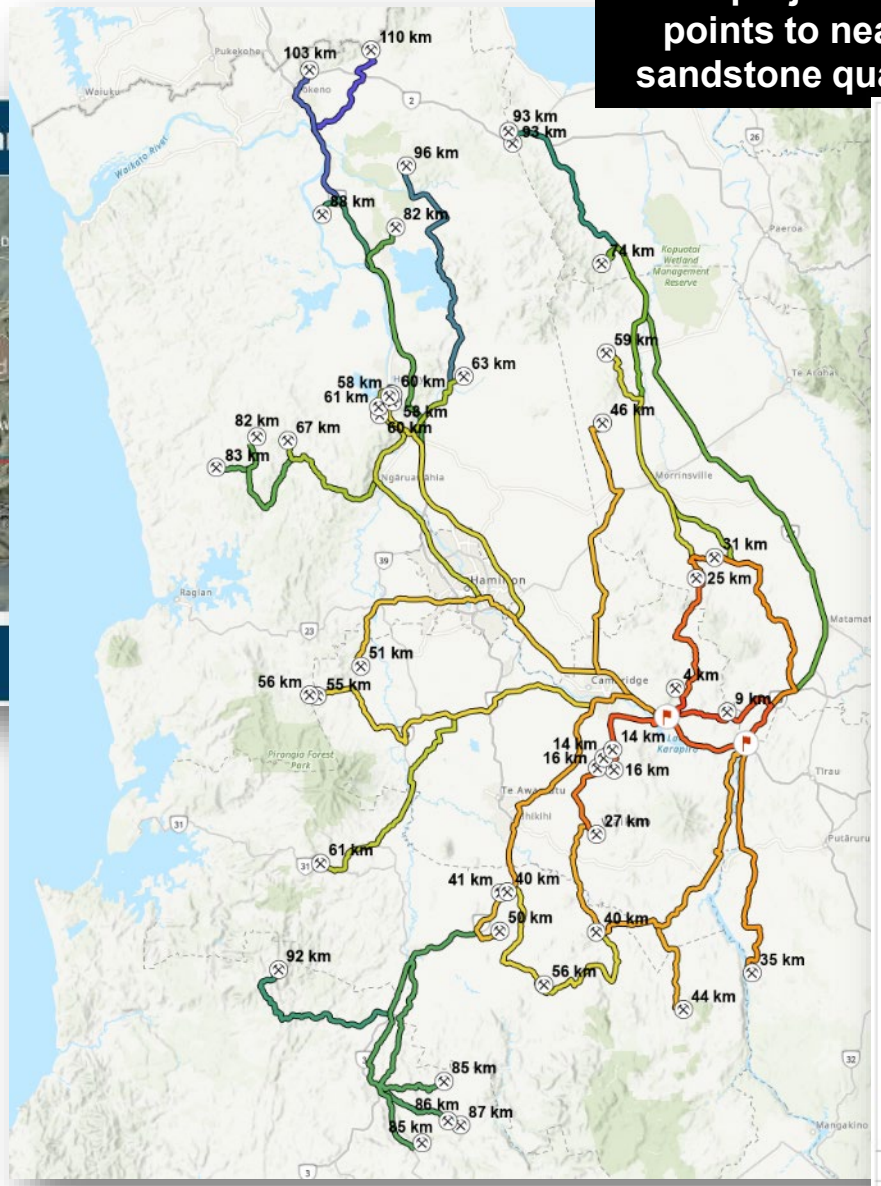




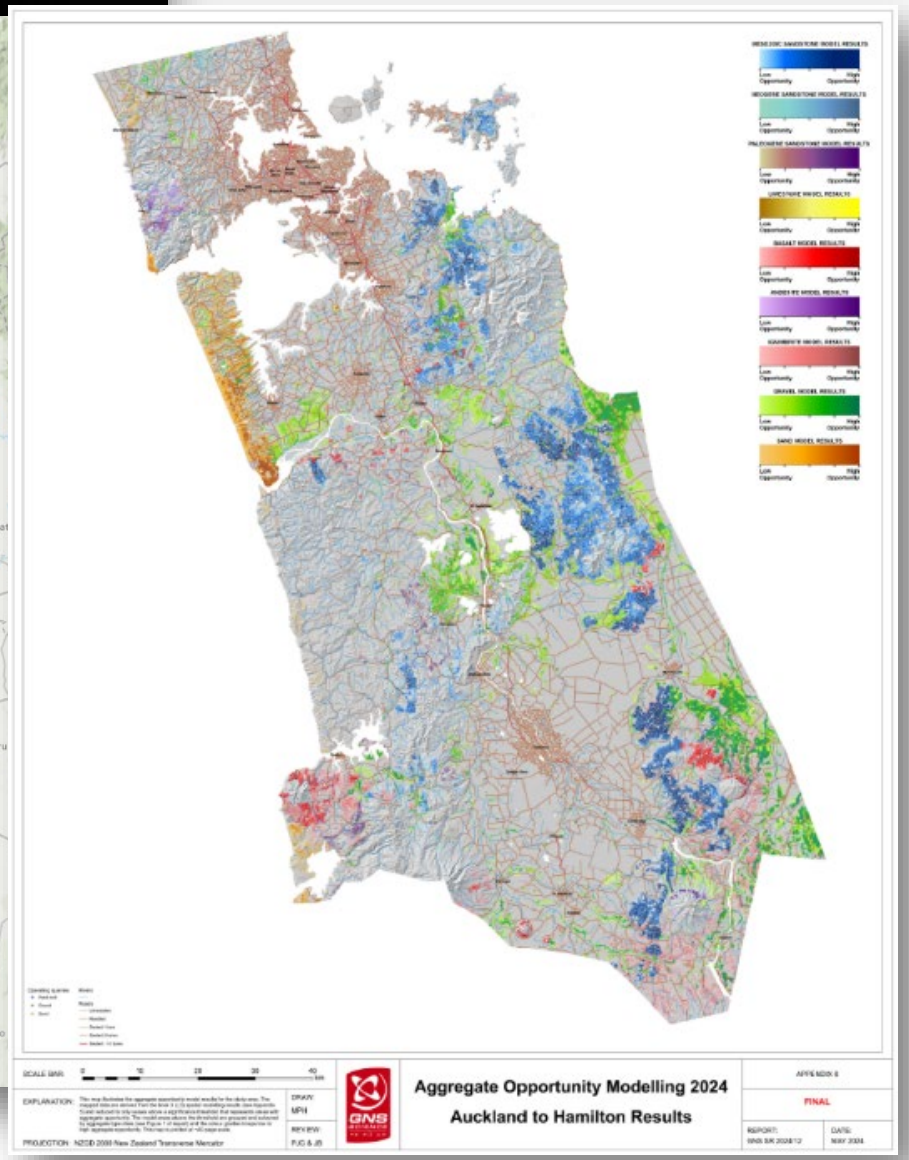


Cambridge

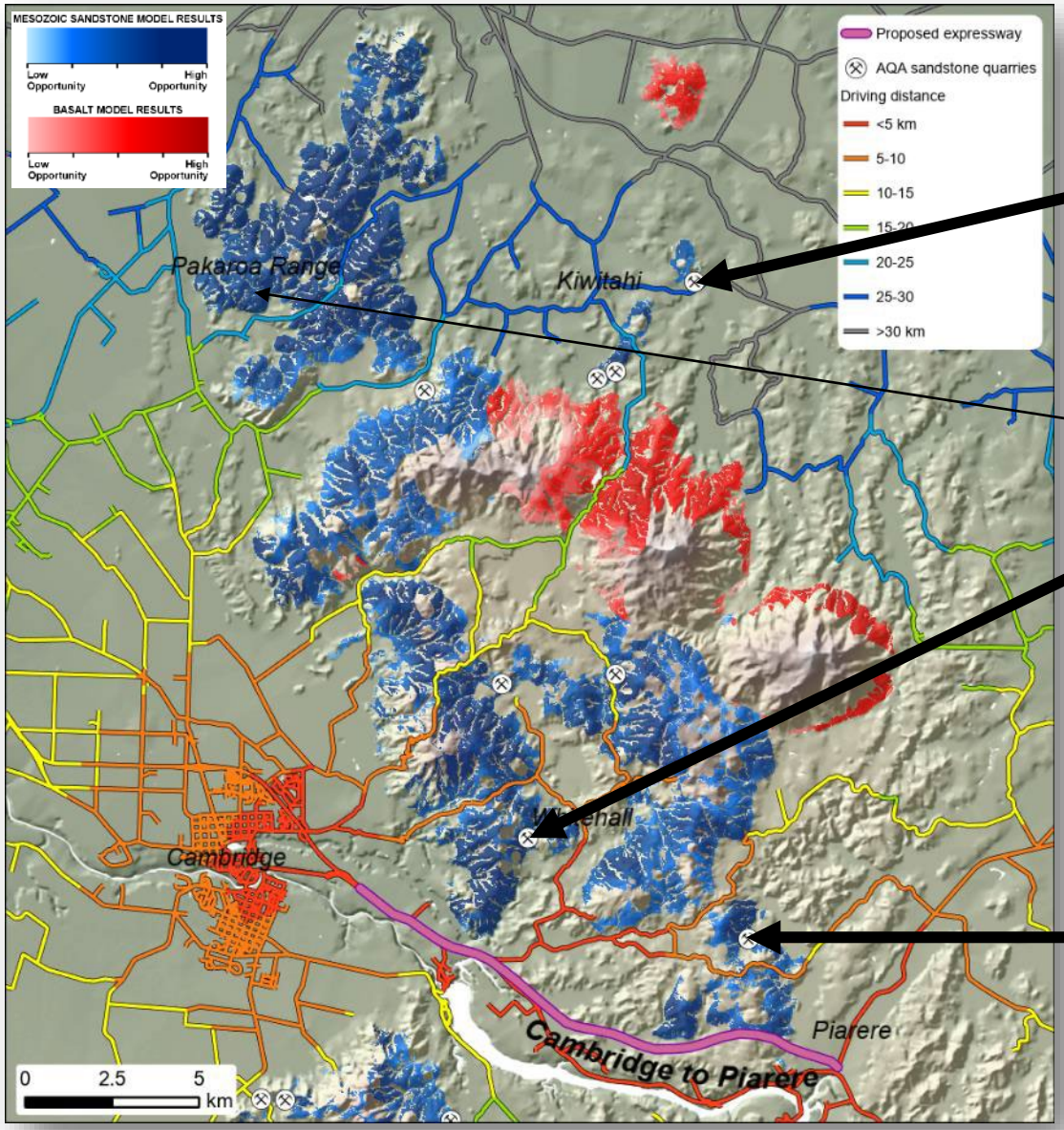
Truck driving distance from project access points to nearest sandstone quarries.

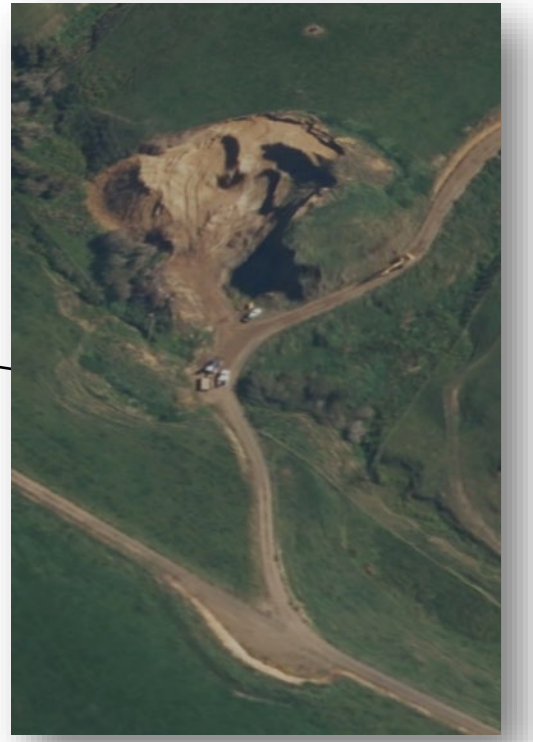


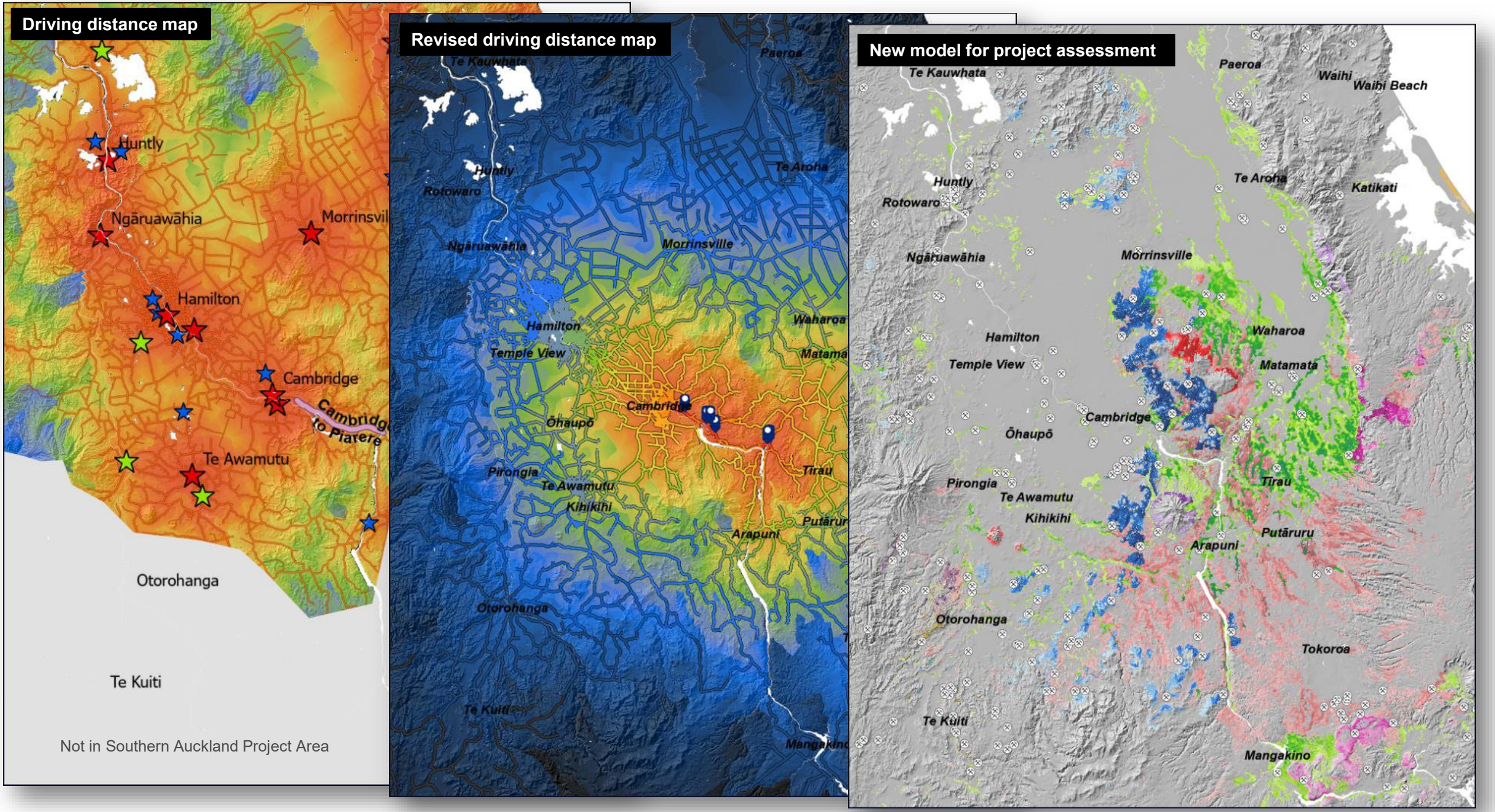
AQA Quarry Database



Cambridge


MESOZOIC SANDSTONE MODEL RESULTS
Low Opportunity
High Opportunity
BASALT MODEL RESULTS
Low Opportunity
High Opportunity
Proposed expressway
AQA sandstone quarries
Driving distance
<5 km
5-10
10-15
15-20
20-25
25-30
>30 km
Pakaroa Range
Kiwitahi
Cambridge
Cambridge to Piarere
Piarere
0
2.5
5
km




Driving distance map
Huntly
Ngāruawāhia
Morrinsvil
Hamilton
Cambridge
Cambridg
to Piatere
Te Awamutu
Otorohanga
Te Kuiti
Not in Southern Auckland Project Area
Revised driving distance map
Te Kauwhata
Paeroa
Huntly
Rotowaro
Te Aroha
Ngāruawāhia
Morrinsville
Hamilton
Waharoa
Temple View
Matama
Cambridge
Ōhaupō
Pirongia
Tirau
Te Awamutu
Kihikihi
Putāruru
Arapuni
Otorohanga
Te Kuiti
Mangakino
New model for project assessment
Te Kauwhata
Paeroa
Waihi
Waihi Beach
Huntly
Te Aroha
Katikati
Rotowaro
Ngāruawāhia
Morrinsville
Hamilton
Waharoa
Temple View
Matamata
Cambridge
Ōhaupō
Pirongia
Tirau
Te Awamutu
Kihikihi
Putāruru
Arapuni
Otorohanga
Tokoroa
Te Kuiti
Mangakino

Summary

- Aggregate is critical for the future development of our regions, so we need to plan for extraction activities.
- It is a bulk commodity, low value and required in large volumes, therefore it's important that extraction is located close to the end use.
- GNS Science has developed aggregate opportunity models that highlight areas with the most suitable geology, land use, feasibility and community conditions.
- The models are divided into hard rock, gravel and sand material types.
- Results can be used:
  - For regional planning and land use reviews;
  - To locate alternative extraction sites;
  - As a catalyst for new industry exploration;
  - In economic analysis of future construction projects.