Utilisation of fire spread simulators to assess power network fire risk

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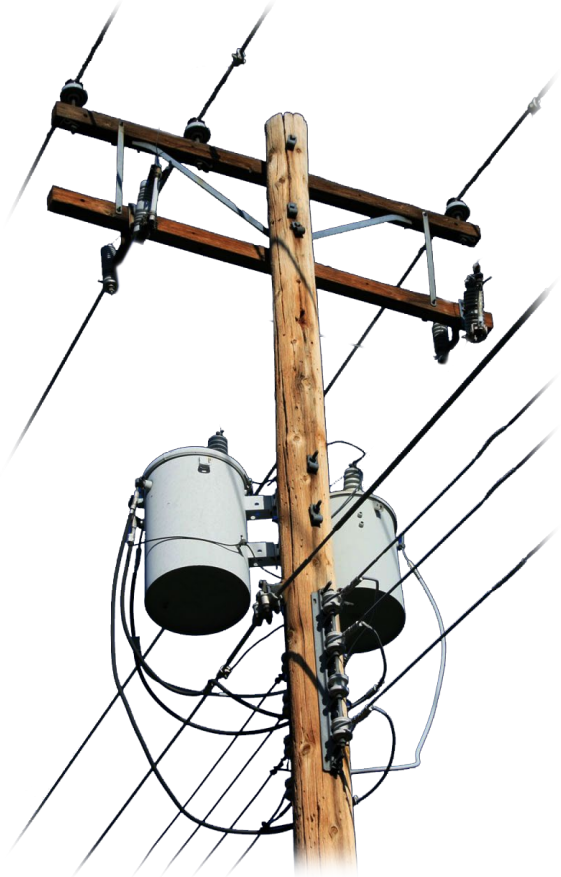
Acknowledgements:
Agnes Kristina, Jonathon Palmer - DFES
Mike Steber, Carolyn McMillan – Landgate



Power line initiated Bushfires

- In Western Australia catastrophic bushfires have resulted due to power transmission system failures under elevated fire weather conditions,
- Disproportionately associated with the majority of bushfire fatalities and asset losses in southern Australia[1] compared to other sources of ignition such arson and lightning
- Ignitions can occur from a variety of modes of failure , these general fall into two categories:
  - Contact
  - Fatigue
- Response from governments and utility providers is to optimise electricity network asset improvement and replacement programs for the cost-effective reduction of power line ignitions in bushfire hazard areas under elevated fire weather conditions.

[1]Roozbahani, R., Huston, C., Dunstall, S., Abbasi, B., Ernst, A., & Schreider, S. (2015). Minimizing bushfire risk through optimal powerline assets replacement and improvement. Paper presented at the MODSIM 2015.

Photo credit ABC News Western Australia

Putting safety first in the bushfire season

- Western Power is a Western Australian State Government owned power network and energy corporation
- In 2013 a review, recommended an improved bushfire risk map for the network based on the consequences of potential network bushfire ignitions.

  “Develop a new fire risk map for the network based on the fire start consequences agreed and used by agencies in Western Australia involved in Bushfire Risk Mitigation”
- In response Western Power entered into a joint collaboration with the Department of Fire and Emergency Services (DFES) and Landgate to develop a bushfire ignition risk analysis product suitable for the power network across the south west of Western Australia.

Picture Lake Clifton Fire Source ABC News: Jade Macmillan

South West Interconnected Network (SWIN)

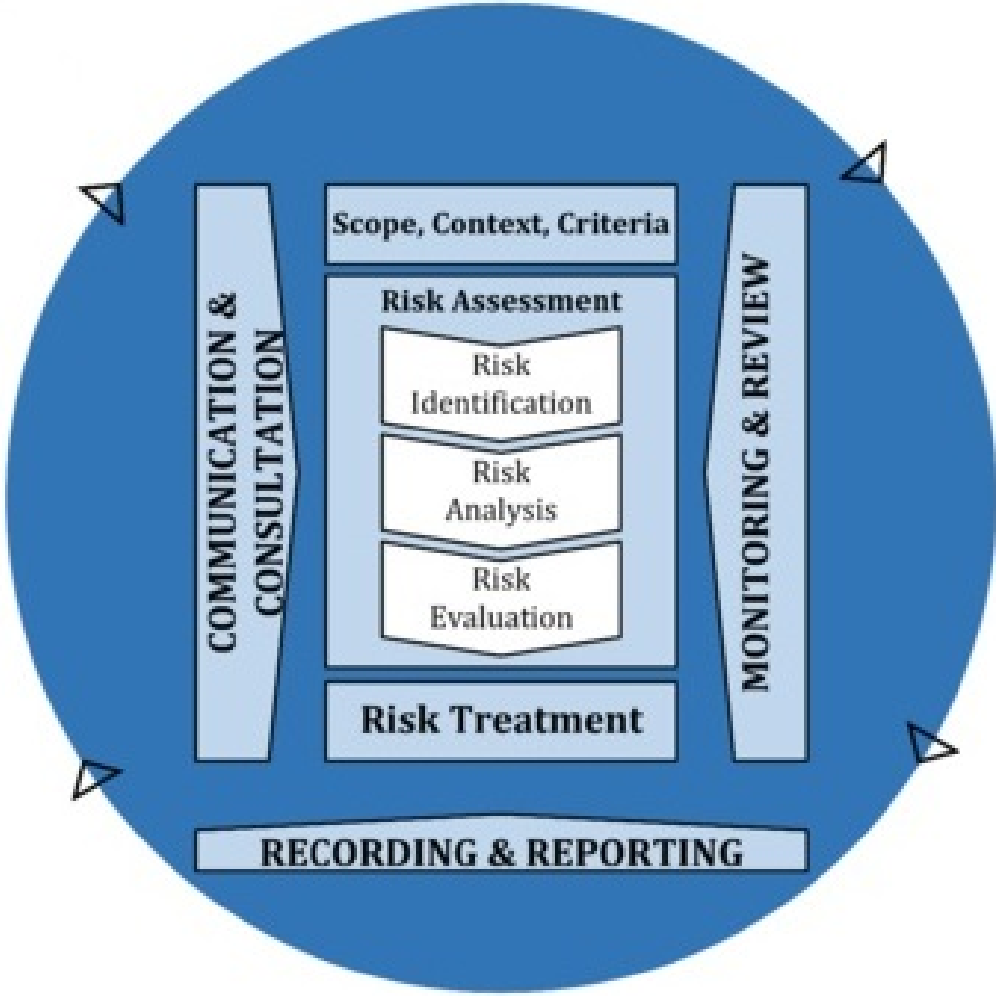
- A uniquely large, remote and low density population catchment for a stand-alone network, less dense than OECD peers
- Over 1.1 million customers
- Essential service for ensuring the safe delivery of electricity to nearly 2.5 million people
- Many of the assets supporting the electricity network are more than 30 years old, with an effective working life of between 30 and 50 years.

Bushfire Consequence Assessment and Methodology

Objectives

- The assessment of risk aligns with the Australian and International Standard Organisation (AS ISO 31000:2018) Risk Management – Guidelines and State Emergency Management Policies
- Enables the prioritisation of asset renewal and maintenance to address sites with the highest potential consequences, therefore realising better public safety out-comes.
- To investigate the utilisation of the fire spread simulator system Aurora, to model the consequences of a bushfire ignition from power poles and wires.

The Risk Management Process



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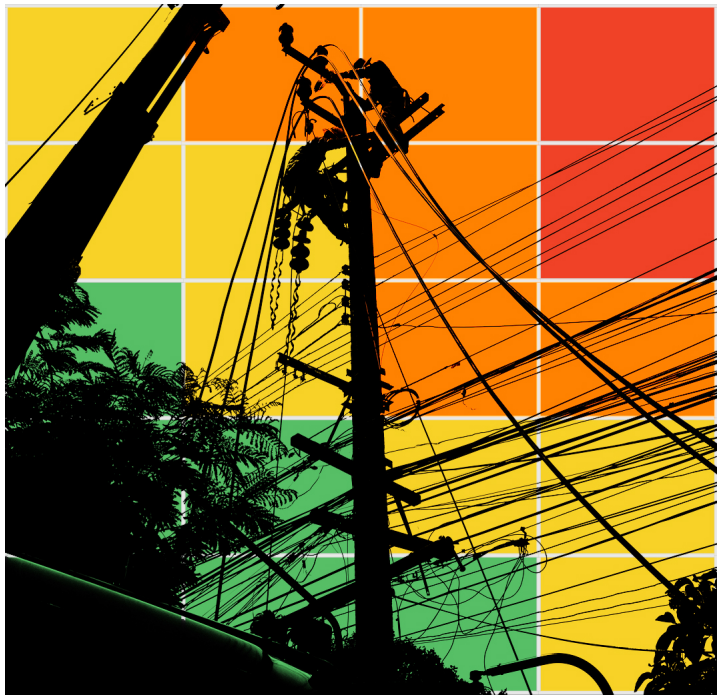
Bushfire Risk Assessment



Likelihood

Determined by the Annual Exceedance Probability of the weather parameters used.

Hazard

Bushfire Ignition and spread from Western Power's South West Network Infrastructure.

Consequence

The number and over all value and vulnerability of assets in the investigation area, allowing an assessment of the relative magnitude of potential bushfire impact. Buildings are the location where life is most likely to be endangered and support individual livelihoods and community financial sustainability.

Risk

Western Power's South West Infrastructure Network assets will be ranked in regards to the potential impact of a bushfire starting from an ignition at each location.

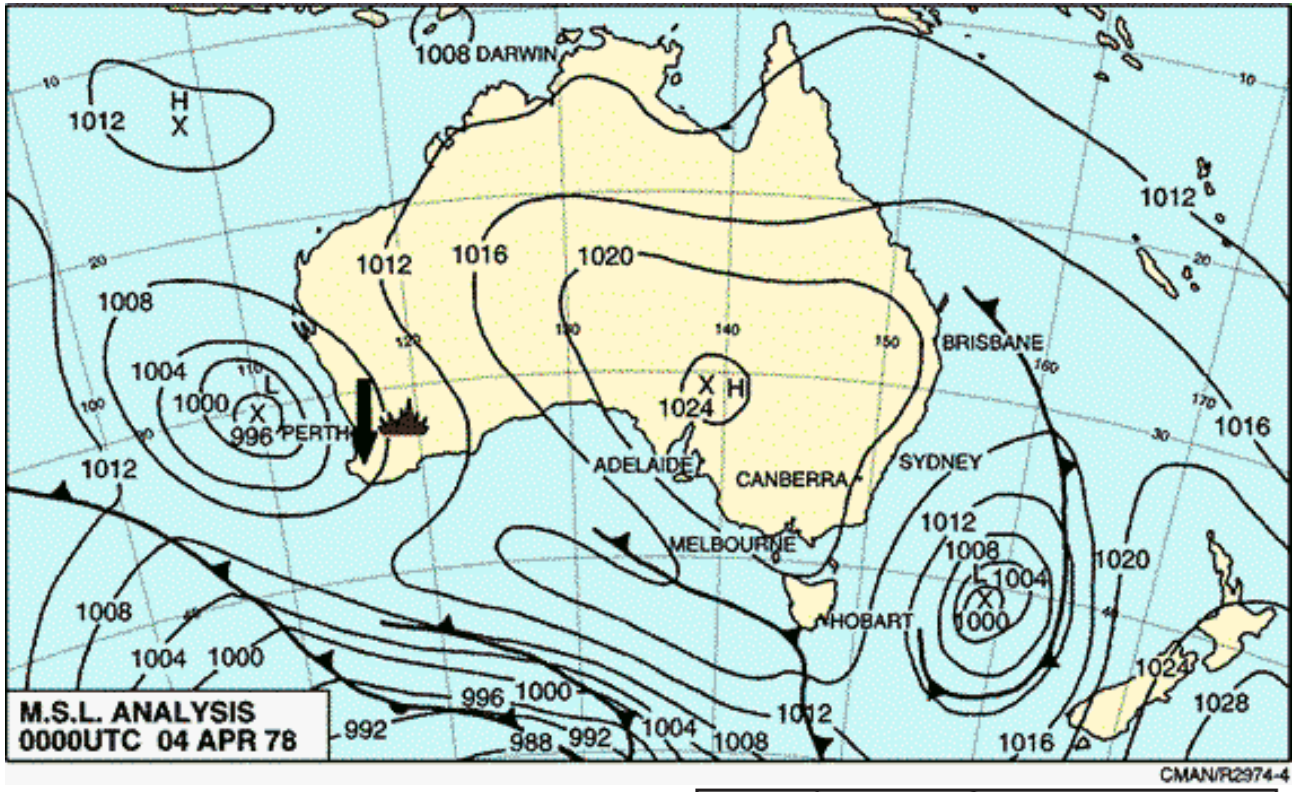
Risk Matrix source: https://utilitymagazine.com.au/beyond-the-risk-matrix/

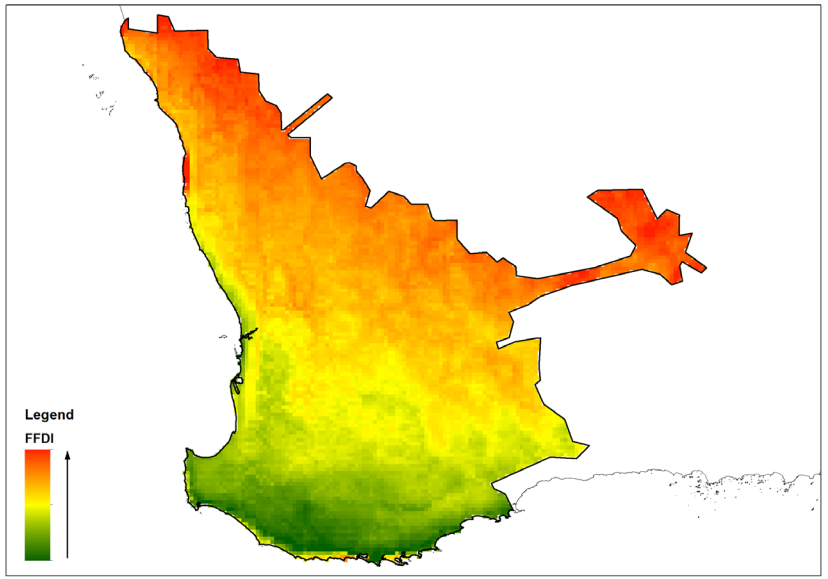
Fire Weather

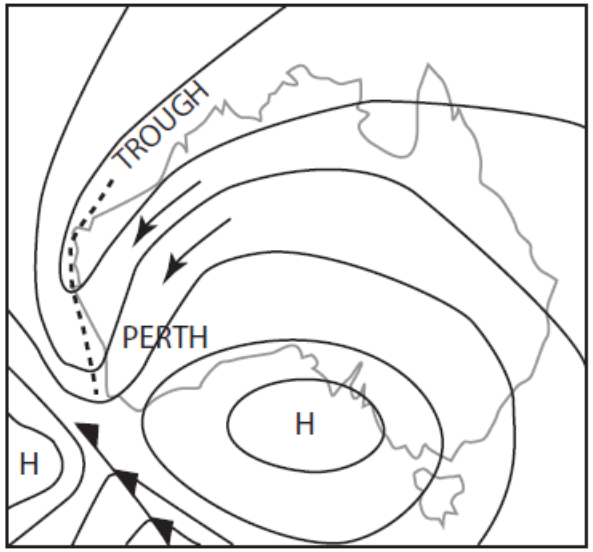
Wind direction?

- Annual Exceedance Probability
- Fine fuels = 1hour fuels
- West Coast Trough
- Cold front convergence
- Radiant Inversions
- Topographic effects
- Cyclones /Subtropical lows

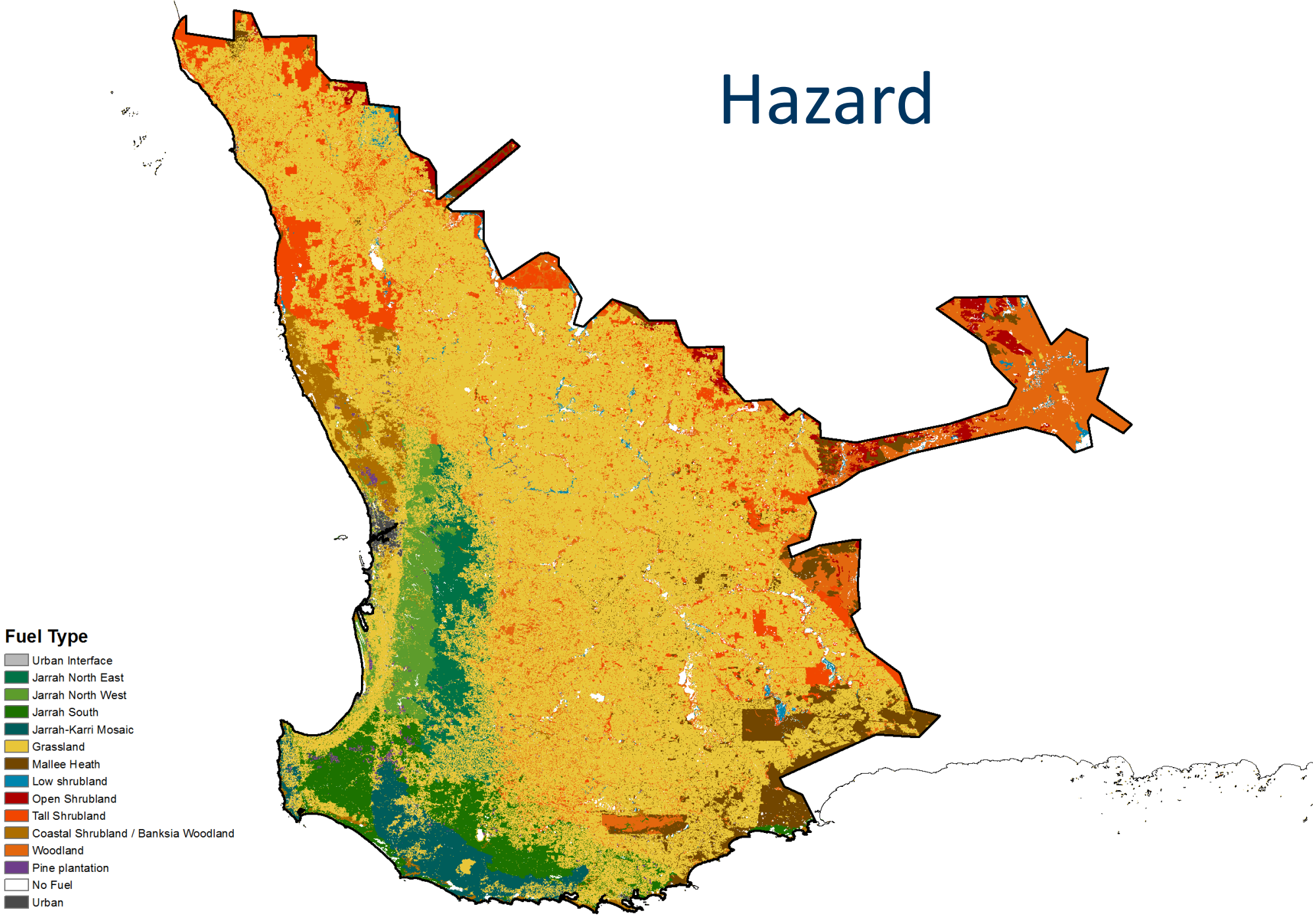
EY	AEP (%)	AEP (1 in x)	ARI
0.5	39.35	2.54	2.00
0.11	10.00	10	9.49
0.02	2.00	50	49.5







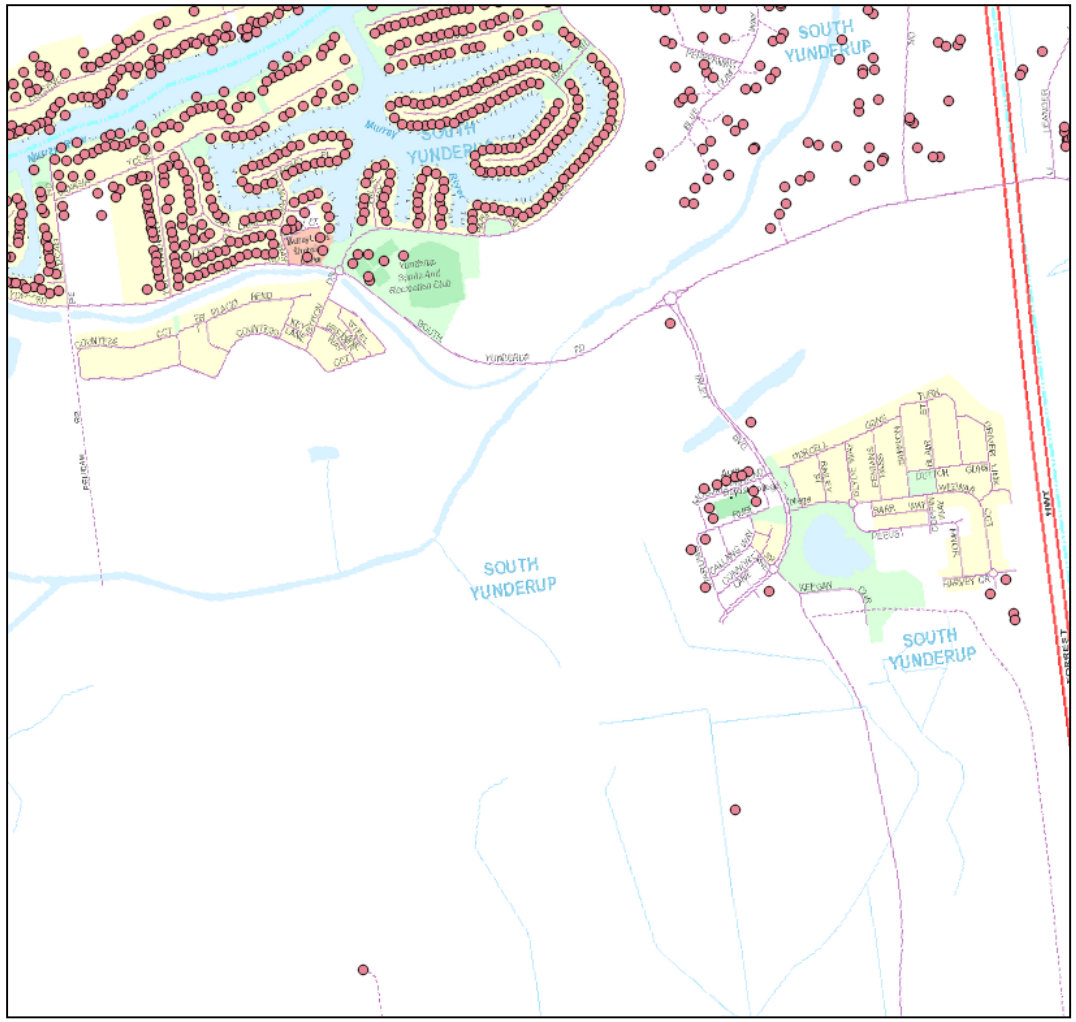
Hazard

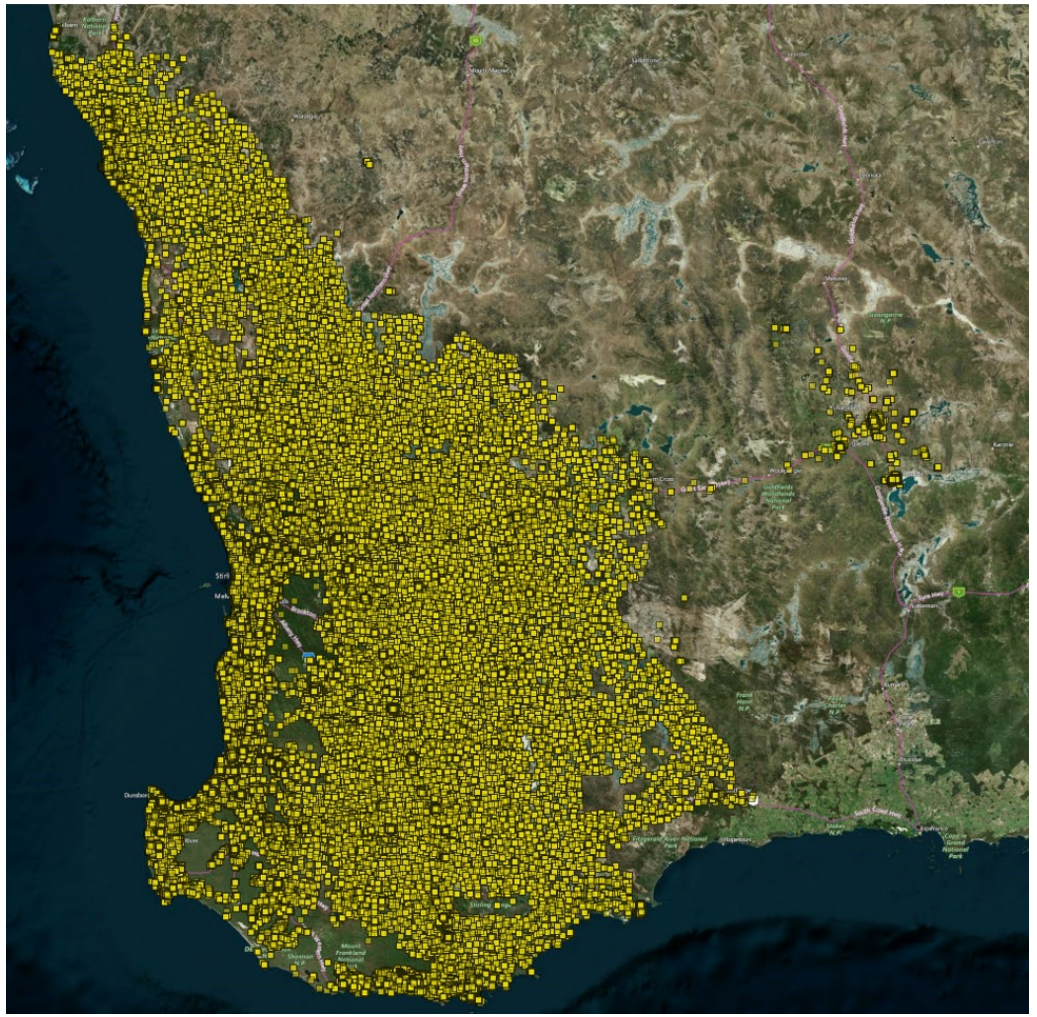

Fuel Type
Urban Interface
Jarrah North East
Jarrah North West
Jarrah South
Jarrah-Karri Mosaic
Grassland
Mallee Heath
Low shrubland
Open Shrubland
Tall Shrubland
Coastal Shrubland / Banksia Woodland
Woodland
Pine plantation
No Fuel
Urban

Datasets used within the Modelling

Datasets used within the modelling

Building locations



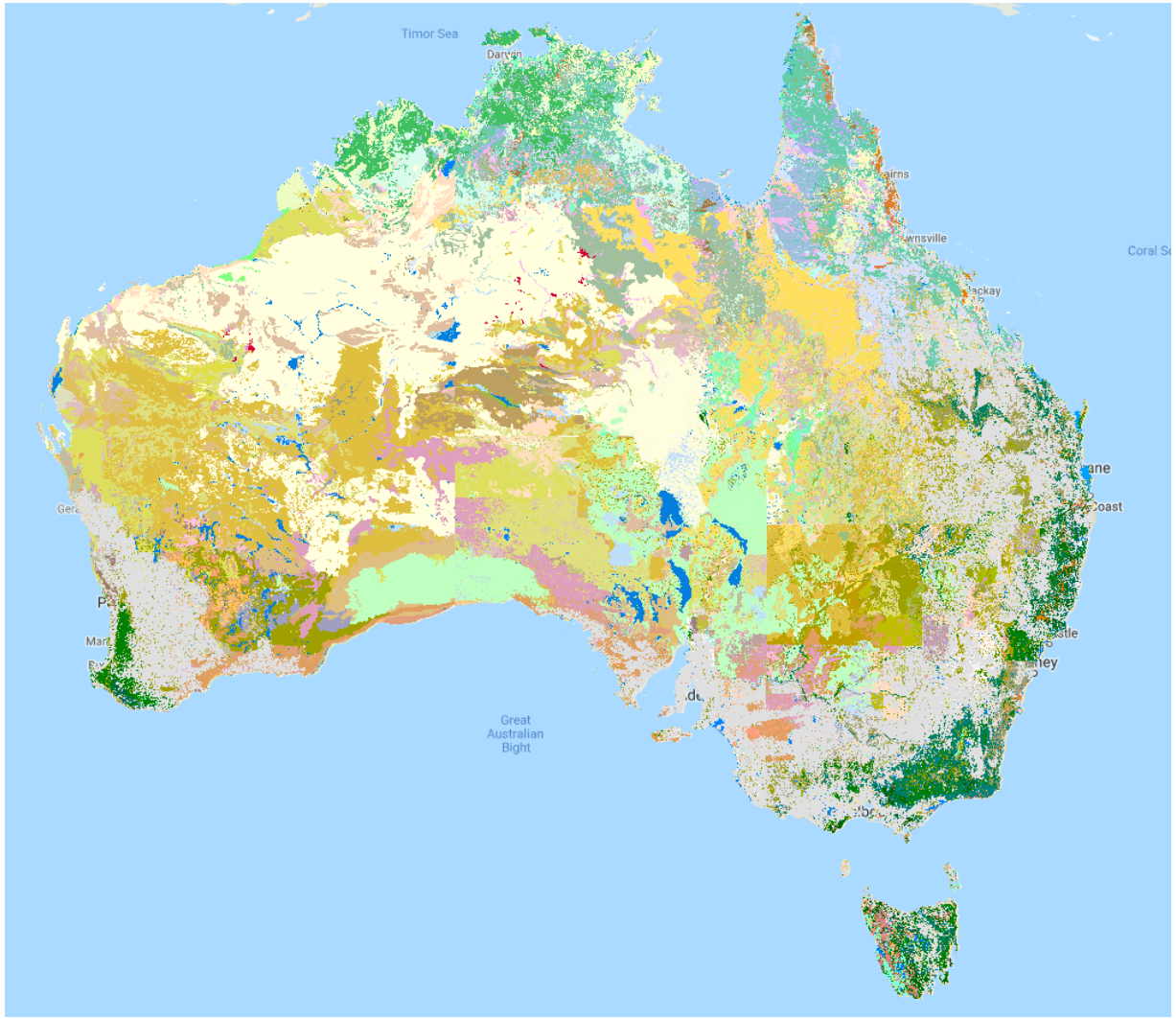


Datasets used within the modelling

Vegetation / Fuel Type Data

Aurora:

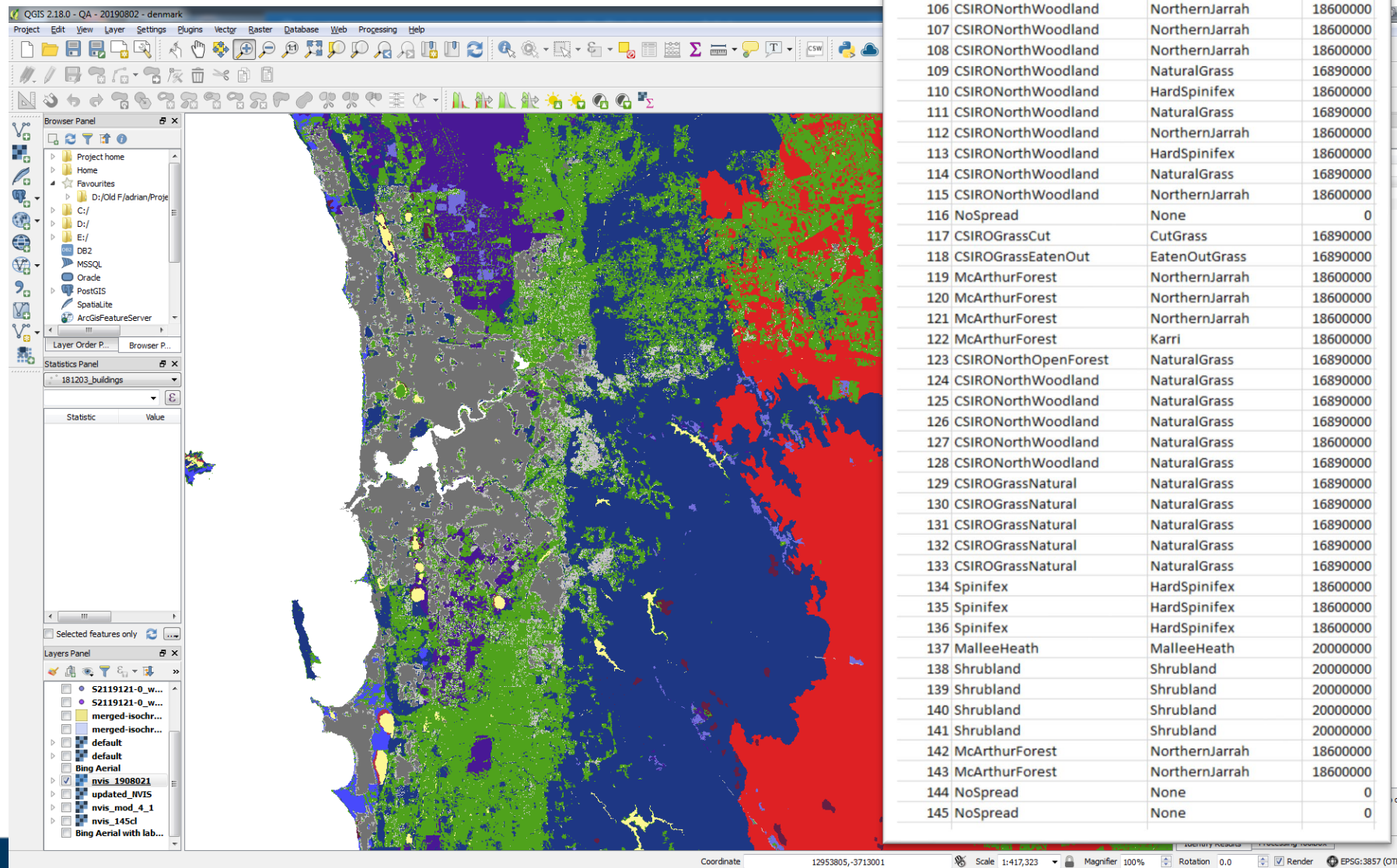
- National Vegetation Information System (NVIS)
- Major vegetation sub-groups
- 100m x 100m cell, across Australia



Datasets used within the modelling

Vegetation / Fuel Type Data

DFES BRAn modified



A	B	C	D
103	CSIRONorthWoodland	NaturalGrass	16890000
104	CSIRONorthWoodland	NorthernJarrah	18600000
105	CSIRONorthOpenForest	NaturalGrass	16890000
106	CSIRONorthWoodland	NorthernJarrah	18600000
107	CSIRONorthWoodland	NorthernJarrah	18600000
108	CSIRONorthWoodland	NorthernJarrah	18600000
109	CSIRONorthWoodland	NaturalGrass	16890000
110	CSIRONorthWoodland	HardSpinifex	18600000
111	CSIRONorthWoodland	NaturalGrass	16890000
112	CSIRONorthWoodland	NorthernJarrah	18600000
113	CSIRONorthWoodland	HardSpinifex	18600000
114	CSIRONorthWoodland	NaturalGrass	16890000
115	CSIRONorthWoodland	NorthernJarrah	18600000
116	NoSpread	None	0
117	CSIROGrassCut	CutGrass	16890000
118	CSIROGrassEatenOut	EatenOutGrass	16890000
119	McArthurForest	NorthernJarrah	18600000
120	McArthurForest	NorthernJarrah	18600000
121	McArthurForest	NorthernJarrah	18600000
122	McArthurForest	Karri	18600000
123	CSIRONorthOpenForest	NaturalGrass	16890000
124	CSIRONorthWoodland	NaturalGrass	16890000
125	CSIRONorthWoodland	NaturalGrass	16890000
126	CSIRONorthWoodland	NaturalGrass	16890000
127	CSIRONorthWoodland	NaturalGrass	18600000
128	CSIRONorthWoodland	NaturalGrass	16890000
129	CSIROGrassNatural	NaturalGrass	16890000
130	CSIROGrassNatural	NaturalGrass	16890000
131	CSIROGrassNatural	NaturalGrass	16890000
132	CSIROGrassNatural	NaturalGrass	16890000
133	CSIROGrassNatural	NaturalGrass	16890000
134	Spinifex	HardSpinifex	18600000
135	Spinifex	HardSpinifex	18600000
136	Spinifex	HardSpinifex	18600000
137	MalleeHeath	MalleeHeath	20000000
138	Shrubland	Shrubland	20000000
139	Shrubland	Shrubland	20000000
140	Shrubland	Shrubland	20000000
141	Shrubland	Shrubland	20000000
142	McArthurForest	NorthernJarrah	18600000
143	McArthurForest	NorthernJarrah	18600000
144	NoSpread	None	0
145	NoSpread	None	0

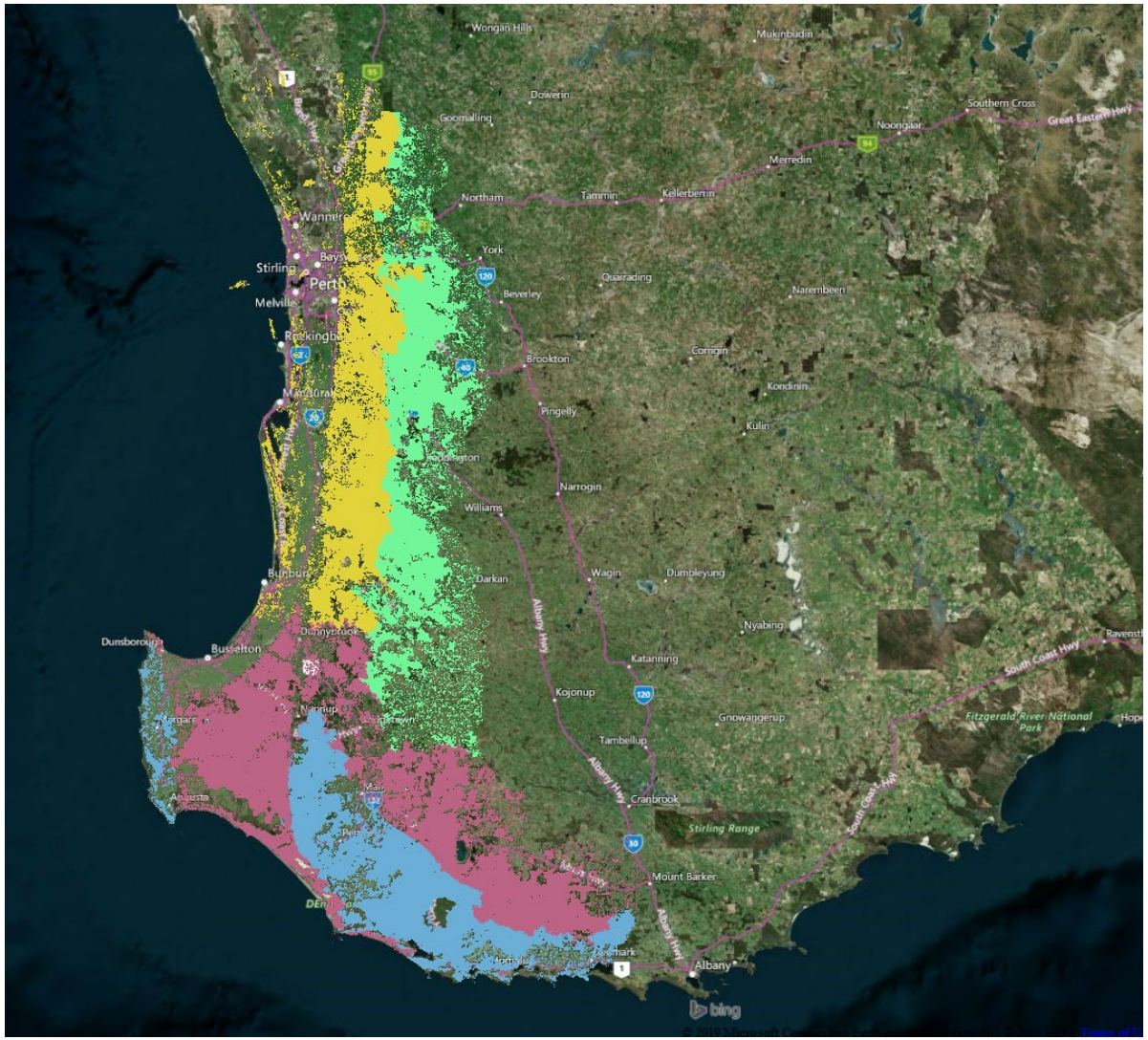
Datasets used within the modelling

Vegetation / Fuel Type Data

CSIRO Dry Eucalypt Forest Fuel Model

Fuel Types SW of WA

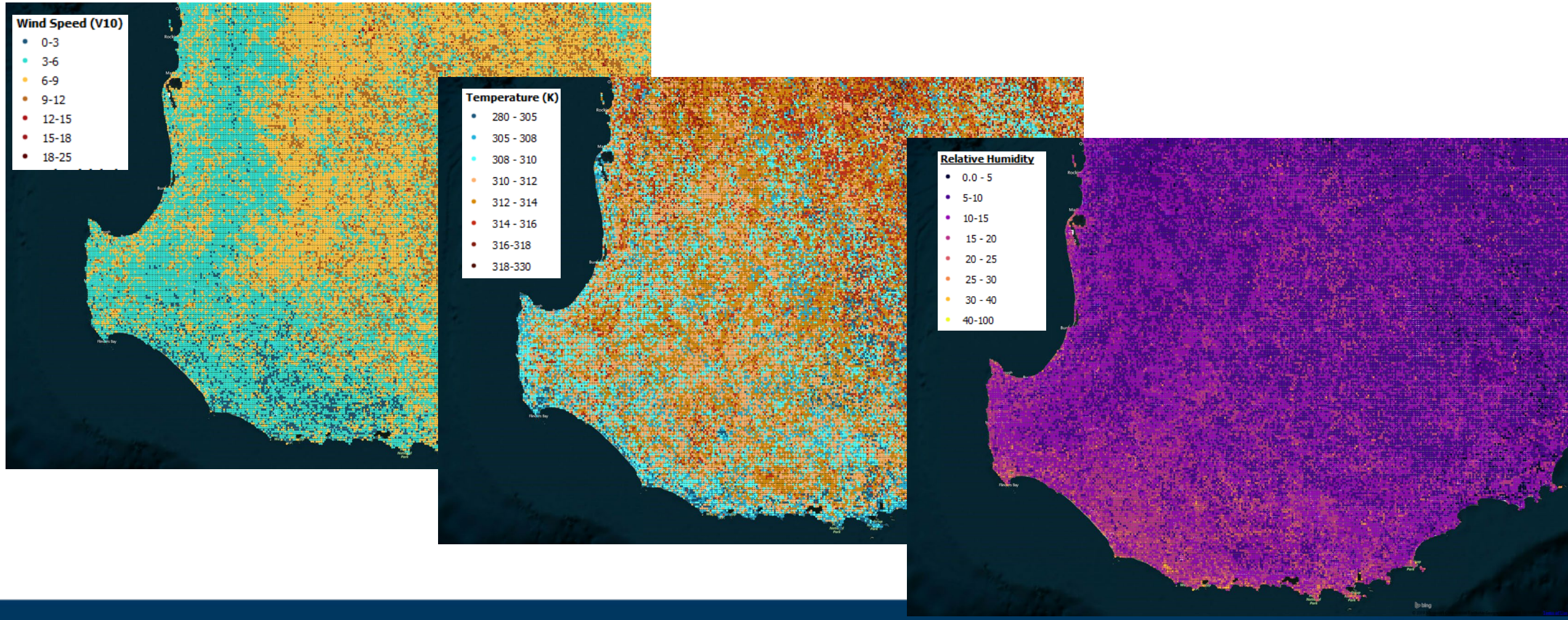
- Jarrah NW
- Jarrah South
- Jarrah East
- Jarrah Mosaic



Datasets used within the modelling

Weather and Soil Moisture

BOM Atmospheric high-resolution Regional Reanalysis for Australia (BARRA)



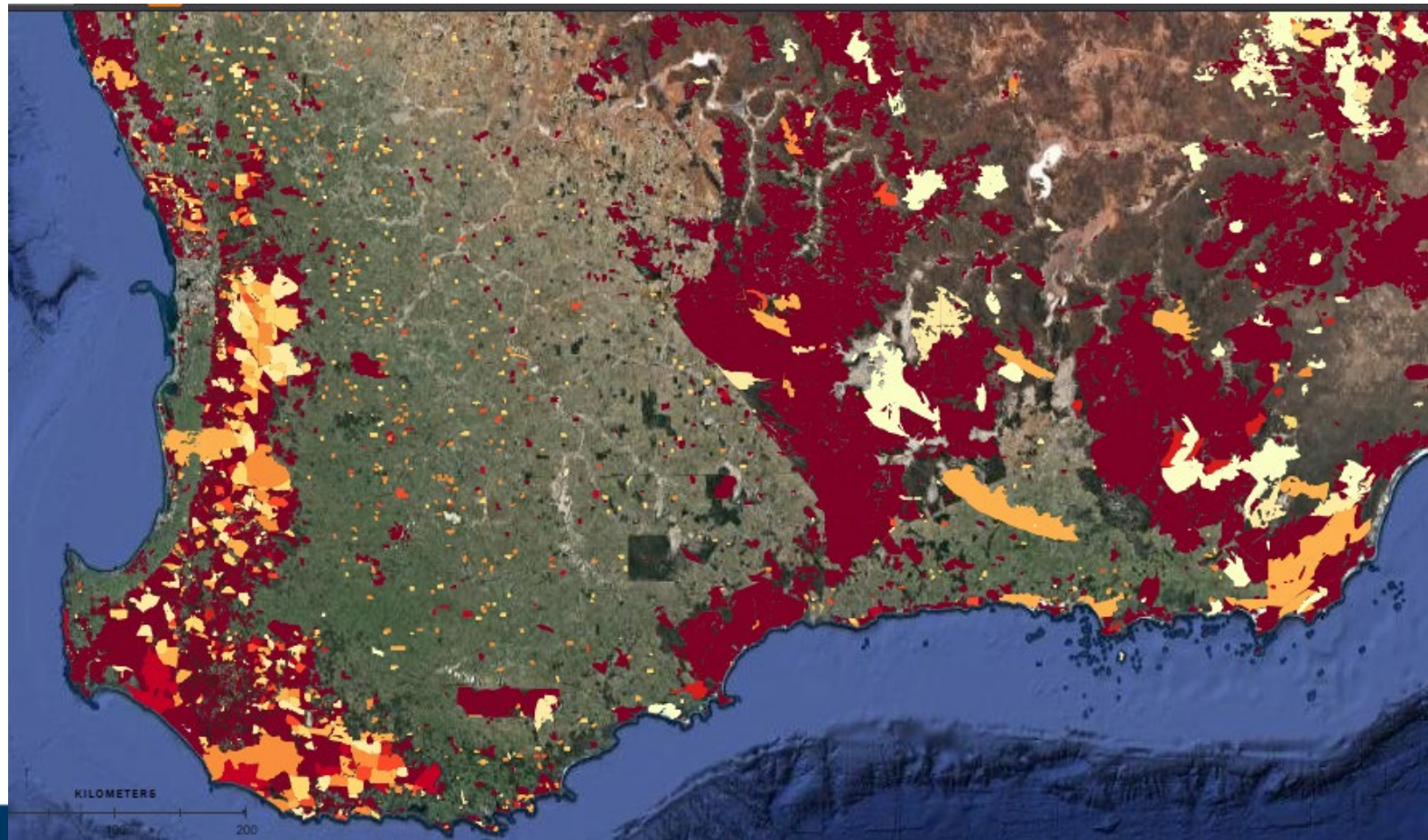
Datasets used within the modelling

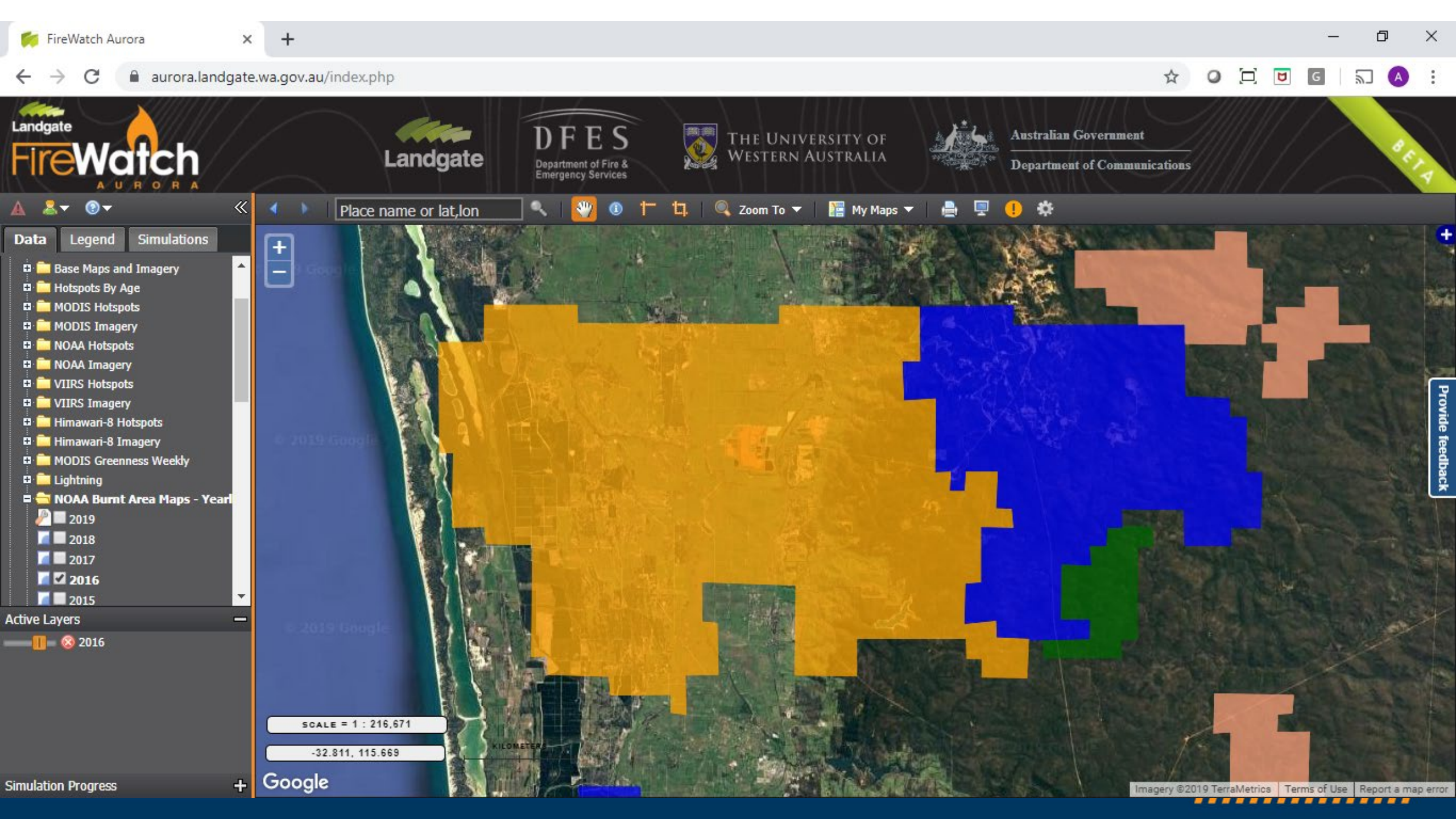
Fuel Age and Fuel Loads

Joint Agency Fuel Age dataset that combines Fire Burnt Area (FBA) mapping sourced from several government agencies into a single dataset that represents the time of last burn for Western Australia

Sourced from:

- DBCA
- DFES
- NAFI
- Landgate.

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aurora.landgate.wa.gov.au/index.php
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DFES Department of Fire & Emergency Services
The University of Western Australia
Australian Government
Department of Communications
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Place name or lat,lon
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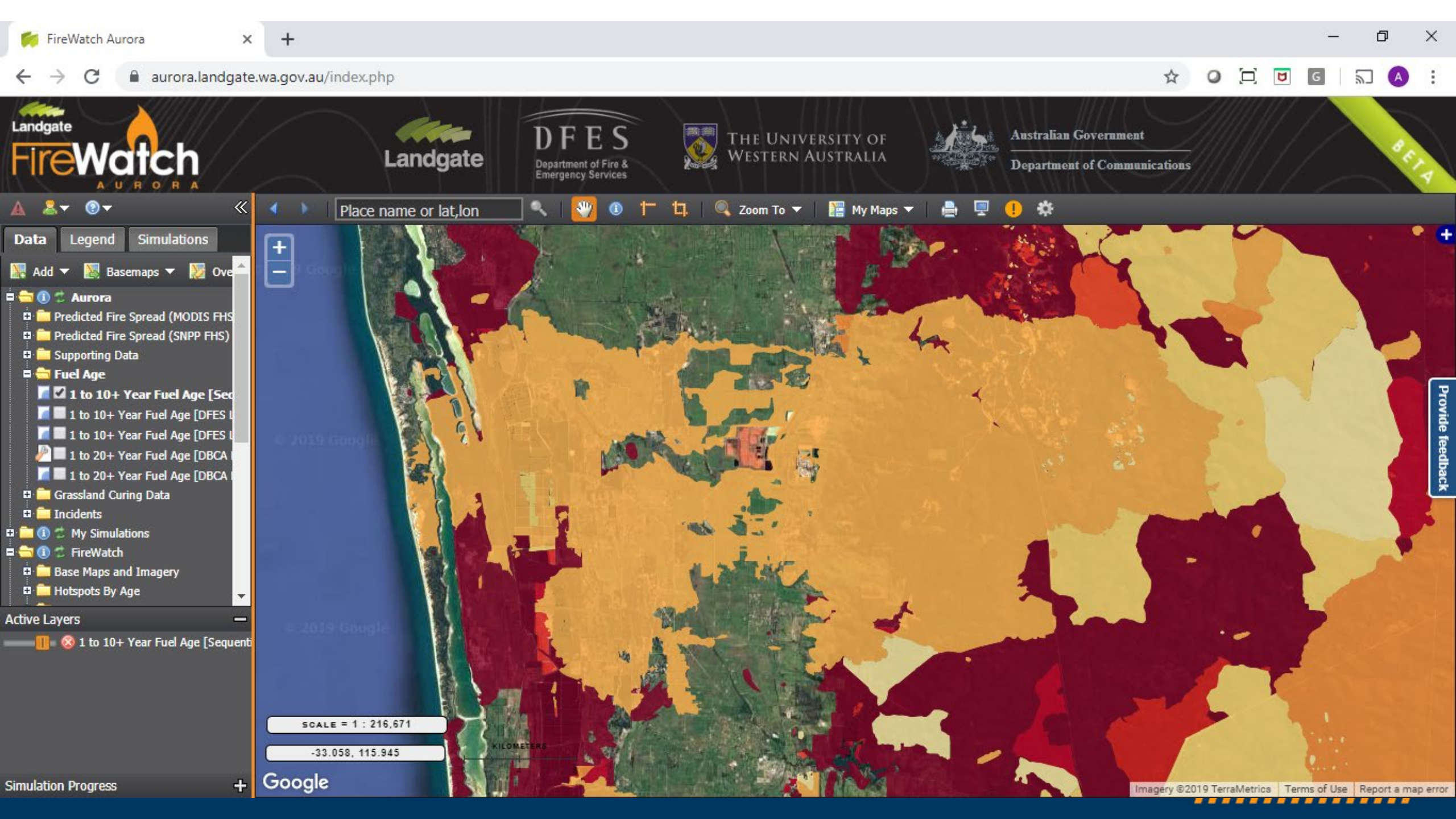
Provide feedback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Basemaps
Aurora
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Predicted Fire Spread (SNPP FHS)
Supporting Data
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1 to 20+ Year Fuel Age [DBCA
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Base Maps and Imagery
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Active Layers
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Report a map error
Provide feedback

Datasets used within the modelling

Grassland Fuel Condition as Rural Urban Transition Zone Surrogates

Number of Buildings per hectare	Surrogate grassland fuel condition
0-2 buildings p/ha (R2)	Natural Grass
3-5 buildings p/ha (R5)	Grazed Grass
6-10 buildings p/ha (R10)	Eaten Out Grass
>10 buildings p/ha (>R10)	No Spread

Buildings density p/ha to define grassland fuel loads and models

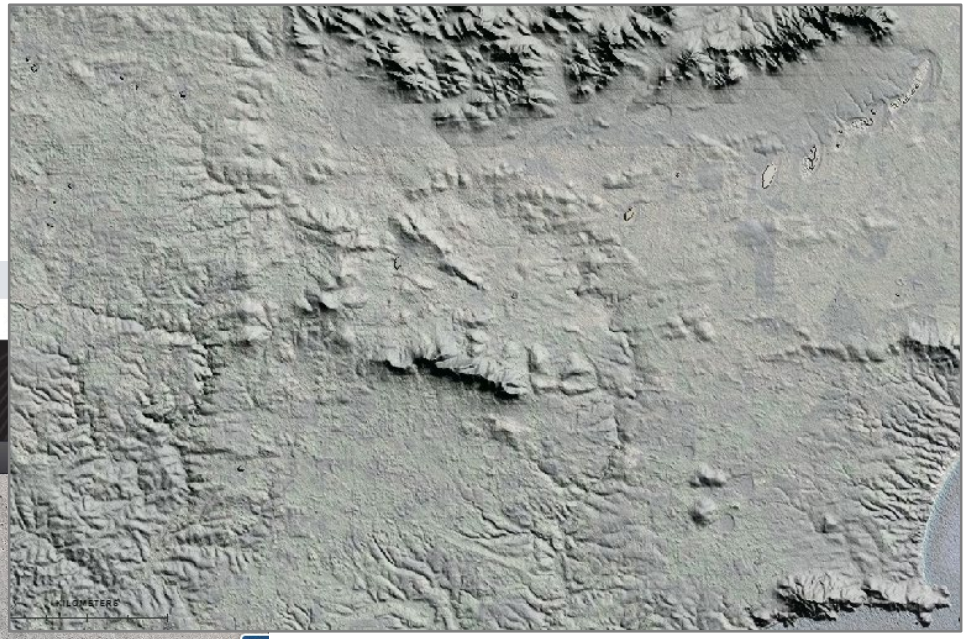
Number of Buildings per hectare	Surrogate grassland fuel condition
0 buildings p/ha	Natural Grass
>=1 building p/ha	No Spread

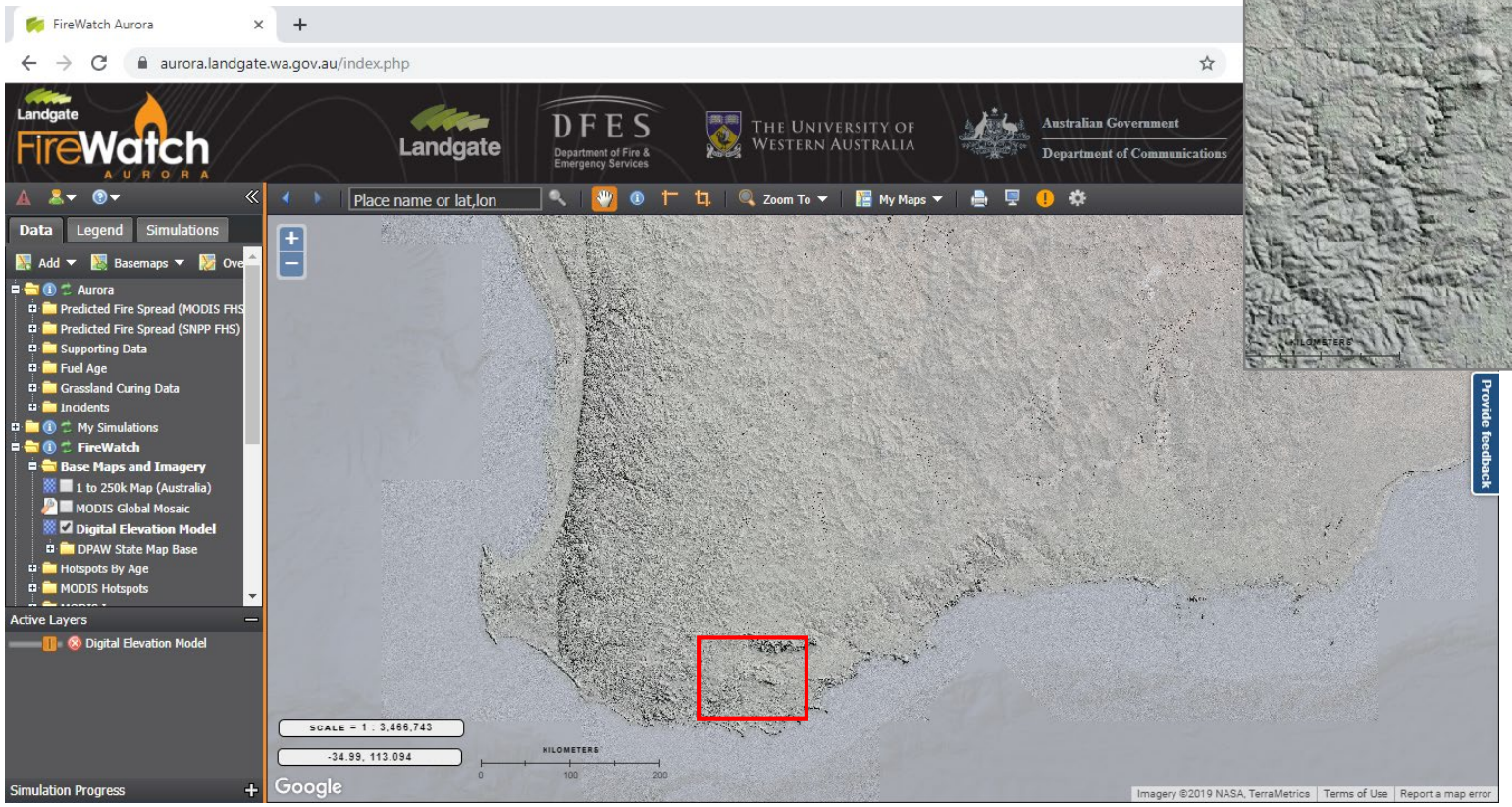
Industrial / Commercial Areas

Datasets used within the modelling

Elevation Data

- Shuttle Radar Topographic Mission (SRTM) data.
- One-second (30m) smoothed digital elevation model
- Vertical accuracy is approximately 5m



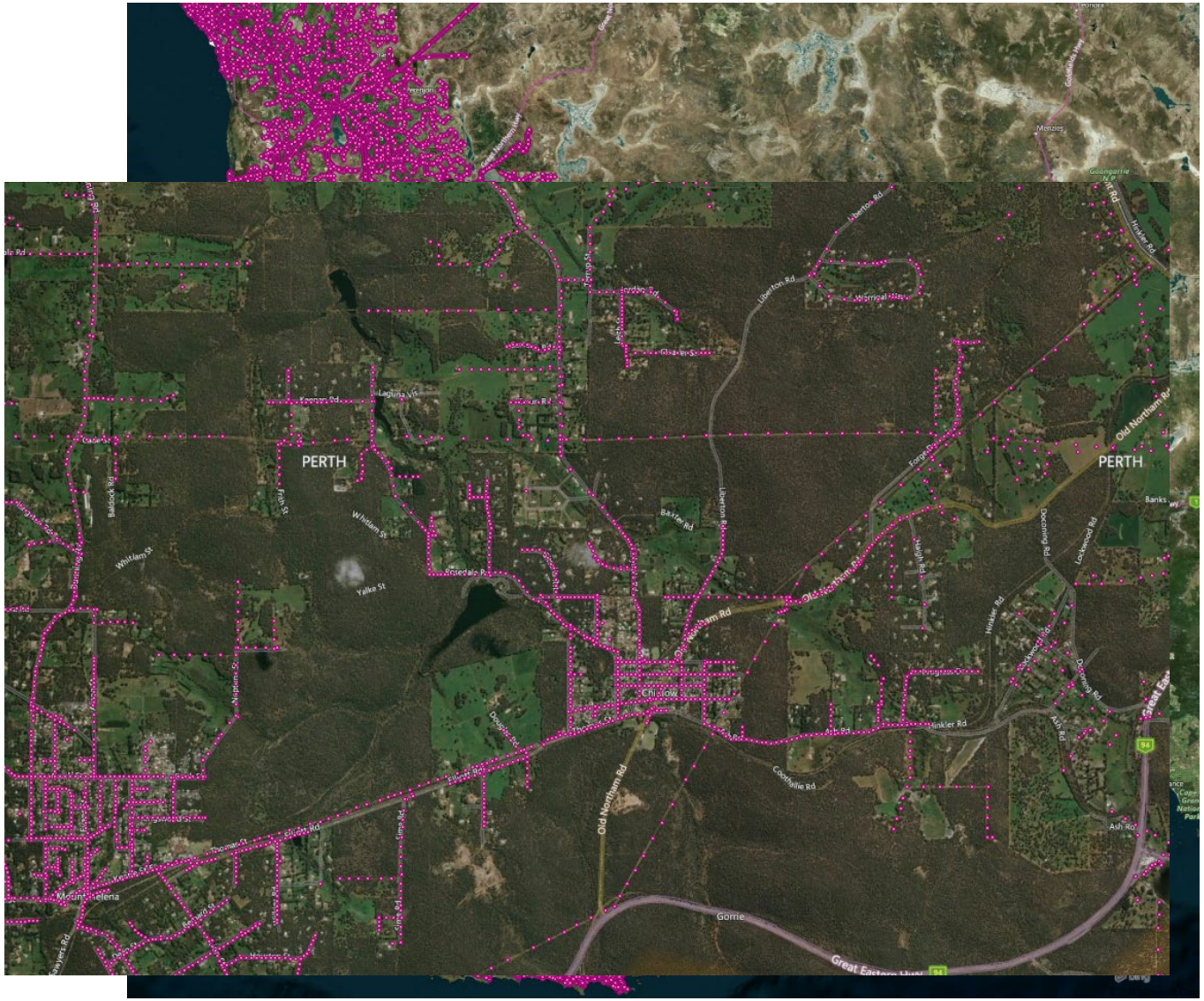


Datasets used within the modelling

Western Power Infrastructure

- 750,000 poles
- First approach : Long line segments
- Second approach : 2km line segments
- Third Approach: Each individual power pole each with its own unique identifier.

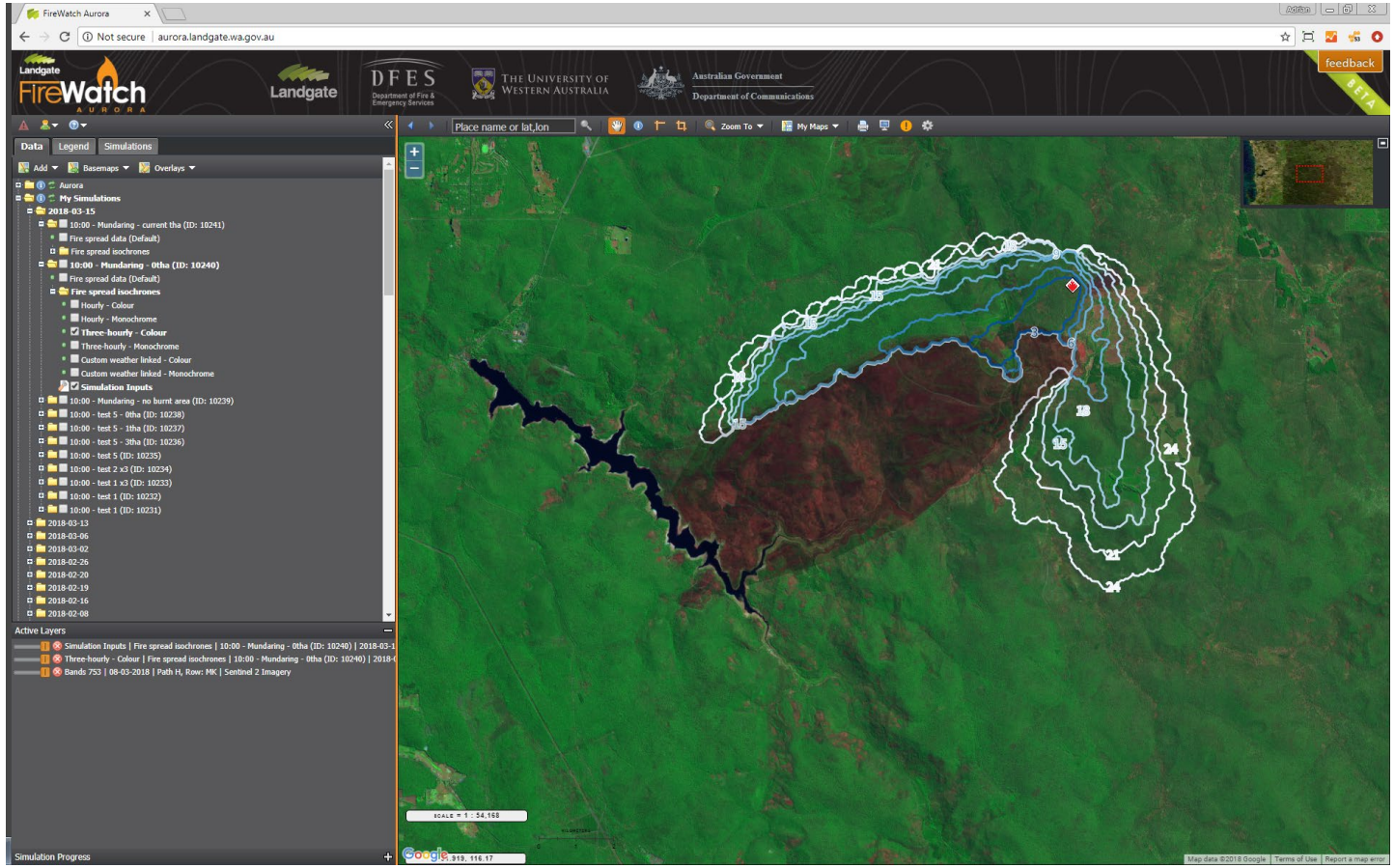
Focus directly on each pole as an independent measure of risk and consequence.



Fire Spread Simulation Modelling

Aurora Fire Spread Simulation System

- Developed 2010-2013
- Partnership:
  - UWA : Australis
  - DFES
  - Landgate



Australis

- Cell-based approach
- Irregular grid.
- Poisson disk distribution.
- Discrete-event simulation methodology

Fire Spread Simulation Processing

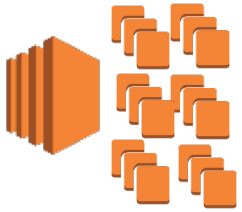
Aurora : Cloud Computing Infrastructure

Number of poles	Number of Simulations (8 wind dir.)	Processing Time (secs)		
750,000	6,000,000	10	60,000,000	Seconds
			16666	Hours
			694	**Days**

Fire Spread Simulation Processing

Aurora : Cloud Computing Infrastructure

Cloud Computing Environment



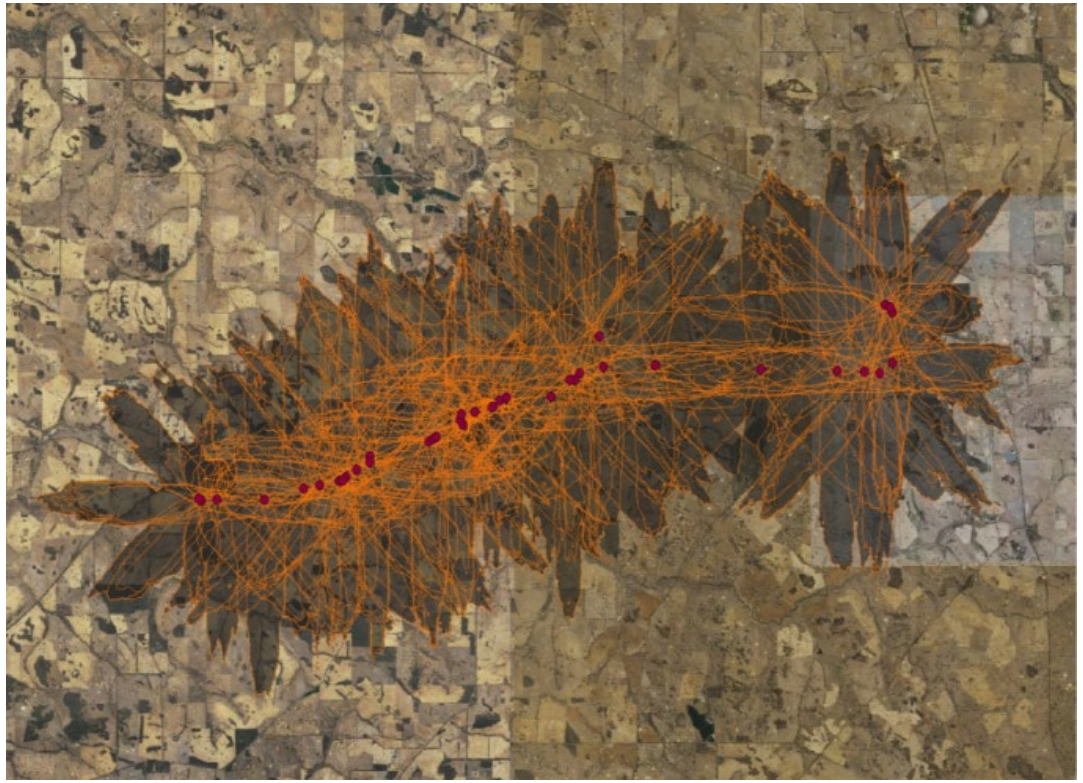
Parallel Processing across multiple servers and CPU cores

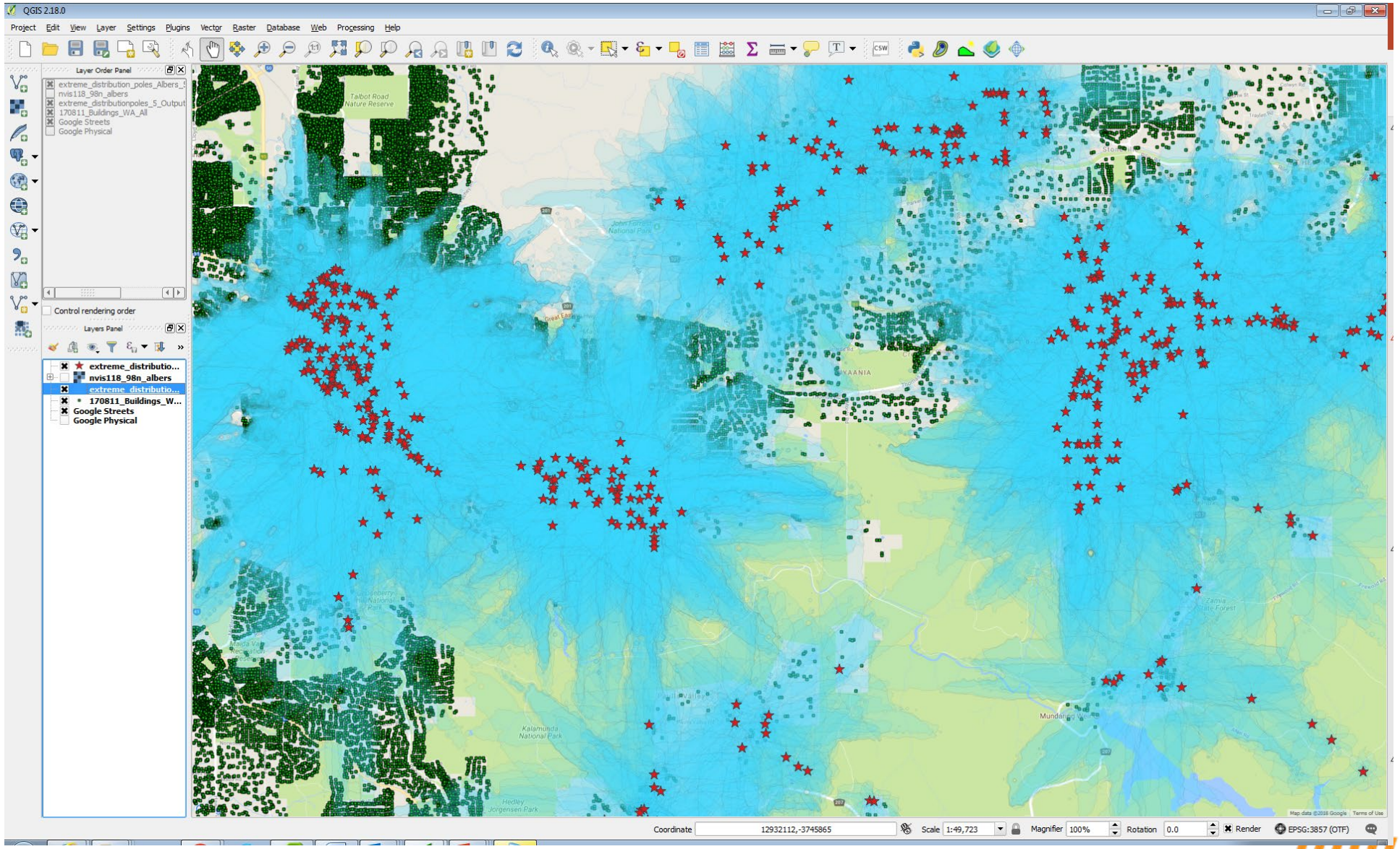
- Centos, 72 Virtual CPU's, 144 GB memory,
- 50,000 power pole subsets

By automating the process of creating over a hundred servers and allocating each 50,000 subset of power poles for the eight wind directions, the whole south west of Western Australia infrastructure can be modelled in days.

Fire Spread Simulation Processing

Aurora : Cloud Computing Infrastructure

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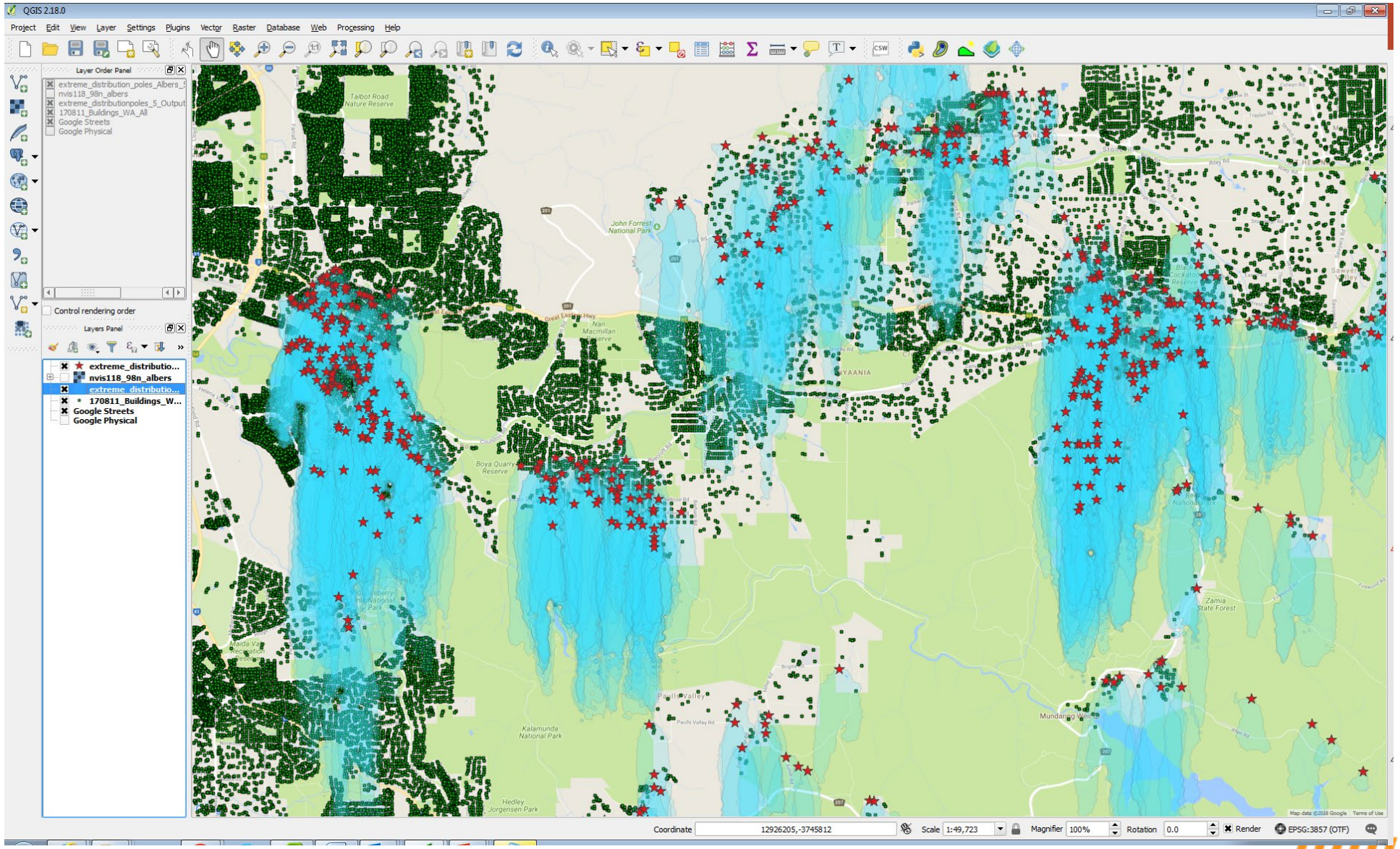
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Great Eastern Hwy
Nan Macmillan Reserve
Boya Quarry Reserve
Kalamunda National Park
Paulls Valley
Zamia State Forest
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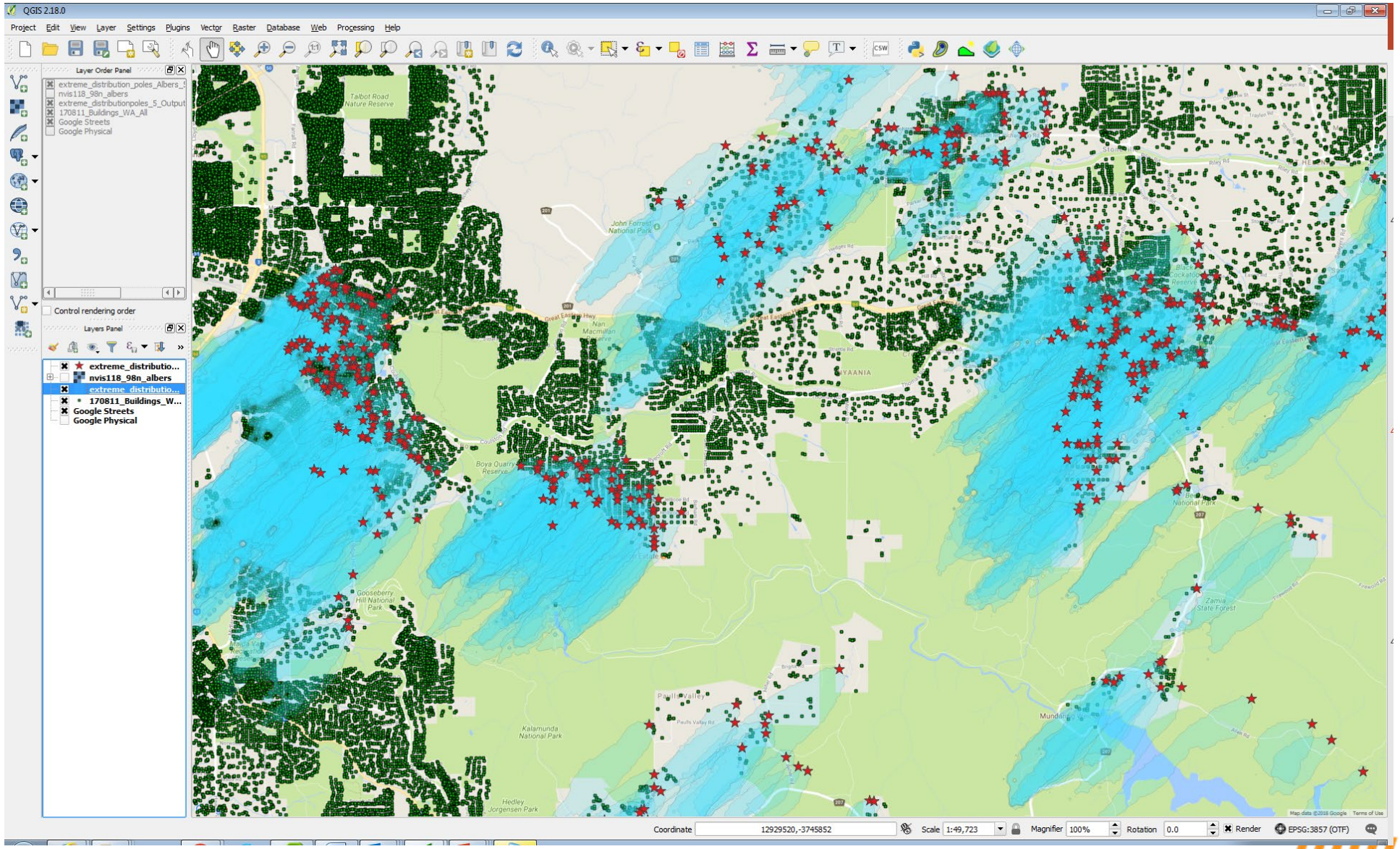
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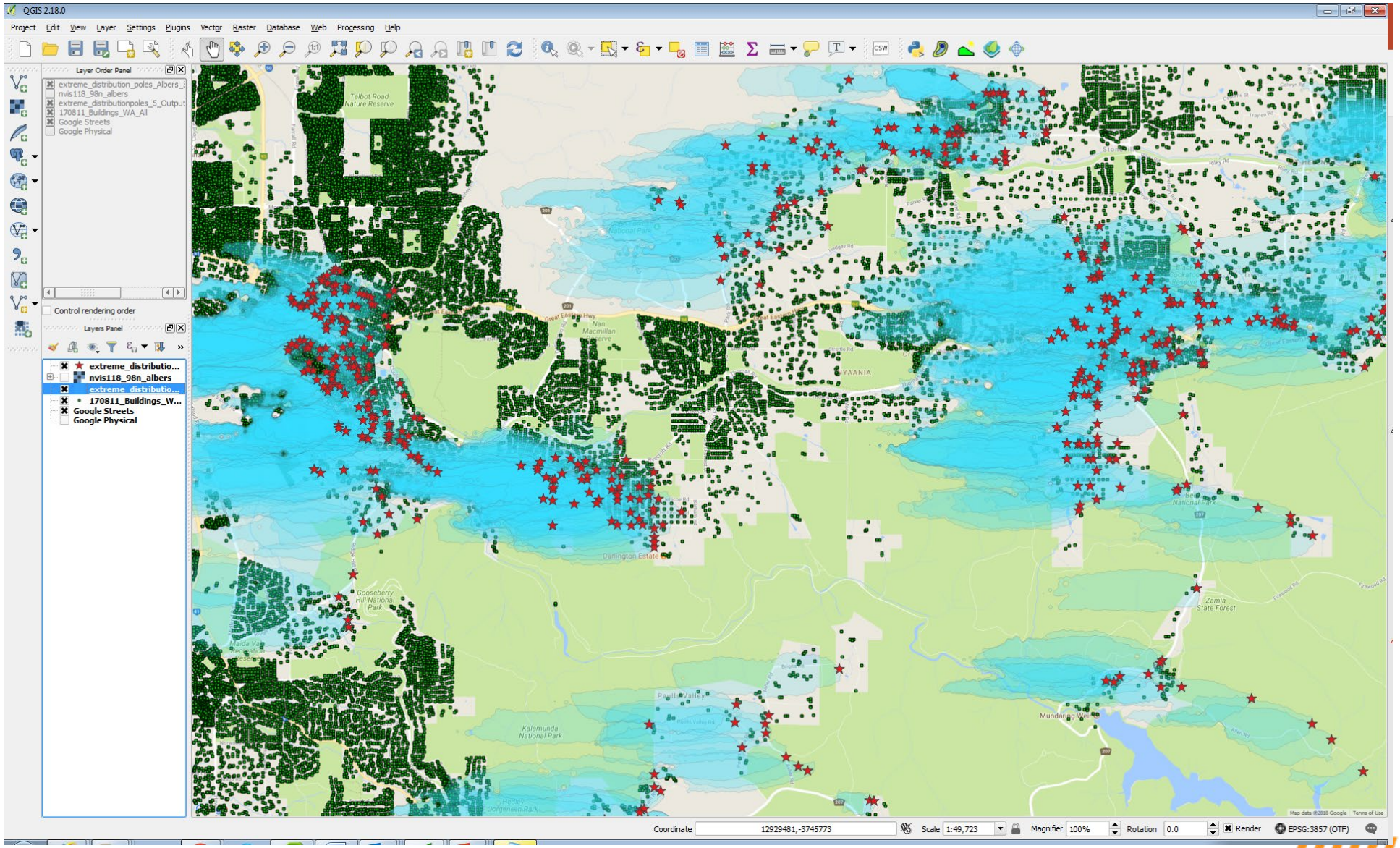
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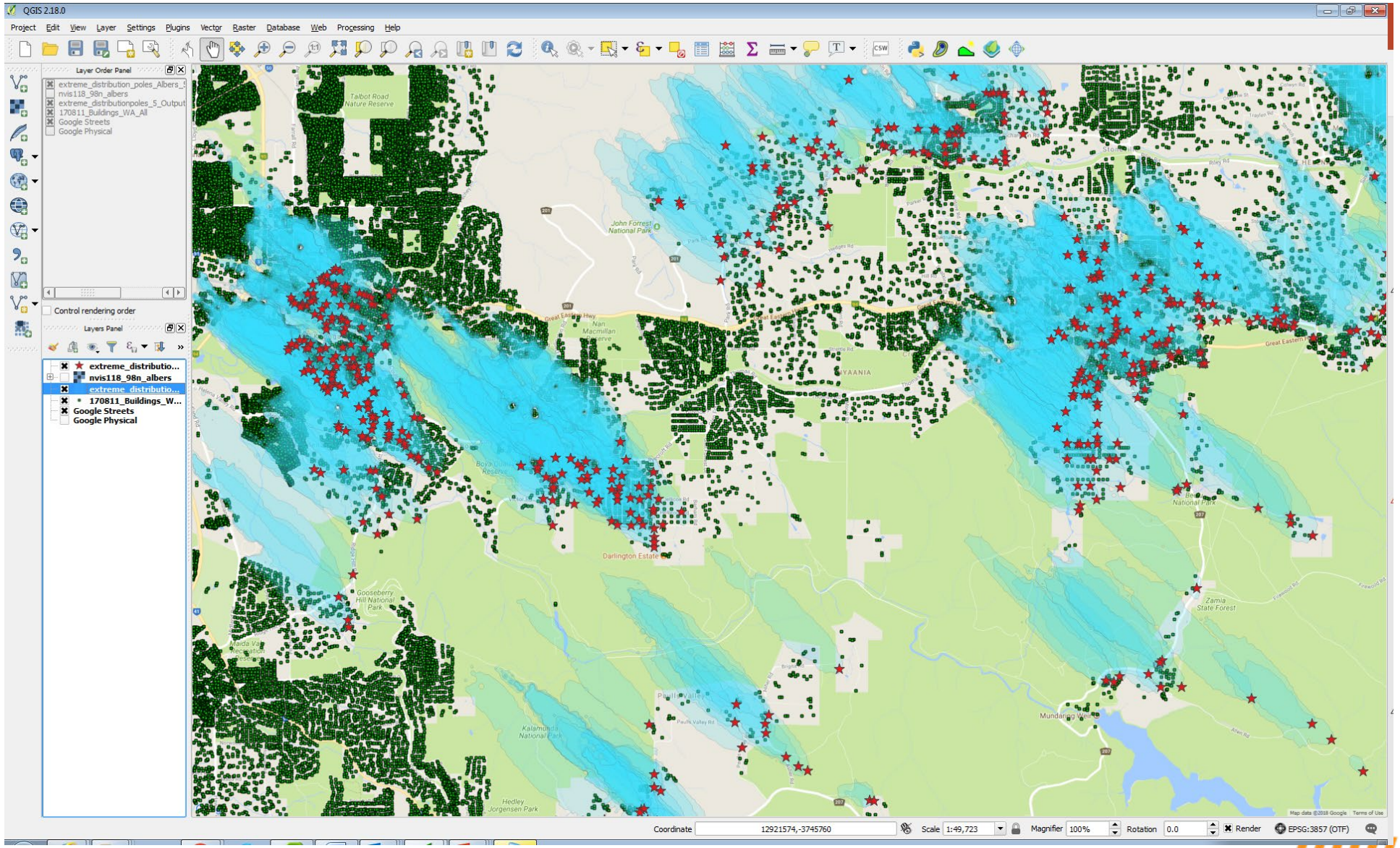
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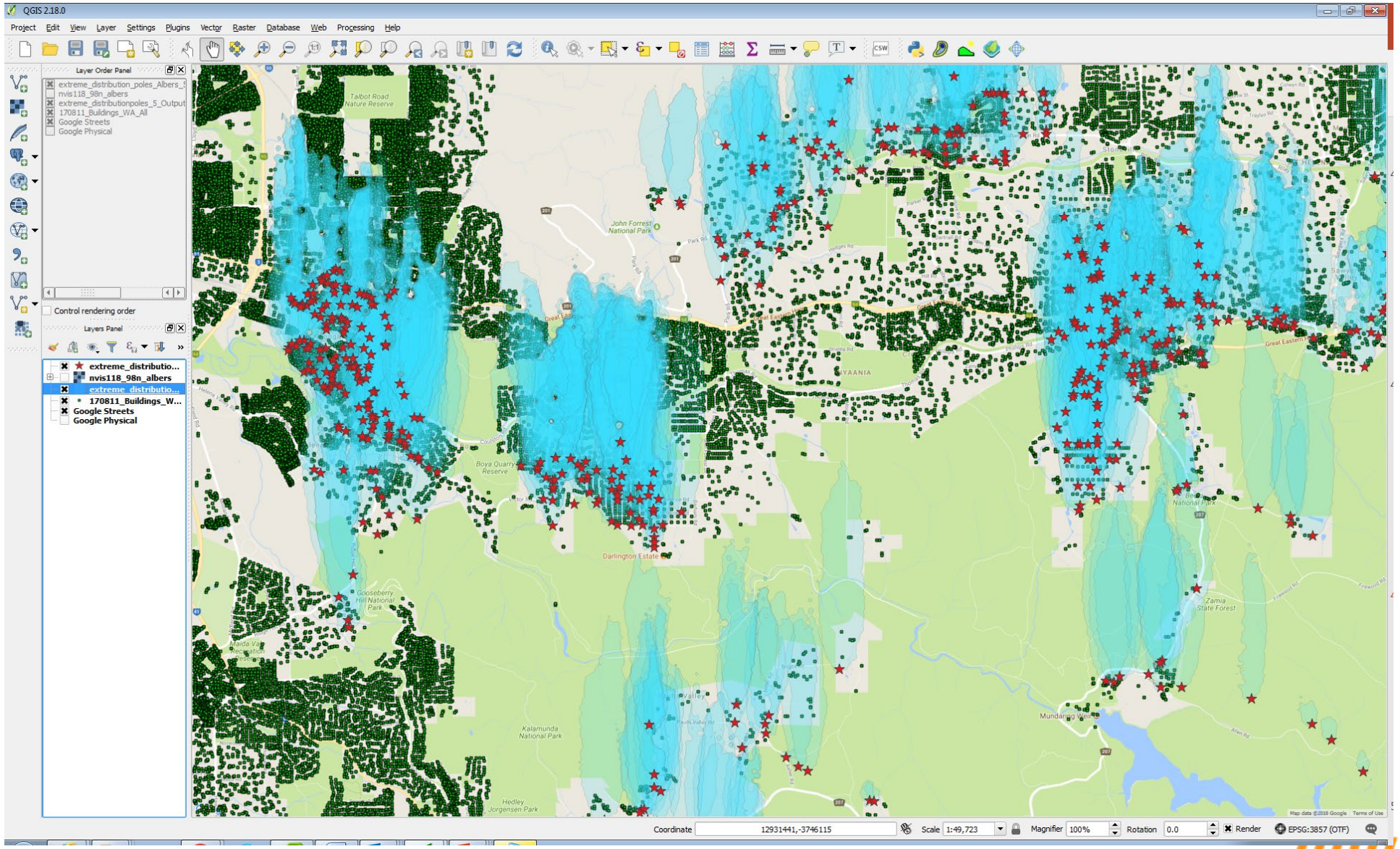
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Boya Quarry Reserve
Darlington Estate
Gooseberry Hill National Park
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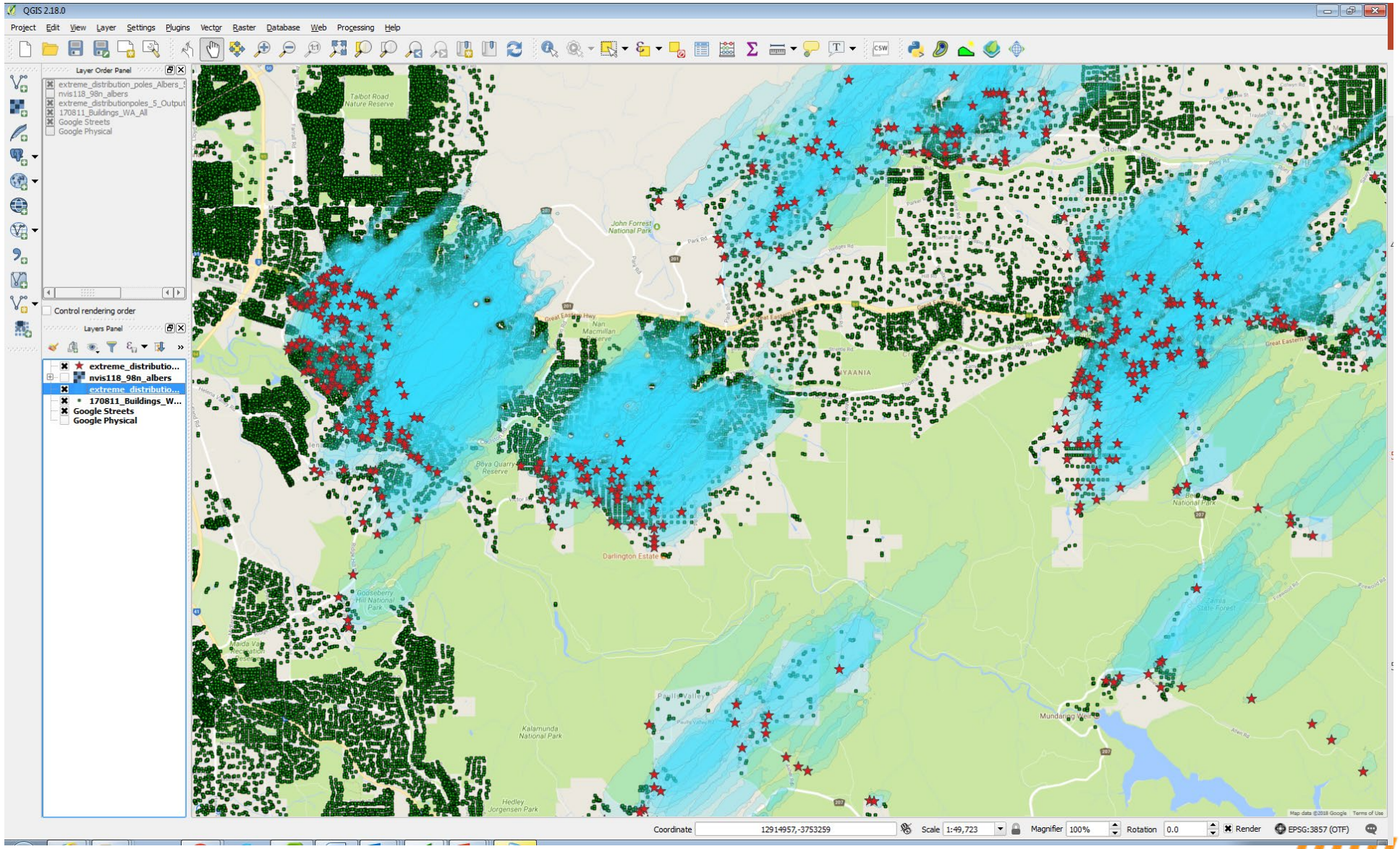
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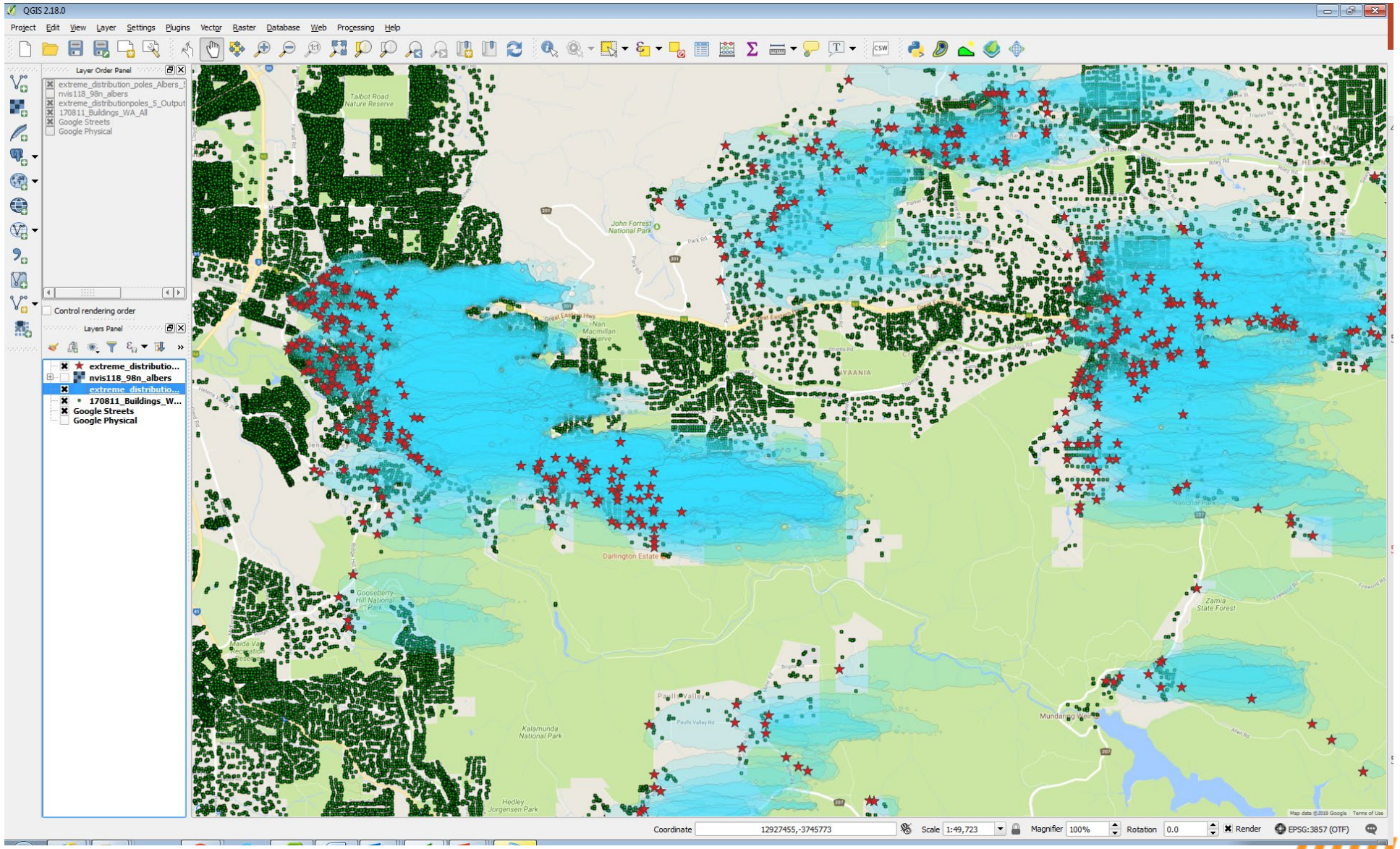
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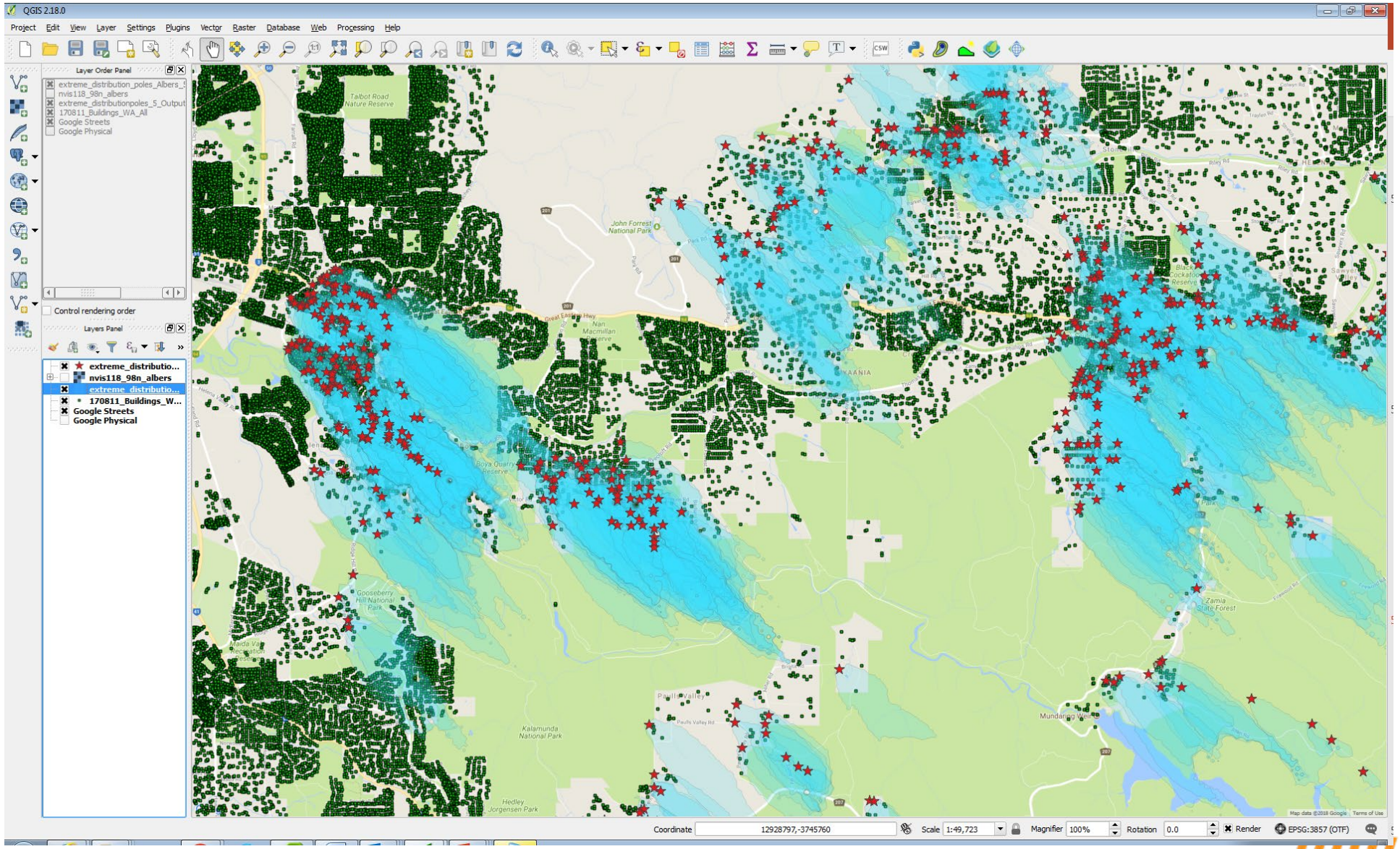
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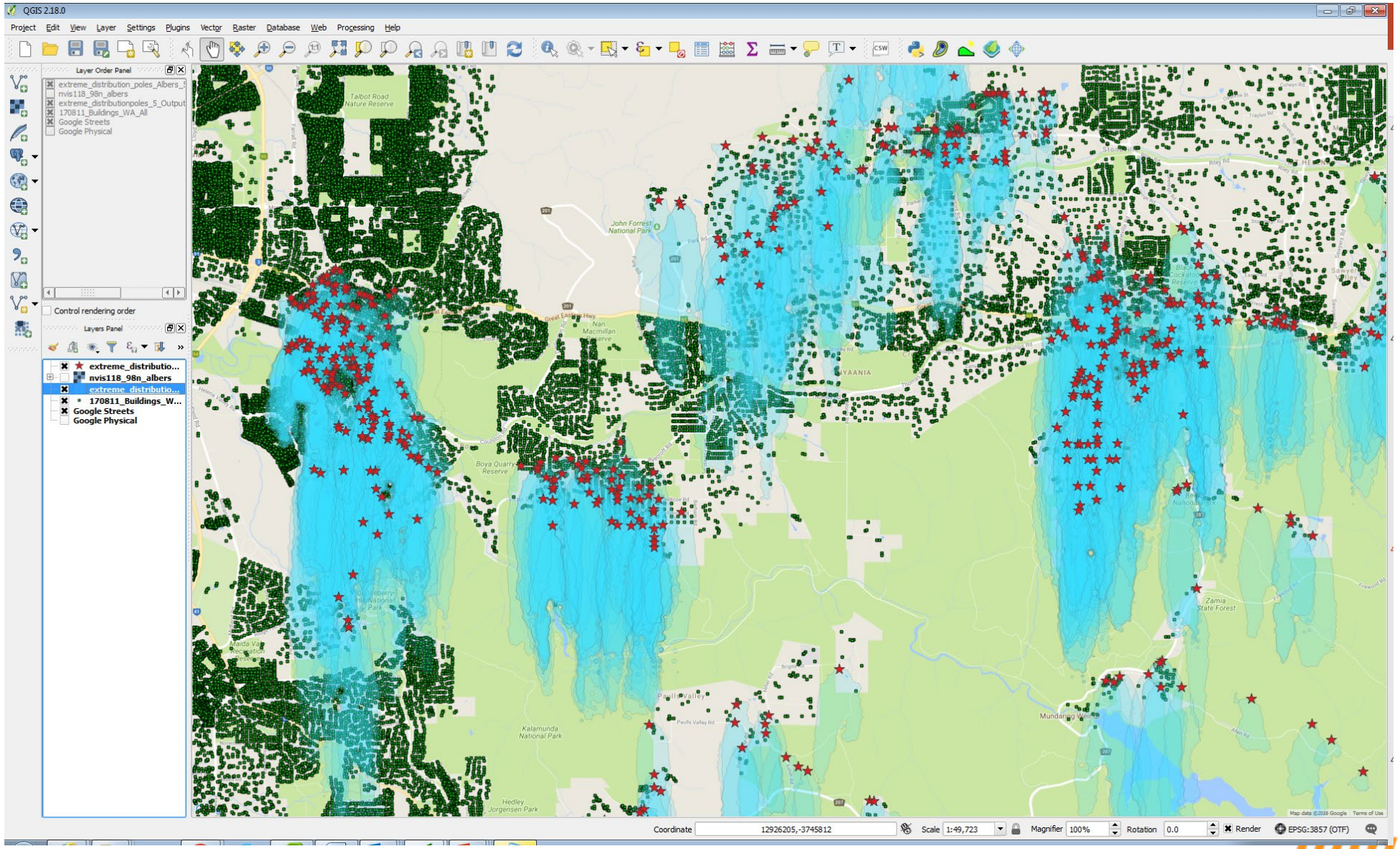
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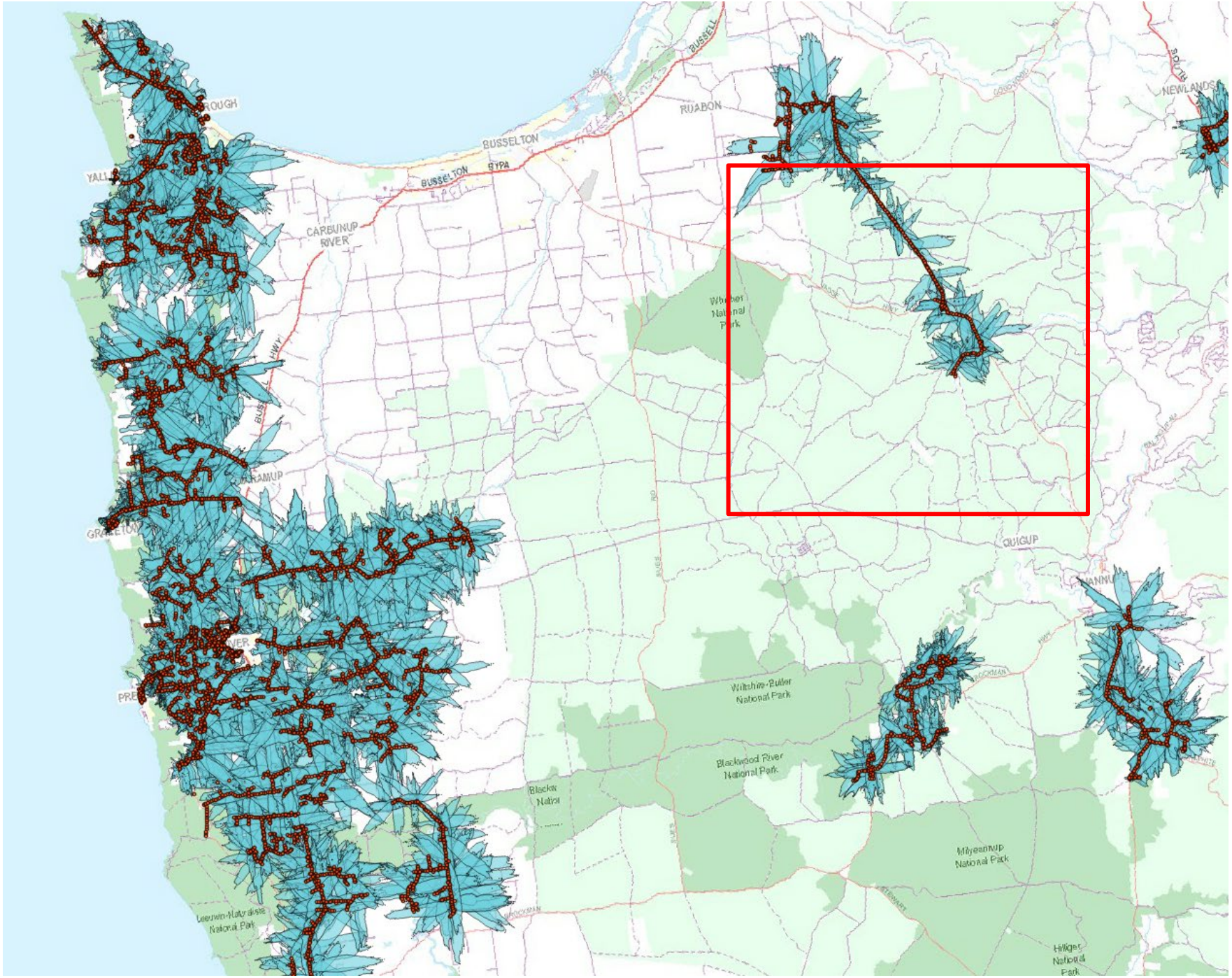
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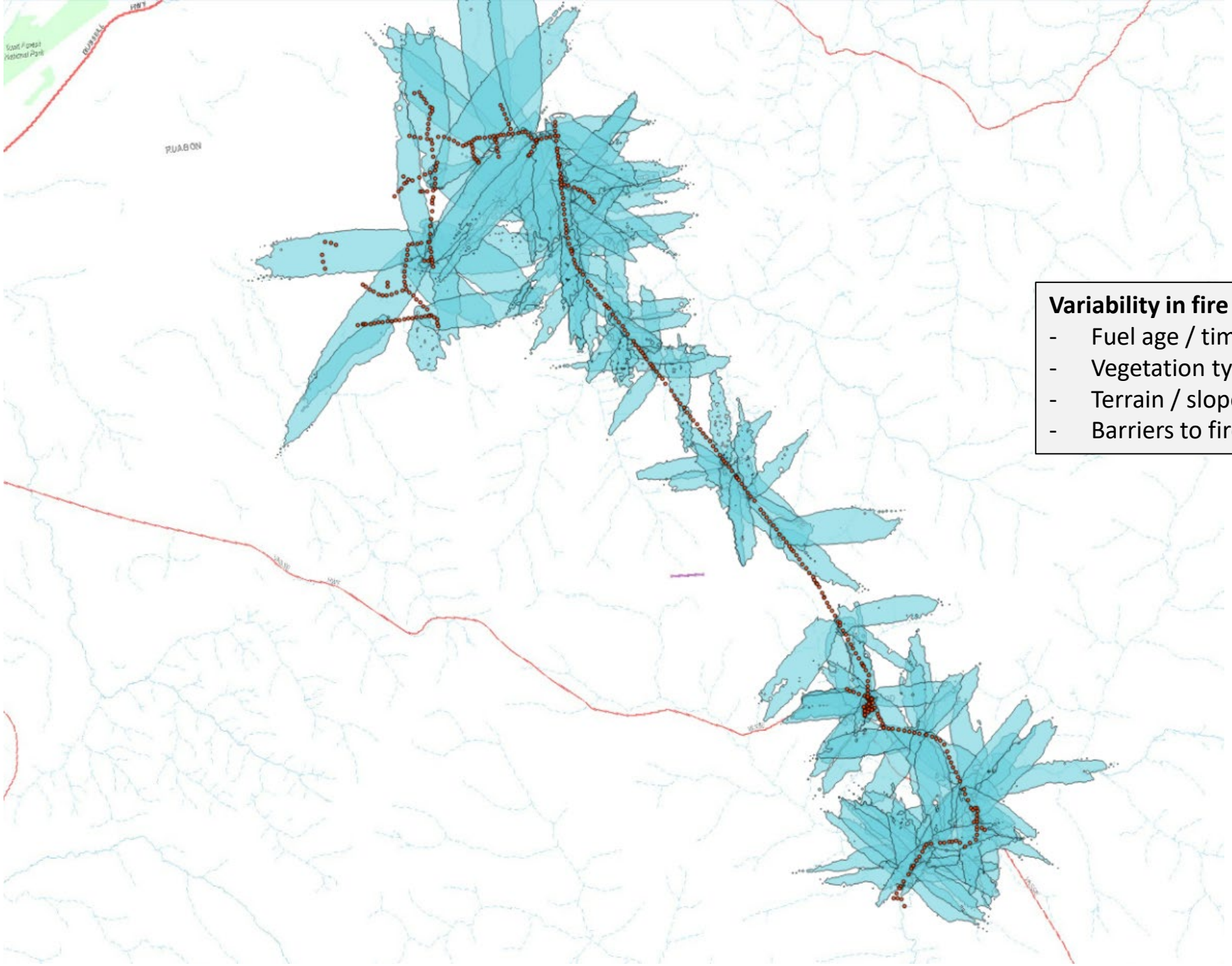
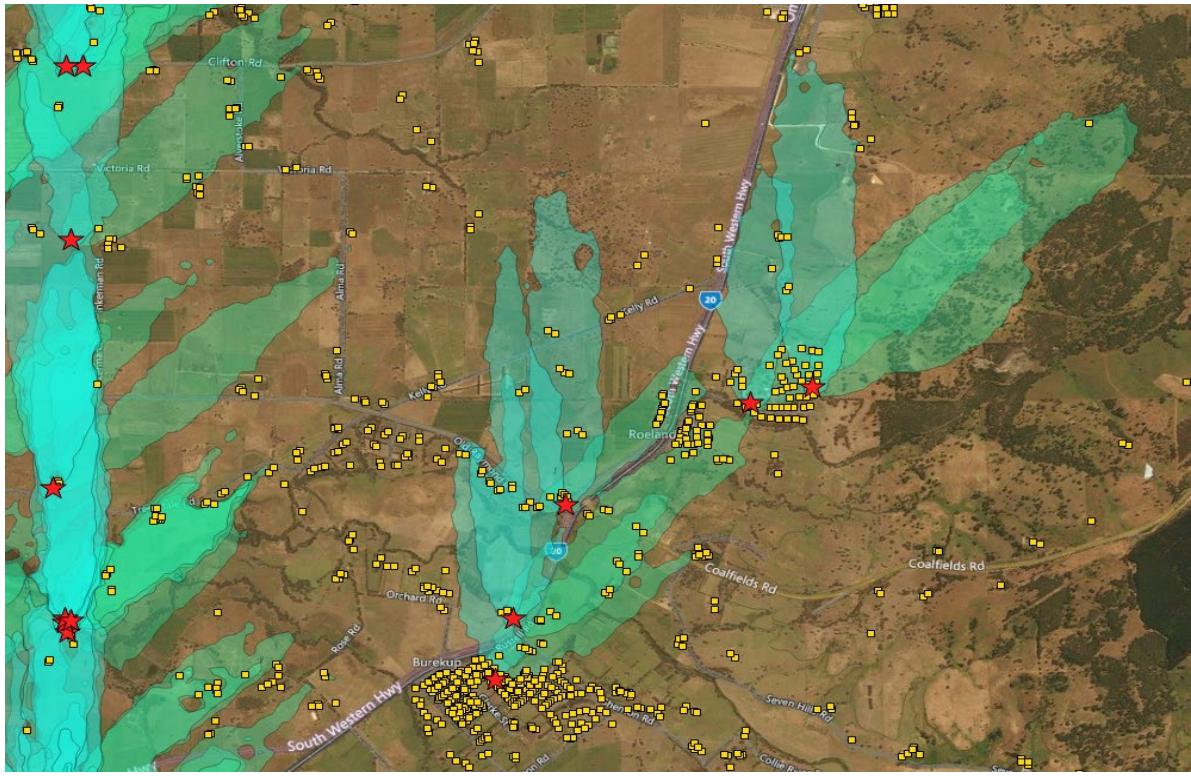


Variability in fire spread

- Fuel age / time since last burn
- Vegetation type vs fire spread model invoked
- Terrain / slope
- Barriers to fire spread

Consequence Mapping

- Isochrones of 1 hour of fire spread with no suppression.
- Risk posed is determined by intersecting the consequence severity layer (buildings) and fire spread isochrones.
- Rank power pole unique identification numbers versus the total potential buildings impacted.
- GIS products developed indicating spatial distribution of consequence.



Summary

- **Western Power**
  - evidence base to focus their asset renewal and maintenance program
  - ensure they have addressed areas with the highest potential consequences, realising better public safety outcomes
  - Further improvements have been requested.

- **Demonstrated the applicability of the Aurora fire spread simulation system**

- **Methodologies Developed**
  - Bushfire Risk Analysis / Consequence

- **Software, and Processes Developed**
  - Suitable for a variety of state-wide applications.

- **Highlighted data improvement requirements.**
  - Opportunity to address data gaps and improve data quality for the State

- **Project has resulted in improvements to Aurora**
  - Leverages the States previous investments and contributes to enhancements

- **Successful cross-agency partnership**
  - Bushfire Behaviour Science R&D, coupled with ICT R&D, to support operational requirements.

Utilisation of fire spread simulators to assess power network fire risk

Thankyou, Questions?

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