GREAT SOUTH
Southland Regional Development Agency

Southland Murihiku Energy Strategy Implementation

Energy in the Landscape

ASSESSMENT OF SOLAR RESOURCES – SOUTHLAND

GREAT SOUTH - OCTOBER 2025

Transitioning to a low-emissions and climate-resilient future

Assessment of renewable power generation opportunities to meet the future energy needs of Southland, New Zealand

REPORT TITLE

Assessment of Solar Resources - Southland

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PROJECT TEAM

Strategic Projects

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Abbreviations

Term	Definition
DEM	Digital Elevation Model
DIF	Diffuse Horizontal Irradiation
DNI	Direct Normal Irradiation
GHI	Global Horizontal Irradiation
GIS	Geographic Information Systems
GSA	Global Solar Atlas
GTI opta	Global Titled Irradiation at Optimum Angle
LiDAR	Light Detection and Ranging
MIT	Minimum Irradiance Threshold
NZTM2000	New Zealand Transverse Mercator 2000
PV	Photovoltaic

Glossary

- **Digital Elevation Model (DEM):** A raster-based representation of the Earth's surface that shows elevation values at regularly spaced intervals.
- **Diffuse Horizontal Irradiation (DIF):** The portion of solar radiation received by a horizontal surface that arrives indirectly, having been scattered by molecules, aerosols, and clouds in the atmosphere. It excludes direct sunlight and is especially relevant under overcast or hazy conditions.
- **Direct Normal Irradiation (DNI):** The amount of solar radiation received per unit area by a surface that is perpendicular to the sun's rays. It represents the direct beam component of sunlight and is crucial for concentrating solar technologies.
- **Global Horizontal Irradiation (GHI):** The total solar radiation received by a horizontal surface. It is the sum of Direct Normal Irradiation (projected onto a horizontal plane) and Diffuse Horizontal Irradiation. GHI is commonly used in photovoltaic system design for flat-mounted panels.
- **Global Tilted Irradiation (GTI):** The total solar radiation received by a surface that is tilted at an angle relative to the horizontal. GTI accounts for the orientation and tilt of the panel, making it more representative of actual energy capture in tilted PV systems.
- **Global Tilted Irradiation at Optimum Angle (GTIopta):** A specific case of GTI where the surface is tilted at the optimal angle to maximize solar energy capture throughout the year. GTIopta is a key metric for evaluating the solar potential of a site and estimating photovoltaic system performance.
- **Map North:** The upward direction on a map, aligned with the direction of the map's grid lines. It depends on the map's projection and purpose. The projection used in this report is NZTM2000.
- **True North:** The direction along the Earth's surface towards the geographic North Pole. Unlike magnetic north, which varies with location and time, true north is a fixed point used in mapping and navigation. In this study area (Southland), true north lies at a ~356° azimuth from map north (NZTM2000).

1. Introduction

1.1 RENEWABLE ENERGY OPPORTUNITIES IN SOUTHLAND

Southland is aiming to significantly reduce its carbon emissions by making better use of renewable energy sources. As electricity demand grows, there's a need to explore new ways of generating clean energy locally.

This report is part of three reports titled "Energy in the Landscape" which highlight promising locations across Southland for potential investment in solar, wind, and hydro power.

This is the second volume in a three-part series and focuses on identifying nine zones in Southland with moderate to strong solar energy potential. These zones were selected based on factors including:

- Sunlight levels (Direct Normal Irradiation ≥ 1200 kWh/m²/year)
- Land slope
- Localised shading
- Power network capacity

While the report outlines areas with good solar resources, it doesn't rank or classify them. Instead, it serves as a starting point for anyone interested in developing solar energy projects. Detailed advice should be sought to determine the energy outputs and financial viability before investing.

1.2 WHY SOLAR ENERGY MAKES SENSE

Electricity prices and distribution costs are expected to rise. At the same time, demand for zero-emissions electricity is increasing due to:

- Electrification of heating systems, industrial boilers, and transport (e.g., Electric Vehicles)
- Consumer preference for low-emissions products
- Export requirements like Climate-Related Disclosures

To support investment, there are financial incentives available such as:

- Low-interest loans from funding banks such as ANZ, ASB, BNZ, Westpac
- 20% tax write-off for capital investment (2025)
- Accelerated depreciation (16% per year as at 2025)

For homes, farms, and businesses, it's best to use generated energy directly to reduce electricity bills. But for larger solar farms, it's crucial to understand the capacity of the local PowerNet network and the national Transpower grid.

Early engagement with PowerNet and Transpower is highly recommended to ensure your project can connect to the grid and operate efficiently.

1.3 OPTIMISING SOLAR PANEL PERFORMANCE

This report models Global Tilt Irradiation (GTI), which estimates solar energy output from panels mounted and tilted toward True North. In Southland, performance can be improved by angling panels slightly — approximately 4° West of North — which can add up to 200 kWh/m² per year, a significant boost in efficiency.

However, each site is unique. Factors like shading from trees or hills can affect how well solar panels perform.

1.4 PLANNING AND CONSENTS

Small-scale solar projects usually face few barriers. But for larger installations, it's important to start conversations early with:

- Transpower and PowerNet
- Local councils
- Iwi, neighbours, and community groups

For larger installations it is important to consider potential reflection impacts on say aviation, landscape values and land use.

This helps ensure smooth consenting and community support.

Site specific information can be found on the Great South website here:

https://greatsouth.nz/resources/solar-map

If further information is required, contact info@greatsouth.nz

Solar PV Investment Decision Flow

Step 1 - Identify your energy needs

- Identify your ICP * number
- Find our your current electricity usage and peak times (Check your electricity bill or ask your provider)
- Consider future energy needs (e.g EV's, heat pump...)

Information:
*ICP - number: (Installation Control Point Number) is a unique, 15-digit number that identifies your specific electricity connection point to the local area power network. You can find your ICP - number on your power bill.

Step 2 - Understand your site potential

- Check your solar energy potential in your location, along with the best panel orientation and tilt angle.
- Check whether land or roof space is available, and determine the size of the area that can be used.
- Check the roof pitch and structural stability of building.
- Check if there is shading from trees or other buildings.

Information:
As an initial indication of Global Tilt Irradiation in your area, please see: *Assessment of Solar Resources – Southland* by Great South at https://greatsouth.nz/resources/solar-map

Step 3 - Technical & Regulatory Review, Financial Feasibility

- **Engage with a technical advisor/installer to find our about grid connection feasibility.**
  - https://www.mysolarquotes.co.nz/solar-quotes/
  - www.powernet.co.nz/future-energy/generation-and-storage/get-connected/
  - www.powernet.co.nz/future-energy/generation-and-storage/solar
- **Determine about export tariffs or net metering**
  - www.mysolarquotes.co.nz/about-solar-power/residential/solar-power-buy-back-rates-nz
- **Compliance with your local regulations**
  - www.mysolarquotes.co.nz/blog/new-zealand-solar-legislation/do-you-need-council-consent-for-solar-panels-in-new-zealand-let-s-clear-the-air
- **Calculate your upfront cost vs your long-term savings**
- **Determine your payback period and operational savings**
  - www.mysolarquotes.co.nz/solar-calculator
  - www.pricemysolar.co.nz
  - www.rewiring.nz/calculator
  - ww.calculate.rewiring.nz
  - www.rewiring.nz/electrification-guides/solar
- **Check your available financing choices (no interests or low interest loans etc.)**
- **Seek quotes for solar investment (Request quotes from multiple suppliers)**
  - www.bnz.co.nz/business-banking/loans-and-finance/green-business-loans
  - www.asb.co.nz/business-banking/asb-smart-solar-loan
  - www.anz.co.nz/agribusiness/agri-finance/good-energy
  - www.westpac.co.nz/agribusiness/sustainable-farm-loan
  - www.kiwibank.co.nz/personal-banking/home-loans/getting-a-home-loan/sustainable-energy-loan

Step 4 - Other Possible Considerations, Environmental & Strategic Fit

- Consider brand reputation benefits for your business/your farm
- Are the emissions reduction targets (if any) of the business, sector, and region in alignment?
  For example: Are you supplying to an exporter?

Optional Further Information:
Emission reduction potential: (Amount of energy you plan to cover by solar in kWh) x emission factor (0.11 kgCO2e)/kWh) = emission reduction potential in kgCO2e

Step 5 - Decision Point

- Proceed with detailed design and procurement

or

- Revisit assumptions and reasses

Residential Solar Checklist

- www.eeca.govt.nz/assets/EECA-Resources/Product-regulations/ResidentialSolar-Checklist.pdf
- www.eeca.govt.nz/regulations/voluntary-guidance/best-practice-guidance-documents/best-practice-guidance-for-residential-solar-pv-and-battery-storage-systems
- www.eeca.govt.nz/insights/eeca-insights/commercial-scale-solar-in-new-zealand

2. Methodology

Solar power requires sunlight to activate photovoltaic cells and produce electricity. Therefore, the amount of sunlight available in a specific location and other factors such as cloud cover, topography and latitude, all play a role in solar power generation. To identify the locations with sufficient potential for solar energy in Southland, all those factors were considered and assessed. The data sources and criteria used to identify and define the potential solar locations are explained below.

2.1 DATA SOURCES

Global solar atlas

The main source of information about the solar irradiation properties was the Global Solar Atlas (GSA)[1]. The GSA includes the following data: Direct Normal Irradiation (DNI), Diffuse Horizontal Irradiation (DIF), Global Horizontal Irradiation (GHI), Global Tilted Irradiation at Optimum Angle (GTIopta), among others such as air temperature, elevation, optimum inclination and electricity output.

The Global Solar Atlas calculates the irradiation through a solar irradiation model using data inputs from geostationary satellites and meteorological models. Next, irradiation is calculated considering a clear sky and then quantifying the attenuation effect of clouds. Finally, the irradiation is post-processed to get direct, diffuse and global irradiation on tilted surfaces, and the values are corrected for shading effects from the surrounding terrain.

Digital Elevation Model

The GSA includes its own Digital Elevation Model (DEM). However, a more accurate DEM for Southland was also considered in the solar assessment. The DEM used is an amalgamation of a number of different datasets compiled by Great South in November 2021 with a spatial resolution of 1x1 metre. The layer is derived from available Regional LiDAR, groundwater bore collar heights, geodetic vertical marks, and protected survey marks.

2.2 POTENTIAL LOCATION SELECTION CRITERIA

This report considered two main factors (irradiation and topography) to identify and select the potential solar energy zones displayed in the results section. Both factors were geospatially interpreted, resulting in a large area with solar energy potential in Southland. Subsequently it was arbitrarily divided into zones to simplify the report of results. The zones were named for toponymic locations nearby.

Direct Normal Irradiation DNI

This report considered areas with Direct Normal Irradiation (DNI) ≥ 1200 kWh/m²/year (see Appendix B). DNI measures direct sunlight, which is a key source of solar energy and directly influences the performance of solar systems.

While there is no universal minimum DNI standard for all solar farms, values below 613 kWh/m²/year (≈ 50–70 W/m²) are generally considered insufficient for power generation. The 1200 kWh/m²/year threshold used here is not a fixed benchmark, but a practical screening level to identify areas with moderate to high solar potential.

According to Energypedia, solar radiation can be classified as:

- Low: < 2.6 kWh/m²/day (< 949 kWh/m²/year)
- Moderate: 2.6–3.0 kWh/m²/day (~949–1095 kWh/m²/year)
- High: 3.0–4.0 kWh/m²/day (~1095–1460 kWh/m²/year)
- Very High: > 4.0 kWh/m²/day (>1460 kWh/m²/year)

Thus, a DNI of 1200 kWh/m²/year falls within the high solar radiation category, making it a reasonable threshold for identifying viable solar energy sites.

This report also presents Global Tilted Irradiation at Optimum Angle (GTIopta) values as the most relevant indicator for estimating the maximum solar energy capture in tilted photovoltaic (PV) systems.

Topography

Topography has two major implications in solar energy. First, tall features such as mountains or ridges can obstruct sunlight at different times of the day, reducing the efficiency of solar panels in affected locations (site shading). Second, slope can influence the suitability of a site for certain solar technologies. While some systems are designed to rotate and follow the sun's path (known as solar tracking), many installations use fixed-tilt systems due to lower cost, simpler maintenance, and suitability for uneven terrain. In such cases, flat or gently sloped surfaces are generally preferred to ensure consistent exposure and ease of installation.

The Global Solar Atlas already considers the effects of topography on the different types of solar irradiation. Additionally, the Digital Elevation Model is used to identify areas with slopes ≤ 10°. These relatively flat surfaces are ideal to deploy solar panels, ensuring sufficient space and a clearer sky. The remaining steep areas are displayed for each zone .

2.3 ADDITIONAL INFORMATION

The following factors are not involved in the selection criteria but are considered important in the field of solar energy for Southland.

Protected areas and crown property

In designated areas of protection or crown property, certain activities or land use may be expressly limited or completely forbidden. These limitations must be considered before starting any action in any area of interest. The protected areas and crown property are identified and displayed for each zone. However, details of the type of protection and specific land use limitations are not included in this report.

Sun path and control points

The sun path represents the movement of the sun across the sky each year, indicating the active hours of sunshine, the azimuth of sunset and sunrise, and solar elevation for each hour. This information helps to identify the rotation and optimum angle for solar panels. Additionally, it depicts the shadow cast by the topography at specific locations. The sun path is obtained from the Global Solar Atlas.

In order to better represent the solar characteristics, a couple of control points are included for each zone. One of the control points is usually located near to the highest Direct Normal Irradiation and another near to tall topographic forms. These control points serve to indicate the maximum potential per zone (attribute tables) and the effects of nearby topography (sun path graphs).

[1] *https://globalsolaratlas.info*

[2] *Remaining steep areas correspond to slopes > 10° that are enclosed within potential zone and were not removed during the selection process.*

3. Assessment of Solar Resources

A total of nine zones have been described with high solar energy potential. Figure 1 shows the geographical location and name of each zone, while Table 1 summarises the total surface area and mean Global Tilted Irradiation at Optimum Angle (GTIopta). Specific details are available in their corresponding report sections.

Figure 1: Potential solar energy zones

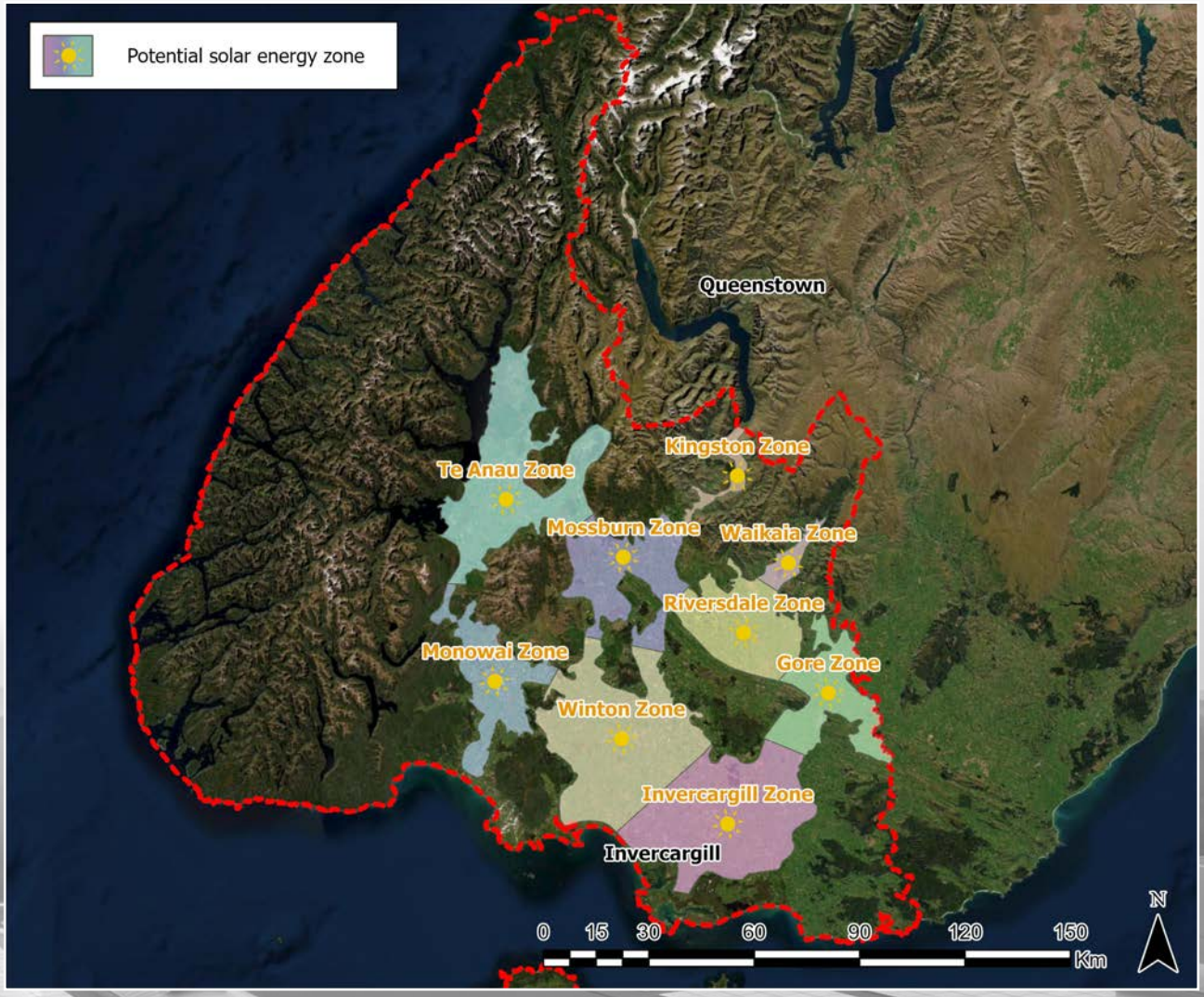


Table 1: Potential zones summary – Annual Global Tilted Irradiation at optimum angle (GTI opta)

Section	Zone	Total Surface Area (km²)	Mean GTI opta (kWh/m²)
3.1	Gore Zone	607	1506
3.2	Invercargill Zone	1430	1458
3.3	Kingston Zone	117	1545
3.4	Monowai Zone	627	1495
3.5	Mossburn Zone	734	1556
3.6	Riversdale Zone	716	1546
3.7	Te Anau Zone	1260	1570
3.8	Waikaia Zone	113	1536
3.9	Winton Zone	1527	1489

GTIopta (Global Tilted Irradiance optimized) is the preferred metric for understanding solar system performance because it provides a more accurate representation of the actual energy yield of tilted photovoltaic (PV) panels. This makes it especially valuable for evaluating real-world performance in fixed or optimally tilted PV installations, ensuring better alignment with system design and energy output expectations.

3.1 GORE ZONE

Named after the town of Gore, this zone extents to Mataura to the South-West, Otama to the North-West, Kaiwera to the South-East, and about Southland-Otago border to the North-East. With a total area of 607.21 km^2, protected areas and crown property are not prominent and are distributed mainly across the Mataura River, while steep areas are identified to the South-West on both sides of Waimumu Stream (Figure 2 and Table 2).

Figure 2: Gore Zone - Crown property, protection and steep areas

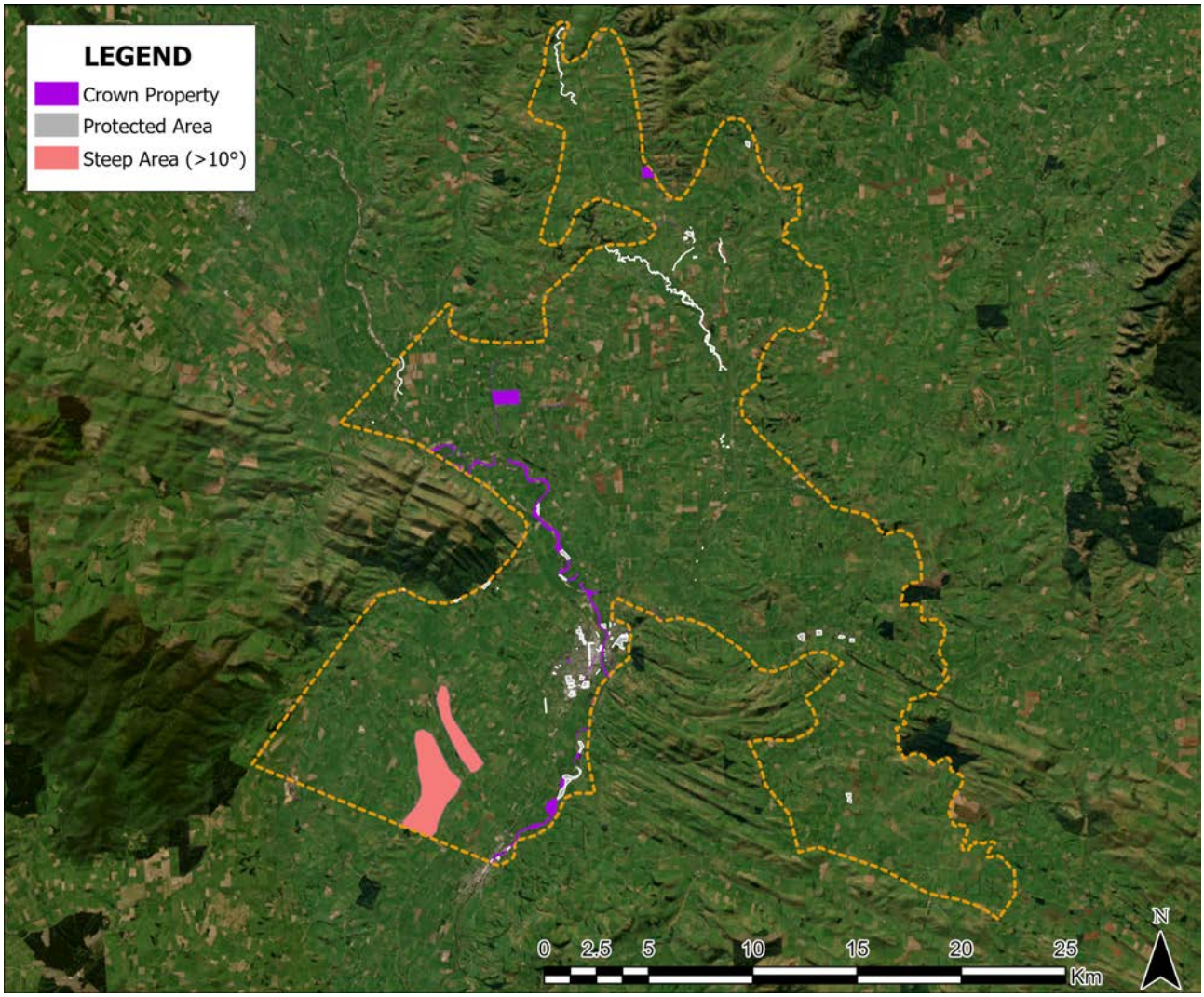
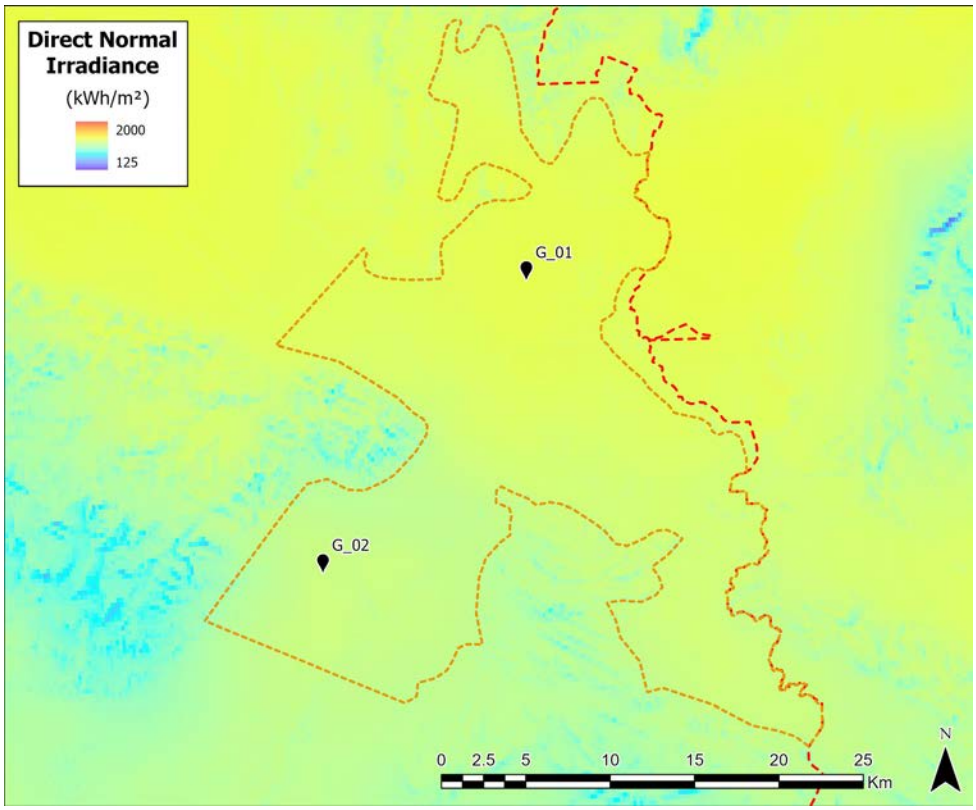


Table 2: Gore Zone - Section Attributes

Category	Area (km^2)
Unrestricted area	589.99
Crown property	4.71
Protected area	2.44
Steep area (>10°)	10.08
TOTAL	607.21

Figure 3 shows a continuous and steady increase in DNI from South to North, and low DNI values in the hilly areas of the Kaiwera and Waterfall Range (South-East and North-West of Gore, respectively).

Figure 3: Gore Zone - Direct Normal Irradiation by GSA. Max: 1405 kWh/m² ; Mean: 1327 kWh/m²



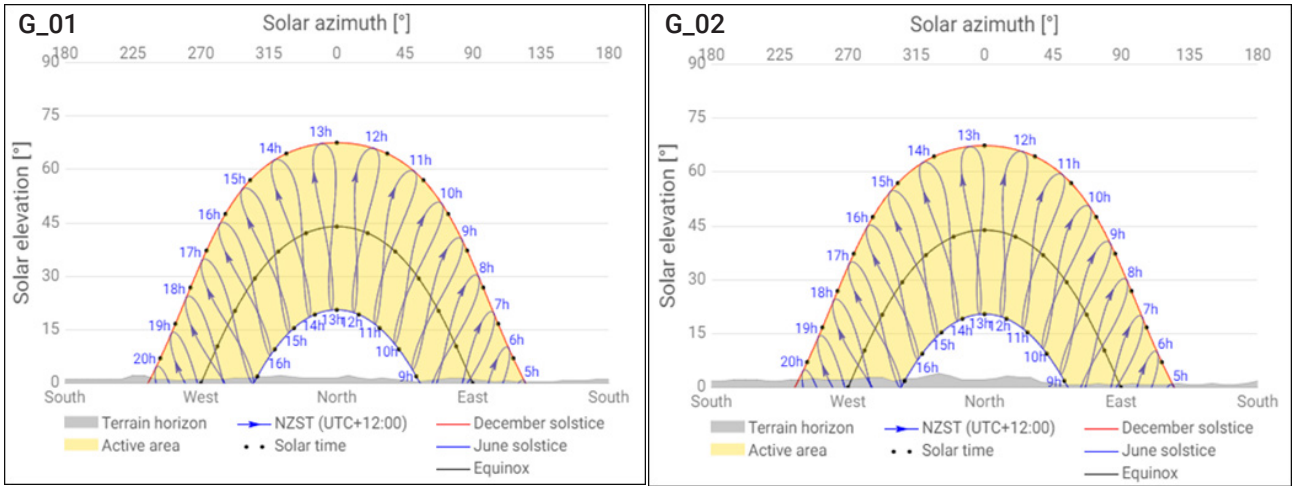
Control Point G_01 is located near to the highest DNI to indicate the best solar features in the zone. Control Point G_02 is located near to the Waterfall Range and Hokonui Hills (to the North-West) to indicate the potential obstruction of sunlight by the topography (Table 3 and Figure 4).

Table 2: Gore Zone - Control points coordinates and annual solar resources

ID	East (NZTM2000)	North (NZTM2000)	DNI (kWh/m²/year)	DIF (kWh/m²/year)	GHI (kWh/m²/year)	GTI opta (kWh/m²/year)*
G_01	1289188	4901748	1398	518	1249.9	1540.5
G_02	1277139	4884403	1301.6	531.7	1211.3	1487.3

** GTIopta is the preferred metric for assessing solar photovoltaic potential*

Figure 4: Gore Zone - Sun path diagrams by the GSA



3.2 INVERCARGILL ZONE

Named after the city of Invercargill, this zone wraps around the New River Estuary and extends to Awarua to the South, Lochiel to the North-West, Mataura Island to the South-East, and the town of Mataura to the North-East. With a total area of 1429.52 km^2, protected areas and crown property are distributed mainly around Invercargill, Forest Hill, and Pebbly Hill, while steep areas are identified to the North-East on both sides of Titipua Stream (Figure 5 and Table 4).

Figure 5: Invercargill Zone - Crown property, protection and steep areas

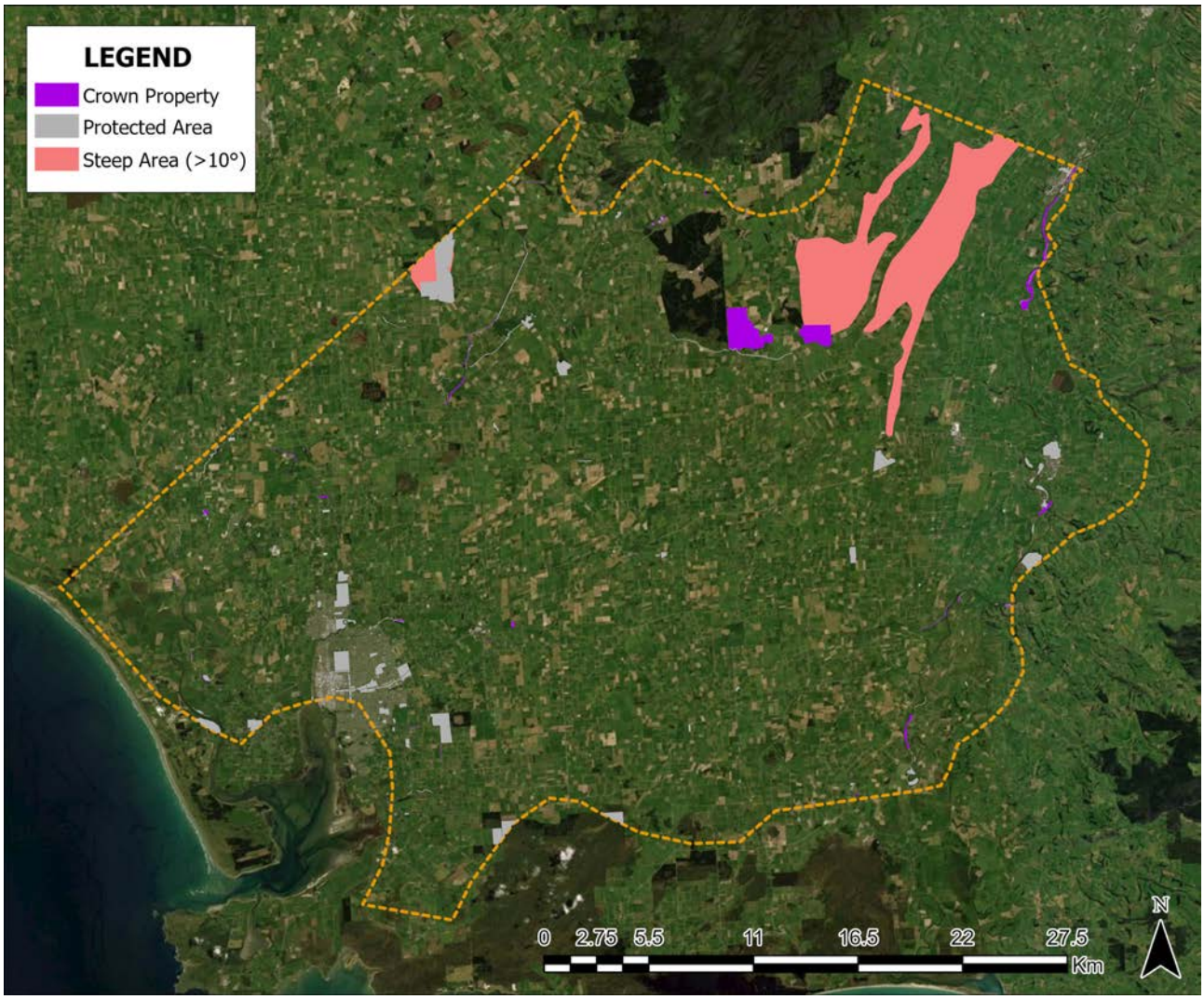
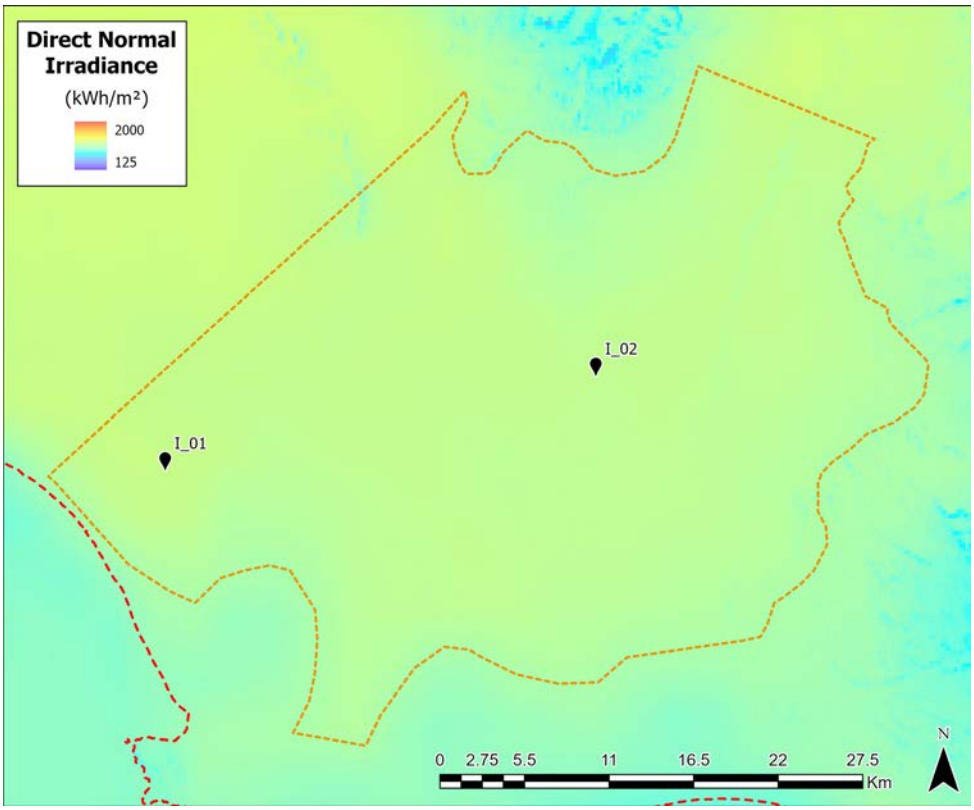


Table 4: Invercargill Zone - Section Attributes

Category	Area (km²)
Unrestricted area	1353.11
Crown property	6.80
Protected area	16.71
Steep area (>10°)	52.90
TOTAL	1429.52

Figure 6 shows a similar and steady DNI across the zone, with a slightly increase to the North-East. Low DNI values are observed to the North (Hokonui Forest) and to the South (coastal and offshore areas).

Figure 6: Invercargill zone – Direct Normal Irradiation. Max: 1288 kWh/m²; Mean: 1249 kWh/m²



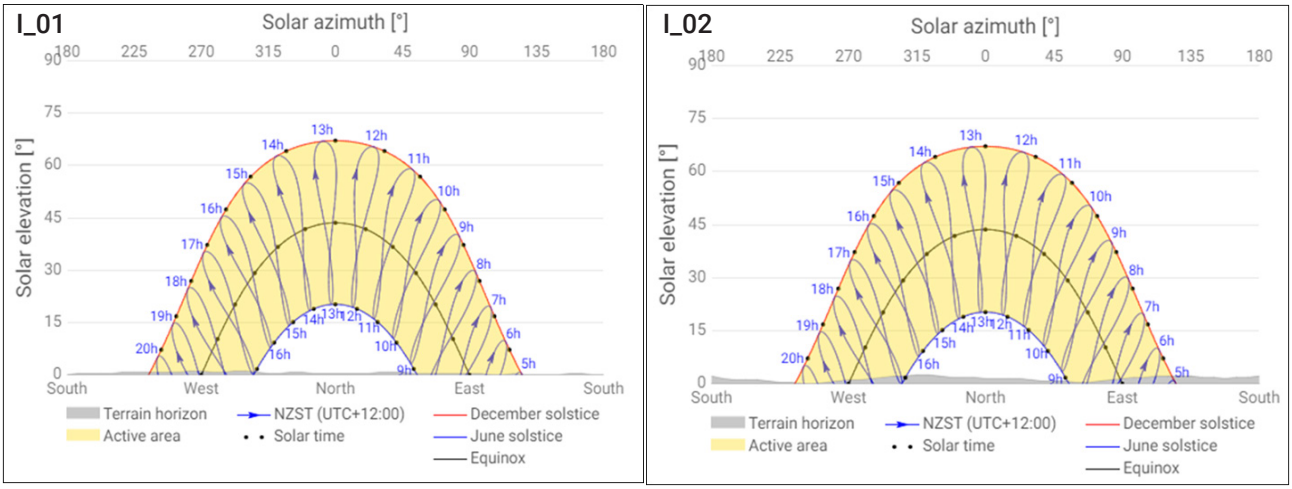
Control Point I_01 is located near to the highest DNI to indicate the best solar features in the zone. Control Point I_02 is located near to the Pebbly Hills to indicate the potential obstruction of sunlight by the topography (Table 5 and Figure 7).

Table 5: Invercargill Zone - Control points coordinates and annual solar resources

ID	East (NZTM2000)	North (NZTM2000)	DNI (kWh/m²/year)	DIF (kWh/m²/year)	GHI (kWh/m²/year)	GTI opta (kWh/m²/year)*
I_01	1235828	4855136	1276.3	535.8	1212.5	1476.3
I_02	1263837	4861240	1257.3	537.8	1195.3	1458.9

** GTIopta is the preferred metric for assessing solar photovoltaic potential*

Figure 7: Invercargill Zone - Sun path diagrams by the GSA



3.3 KINGSTON ZONE

Named after the town of Kingston, this zone extents to Lowther to the South-West, Eyre Mountains to the North-West, Slate Range to the South-East, and Southland-Otago border to the North-East. With a total area of 116.65 km^2, protected areas are not prominent and are distributed mainly across the Mataura River and Eyre Creek, while crown property has a large extension in the North. There are no steep areas in the zone (Figure 8 and Table 6).

Figure 8: Kingston Zone - Crown property, protection and steep areas

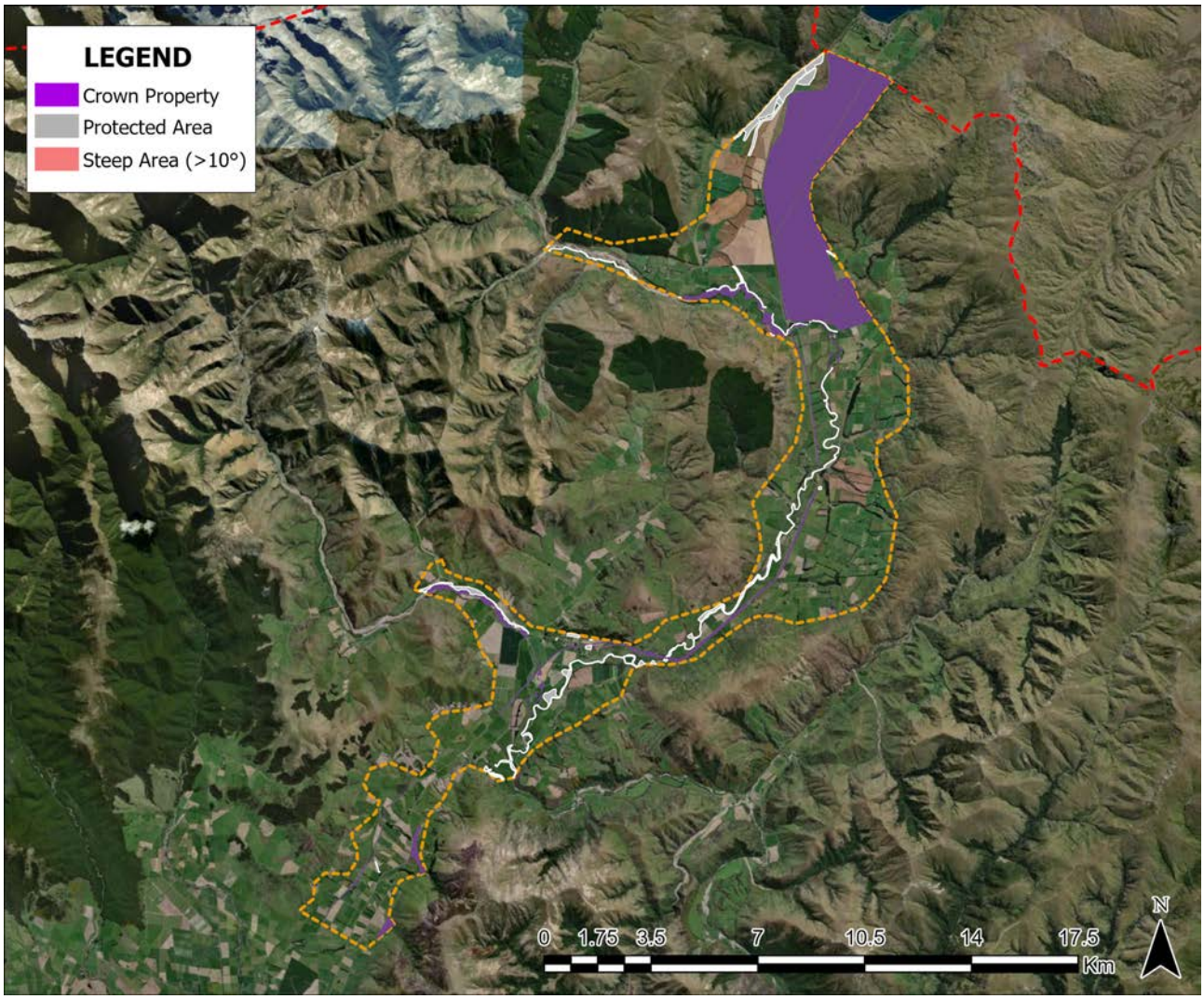
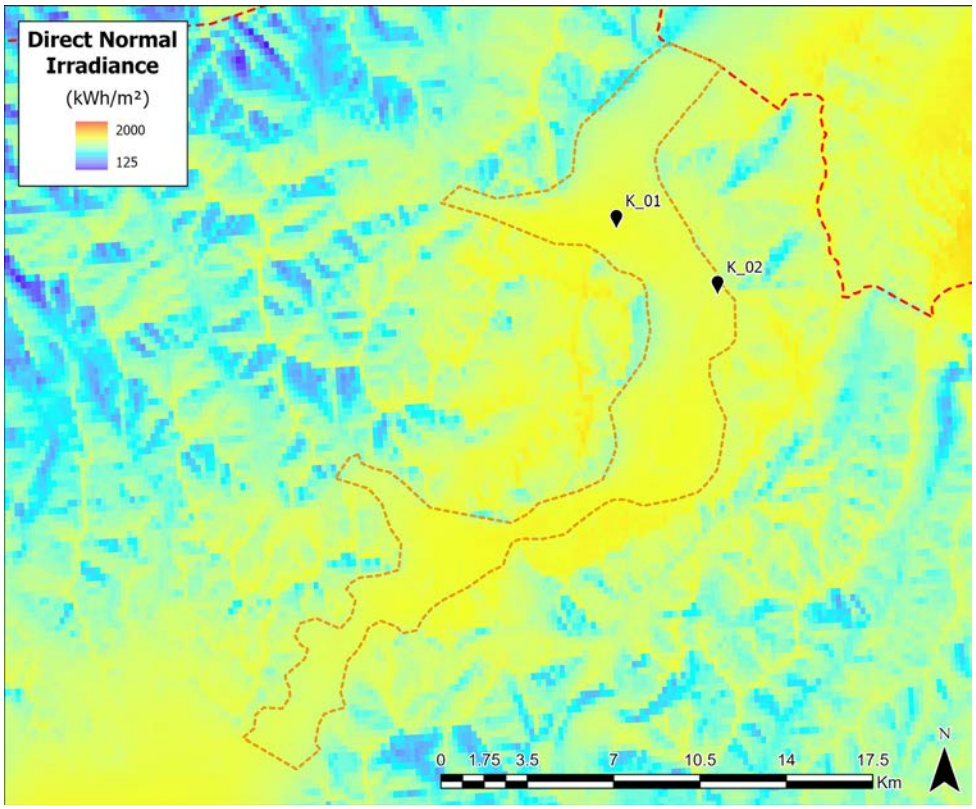


Table 6: Kingston Zone - Section Attributes

Category	Area (km^2)
Unrestricted area	93.36
Crown property	20.50
Protected area	2.78
Steep area (>10°)	0.00
TOTAL	116.65

Figure 9 shows a high and steady DNI across the zone. DNI values drop abruptly in the hilly areas of the Eyre Mountains to the North-West, and the Slate Range / Garvie Mountains to the South-East.

Figure 9: Kingston zone – Direct Normal Irradiation. Max: 1466 kWh/m²; Mean: 1376 kWh/m²



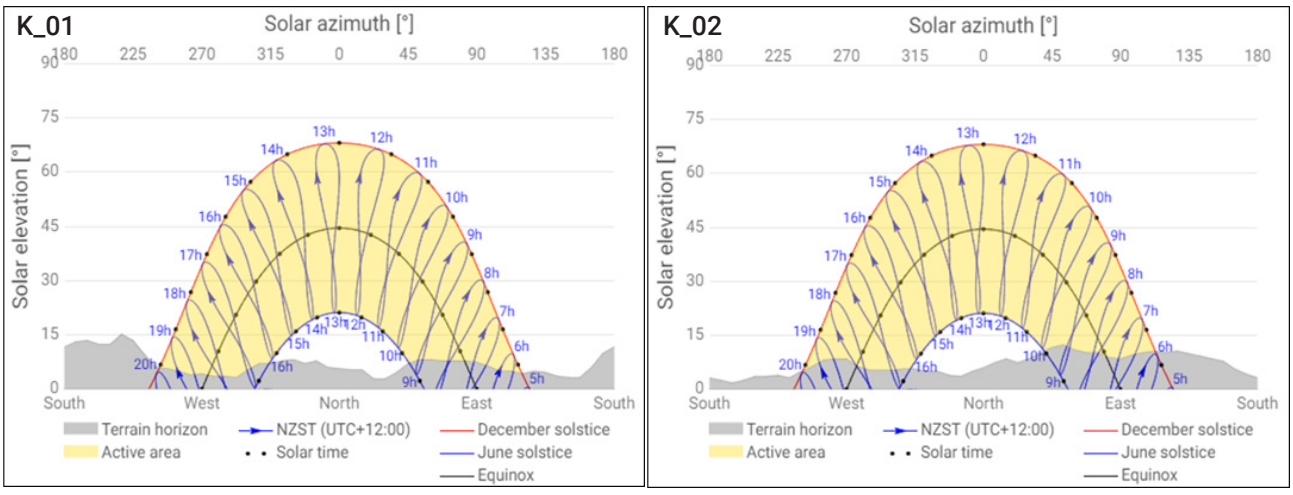
Control Point K_01 is located near to the highest DNI to indicate the best solar features in the zone. Control Point K_02 is located near to the Tapuae-o-Uenuku / Hector Mountains to indicate the potential obstruction of sunlight by the topography (Table 7 and Figure 10).

Table 7: Kingston Zone - Control points coordinates and annual solar resources.

ID	East (NZTM2000)	North (NZTM2000)	DNI (kWh/m²/year)	DIF (kWh/m²/year)	GHI (kWh/m²/year)	GTI opta (kWh/m²/year)*
K_01	1260706	4962617	1447.5	503.2	1288.2	1581.1
K_02	1264810	4959938	1373.7	498.4	1271.2	1545.9

** GTIopta is the preferred metric for assessing solar photovoltaic potential*

Figure 7: Kingston Zone - Sun path diagrams by the GSA



3.4 MONOWAI ZONE

Named after the hydroelectric station of Monowai, this zone extents to the town of Tuatapere to the South, Rowallan and Dean Forest to the West, Woodlaw Forest and the town of Ohai to the East, and Takitimu Mountains to the North. With a total area of 626.99 km^2, protected areas and crown property are largely distributed mainly across the Waiau and Wairaki rivers, while steep areas are identified to the centre (Figure 11 and Table 8).

Figure 11: Monowai Zone - Crown property, protection and steep areas

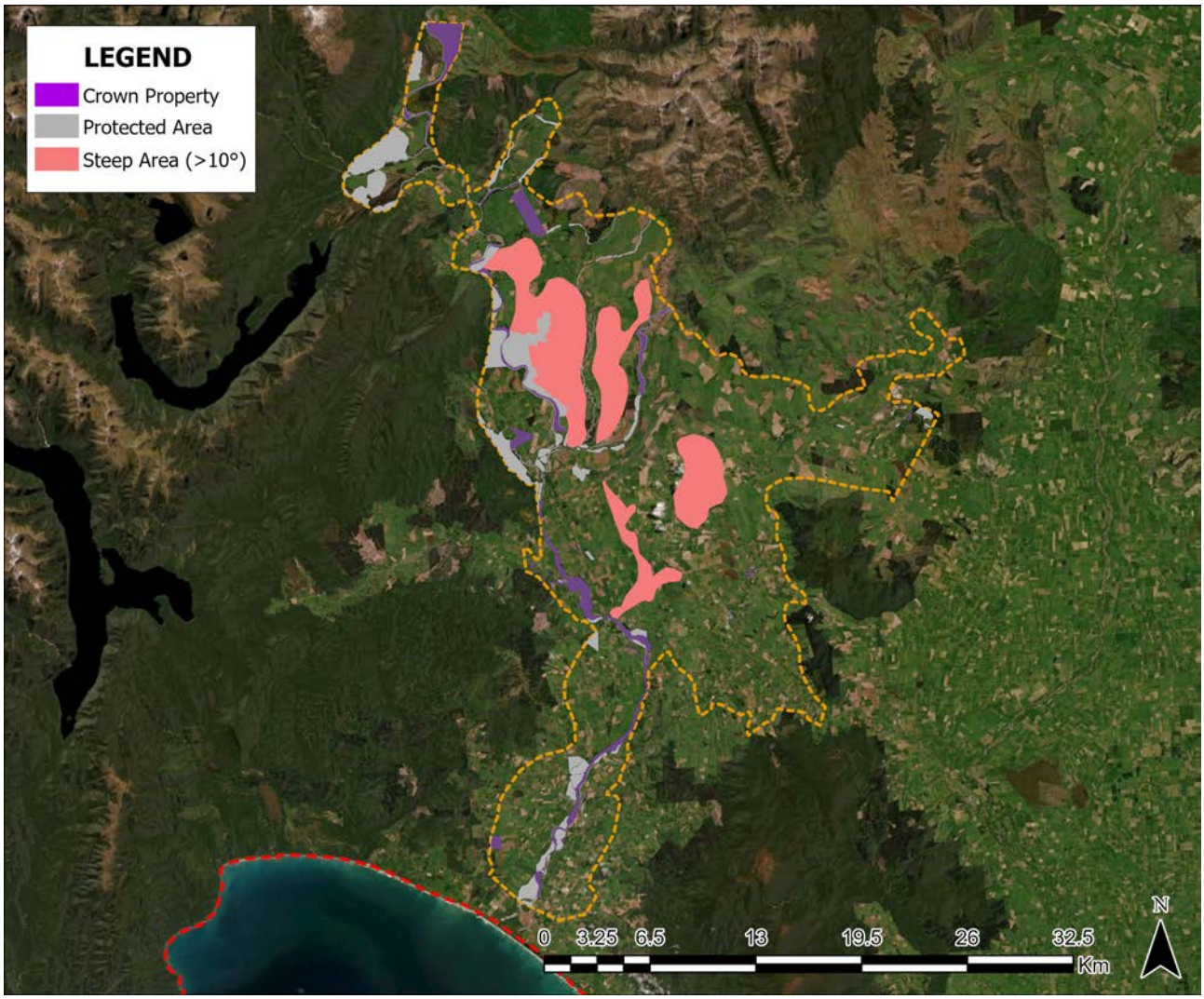
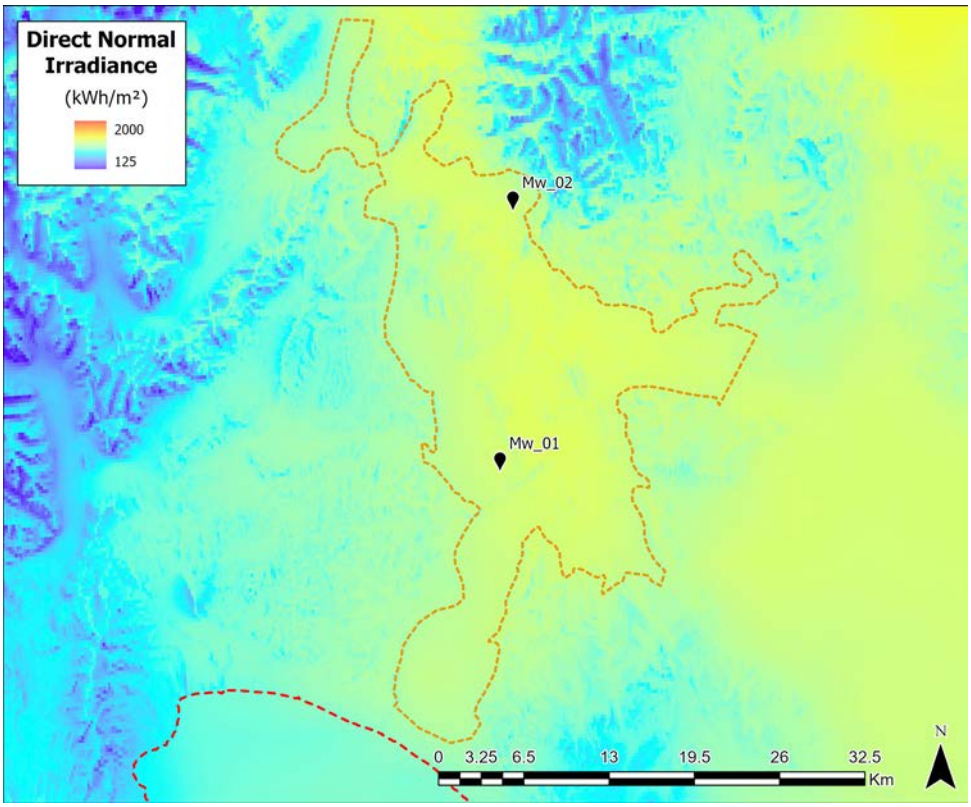


Table 8: Monowai Zone - Section Attributes

Category	Area (km^2)
Unrestricted area	499.65
Crown property	20.06
Protected area	36.88
Steep area (>10°)	70.40
TOTAL	626.99

Figure 12 show a slight increase in DNI to the East of the zone, while values drop abruptly to the North, West and South (Takitimu Mountains, The Fiorlands, and Longwood Range, respectively).

Figure 12: Monowai zone – Direct Normal Irradiation. Max: 1373 kWh/m²; Mean: 1292 kWh/m²



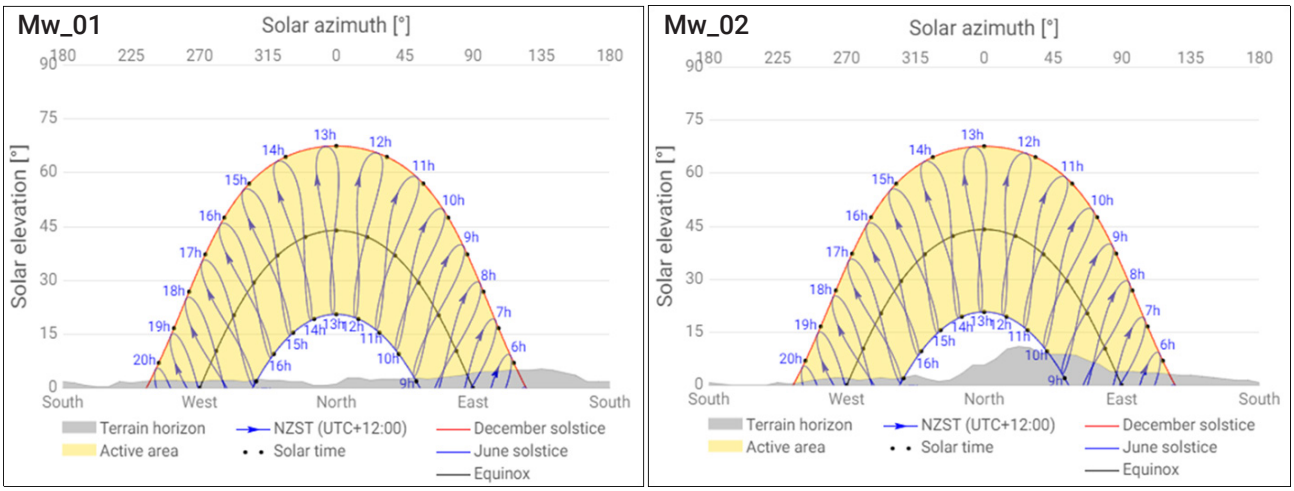
Control Point Mw_01 is located near to the highest DNI to indicate the best solar features in the zone. Control Point Mw_02 is located near to the Takitimu Mountains to indicate the potential obstruction of sunlight by the topography (Table 9 and Figure 13).

Table 9: Monowai Zone - Control points coordinates and annual solar resources.

ID	East (NZTM2000)	North (NZTM2000)	DNI (kWh/m²/year)	DIF (kWh/m²/year)	GHI (kWh/m²/year)	GTI opta (kWh/m²/year)*
Mw_01	1192167	4891191	1323.2	535.2	1230.9	1510.6
Mw_02	1193155	4911029	1333.6	524.8	1232.4	1502.7

** GTIopta is the preferred metric for assessing solar photovoltaic potential*

Figure 13: Monowai Zone - Sun path diagrams by the GSA



3.5 MOSSBURN ZONE

Named after the town of Mossburn, this zone extents to the town of Dipton to the South, Centre Hill to the West, the town of Lumsden to the East, and Lowther to the North. With a total area of 734.28 km^2, protected areas and crown property are distributed mainly across the Oreti and Aparima rivers. There are no steep areas in the zone (Figure 14 and Table 10).

Figure 14: Mossburn Zone - Crown property, protection and steep areas

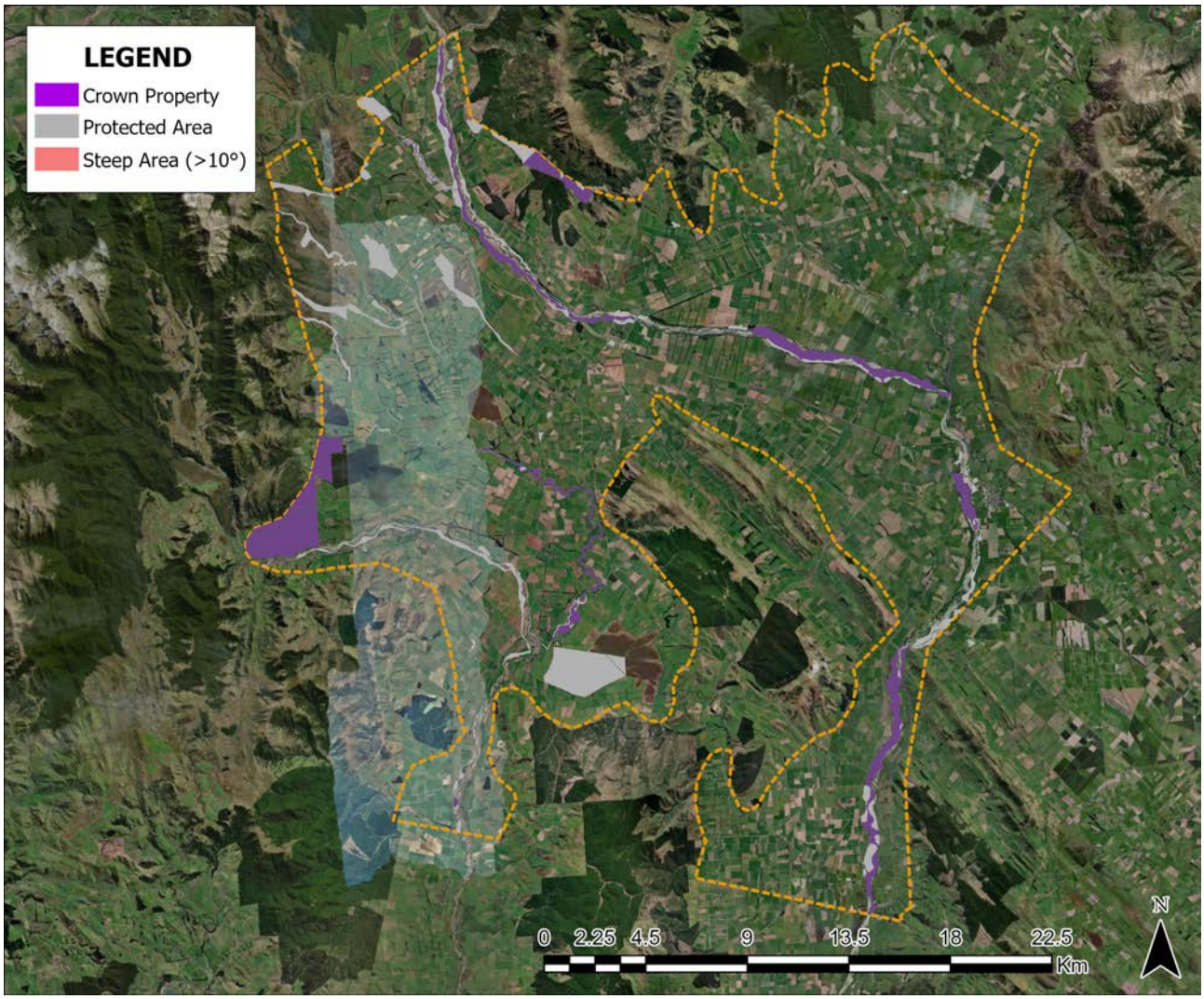
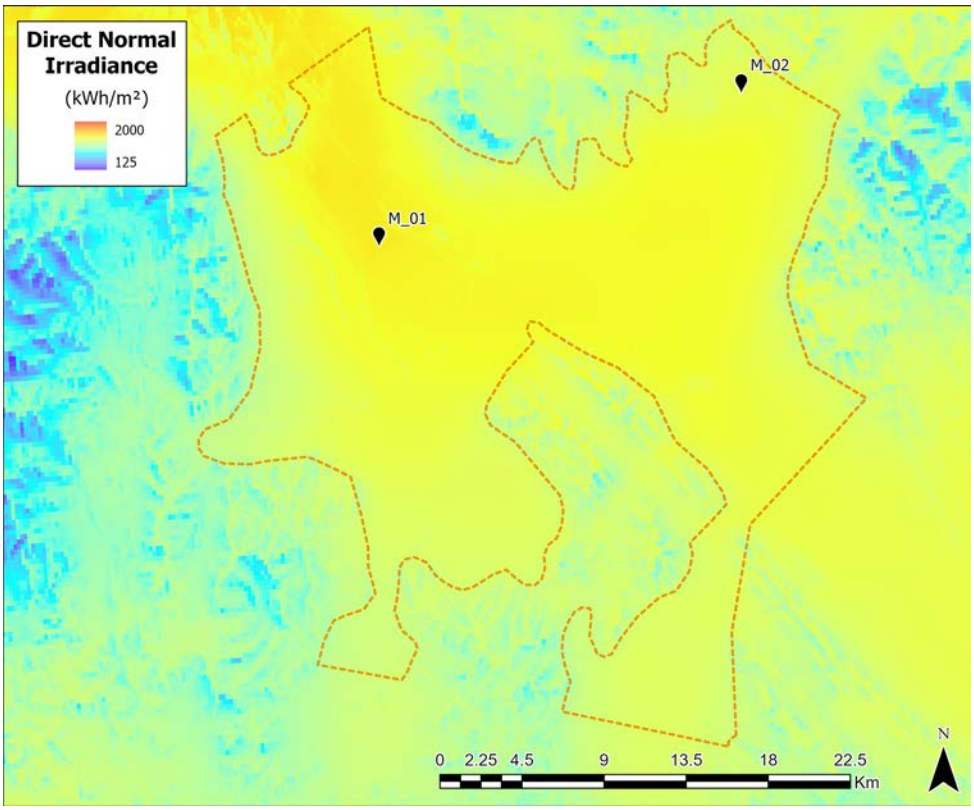


Table 10: Mossburn Zone - Section Attributes

Category	Area (km^2)
Unrestricted area	687.74
Crown property	23.09
Protected area	23.45
Steep area (>10°)	0.00
TOTAL	734.28

Figure 15 shows a significant increase in DNI towards the North-West, with low DNI values in the Takitimu Mountains to the West, the Mataura Range the North-East, the Eyre Mountains to the North, and the Taringatura Hills to the South.

Figure 15: Mossburn zone – Direct Normal Irradiation. Max: 1503 kWh/m²; Mean: 1400 kWh/m²



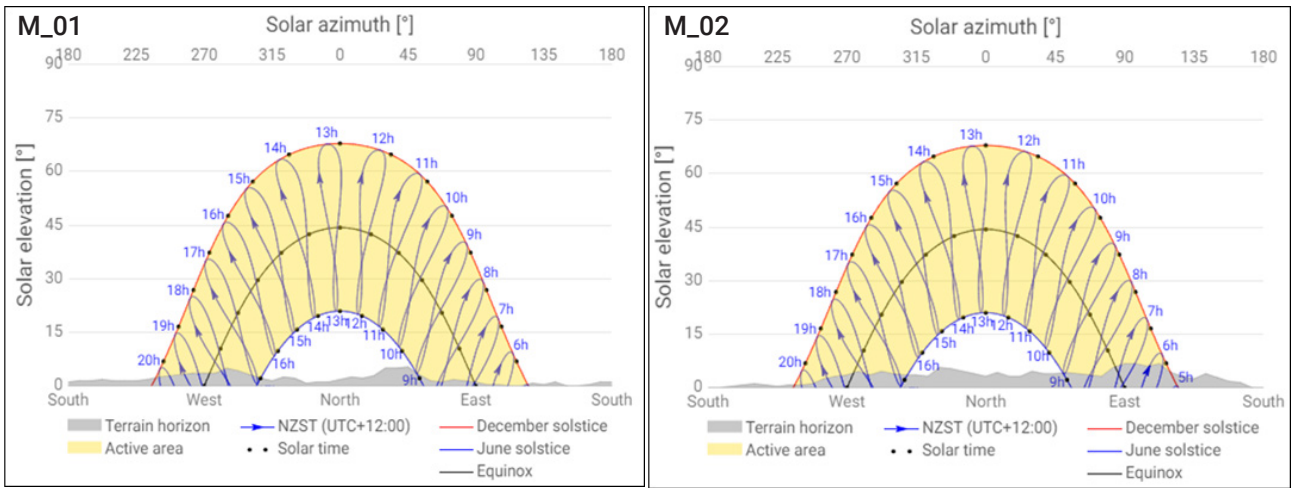
Control Point M_01 is located near to the highest DNI to indicate the best solar features in the zone. Control Point M_02 is located near to the Eyre Mountains to indicate the potential obstruction of sunlight by the topography (Table 11 and Figure 16).

Table 11: Mossburn Zone - Control points coordinates and annual solar resources.

ID	East (NZTM2000)	North (NZTM2000)	DNI (kWh/m²/year)	DIF (kWh/m²/year)	GHI (kWh/m²/year)	GTI opta (kWh/m²/year)*
M_01	1222464	4933458	1490.2	518.9	1300.2	1607.8
M_02	1242327	4941857	1414.4	513.5	1261.5	1557.5

** GTIopta is the preferred metric for assessing solar photovoltaic potential*

Figure 16: Mossburn Zone - Sun path diagrams by the GSA



3.6 RIVERSDALE ZONE

Named after the town of Riversdale, this zone extents to the Hokonui Hills to the South-West, Lintley to the North-West, Otama to the South-East, and Freshford to the North. With a total area of 715.92 km^2, protected areas and crown property are not prominent and are distributed mainly across the Mataura and Waikaia rivers, while steep areas are identified in the South-East (Figure 17 and Table 12).

Figure 17: Riversdale Zone - Crown property, protection and steep areas

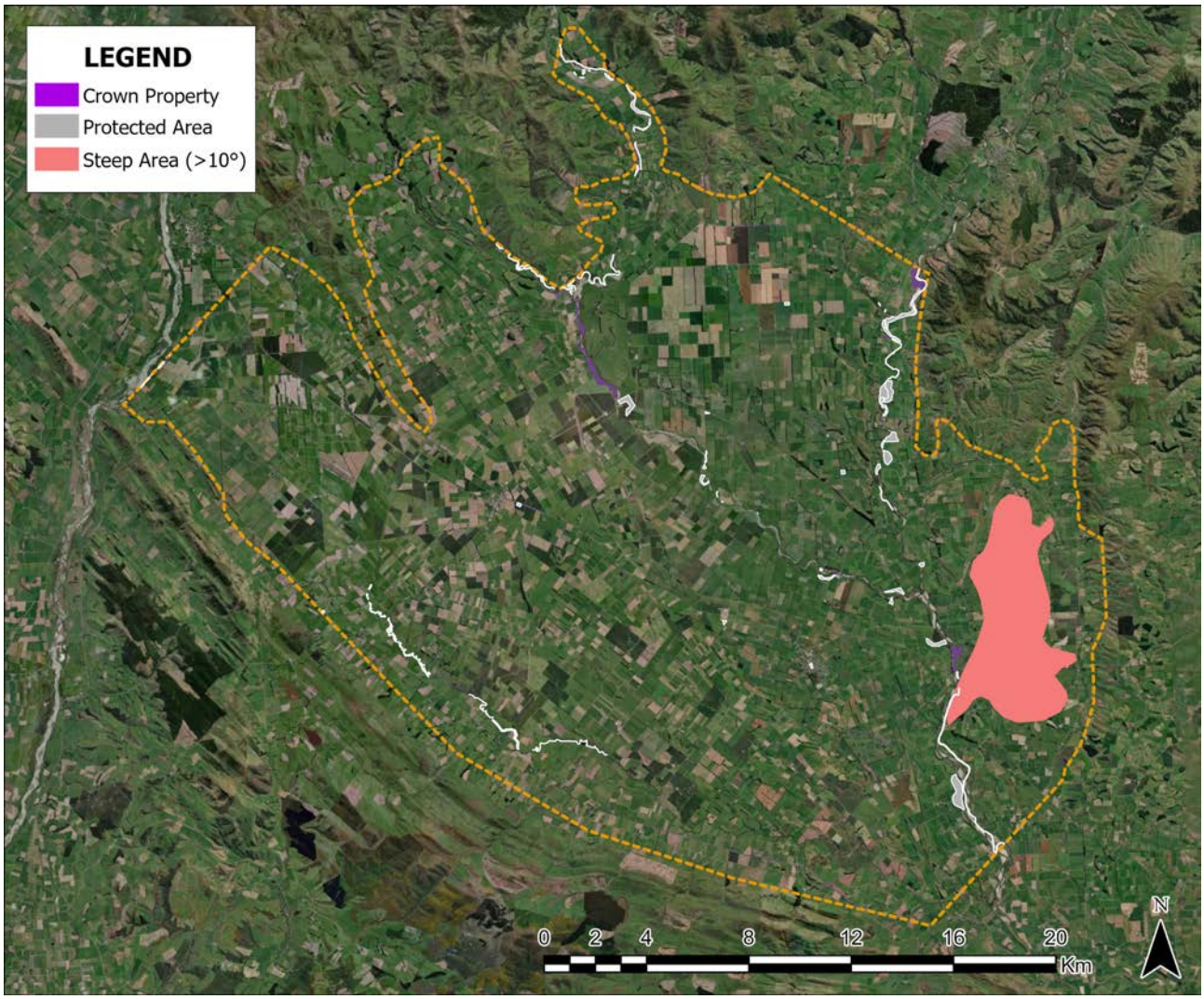
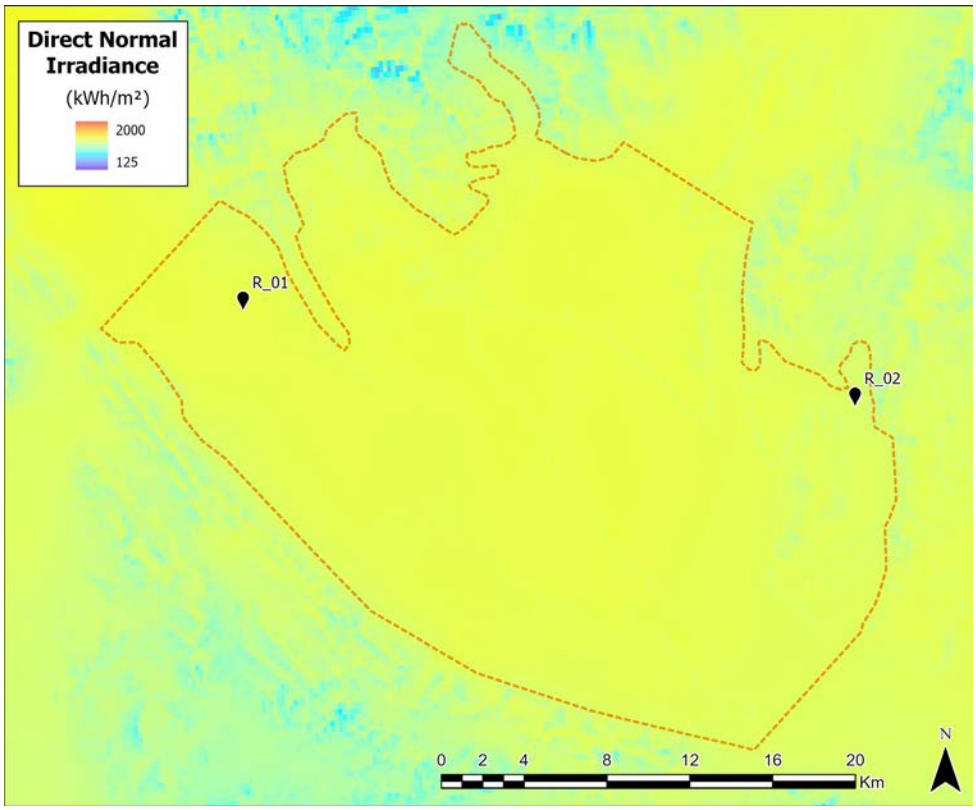


Table 12: Riversdale Zone - Section Attributes

Category	Area (km^2)
Unrestricted area	686.09
Crown property	1.94
Protected area	3.34
Steep area (>10°)	24.56
TOTAL	715.92

Figure 18 shows a high and steady DNI across the zone. Low DNI values are observed in the Hokonui Hills to the South-West, the Mataura Range to the North-West, and the Round Downs to the North-East.

Figure 18: Riversdale zone – Direct Normal Irradiation. Max: 1412 kWh/m²; Mean: 1388 kWh/m²



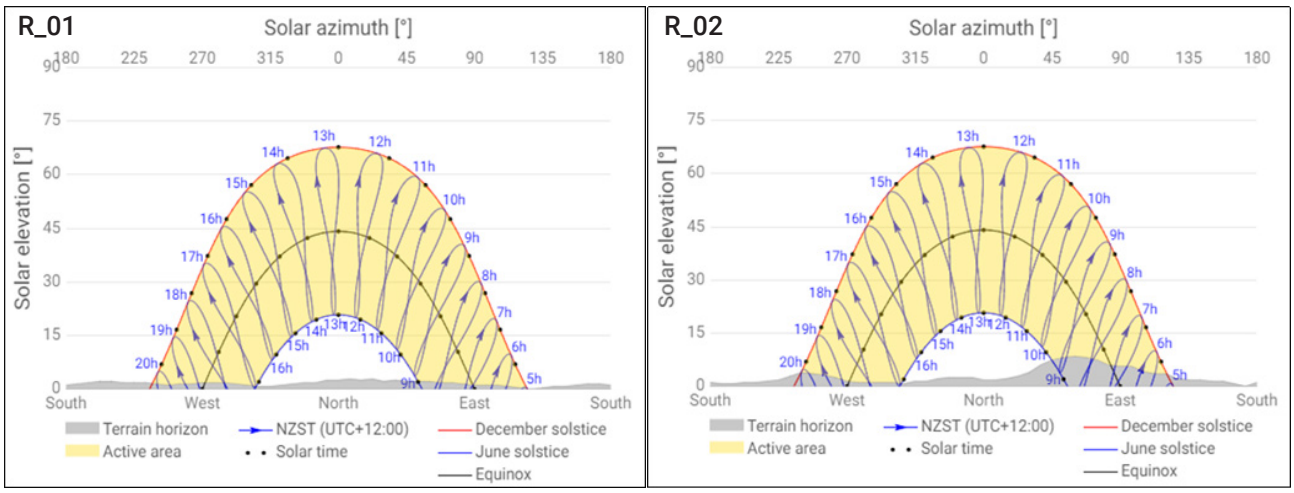
Control Point R_01 is located near to the highest DNI to indicate the best solar features in the zone. Control Point R_02 is located near to the Round Downs and Umbrella Mountains to indicate the potential obstruction of sunlight by the topography (Table 13 and Figure 19).

Table 13: Riversdale Zone - Control points coordinates and annual solar resources.

ID	East (NZTM2000)	North (NZTM2000)	DNI (kWh/m²/year)	DIF (kWh/m²/year)	GHI (kWh/m²/year)	GTI opta (kWh/m²/year)*
R_01	1249681	4919127	1405.8	514.3	1253.6	1546.1
R_02	1279246	4914491	1355	510.3	1233.7	1512

** GTIopta is the preferred metric for assessing solar photovoltaic potential*

Figure 19: Riversdale Zone - Sun path diagrams by the GSA



3.7 TE ANAU ZONE

Named after the town of Te Anau, this zone extents to the Takitimu Mountains to the South, lakes Manapouri and Te Anau to the West, Centre Hill to the East, and Livingstone Mountains to the North. With a total area of 1259.84 km^2, protected areas are distributed to the North and West corresponding to Snowdon Forest Conservation state and Fiordland National Park, respectively. Steep areas are identified to the East in The Haycocks (Figure 20 and Table 14).

Figure 20: Te Anau Zone - Crown property, protection and steep areas

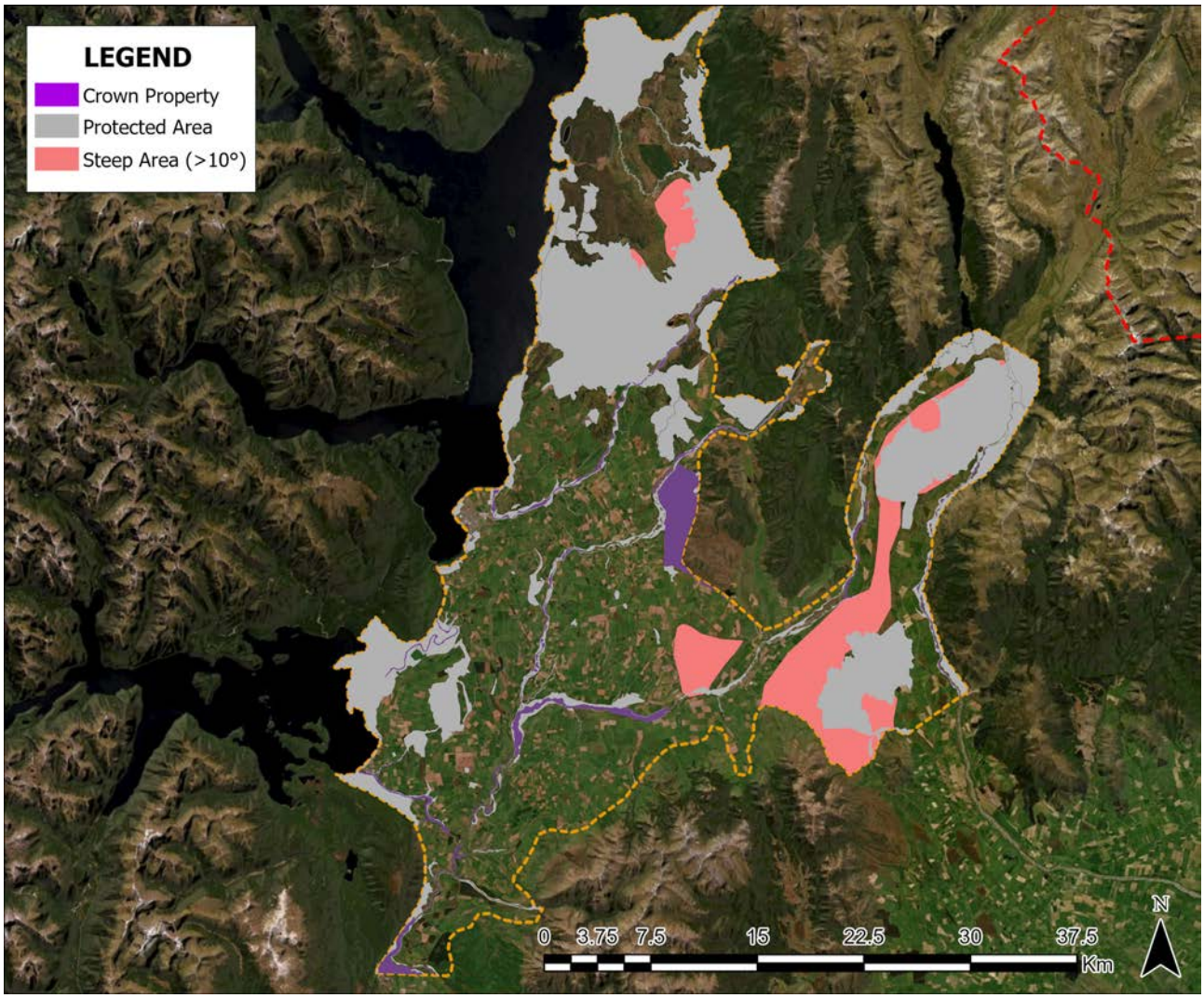
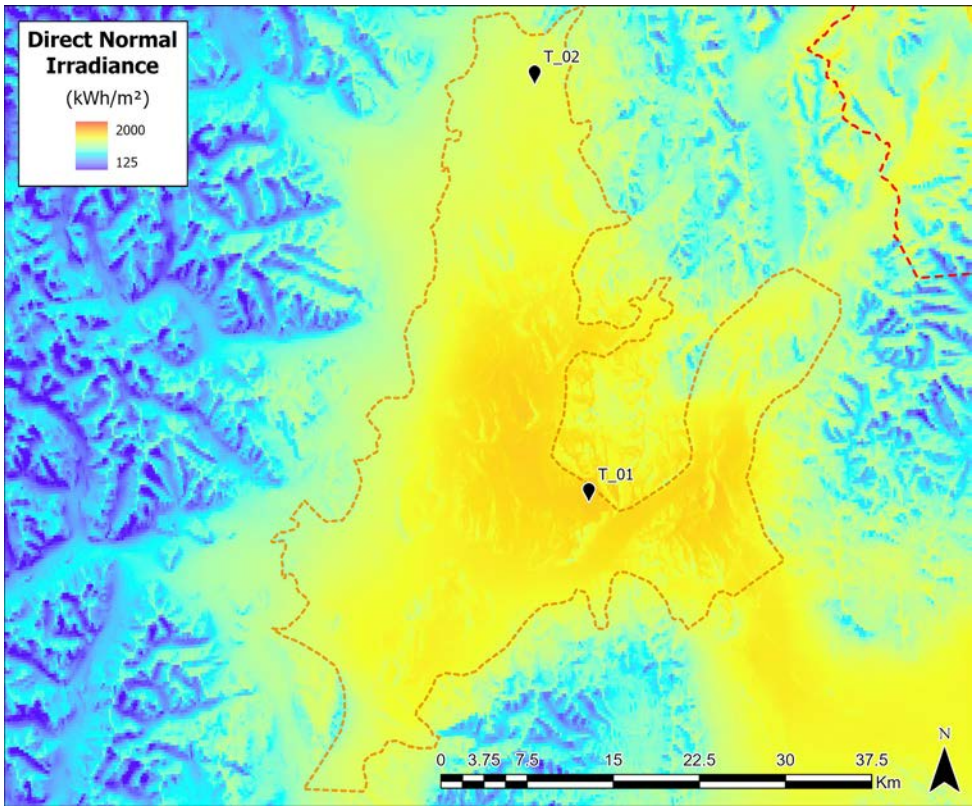


Table 14: Te Anau Zone - Section Attributes

Category	Area (km^2)
Unrestricted area	753.56
Crown property	32.96
Protected area	386.48
Steep area (>10°)	86.84
TOTAL	1259.84

Figure 21 shows an important increase in DNI towards the centre of the zone. Low DNI values are observed in the Kepler and Hunter Mountains to the West, the Takitimu Mountains to the South, the Longstone Mountains to the North, and the Eyre Mountains to the East.

Figure 21: Te Anau zone – Direct Normal Irradiation. Max: 1589 kWh/m²; Mean: 1426 kWh/m²



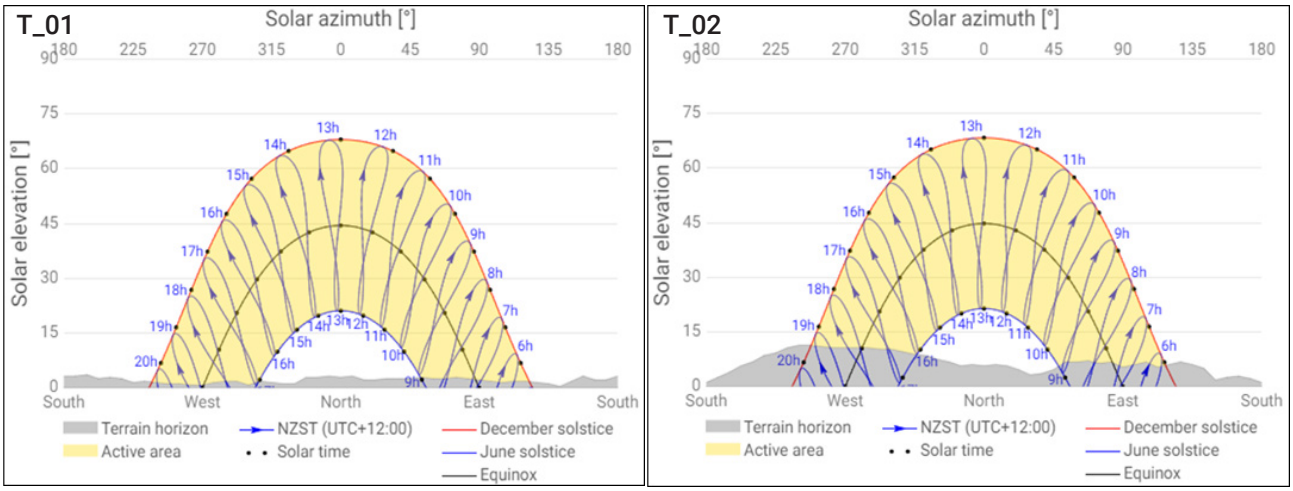
Control Point T_01 is located near to the highest DNI to indicate the best solar features in the zone. Control Point T_02 is located near to the Livingstone and Stuart Mountains to indicate the potential obstruction of sunlight by the topography (Table 15 and Figure 22).

Table 15: Te Anau Zone - Control points coordinates and annual solar resources.

ID	East (NZTM2000)	North (NZTM2000)	DNI (kWh/m²/year)	DIF (kWh/m²/year)	GHI (kWh/m²/year)	GTI opta (kWh/m²/year)*
T_01	1204896	4950543	1570.1	516.7	1344	1659.3
T_02	1200173	4986860	1368.7	505.1	1260.3	1513.3

** GTIopta is the preferred metric for assessing solar photovoltaic potential*

Figure 22: Te Anau Zone - Sun path diagrams by the GSA



3.8 WAIKAIA ZONE

Named after the town of Waikaia, this zone extents to Freshford to the South, the Garvie Mountains to the North-West, the Black Umbrella Range to the South-East, and Piano Flat the North-East. With a total area of 113.16 km^2, protected areas and crown property are distributed mainly across the Waikaia River and Dome Burn. There are no steep areas in the zone (Figure 23 and Table 16).

Figure 23: Waikaia Zone - Crown property, protection and steep areas

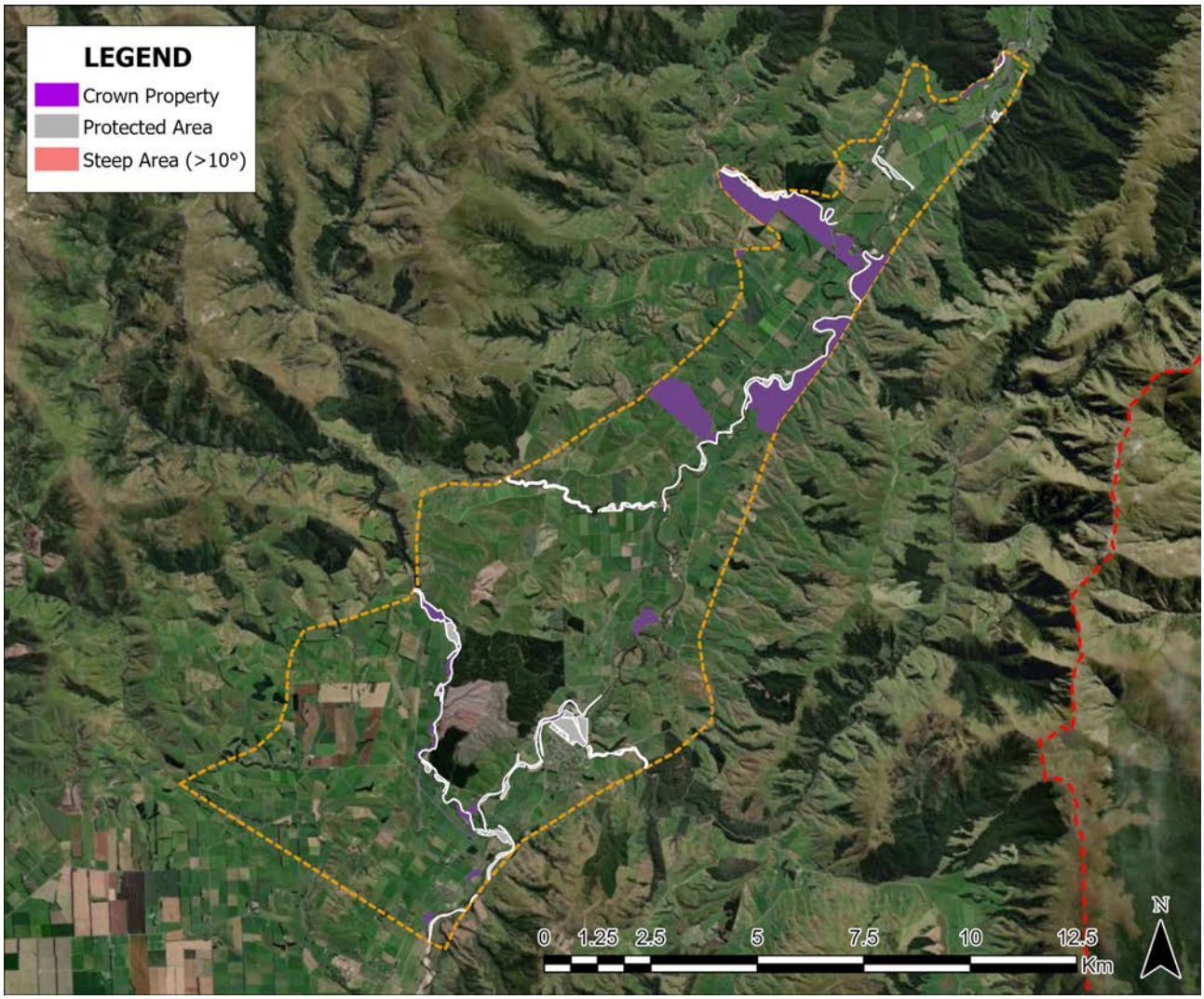
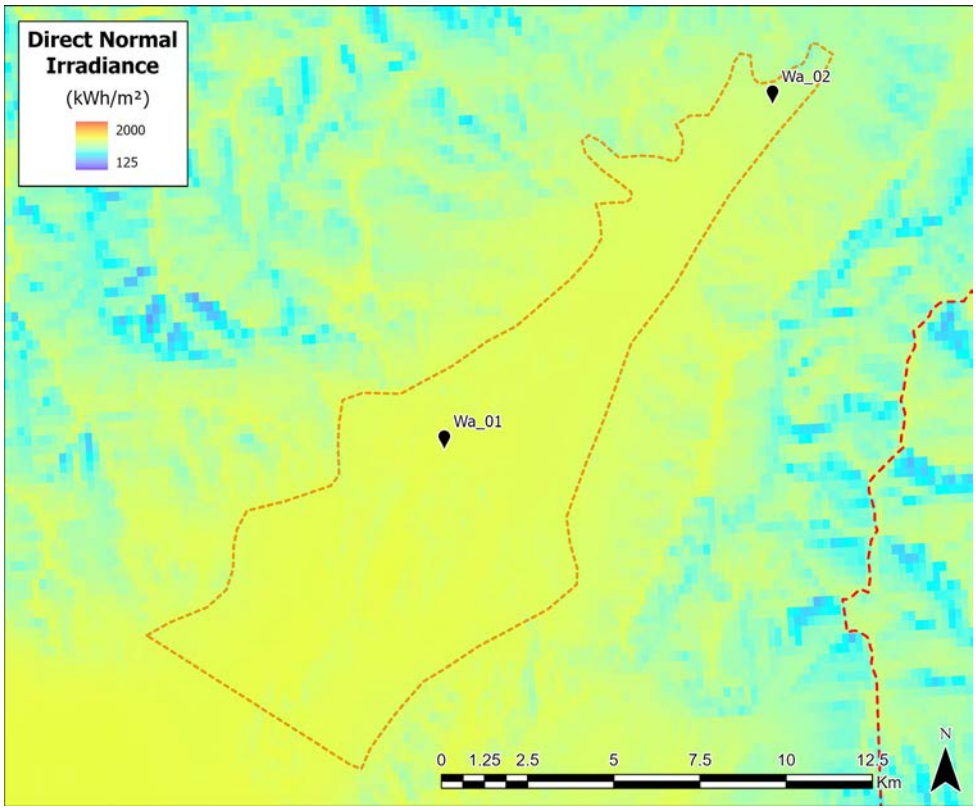


Table 16: Waikaia Zone - Section Attributes

Category	Area (km^2)
Unrestricted area	104.98
Crown property	5.97
Protected area	2.21
Steep area (>10°)	0.00
TOTAL	113.16

Figure 24 shows a gradual increase in DNI towards the South-West. Low DNI values are observed in the Garvie Mountains to the North-West, and the Black Umbrella Range to the East.

Figure 24: Waikaia zone – Direct Normal Irradiation. Max: 1407 kWh/m²; Mean: 1370 kWh/m²



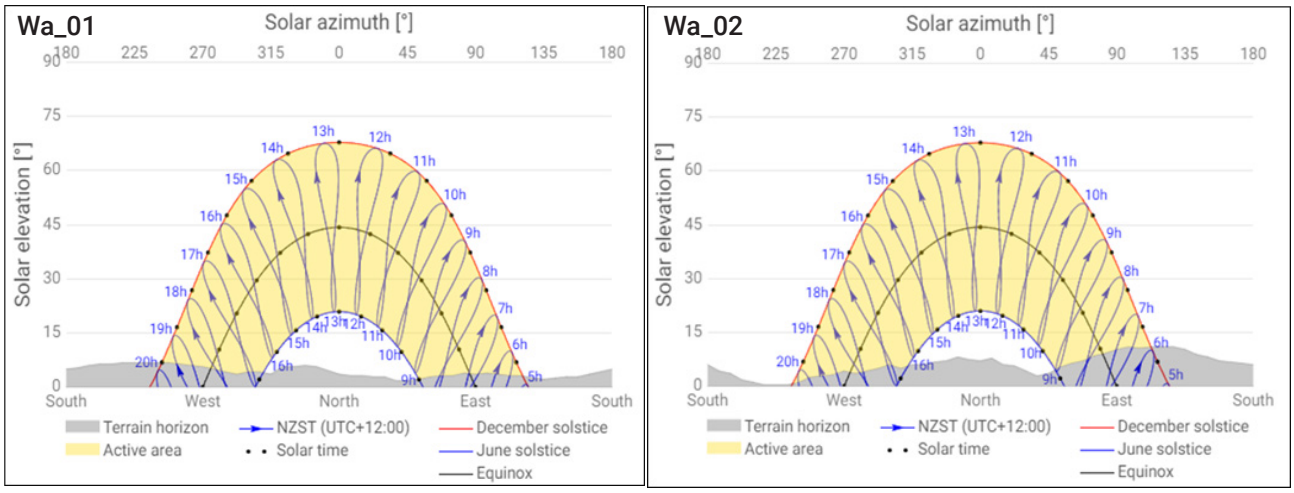
Control Point Wa_01 is located near to the highest DNI to indicate the best solar features in the zone. Control Point Wa_02 is located to the North between the Garvie and Umbrella Mountains to indicate the potential obstruction of sunlight by the topography (Table 17 and Figure 25).

Table 17: Waikaia Zone - Control points coordinates and annual solar resources.

ID	East (NZTM2000)	North (NZTM2000)	DNI (kWh/m²/year)	DIF (kWh/m²/year)	GHI (kWh/m²/year)	GTI opta (kWh/m²/year)*
Wa_01	1276698	4932660	1393.2	511.6	1252.5	1550.4
Wa_02	1286219	4942664	1309.9	501.6	1207.7	1480.2

** GTIopta is the preferred metric for assessing solar photovoltaic potential*

Figure 25: Waikaia Zone - Sun path diagrams by the GSA



3.9 WINTON ZONE

Named after the town of Winton, this zone extents to Lochiel to the South-East, the Longwood Range and Woodlaw Forest to the West, the Taringatura Hills to the North, and the Hokonui Hills to the North-East. With a total area of 1526.94 km^2, protected areas and crown property are distributed mainly across the Oreti and Aparima rivers, while steep areas are identified to the East of Winton (Figure 26 and Table 18).

Figure 26: Winton Zone - Crown property, protection and steep areas

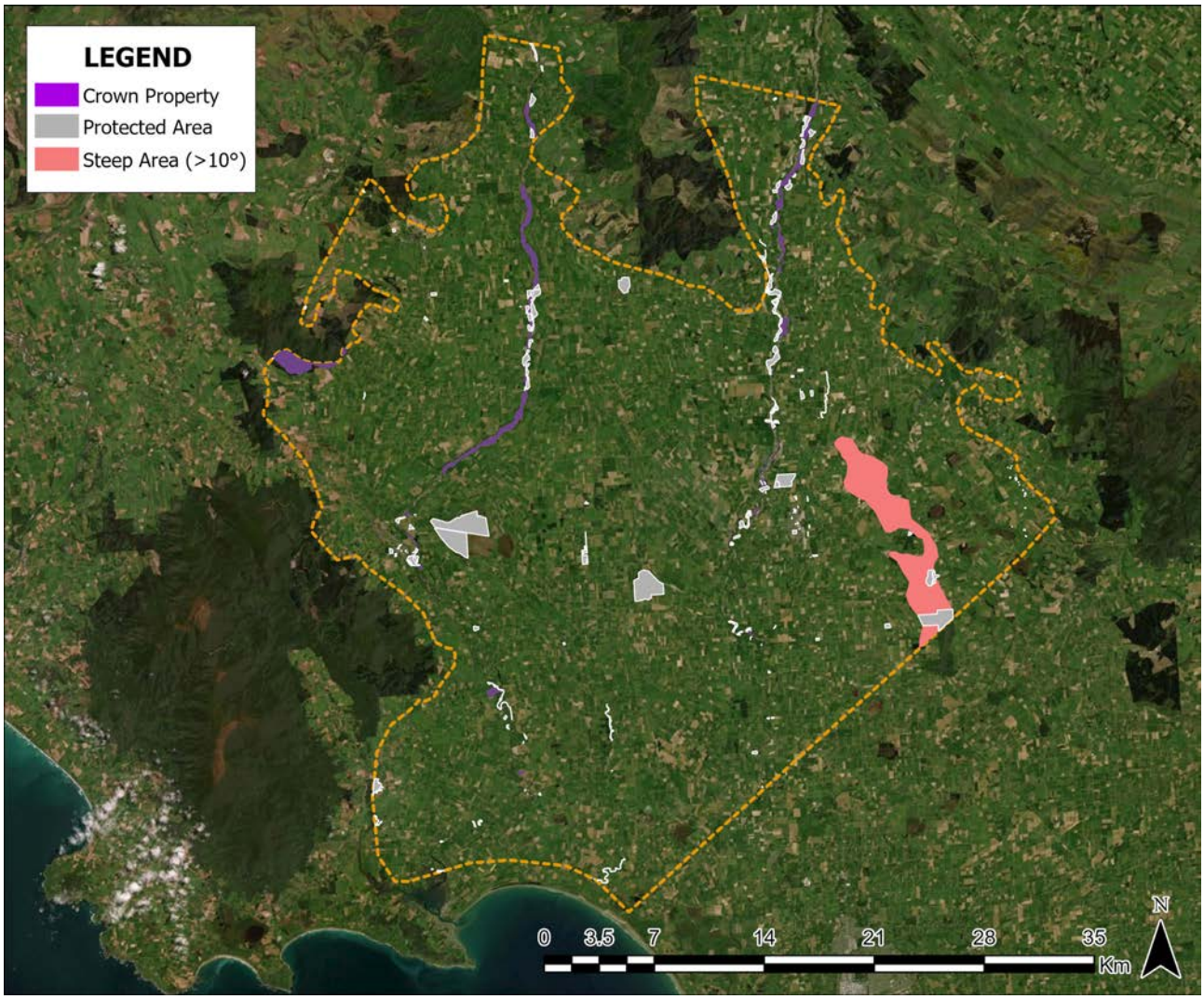
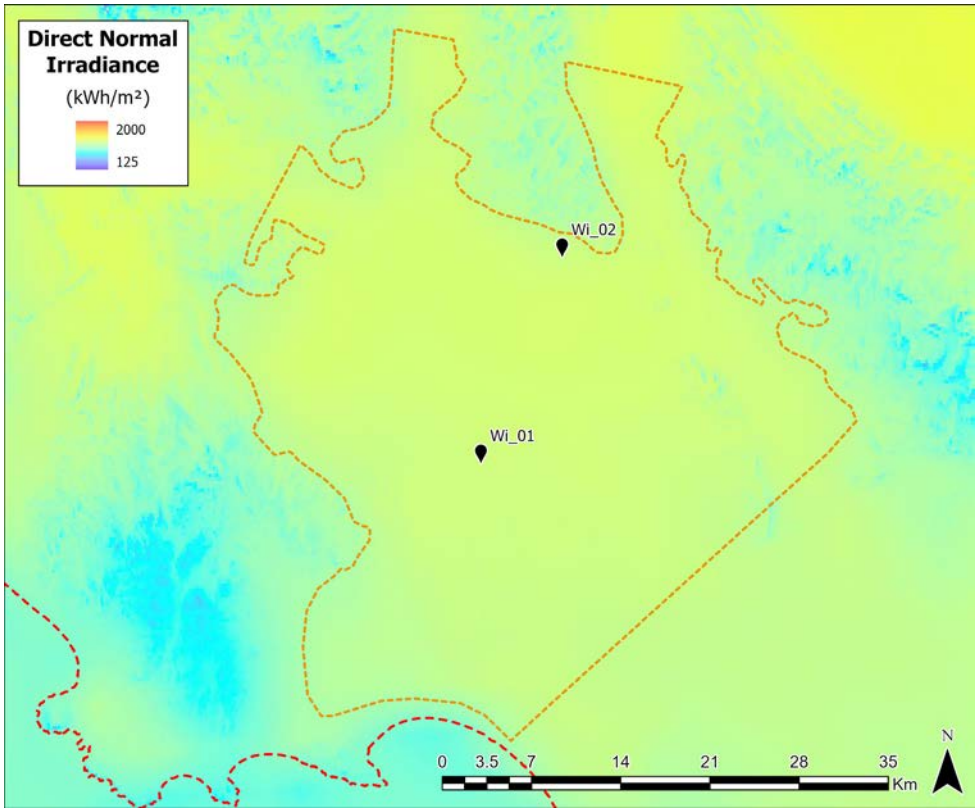


Table 18: Winton Zone - Section Attributes

Category	Area (km^2)
Unrestricted area	1470.14
Crown property	13.53
Protected area	19.47
Steep area (>10°)	23.81
TOTAL	1526.94

Figure 27 shows a gradual increase in DNI towards the North. Low DNI values are observed in the Longwood Range to the South-West, the Taringatura Hills to the North, and the Hokonui Hills to the North-East.

Figure 27: Winton zone – Direct Normal Irradiation. Max: 1356 kWh/m²; Mean: 1295 kWh/m²



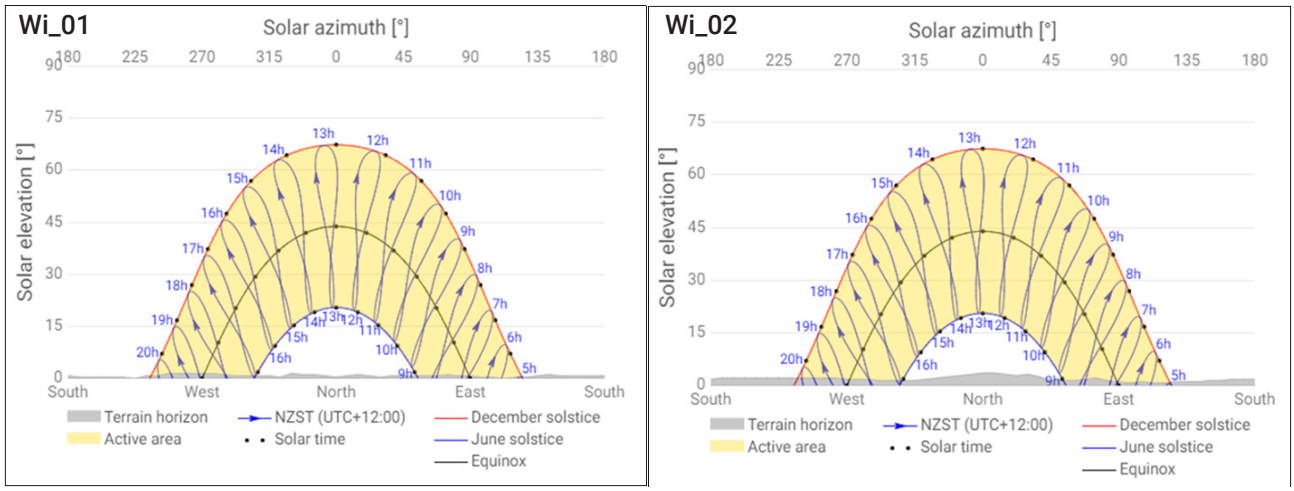
Control Point Wi_01 is located near to the Taringatura Hills to indicate the potential obstruction of sunlight by the topography (Figure 28). Control Point Wi_02 is located near to the average DNI to indicate the solar features in the zone (Table 19).

Table 19: Winton Zone - Control points coordinates and annual solar resources.

ID	East (NZTM2000)	North (NZTM2000)	DNI (kWh/m²/year)	DIF (kWh/m²/year)	GHI (kWh/m²/year)	GTI opta (kWh/m²)/year)*
Wi_01	1225878	4876501	1307.2	534.7	1217.1	1490.7
Wi_02	1232252	4892656	1307.9	528.1	1206.3	1483.8

** GTIopta is the preferred metric for assessing solar photovoltaic potential*

Figure 28: Winton Zone - Sun path diagrams by the GSA



Summary

- **Solar resources are broken-down into three categories: Direct Normal Irradiation (DNI), Diffuse Horizontal Irradiation (DIF), and Global Horizontal Irradiation (GHI)**
  - Irradiation quantifications were obtained from the Global Solar Atlas (GSA)
- **The DNI was used to identify the solar resources within the region.**
  - Solar resources tend to be higher in relatively flat areas and lower in hilly areas.
  - Solar resources tend to gradually decrease towards the South
  - The highest solar resources within Southland are in the Te Anau Zone (Appendix A)
- **To define the potential zones for solar energy, the areas with DNI ≥ 1200 kWh/m^2 and slopes ≤ 10° were considered**
  - A large area with solar potential in central and eastern Southland was identified.
  - The potential area was divided into 9 smaller zones to simplify the reporting of results.
  - Potential zones were named after notable geographic or toponymic locations nearby.
  - Protected areas, crown property and steep areas (>10°) are identified and displayed for each zone.
- **Two control points were added to each location.**
  - One control point located near to the highest DNI to indicate the solar resources, and another near to high topography to indicate its potential obstruction of sunlight.
  - Hours of sunlight are shown in the sun path diagrams provided by the GSA.
  - The best solar resources are found in the Te Anau Zone, control point T_01, with a DNI of 1575.7 kWh/m^2 and a GHI Opta of 1659.3 kWh/m^2 (Table 20).
  - The duration of daily sunlight obstruction by topography varies depending on specific location and the time of the year. The largest duration observed is approximately between 2 and 2.5 hours in a day for the control point K_02 during winter (Figure 10).

Table 20: Control points annual solar resources summary.

Zone	Control Point	DNI (kWh/m²)	DIF (kWh/m²)	GHI (kWh/m²)	GTI opta (kWh/m2)*
Te Anau	T_01	1575.7	516.7	1344	1659.3
	T_02	1368.7	505.1	1260.3	1513.3
Mossburn	M_01	1490.2	518.9	1300.2	1607.8
	M_02	1414.4	513.5	1261.5	1557.5
Kingston	K_01	1447.5	503.2	1288.2	1581.1
	K_02	1373.7	498.4	1271.2	1545.9
Waikaia	Wa_01	1393.2	511.6	1252.5	1550.4
	Wa_02	1309.9	501.6	1207.7	1480.2
Riversdale	R_01	1405.8	514.3	1253.6	1546.1
	R_02	1355	510.3	1233.7	1512
Gore	G_01	1398	518	1249.9	1540.5
	G_02	1301.6	531.7	1211.3	1487.3
Invercargill	I_01	1276.3	535.8	1212.5	1476.3
	I_02	1257.3	537.8	1195.3	1458.9
Winton	Wi_01	1307.2	534.7	1217.1	1490.7
	Wi_02	1307.9	528.1	1206.3	1483.8
Monowai	Mw_01	1323.2	535.2	1230.9	1510.6
	Mw_02	1333.6	524.8	1232.4	1502.7

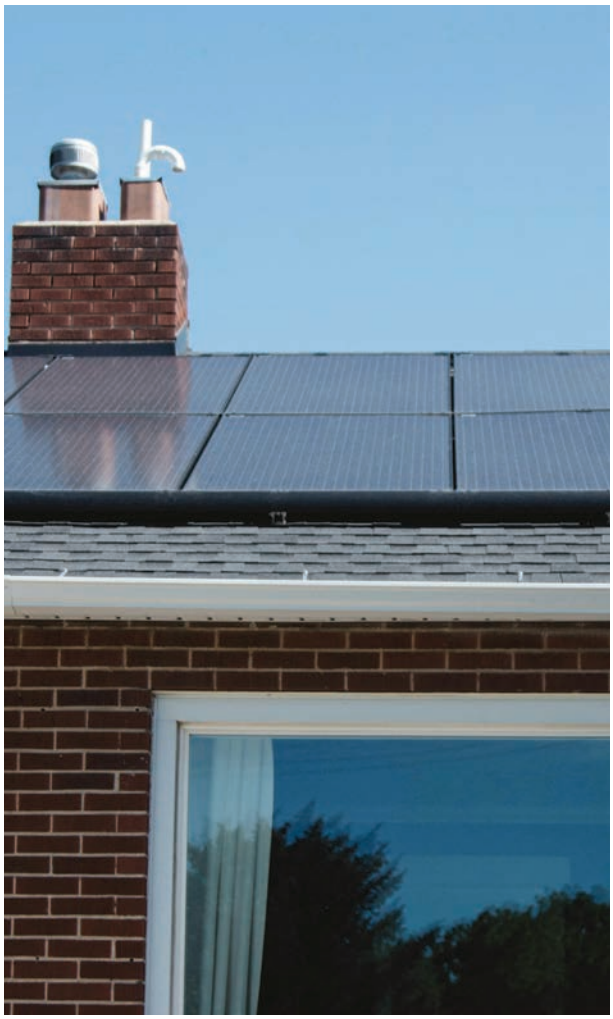
** GTIopta is the preferred metric for assessing solar photovoltaic potential*

Limitations

- In comparison with the global values of Irradiation (according to GSA), New Zealand in general has low to moderate values of DNI. Though solar resources in Southland are not the best, they are high enough to be worthy of consideration and further evaluation.
- Other factors such as weather and climate change are not directly considered in this report. Those factors may affect the amount of irradiation received and, if necessary, should be evaluated further. Note that the GSA model already considers the attenuation effect of clouds by means of cloud index calculation.
- The amount of direct sunlight received can be affected by the topography nearby. In this situation the duration of underperformance will vary significantly according to the location and time of the year.
- This report is limited to identifying areas with sufficient solar resources. It does not analyse the specific yield (Photovoltaic Power Potential), which varies according to different photovoltaic systems.

Recommendations

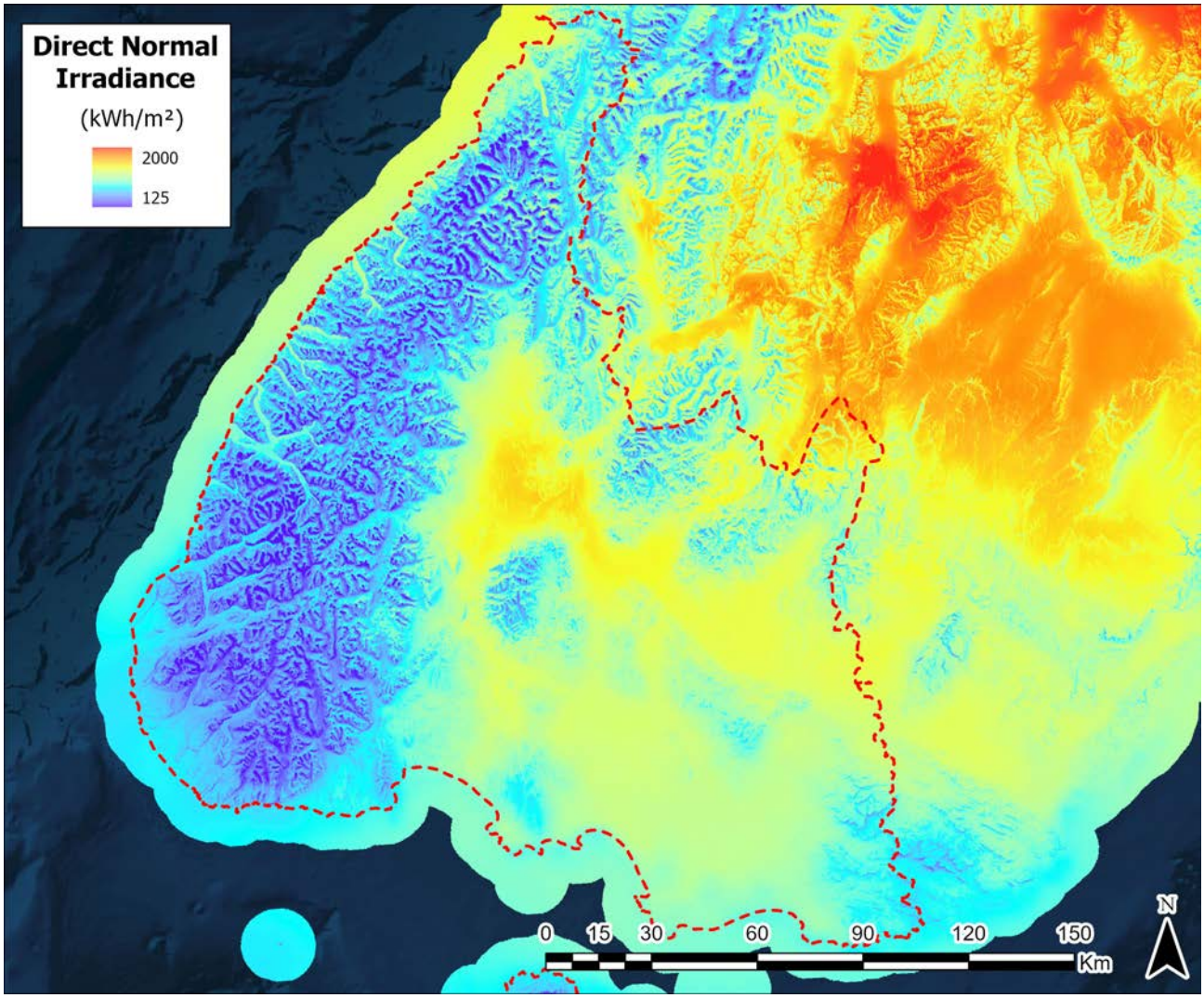
- It is important to seek third part advice when planning solar or any renewable energy investment.
- If any location is of interest, an analysis of accessibility to existing transmission infrastructure should be carried out. This will help to better identify the needs and required actions.
- Nearby topography should be considered carefully, as it will affect the amount of solar Irradiation received.
- To obtain the maximum benefit from solar power, solar panels should rotate and point directly to the sun. For static systems, the latitude must be considered to identify the optimum angle from which the greater solar power can be harnessed. For Southland, the optimum angle is around 40°pointing to the True North (may vary slightly for different locations.



For further information please contact info@greatsouth.nz subject line "Solar Resources Inquiry".

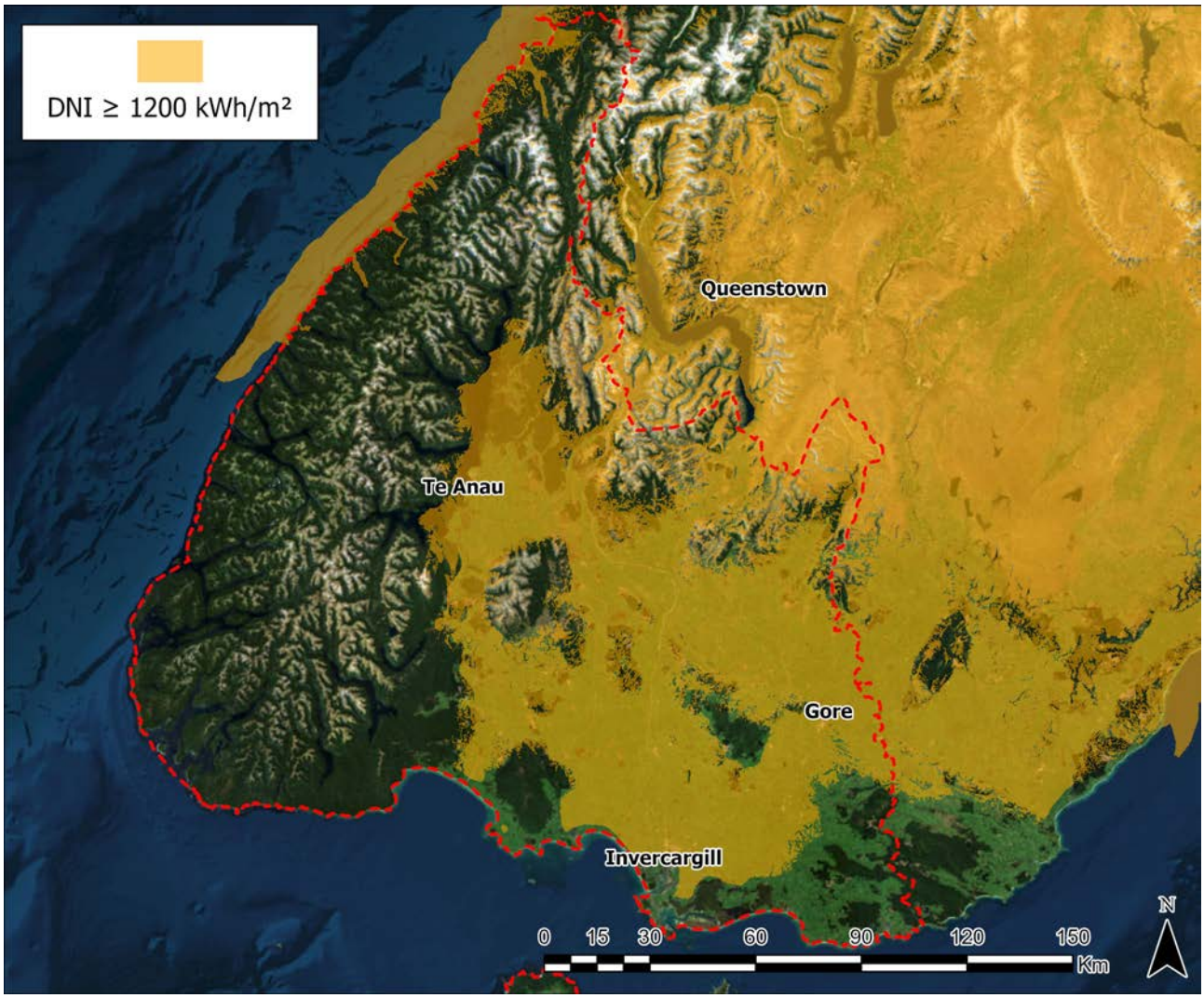
Appendix A

Figure 29. Annual Direct Normal Irradiation map – Southland (Source: GSA).



Appendix B

Figure 30. Annual Direct Normal Irradiation over 1200 kwh/m² – Southland (Source: GSA).



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