APPENDIX 3

Engineering Alternatives and Optimisation Report - Ruakākā Energy Park Solar Farm

Ruakākā Energy Park Solar Farm

Prepared for Meridian Energy Ltd
Prepared by Beca Limited

30 August 2023

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Table of Contents

Revision History

Revision Nº	Prepared By	Description	Date
1	Tim Hopkins	Draft for client review	02/06/2023
2	Tim Hopkins	First Issue	07/07/2023
3	Tim Hopkins (with input from Meridian & Reyburn & Bryant)	Second Issue	03/08/2023
4	Isaac Kenny	Removing Watermark	30/08/2023

Document Acceptance

Action		Name	Signed	Date
Prepared by		Tim Hopkins		30/08/2023
Reviewed by		Harshal Patel		30/08/2023
Approved by		Alex Aramakutu		30/08/2023
on behalf of	Beca Limited	Beca Limited		

Executive Summary

Beca Limited (Beca) has been engaged by Meridian Energy Limited (Meridian) to prepare a consent level design for the proposed Ruakākā Energy Park Solar Farm in Northland. Boffa Miskell have been engaged by Meridian to undertake an ecological assessment as part of this development and have identified the presence of natural wetlands on Site 1.

To inform an application of the effects management hierarchy under the National Policy Statement for Freshwater Management 2020 (NPS-FM) and the National Environmental Standards for Freshwater Management (NES-FM) in relation to the proposed solar farm, Beca have developed and assessed a do nothing option and six site configuration options with a view to achieving an efficient and practicable solar farm with regional benefits.

The options are as follows:

- Option 1 - No solar development on Site 1
- Option 2 - Full wetlands removal on Site 1 with full offset on Site 3
- Option 3 - Full solar development on Site 1, constructing and operating the solar farm while maintaining existing wetlands
- Option 4 - Partial wetland removal on Site 1 to avoid most open water pond habitat, partial offset on Site 3
- Option 5 - Partial wetland removal on Site 1 to avoid majority of wetlands, partial offset on Site 3
- Option 6 - Partial wetland removal on Site 1 to avoid most southern open water areas and enlarging and enhancing the wetland in this area while creating an ecological corridor to the kanuka forest.
- Option 7 - Partial wetland removal on Site 1 to avoid most eastern wetland areas

The report also includes analysis and optimisation; considering fixed tilt, single axis tracking, and contour following single axis tracking solar farm arrangements.

The effects management hierarchy is a consenting gateway test applied by consent authorities when considering an application for resource consent to authorise the construction or upgrade of specified infrastructure (in this case a solar farm) that impacts on identified wetland areas.

This report uses a multi-criteria analysis to evaluate the options against relevant criteria including extent of wetland impact, flood risk to assets and other properties, safety, maintainability, sustainability, cost, capacity, yield and transmission route.

This analysis and optimisation has determined that Option 6 is the preferred engineering solution and optimal solar farm arrangement for the Ruakākā Energy Park Solar Farm for the following reasons:

- It is a viable and practicable option which we understand provides significant benefits to the Northland region.[1]
- It has high yield and capacity, which is essential to create an economically viable project and return on investment for Meridian, a criterion which is required for the Solar Farm to be constructed.

[1] Significant benefits as described in Section 5.3 'Assessment of environmental effects, Positive effects' of Reyburn & Bryant's 'Proposed solar energy development' document.

- Workers' safety during construction and operations are crucial factors, with Option 6 considered the safest option.
- Maintainability (and in turn improved operational resilience), with Option 6 considered the most manageable option.
- Sustainability outcomes are achieved by minimising earthworks required and excavation in peat-dominated areas; and
- It demonstrates a practicable extent of wetland avoidance and the impact minimisation on residual wetland areas

Option 6 is recommended as the design basis for the resource consent applications.

1 Introduction

Meridian Energy Limited (Meridian) are undertaking the development of a new solar farm across three sites in Ruakākā, Northland, as shown in Figure 1-1 as part of the Ruakākā Energy Park. The first stage of the Ruakākā Energy Park is Meridian's Battery Energy Storage System and is currently under construction. The solar farm is the second stage of this development.

Beca Limited (Beca) has been engaged by Meridian to prepare a resource consent level design and supporting technical documentation for the consent application.

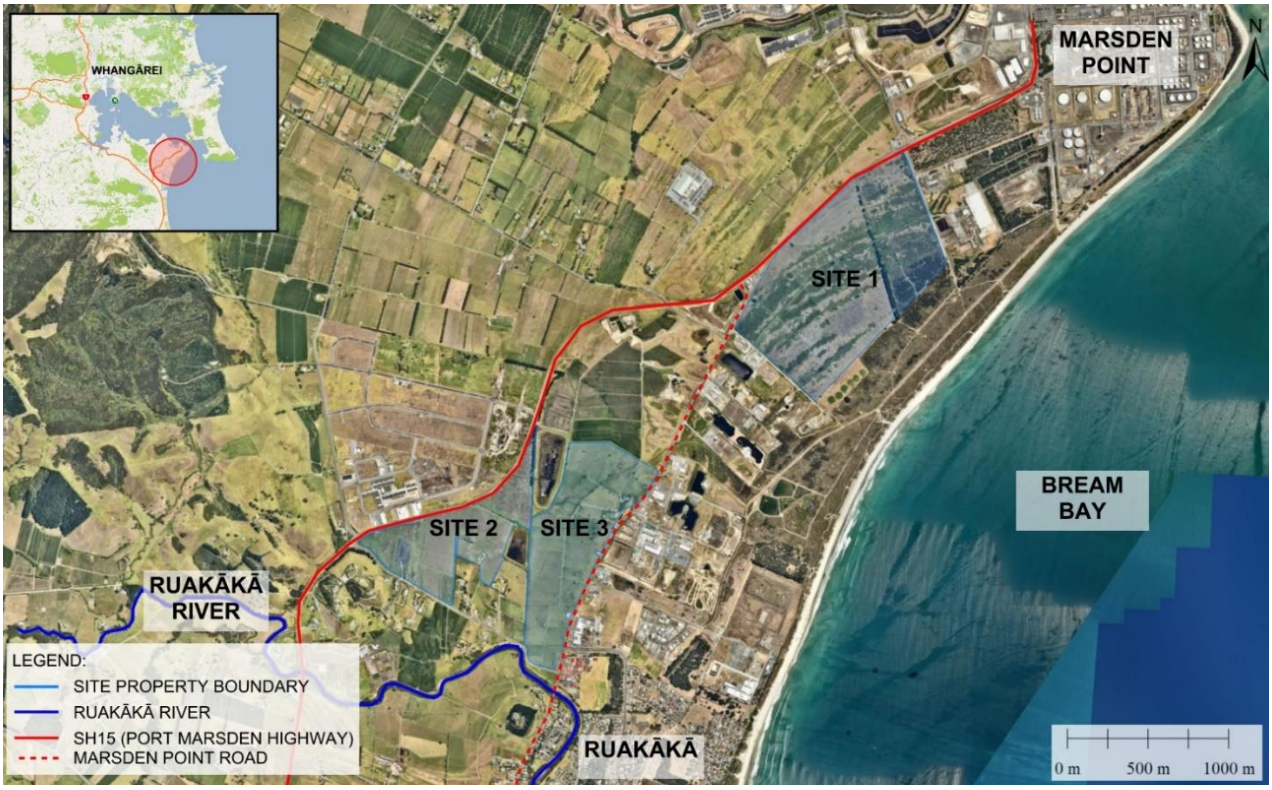


Figure 1-1: Site locations (image obtained from https://www.nearmap.com/nz/en, Nearmap Australia Pty Ltd (2023))

Ecological assessment of Ruakākā Energy Park undertaken by Boffa Miskell has identified the presence of natural wetlands of varying ecological value.

Where wetlands are identified in the vicinity of the proposed works, Regulation 45(6)(c) of the NES-FM requires that the effects management hierarchy be applied to address the potential adverse effects.[2] Step 1 of the hierarchy is to avoid the loss of wetlands "where practicable". This report presents the Engineering options assessment undertaken for the Ruakākā Energy Park Solar Farm against a range of criteria to determine a solar farm layout that achieves an efficient and practicable (commercially viable) solar farm on the sites that avoids the maximum extent of wetlands.

[2] It is understood that the proposed solar farm is "Specified Infrastructure" as defined in the NPS-FM.

2 Purpose

The purpose of this report is to determine from an engineering perspective a solar farm layout that achieves an efficient and practicable (commercially viable) solar farm on the sites that avoids the maximum extent of wetlands.

2.1 Statutory Requirements

Planning advice to inform this report has identified that where wetlands are located in the vicinity of the proposed works area, Regulation 45(6)(c) of the NES-FM requires that the effects management hierarchy be applied to address the potential adverse effects.

The effects management hierarchy is defined in Section 3.21 of the NPS-FM as:

effects management hierarchy, in relation to natural inland wetlands and rivers, means an approach to managing the adverse effects of an activity on the extent or values of a wetland or river (including cumulative effects and loss of potential value) that requires that:

(a) adverse effects are avoided where practicable; then

(b) where adverse effects cannot be avoided, they are minimised where practicable; then

(c) where adverse effects cannot be minimised, they are remedied where practicable; then

(d) where more than minor residual adverse effects cannot be avoided, minimised, or remedied, aquatic offsetting is provided where possible; then

(e) if aquatic offsetting of more than minor residual adverse effects is not possible, aquatic compensation is provided; then

(f) if aquatic compensation is not appropriate, the activity itself is avoided.

Step 1 of the hierarchy is to avoid the loss of wetlands “where practicable”. This is the focus of this report.

3 Methodology

Discussions were held between Meridian and Beca, taking into consideration ecological input from Boffa Miskell to shortlist seven development options for further consideration.

These are:

- Option 1 - No solar development on Site 1
- Option 2 - Full wetlands removal on Site 1 with full offset on Site 3
- Option 3 - Full solar development on Site 1, constructing and operating the solar farm while maintaining existing wetlands
- Option 4 - Partial wetland removal on Site 1 to avoid most open water pond habitat, partial offset on Site 3
- Option 5 - Partial wetland removal on Site 1 to avoid majority of wetlands, partial offset on Site 3
- Option 6 - Partial wetland removal on Site 1 to avoid most southern open water areas and enlarging and enhancing the wetland in this area while creating an ecological corridor to the kanuka forest.
- Option 7 - Partial wetland removal on Site 1 to avoid most eastern wetland areas

The solar farm layout plans for these options are presented in Appendix A

Option 1 was eliminated from further assessment as it was deemed to be not practical, as a functional need has been demonstrated for a solar farm at this site. This functional need is outlined within the Assessment of Environmental Effects (AEE).

The remaining six wetland mitigation options have been assessed for Fixed Tilt, Single Axis Tracking & Contour Following Single Axis tracking solutions using the following methodology:

1. Agree with Meridian on assessment criteria and weightings for multi-criteria analysis (MCA)
2. Produce a solar farm layout for each option which details the following parameters: DC system size, AC system size, annual yield, location of Inverter power stations, volumes of earthworks (based on grading, laydown areas, access track requirements)
3. Develop high level cost for each option (+50% / -30%) based on AACE Class 4 Estimate
4. Calculate life-time yield (based on a 30-year operation)
5. Provide commentary and rating (1-5) for each option against agreed criteria
6. Rank options from least preferred to most preferred

4 Multi-Criteria Analysis

The criteria and weightings for this analysis were provided by Meridian, with the following parameters agreed:

Criteria	Cost	Capacity	Yield	Transmission Route	Flood Risk to Asset	Flood risk to Other Properties
Weighting	100	25	100	50	90	100

Criteria	Wetland Effect	Constructability	Safety	Maintainability	Sustainability
Weighting	50	75	100	100	75

This provides a total weighting of 865 across the 11 categories. This weight has then been normalised allowing for the highest weighted criteria to have greater impact on results. Each of these criteria have then been assessed by Beca's design team and have been rated from 1-5 for each option, with justification.

Refer to **Appendix B – Multi-Criteria Analysis** for results which identifies Option 6 as the preferred solution.

4.1 Options Assessment Discussion

Option 6 achieves a practical and economically viable solar farm, while optimising the overall ecological value of existing and proposed wetlands and considering the effects management hierarchy. The highest ecological value wetland, in the south of Site 1 is retained and enhanced, and wetlands with predominately lower ecological values are offset with higher value wetlands to be developed on Site 3. This leads to a minimising of adverse effects caused by wetland disturbance on Site 1. Wetland loss from the site is offset with appropriate quantities and the constructed relocated wetland on Site 3 provides an opportunity of a wetland corridor to the Ruakaka River.

The constructed wetland on Site 3 creates the potential for filtering existing stormwater runoff. Likewise, the retained and enhanced wetland on Site 1 creates a corridor to the retained Kanuka area in the east of the site.The table below summarises the key advantages and disadvantages of each option.

Option	Key Disadvantage(s)	Key Advantage(s)
Option 1	• Not commercially viable	N/A
Option 2	• Highest value wetlands on Site 1 are removed	• Maximises use of Site 1 (which will result in increased yield)
Option 3	• Presents significant risk to safety during construction and operation. • Likely to limit appetite from market to construct, impacting CAPEX and OPEX costs	• Retains all wetlands in their current locations (however the resulting effect from shading the wetlands is unknown)
Option 4	• Capacity of the solar farm is reduced ,effecting the economic viability and yield of the solar farm.	• A significant number of wetlands on Site 1 are retained.
Option 5	• Capacity of the solar farm is reduced ,effecting the economic viability and yield of the solar farm.	• A significant number of wetlands on Site 1 are retained.
Option 6	• Majority of low value wetlands on Site 1 are removed	• Highest value wetland on Site 1 is retained and enhanced

		• Presents a practicable and economically viable solar farm
Option 7	• Highest value wetlands on Site 1 are removed	• Small indigenous wetland is retained on Site 1

Without a high energy yield and capacity, this project will not proceed as Meridian requires yield to create a return on investment. We understand from Meridian that Option 4 and particularly Option 5 would likely deem the project commercially unfeasible, resulting in a high likelihood that the project would not proceed.

The flood risk to this project is high, and while some options present mitigation opportunities, there is no option that eliminates flood risk. Options 2 and 7 offer the best flood mitigation, while only Option 3 will increase flood risk to the assets on site. The increase of flood risk for option 3 is due to earthworks and solar arrays without a proposed wetland on Site 3. Earthworks and solar arrays increase flood risk, whilst a wetland would provide flood mitigation.

Wetland offset is required for all options other than Option 3, which has been deemed not practical. Further discussion on this specific option is presented in Appendix C. Considering the other options, Options 4-6 can retain the critical open water wetland on the south side of Site 1, receiving an increased 'Wetland effect' rating. Option 6 also provides the opportunity of enhancing this critical open water wetland on Site 1 and therefore reducing the size of wetland construction on Site 3. Option 7 and Option 2 are highly expensive and have large wetland impacts, which also increases the cost of this project, deeming these options economically unfeasible.

Constructability is a critical success factor to give confidence in undertaking this project. While the land across the 3 sites presents different challenges, it is the wetland area on Site 1 and wetland construction on Site 3 that present key issues for construction. With the wetland on Site 1, personnel are required to navigate through or around wetlands to construct the solar farm. The construction of new wetlands is not an easy undertaking but is not determined to be as challenging as attempting to construct solar arrays within existing wetlands. Constructing solar arrays within existing wetlands presents the greatest risk to constructability and health & safety, and as such options have been rated accordingly.

Option 3 presents the least safe option as personnel will need to attend the site more often, with more equipment and larger vehicles to maintain and cross undeveloped/undulating land. Considering this, Option 3 is therefore likely to elicit less interest from contractors due to the complexities and potential safety risks.

Option 6 presents a safer and more maintainable environment for personnel, by clearly separating wetlands and solar farm areas. Areas within the solar farm will be graded to reducing safety risks related to piling during construction, lifting on uneven ground, trips and falls, and improves ease of movement throughout the solar farm.

Sustainability considers the amount of earthwork required and excavation in peat dominated areas. Option 2 and 7 require large wetland construction on Site 3, requiring large peat disturbance. Option 3 requires significant amount of piling, increasing the amount of steel to be used.

It is highly likely that the selection of Options 2, 4, 5 or 7 would deem the project no longer feasible, due to economic or environmental reasons. This is due to options 4 and 5 having very low yield and capacity, making the solar farm no longer financially viable. Option 2 and 7 also have large wetland effects and are therefore removed from consideration due to large wetland disturbance and the loss of critical open water areas.

The multi-criteria analysis results demonstrate that while some options score highly in certain criteria, Option 6 presents the most efficient and effective outcome when considering all aspects. This option particularly provides high yield and capacity, which is critical to ensure the solar farm is commercially viable, while also considering flooding, safety, maintainability and retaining the ability to optimise the overall ecological value of existing and potential future wetlands.

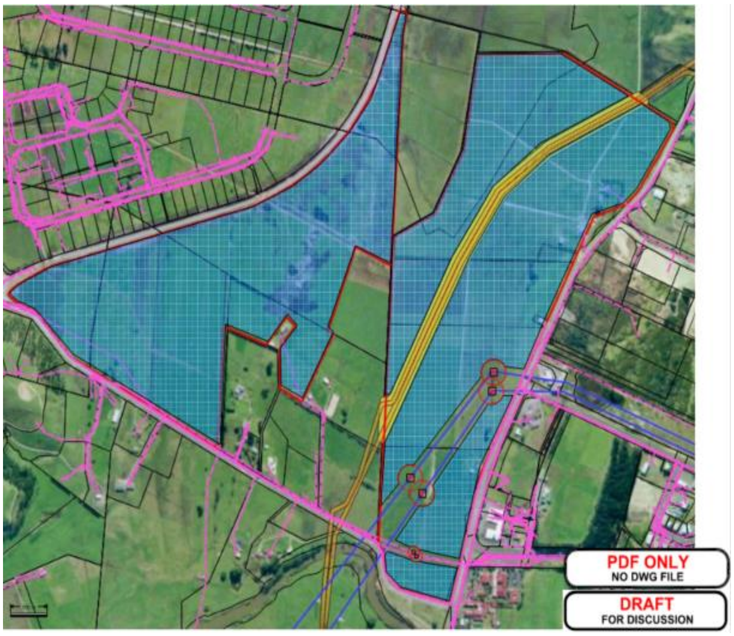
5 Conclusion

The multi-criteria analysis results demonstrate that while some options score highly in certain criteria, Option 6 presents the most efficient and effective outcome when considering all aspects. This option particularly provides high energy yield and capacity, which is critical to ensure the solar farm is commercially viable, while also considering flooding, safety and maintainability, and optimising the overall ecological value of existing and potential future wetlands. Under this option, wetland removal is avoided to the extent practical as directed by the NES-FM and NPS-FM.

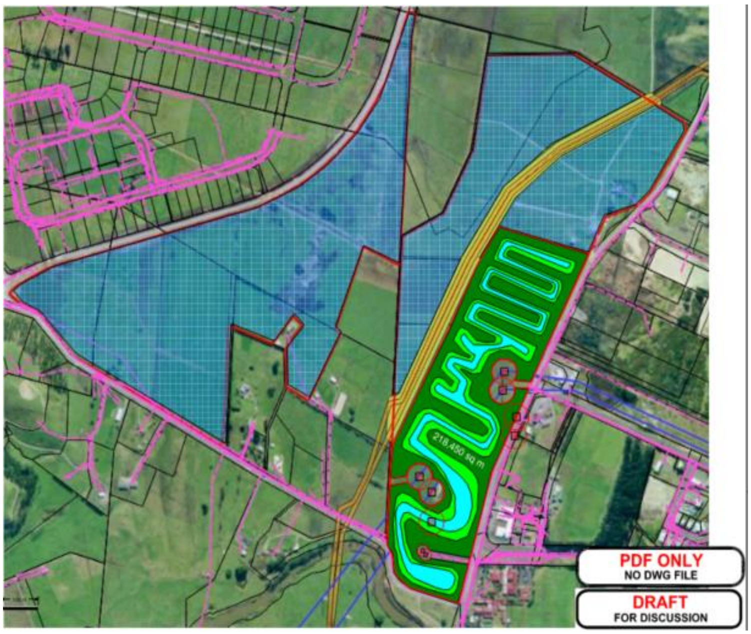
A

Appendix A – Wetland Optioneering Solar Farm Layouts

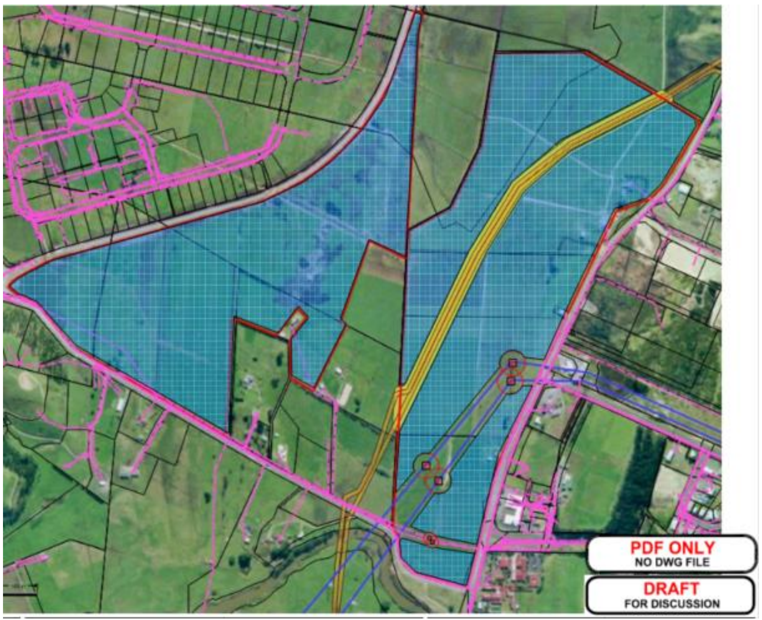
Option 1 Solar Farm Layouts - No solar development on Site 1



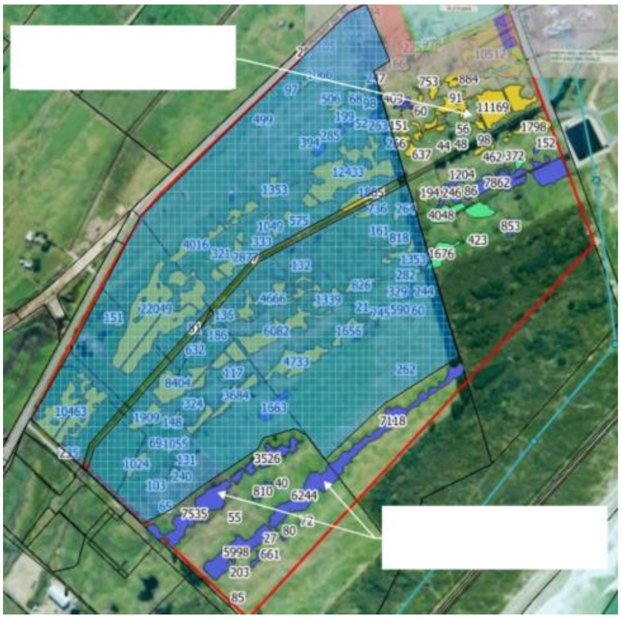
Option 2 Solar Farm Layouts - Full wetlands removal on Site 1 with full offset on Site 3

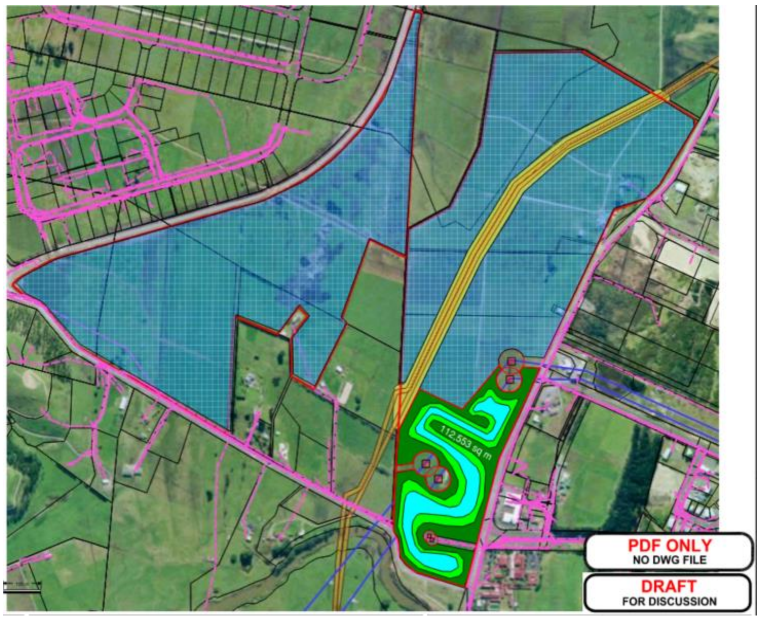


Option 3 Solar Farm Layouts - Full solar development on Site 1, constructing and operating the solar farm while maintaining existing wetlands

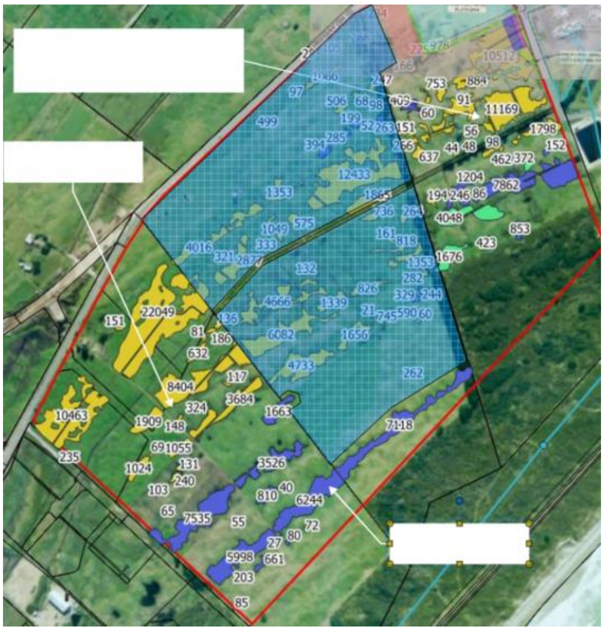


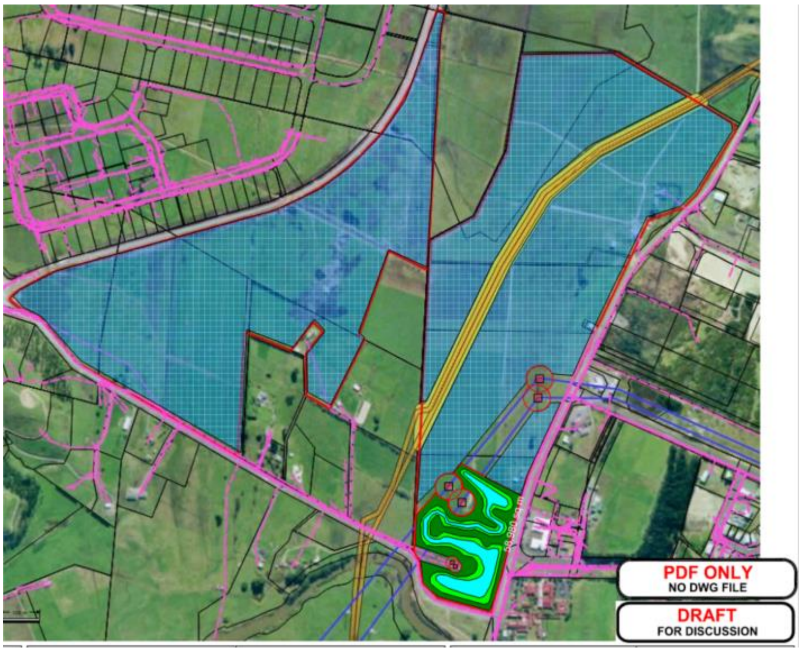
Option 4 Solar Farm Layouts - Partial wetland removal on Site 1 to avoid most open water pond habitat, partial offset on Site 3



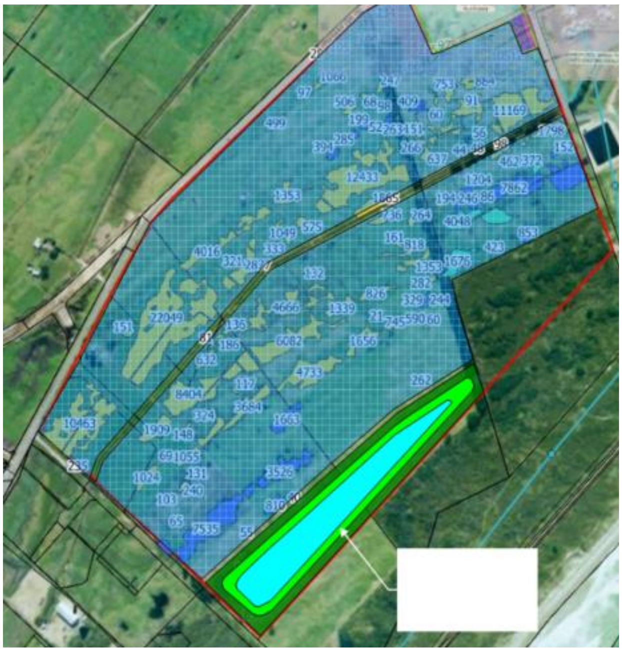


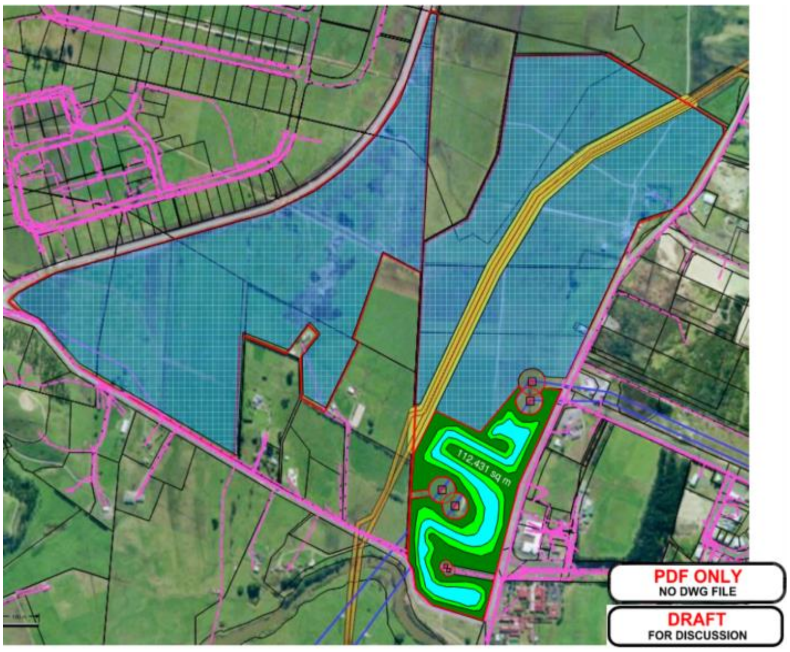
Option 5 Solar Farm Layouts - Partial wetland removal on Site 1 to avoid majority of wetlands, partial offset on Site 3



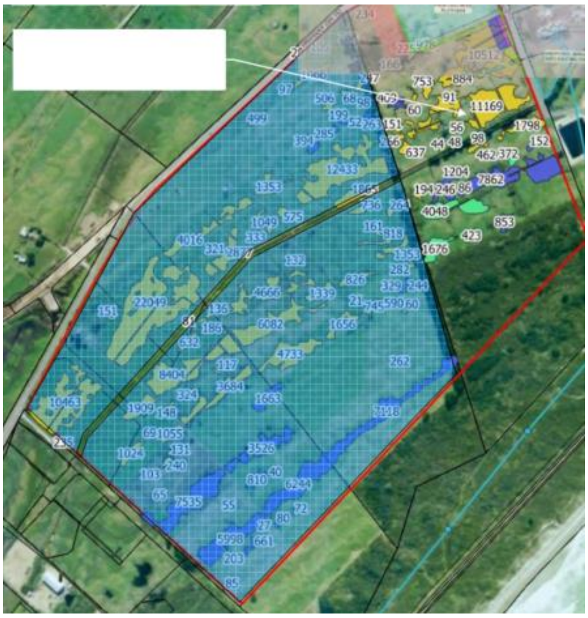


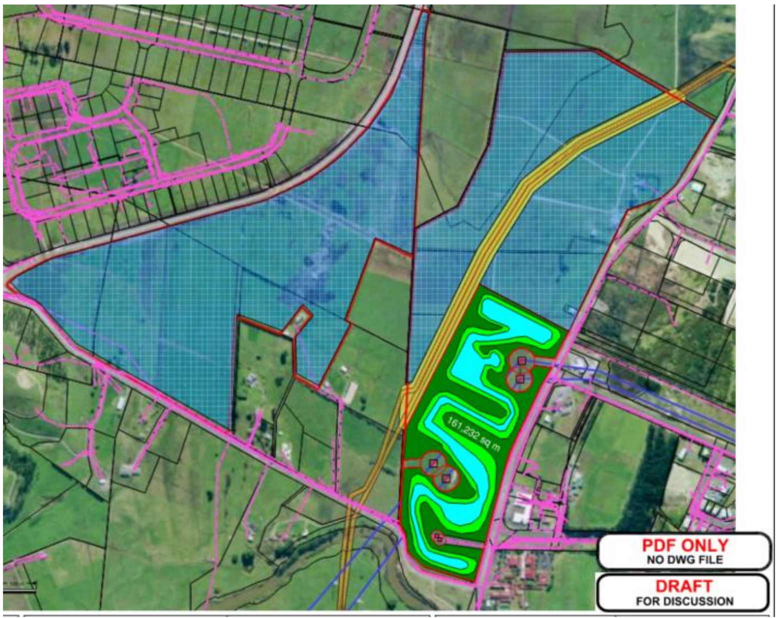
Option 6 Solar Farm Layouts - Partial wetland removal on Site 1 to avoid most southern open water areas and enlarging and enhancing the wetland in this area while creating an ecological corridor to the kanuka forest.





Option 7 Solar Farm Layouts - Partial wetland removal on Site 1 to avoid most eastern wetland areas





B

Appendix B – Multi-Criteria Analysis

Criteria	Weight (1-x)	Normalised Weight (as a %)	Rating (1-5)	Option 2 'Full Site 1 Solar Panels' Option Rating: 2960	Rating (1-5)	Option 3 ''Full Site 1 Solar Panels, Pile Through Ecological Areas' Option Rating: 1990	Rating (1-5)	Option 4 'Partial Site 1 Solar Panels - Avoid most open water' Option Rating: 2920
Cost	100	12%	1	Highest estimated cost, large earthwork volumes.	2	Above average estimated cost, due to increased O&M & BoP costs and building & maintaining a solar farm within wetland.	4	Below average estimated cost, below average earthwork volumes.
Capacity	25	3%	4	Above average capacity, majority of available land is productive.	5	Highest capacity, all available land is productive.	2	Below average capacity, some large areas of unproductive land.
Yield	100	12%	4	Above average yield	5	Highest yield	2	Below average yield
Transmission Route	50	6%	3	No effect on Transmission route. Cost for underground is estimated to be 2x cost of above ground. Refer to Transmission Line Report - Ruakākā Energy Park Solar Farm Consent Design report for further details	3	No effect on Transmission route. Cost for underground is estimated to be 2x cost of above ground. Refer toTransmission Line Report - Ruakākā Energy Park Solar Farm Consent Design report for further details	3	No effect on Transmission route. Cost for underground is estimated to be 2x cost of above ground. Refer to Transmission Line Report - Ruakākā Energy Park Solar Farm Consent Design report for further details
Flood Risk to Asset	90	10%	4	Site 1: Flood risk is small, with some flooding expected through the middle of the site. Site 2: Minimal flood risk. Site 3: Significant flood risk with the Site being largely part of the Ruakaka River floodplain. Most of the site is wetland in this option so risk to asset is minor.	1	Site 1: Flood risk is small, with some flooding expected through the middle of the site. Site 2: Minimal flood risk. Site 3: Significant flood risk with the Site being largely part of the Ruakaka River floodplain. Site 3 is full solar and includes the most PV modules in the worst flood hazard zone.	3	Site 1: Flood risk is small, with some flooding expected through the middle of the site. Site 2: Minimal flood risk.. Site 3: Significant flood risk with the Site being largely part of the Ruakaka River floodplain. Medium sized wetland on site 3 (similar size to option 6)
Flood Risk to Other Properties	100	12%	5	Site 1: Neutral effect with a large cut to site 1 for grading. Site 3: Largest excavation and most benefit offered to neighbours.	1	Least benefit to neighbours. Inverter stations and PV module in the floodplain, effects are expected to be adverse everywhere.	3	Expected to have a neutral effect on the neighbours and balanced with the wetland on site 3.
Extent of Wetland Impact	50	6%	1	21.8 Ha of aquatic comepnsation required on site 3. Site 1: Major wetland disturbance. Site 3: Major wetland consutrction required.	5	0 Ha ofaquatic comepnsation required. Wetland location is maintained on site 1. The critical open water on the south of site 1 is untouched.	3	11 .3 Ha of aquatic compensation required on site 3 Indigenous and open water wetlands are maintained on site 1. Majority of exotic dominated wetland is relocated to site 3.
Constructability	75	9%	3	Ease of access to all construction areas for solar farm. Very large wetland to be constucted on site 3.	1	Pile installation likely to require specialised plant. Increased pile lengths to raise key electrical components above flood levels. Increased material costs or decreased service life due to aggressive conditions. Delays in construction speed is to be expected.	5	Ease of access to all construction areas for solar farm. Moderate wetland construction required on site 3.
Safety	100	12%	5	All areas for development are earthworked to create a safe environment for workers. Wetland areas are well seperated from the solar farm and workers will not have to cross wetland to attend solar farm. Workers will not have to cross transpower assets to attend solar farm.	1	Wetland is within the solar farm, workers will have to work within the wetland when maintaining the solar farm. Larger all terrain vehicles will be required to traverse the wetland. Increase risk of accident due to hazardous ground and more dangerous equipment.	4	Majority of area will be earthworked to create a safe environment for workers. Harzardous area will be north-east of site 1. Wetland areas are well seperated from the solar farm but workers will have to cross wetland if accessing from north-east. Workers will not have to cross transpower assets to attend solar farm
Maintainability	100	12%	5	Easy access to all PV modules & MVPSs. Wetland areas are well seperated from the solar farm and workers will not have to cross wetland to attend solar farm.	1	Ongoing access for maintenance and fault response during high water levels in the wetlands is a major risk. Site accessibility to MVPS and combiner boxes is key for operations and maintenance, but also modules and trackers typically need some form of physical check or inspection every 3 months. Site vegetation is also a big consideration and overgrowth impacting module performance and or tracker movements. Rough estimate on increased costs for operations and maintenance is approximately 30-40% on baseline.	4	Limited access from Rama Road or BESS, otherwise good access to all PV modules & MVPS . Wetland areas are well seperated from the solar farm but workers will have to cross wetland if accessing from north-east. Once within the solar area, site will be easy to maintain.
Sustainability	75	9%	1	Destruction of all wetland on site 1 and complete aquatic comepnsation on site 3. Major disturbance of peat dominated land on site 3 due to wetland construction.	4	Wetlands and associated vegetation will be significantly disturbed requiring remediation which will not be practicable once infrastructure is installed without risk of damage. No excavation required Most piling required on site 3, large amount of steel required.	3	Critical open water and indigenous wetlands are maintained on site 1 . Piling within peat dominated area required on site 3. Average excavation for wetland on site 3

Criteria	Weight (1-x)	Normalised Weight (as a %)	Rating (1-5)	**Option 5** *'Partial Site 1 Solar Panels - Avoid most open water wetland and wetland'* **Option Rating: 2745**	Rating (1-5)	**Option 6** *'Partial Site 1 Solar Panels - Avoid most southern open water areas'* **Option Rating: 3320**	Rating (1-5)	**Option 7** *'Partial Site 1 Solar Panels - Avoid most eastern (BESS) wetland areas'* **Option Rating: 2660**
Cost	100	12%	5	Lowest estimated cost, lowest earthworks volumes.	3	Average esimated cost, moderate earthworks volumes.	1	Highest esimated cost, large earthwork volumes.
Capacity	25	3%	1	Poor capacity, many large areas of unproductive land.	5	Highest capacity, all available land is productive.	3	Average capacity, some areas of unproductive land.
Yield	100	12%	1	Lowest yield	5	Highest yield	3	Average yield
Transmission Route	50	6%	3	No effect on Transmission route. Cost for underground is estimated to be 2x cost of above ground. Refer to Transmission Line Report - Ruakākā Energy Park Solar Farm Consent Design report for further details	3	No effect on Transmission route. Cost for underground is estimated to be 2x cost of above ground. Refer to Transmission Line Consent Design Basis report for further details	3	No effect on Transmission route. Cost for underground is estimated to be 2x cost of above ground. Refer to Transmission Line Report - Ruakākā Energy Park Solar Farm Consent Design report for further details
Flood Risk to Asset	90	10%	3	Site 1: Flood risk is small, with some flooding expected through the middle of the site. Site 2: Minimal flood risk. Site 3: Significant flood risk with the Site being largely part of the Ruakaka River floodplain.	3	Site 1: Flood risk is small, with some flooding expected through the middle of the site. Site 2: Minimal flood risk. Site 3: Significant flood risk with the Site being largely part of the Ruakaka River floodplain. Medium sized wetland on site 3 (similar size to option 3).	4	Site 1: Flood risk is small, with some flooding expected through the middle of the site. Site 2: Minimal flood risk. Site 3: Significant flood risk with the Site being largely part of the Ruakaka River floodplain. Half of the site is wetland in this option which is the second largest wetland option.
Flood Risk to Other Properties	100	12%	3	Expected to have a neutral effect on the neighbours and balanced with the wetland on site 3.	3	Expected to have a neutral effect on the neighbours and balanced with the wetland on site 3.	4	Expected to have a slight reduction to flood effect on the neighbours with the second largest wetland on site 3.
Extent of Wetland Impact	50	6%	4	5.9 Ha of aquatic compensation required on site 3. Indigenous and open water wetlands are maintained on site 1. Limited areas of exotic dominated wetland are relocated to site 3.	3	11.2 Ha of aquatic compensation required on site 3. Critical open water wetlands are maintained on Site 1. Distrubed wetlands are reconstructed on site 3 close to the river, creating a wetland corridor.	2	16.1 Ha of aquatic compensation required on site 3. Indigenous wetlands are maintained on site 1. Critical open water area is disturbed and relocated to site 3. Majority of exotic dominated wetland are relocated to site 3.
Constructability	75	9%	4	Requirement to access centre of site 1 without disturbing surround wetland to the north and south. Small wetland requirement on site 3.	4	Ease of access to all construction areas for solar farm. Moderate wetland construction required on site 1 and site 3.	3	Large wetland to be constucted on site 3. Requirement to access site 1 without disturbing northern wetland.
Safety	100	12%	3	Only half of site 1 will be earthworked before construction. Workers will have to travel near wetland to attend to the solar farm. Challenges will be faced getting equipment to the solar farm on site 1. Solar farm being on both sides of transmission line will require workers to cross near Transpower assets	5	All areas for development are earthworked to create a safe environment for workers. Wetland areas are well seperated from the solar farm and workers will not have to cross wetland to attend solar farm. Workers will not have to cross transpower assets to attend solar farm.	4	Majority of area will be earthworked to create a safe environment for workers. Harzardous area will be north-east of site 1. Workers will have to cross wetland to attend solar farm if accessing from north-east. Workers will not have to cross transpower assets to attend solar farm
Maintainability	100	12%	3	Difficulty accessing PV modules & MVPS on site 1, access recommended through BESS. Workers will have to travel near wetland to attend to the solar farm.	5	PV modules & MVPSs accessible from all proposed entrances & adjacent roads. Wetland areas are well seperated from the solar farm and workers will not have to cross wetland to attend PV modules or MVPS.	4	Limited access from Rama Road or BESS, otherwise good access to all PV modules & MVPS . Wetland areas are well seperated from the solar farm but workers will have to cross wetland if accessing from north-east. Site easy to maintain once within solar area.
Sustainability	75	9%	4	Open water, indigenous and majoirty of exotic wetlands are maintained on site 1. Piling within peat dominated area required on site 3. Smallest peat excavation for wetland on site 3	3	Critical open water within the south of Site 1 is maintained and enhanced. Piling within peat dominated area required on site 3. Average excavation for wetland on site 3	2	Loss of most open water on site 1. Indigenous area is maintained and limited piling required on site 3. Above average excavation for wetland on site 3

C

Appendix C – Solar Farm Development within Wetlands (Option 3)

Consideration has been given to constructing and operating the solar farm within the existing wetlands on Site 1 to minimise adverse wetland effects. This has included a review by Beca's interdisciplinary project team, discussion with an experienced solar farm contractor and solar equipment supplier and feedback from Meridian's Renewable Construction team.

Risks identified to the construction of the solar farm within wetlands include:

- Pile installation likely to require specialised plant. Standard Solar Pile drivers are unlikely to be able to operate in and around the wetlands on Site 1.
- Increased pile lengths to raise key electrical components above flood levels
- Increased material costs or decreased service life due to aggressive conditions
- It's common practice to delay construction until the ground is dry or at least somewhat constructible so delays (or implausibility, for continuously wet areas) in construction speed is to be expected. This is specifically related to the following work activities:
    - Piling
    - Foundations work
    - Trenching
    - Underground cabling
    - Other civil related tasks
- Buried electrical cables may need to have superior water blocking properties to be suitable for the installation hence may lead to higher project costs.
- Health and safety implications related to working in wet muddy conditions, including vehicle operation, manual handling, and operating dangerous piling equipment.
- Wetlands and associated vegetation will be significantly disturbed requiring remediation which will not be practicable once infrastructure is installed without risk of damage. This unpracticality and risk of damage arises from the need to restore the ground surface, transport replacement vegetation between solar arrays and plant underneath racking structures,.
- Rough estimate would be an additional 15-30% on BoS costs (Balance of System costs) for the solar farm.

Risks identified to the operation and maintenance of the solar farm within wetlands include:

- Ongoing access for maintenance and fault response during high water levels in the wetlands is a major risk
- Site accessibility to the Medium Voltage Power Stations (MVPS) and combiner boxes is key for operations and maintenance, but also modules and trackers typically need some form of physical check or inspection every 3 months.
- Site vegetation is also a big consideration and overgrowth impacting module performance and or tracker movements.
- Rough estimate on increased costs for operations and maintenance is approximately 30-40% on baseline pricing scope
- Concrete that is submerged in water or exposed to moisture for extended periods can become more brittle over time due to concrete carbonation, and water absorption into concrete can further weaken its structure.

The experienced solar farm contractor consulted with noted that it will be difficult to find a contractor who will take on the performance risk of a site which poses such a high risk of impact from flooding or water damage. The solar equipment supplier (one of Australia's largest solar farm EPC Contractors) consulted was not aware of their equipment having been installed in these sorts of conditions previously.