MAPPING WETLANDS IN THE UPPER TAIERI SCROLL PLAIN COMPLEX, OTAGO

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MAPPING WETLANDS IN THE UPPER TAIERI SCROLL PLAIN COMPLEX, OTAGO

Contract Report No. 6200

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CONTENTS

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1. INTRODUCTION

Wetlands are particularly valuable ecosystems in the Otago Region, and as part of previous work to recognise and protect their ecological, cultural and socio-economic values, Otago Regional Council (ORC) have identified 170 Regionally Significant Wetlands. However, the recently revised and operative National Policy Statement for Freshwater Management 2020 (NPS-FM) provides a definition of natural wetlands and requires regional councils to identify these within each Freshwater Management Unit (FMU). Additionally, Policy 6 of the NPS-FM requires **"*no further loss of extent of natural inland wetlands, their values are protected, and their restoration is promoted*".**

The Upper Strath Taieri Wetland Complex is large scroll plain wetland complex that has a very complex topography, formed by the Taieri River meandering over its upper flood plain (Figure 1). The result is an active still-meandering river channel and numerous oxbows, marsh wetlands, and old channels. The wetland complex boundary was updated following site visits to exclude areas of pasture, crops, and an artificial wetland, and other areas that are not wetland. Nevertheless, the boundary of the regionally significant wetland still contains large areas of non-wetland habitat.

The Tiaki Maniototo project, run by local catchment group Upper Taieri Wai, has received significant freshwater improvement fund funding, and plans to erect fencing along the boundary of the wetland complex, restore indigenous plants to the wetland, and undertake extensive weed and pest control. A key issue for the Tiaki Maniototo project is better definition of the Upper Taieri Wetland Complex to allow identification of sensitive wetland areas, and enable the identification of a practical fencing alignment.

This report summarises the results of a desktop wetland identification exercise using various geospatial data sources, machine learning techniques and manual mapping. A three-phase methodology comprising potential wetland modelling, depression analysis, and manual mapping was applied to provide an improved description of the Upper Taieri Wetland Complex. This report provides details of the methodology and an overview of the outputs. It accompanies the geospatial layers containing the derived potential wetland polygons ≥500 m^2 and between 50-500 m^2 in size.

2. METHODOLOGY

2.1 Deriving wetland areas

The goal of this work is to identify wetland areas >500m^2 in selected parts of the Taieri River scroll plain system. There have been recent developments in geospatial data analysis that have provided potential methods for the automated identification of wetlands using only geospatial data inputs, such as LiDAR, RGBN imagery and their derived indices (Figure 2). ORC are interested in testing these methods in the Upper Strath Taieri Wetland Complex to assess potential applicability elsewhere in Otago. By using a combination of newly developed wetland modelling tools and traditional spatial analysis tools along with manual identification we were able create wetland polygons to a very small size.

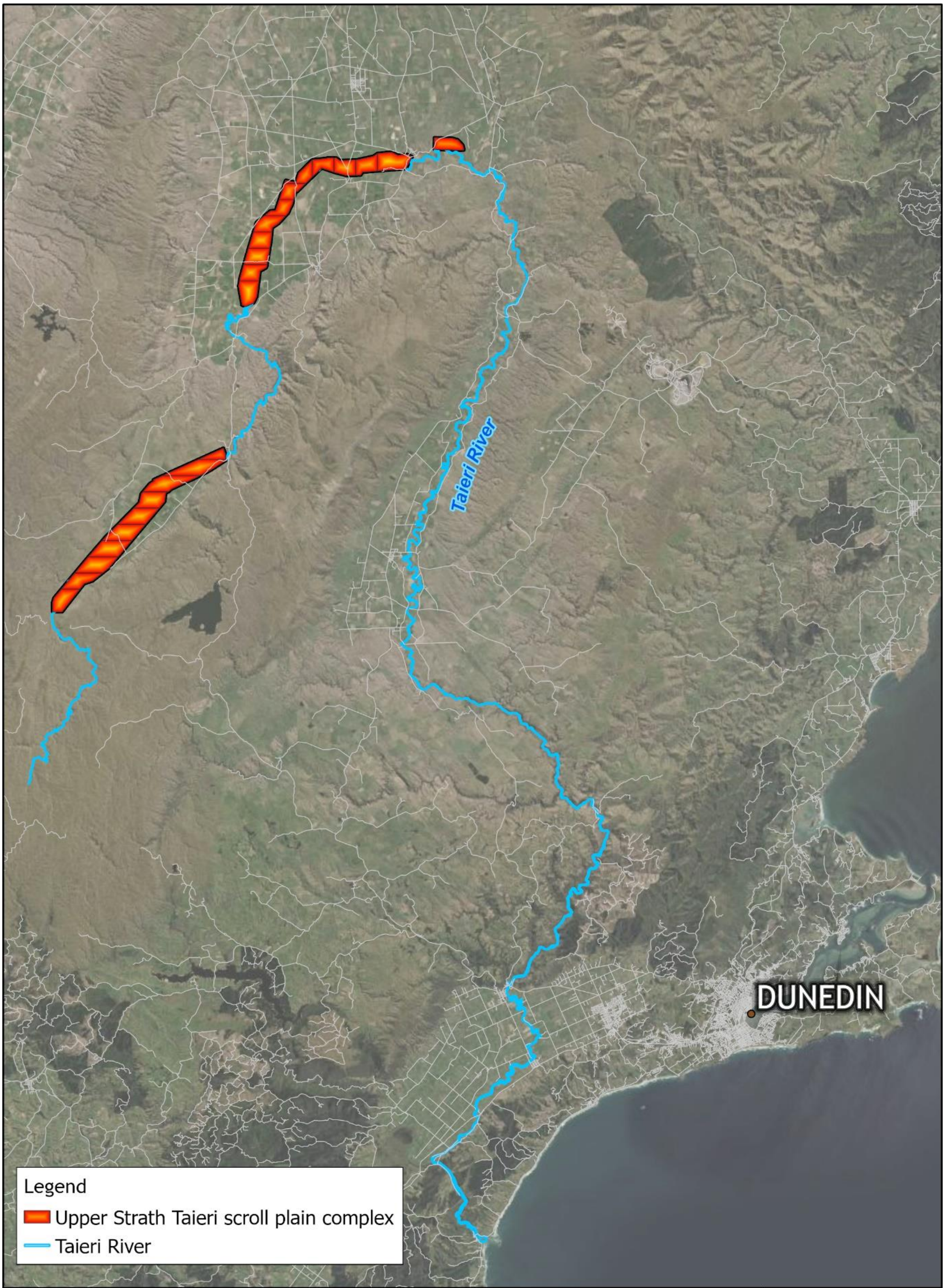

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Figure 1. Location areas for wetland modelling in the Upper Taieri Scroll Plain Complex

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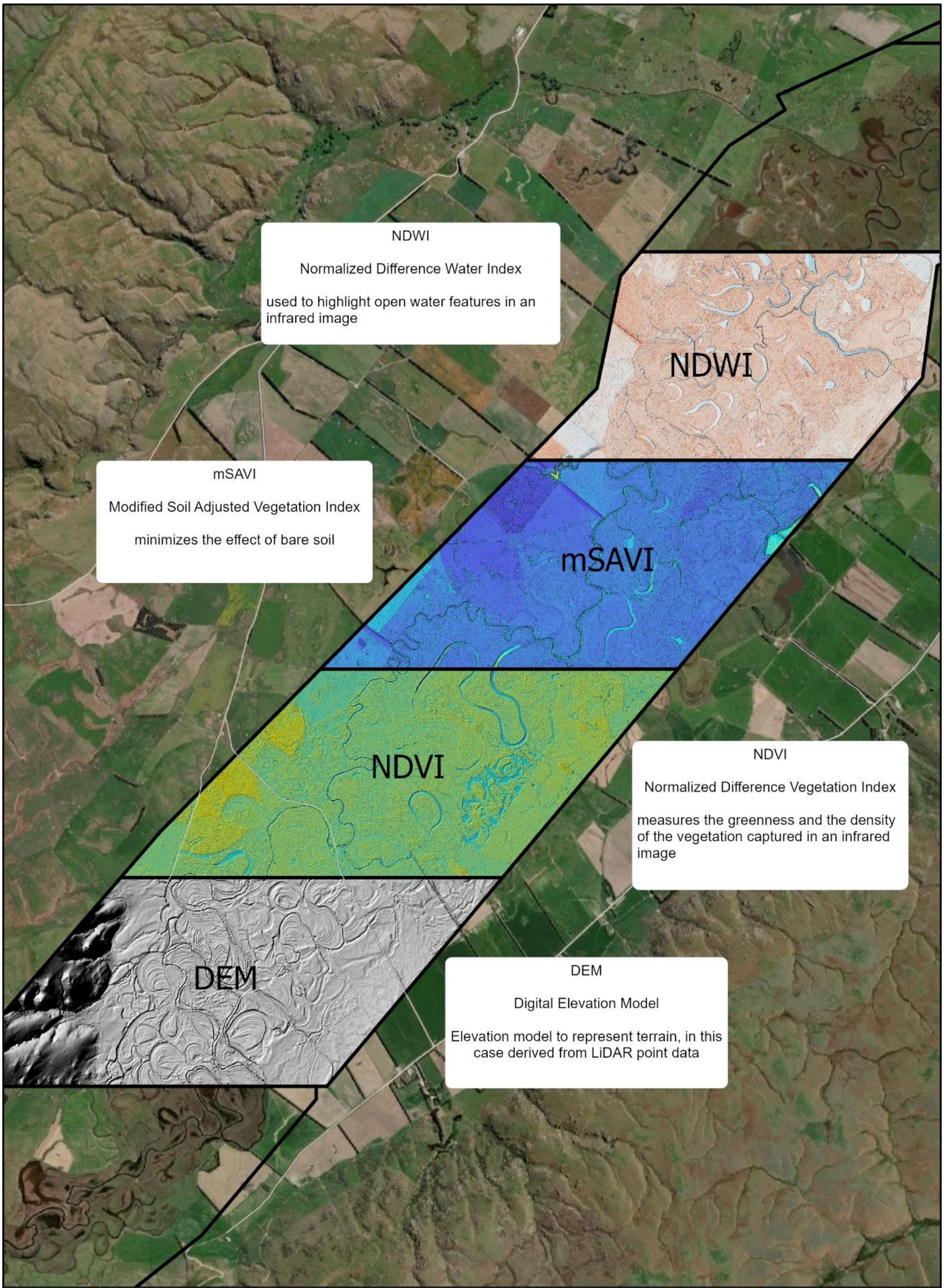

Figure 2. LiDAR and Near-infrared imagery derived products in the Upper Taieri Scroll Plain Complex

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2.2 Software/data dependencies

- ArcGIS Pro software (Standard or Advanced licensing).
- ArcGIS Pro Spatial Analyst Extension.
- ArcHydro for ArcGIS Pro.
- ArcGIS Pro compatible – Geoprocessing tools developed at Bingham University. For further information refer to Wu and Lane (2017).
- ArcGIS Pro compatible – Wetland Identification Model (WIM)[1].
- Adjusted Python work environment as per WIM.
- Very high resolution near-infrared imagery (0.05 metre cell size)[2].
- DEM from very high resolution LiDAR data (0.25 metre cell size)[2].
- Known wetland polygons.

2.3 Data limitations and issues encountered.

- Most surface water areas were removed from the LiDAR data. It would have been helpful to have this data to create a continuous surface digital elevation model (DEM). The DEM used in the project contained gaps wherever there would have been surface water and these were filled using standard geospatial techniques.

- A considerable amount 'NoData' cells in near-infrared imagery. This caused problems by not having enough data for analysis at many locations. Collectively these account for the majority of missed wetlands in the WIM model due to no data being available.

- It is also important to note that the infrared imagery was captured in May 2021 during a mostly normal dry period. It would be much better to collect this imagery in spring/early summer when ground conditions would be wetter.

- The spatial extent of the Upper Strath Taieri Wetland Complex extended beyond the area of data capture. This limited the extent of data analysis to that of the provided data layers and required manual mapping outside this.

- Initial attempts to process land areas >10 km^2 were unsuccessful so small areas of 1-2 km^2 had to be processed separately. This greatly extended the data preparation and processing times beyond what was initially estimated.

- The WIM Deep learning model is basically a commercial off-the-shelf (COTS) package but does require in-depth knowledge of Python coding to make corrections to some core applications.

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[1] Wetland Identification Model which is contained within the free add-on Arc Hydro Tools Pro along with Python scripting environment.

[2] Imagery and LiDAR provided by ORC. For further information on data refer to Landpro (2021).

3. WETLAND MAPPING

Various geospatial wetland identification procedures were trialed. Due to the complexity of the site and limitations of the input data it was found that no single method adequately described wetlands within the study area. Consequently, a three-phase methodology was applied to identify areas of potential wetland utilizing three wetland mapping techniques. The output polygon layer comprises the merged results of the three wetland designation approaches.

Step 1: Potential wetlands derived from Arc Hydro Wetland Identification Model (WIM)

The core of the WIM model is to use infrared imagery combined with an underlying DEM to identify areas that are (1) depressions and (2) have very similar infrared signatures to probable wetlands.

The creation of the baseline wetland polygons was a necessary step in order to identify potential wetlands and give the WIM model training polygons.

The geoprocessing tools developed by Bingham University (Wu & Lane 2021) are ideally suited to quickly creating a baseline of wetland polygons by use of the high-resolution DEM created from LiDAR data. Only the Extract Sink tool was used as it allowed a precise specification for a minimum size output polygon.

The resulting polygons were then evaluated by Wildland Consultants Limited ecologists using available colour imagery to remove all areas not obviously wetlands. The result is a set of polygons that were used as reference wetland polygons in the WIM model.

With a baseline of polygons to use as reference wetlands the WIM modelling process was used to create a series of polygon outputs. The details of using the WIM model are very well documented in the user manual. The workflow derives topographic indices from a high-resolution DEM along with high-resolution near-infrared imagery and its associated derivative products (NDVI, NDWI, mSAVI) and uses these as inputs to a machine learning algorithm to predict the areal extent of wetlands.

The WIM model output quality will only be as good as the input data quality. In this case the input data was high quality, but also partially incomplete. The LiDAR data had gaps wherever there was open water and the infrared imagery contained a lot of NoData cells. When two layers were combined in the modelling process and one of them has no data it eliminates the areas of no data as possible wetlands.

There was no attempt to quantify how much area might have been impacted by the incomplete data. The focus was on what could be produced as good quality data.

Initially, the model was set to examine an area of around 10 square kilometers. After numerous failed attempts it was determined that the area being modelled contained too much data for the desktop computer to handle. All the input data layers to the model had to be rescaled down to about three square kilometres to get a successful output from the model using the desktop computer. It is possible that this limitation may have affected the outputs by not being able to compare and analyze a wide enough range of data.

The resulting output polygons of all the modelling were assembled in a single polygon layer (Figure 2) and evaluated for completeness by ecologists. It was determined that some known wetland areas were not in the expected output polygon layer. Further examination revealed that the NoData areas were almost all excluded from output polygons therefore limiting the effectiveness of the model.

In order to capture the missing areas another process was evaluated and run to obtain more polygons.

Step 2: Potential wetland derived by depression analysis

Topographic depressions, which can indicate potential wetlands, were identified from the LiDAR derived DEM using the Depression Evaluation tool in the ArcHydro extension to ArcGIS Pro. The tool generates and characterises depressions in the input DEM by subtracting the input DEM from its filled DEM. The process then creates polygons from all the areas that qualify as depressions.

This results in a considerable number of polygons, some very small, some in close proximity to each other and other larger polygons. In order to reduce the complexity of data and generate a more continuous surface a smoothing process was run over all the derived depression polygons. This was a process of buffering outside then inside by the same amount and iterating this a number of times until satisfactory smoothness was obtained.

Many of the resulting polygons created by this process were still smaller than the 500 square metre minimum required. It was decided to retain all the smaller areas down to a minimum size of 50 square metres and keep these as a separate layer.

The polygons over 500 square metres were evaluated by ecologists using current aerial imagery and areas identified as not a wetland were removed. The resulting layer was merged with the results of the WIM modelled polygons and exported as a single data layer.

This output was again evaluated by ecologists and determined to still be missing a few outlying wetland areas, primarily areas outside the LiDAR data area.

In order to capture these last few remaining wetland areas a manual process of identifying these areas was completed by ecologists.

Step 3: Manual mapping of remaining wetland areas and validity check of output datalayer

Missing areas of potential wetland were manually mapped by an ecologist using a combination of the Landpro (2021) RGB Imagery and LINZ aerial imagery basemap in an ArcGIS Online app.

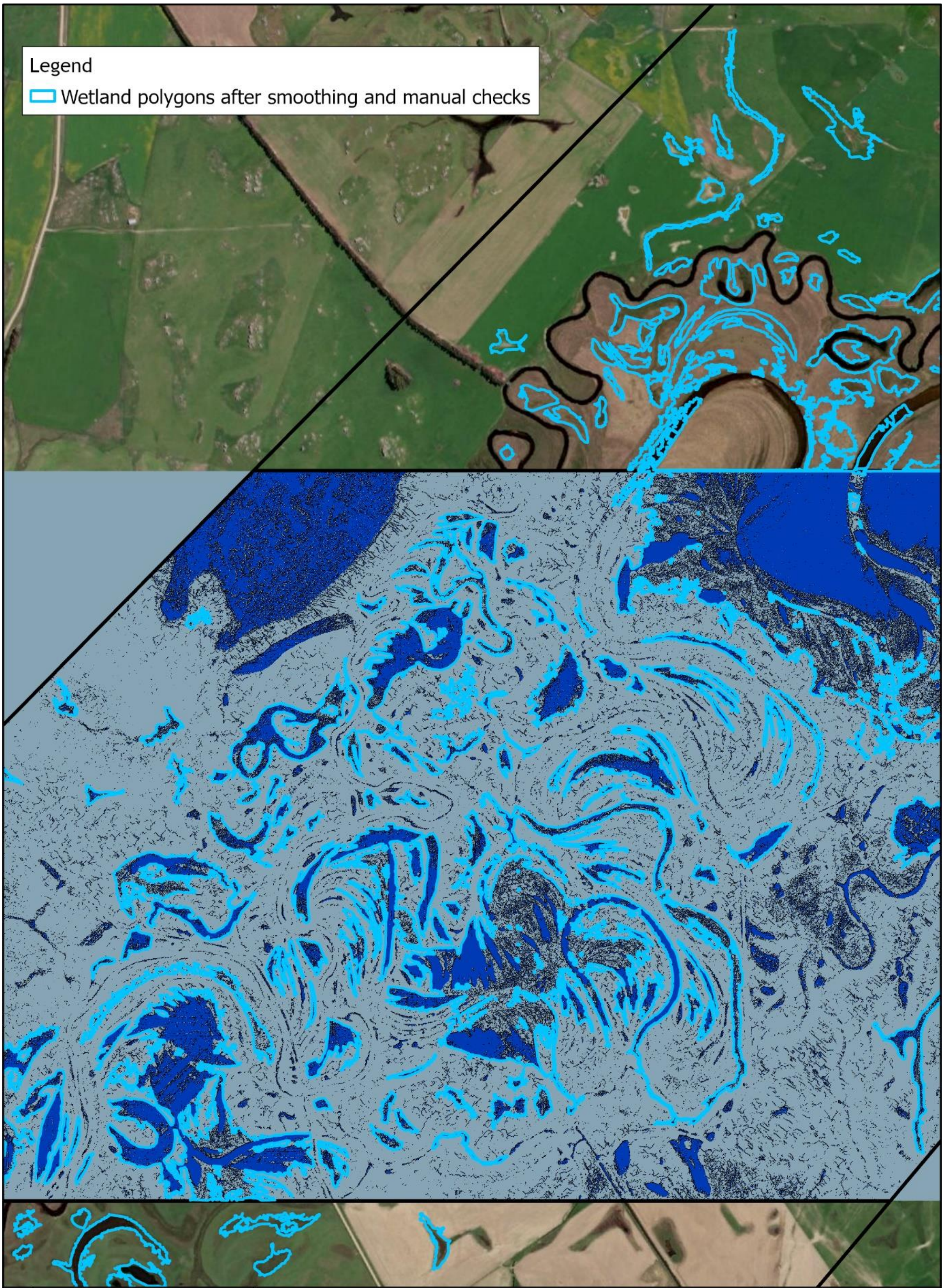

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Figure 3. Raster output from Arc Hydro Wetland Identification Modelling converted to polygons

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Cartographer: TP
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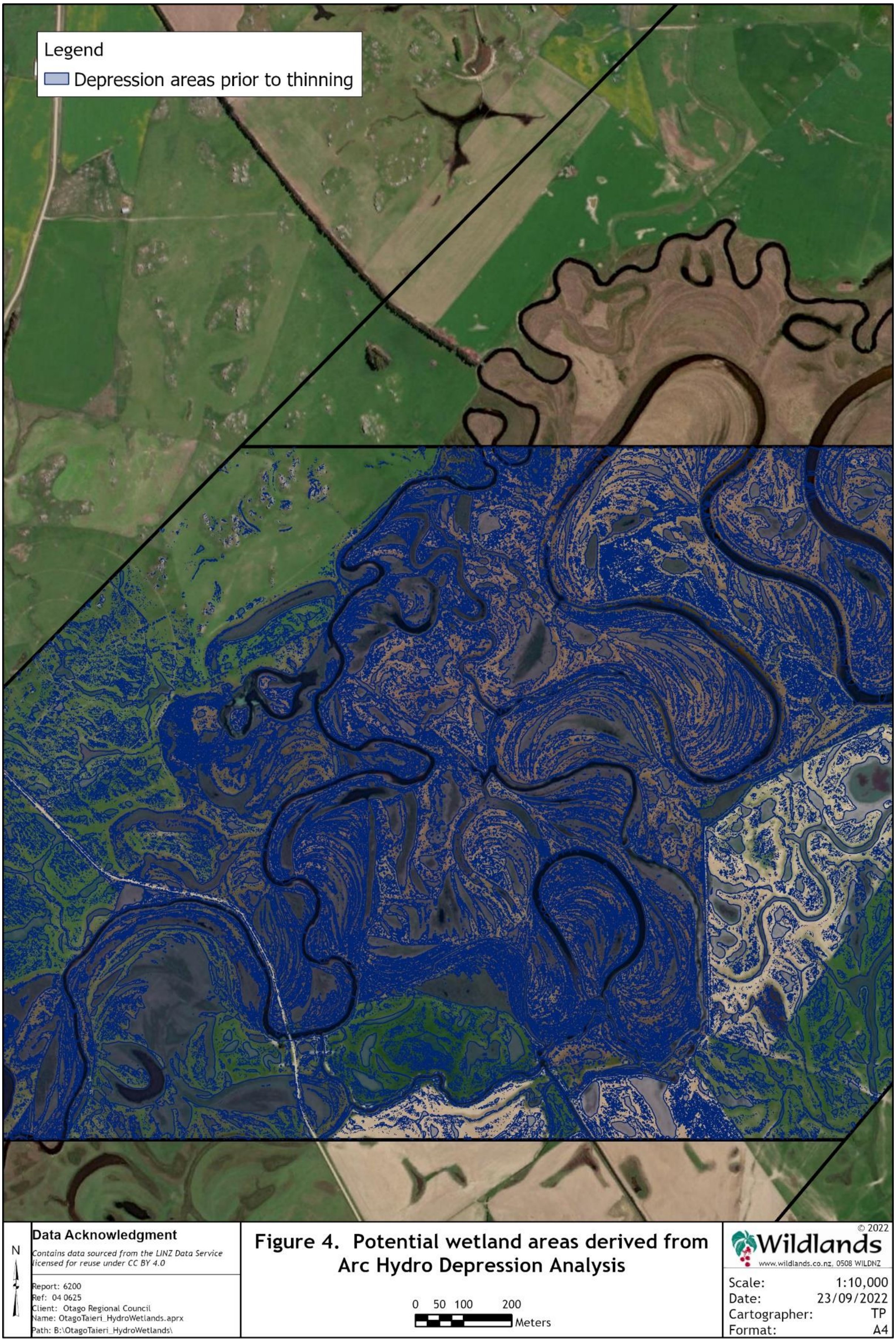

Figure 4. Potential wetland areas derived from Arc Hydro Depression Analysis

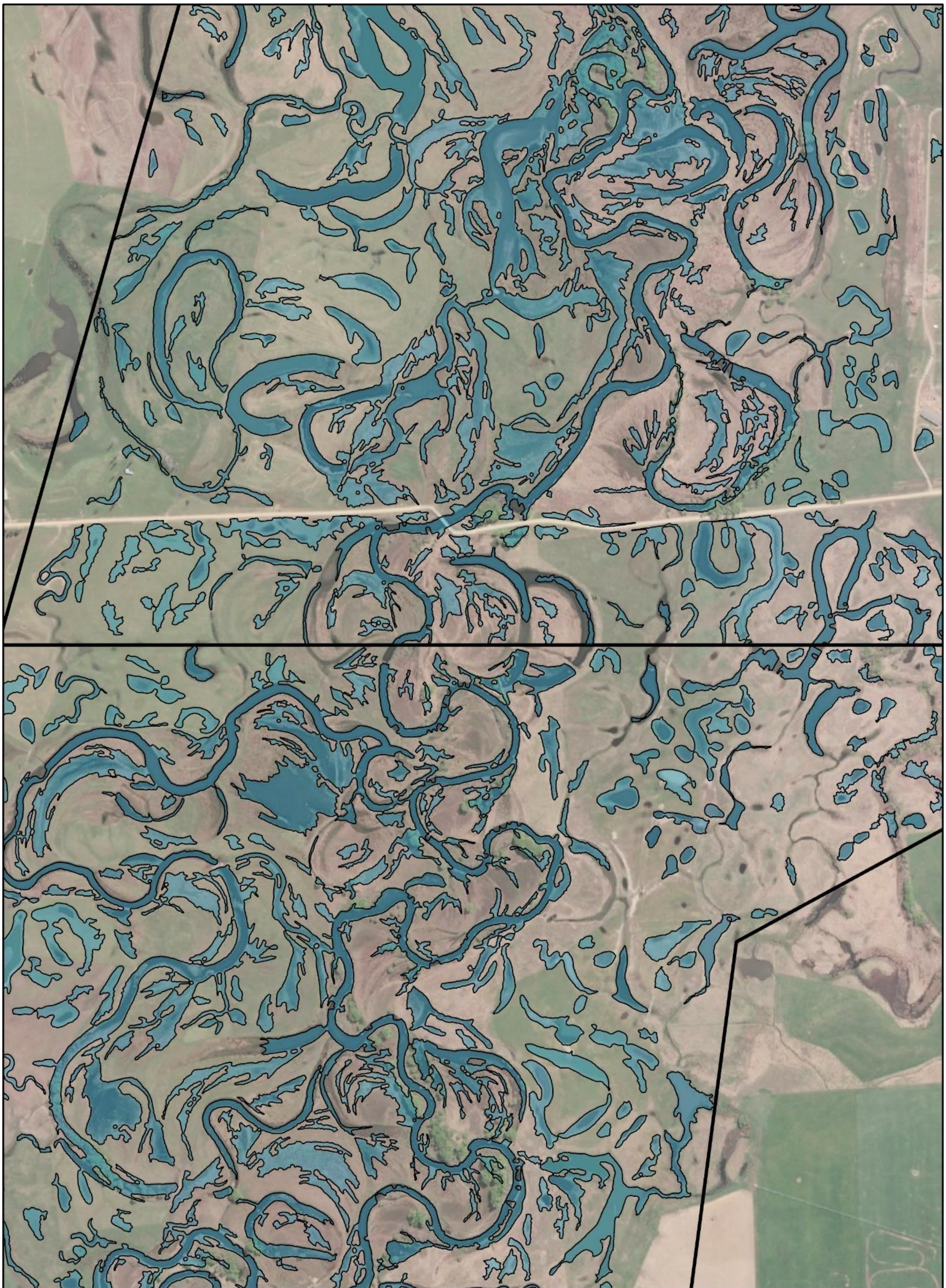

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Figure 5. Potential wetland areas from combining modelled data, depression data and manual examination

0 50 100 200
Meters

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The resulting polygons were merged to create a single potential wetland data layer. A visual check of the resulting polygons was undertaken and areas that were clearly incorrectly identified as potential wetlands were removed.

4. SUGGESTIONS FOR FUTURE ANALYSIS

A key issue was that infrared imagery was collected at a relatively dry time of year, and should be obtained in spring or early summer, choosing a time when the site has relatively wet ground conditions.

The following recommendations are provided for future data supply:

- LiDAR data and high resolution near-infrared imagery must be the same resolution (about 0.25 - 0.5 metres).
- There should be no NoData areas of near-infrared imagery in target areas.
- High resolution imagery should be tiled and made available for specified online users.
- LiDAR data should be supplied as point clouds and must not have open water areas removed.

5. SUMMARY OF OUTPUTS

The above methodological approach identified 4,681.5 hectares of wetlands in the Upper Strath Taieri Wetland Complex, totaling 11,450 wetland polygons, comprising:

- 2,440 potential wetland polygons over 500m^2 (WIM plus depression analysis).
- 8,064 wetlands smaller than 500 m^2 from depression analysis.
- 946 wetland polgyons derived solely from manual digitisation (mostly in areas outside the LiDAR/near-infrared coverage).

The combination of WIM and depression analysis was effective in identifying most areas of ephemeral wetland and swamp. It was least effective in identifying areas of marsh wetlands close to the Taieri River.

The methodology only identifies potential wetlands. These wetlands most likely meet the RMA definition of 'wetland', but ground truthing would be required to confirm whether these wetlands meet the 'natural wetland' definition in the National Policy Statement for Freshwater Management 2020.

ACKNOWLEDGMENTS

Sami Khan (for Otago Regional Council) is thanked for provision of information and project liaison.

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