The selection of a Canterbury high-country braided river for UNESCO World Heritage and Ramsar status, using multiple combined ranked metholdogies.

In association with the University of Canterbury, and the Canterbury Aoraki Conservation Board.

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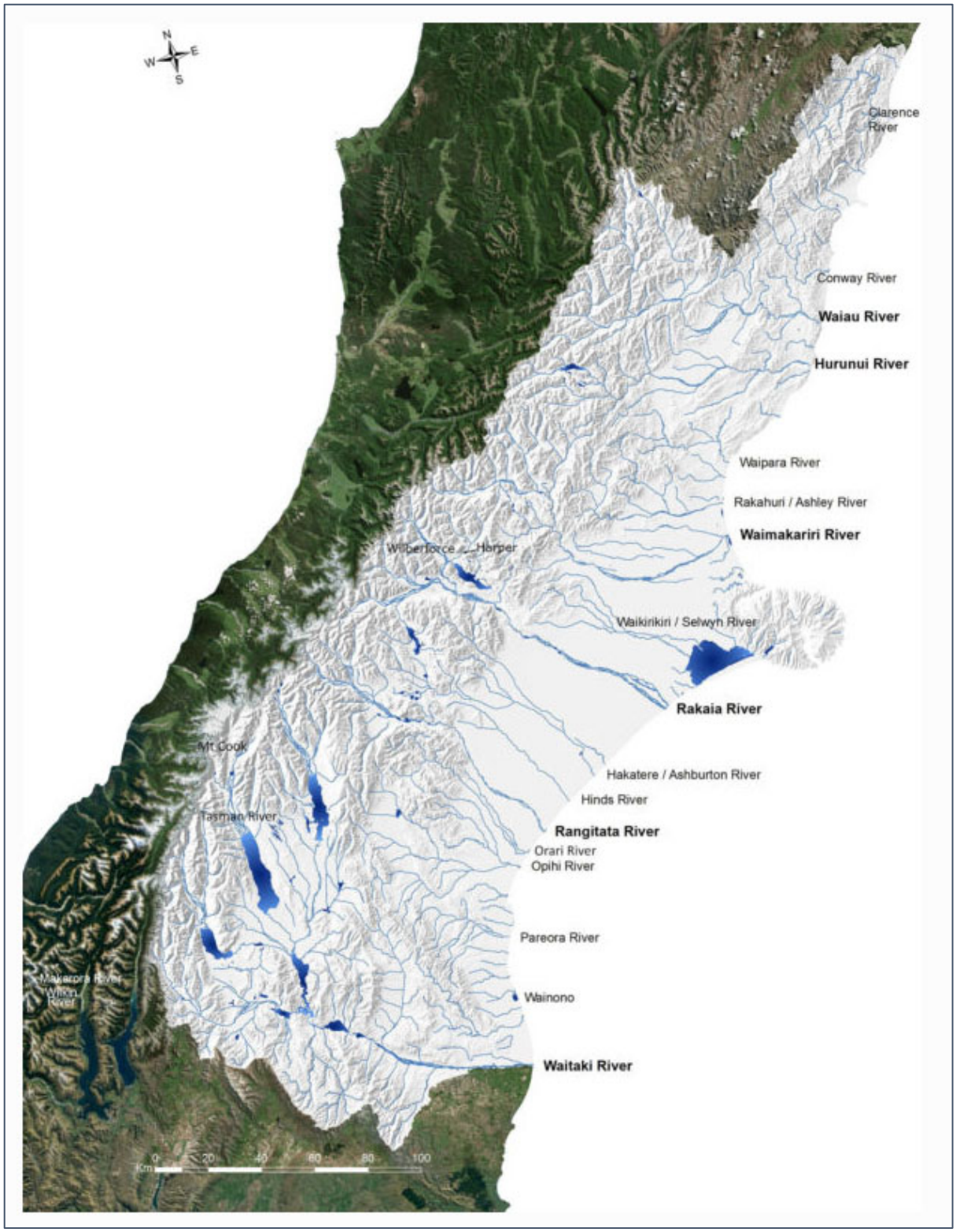

Figure 1: There are a multitude of braided rivers throughout Canterbury: the above highlight rivers are but a few of the 60+ braided rivers that are distributed within the area (BRaid, 2019).

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I. Executive Summary.

The Canterbury Aoraki Conservation Board has acknowledged the significance of braided rivers within the Canterbury region; consequently, an aim within the 2016 Conservation Management Strategy is to recognise one braided river for UNESCO World Heritage or Ramsar international status. The aim of this project was to determine the best suited Canterbury high-country river, using multiple combined ranked methodologies. Variables ranked within these methodologies were identified using in-depth literature review, in association with criteria defined within the UNESCO World Heritage and Ramsar requirements. Five ranking methodologies were created, based on cultural significance, ecological value, hydrological value, geomorphological value, and recreation & tourism value. Data used within the ranking systems were GIS shapefiles supplied by ECan and the Department of Conservation, indicative quantitative measurements, and qualitative rankings. The results of these methodologies were combined. The highest ranking river was the Rakaia. This is due to a combined high cultural significance and ecological value, in conjunction with high natural characteristics, and a large scope for recreation & tourism activities.

II. Introduction.

Globally, braided rivers are renowned due to their rarity and their ability to form interlacing river channels that meander across high-country basins, through spectacular gorges, and across low-lying plains. Within Canterbury, they are exceptional, as the high sediment budget provided by the young Southern Alps, and the widespread Canterbury plains provides the ideal setting for their formation, resulting in over 60 braided rivers across the high country. As such, they are recognised as a significant landscape by the Canterbury Aoraki Conservation Board (CACB), due to their ecological, cultural and natural characteristics. Within the 2016 Conservation Management Strategy (CMS), the CACB created a milestone to support international status recognition for one of the high-naturalness high-country braided rivers, as either a UNESCO World Heritage or Ramsar site.

The requirements for World Heritage and Ramsar status revolves around a multitude of factors, all of which were aimed to be addressed within this study. World Heritage criteria recognises cultural and natural values of environments, architecture, landscapes and technology. Within the cultural area, the criteria recognises the interchange of human values, over a span of time or within a cultural area of the world, to bear a unique or at least exceptional testimony to a cultural tradition, or to be an outstanding example of a traditional human settlement, land-use, or sea use which is representative of a culture, or human interaction with the environment. Within the natural area, the criteria recognises superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance, to be outstanding examples representing major stages of earth's history, significant on-going geological processes in the development of landforms, outstanding examples representing significant on-going ecological and biological processes, significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point

of view of science or conservation. Ramsar criterion involve two key areas, one being sites containing representative, rare or unique wetland types and the other being sites of international importance for conserving biological diversity. This covers four main areas: species and ecological communities, water birds, fish and other taxa (World Heritage Centre - UNESCO, 2019; Ramsar: Convention on wetlands, 1975;2019).

In order to achieve the milestone outlined within the 2016 CMS, a river must first be nominated for international recognition. As such, the research aim is to use multiple combined ranked methodologies, to find which Canterbury braided river would be best suited as a World Heritage or Ramsar site (DOC, 2016).

III. Review of Literature.

The ranking systems were developed through combining elements from existing ranking systems with criteria outlined in the UNESCO and Ramsar criteria. The following section reviews relevant literature for each of the five individual ranking systems: cultural, ecological, hydrological, geomorphological and recreation & tourism.

i. Cultural Significance.

Developing a cultural framework included use of previous studies that explored cultural significance of unique environments and environmental management plans. The initial framework was based off two texts; Lyver et al. (2017) which discusses the key cultural values for ecosystem services of a forest in the North Island, and Harmsworth & Awatere (2013), which discusses key Maori knowledge and perspectives of ecosystems and environments. In addition, Tipa (2009) discussed Maori understandings and perspectives on river dynamics and

environmental management, and Lyver et al. (2016) discussed the key cross-cultural approach needed to conserve, manage and restore nature areas within New Zealand. These texts provided the basis for five key elements of the cultural framework. This information was validated by environmental management plans published by Hapu in Canterbury, including the Canterbury Water Management Strategy (Canterbury Water, 2009), Te Runanga o Kaikōura Environmental Management Plan (Te Runanga o Kaikōura, 2007), Te Waihora Joint Management Plan (Te Runanga o Ngai Tahu, 2005), Ashley River/Rakahuri Management Strategy (ECan, 2008), and Cultural Values for the Rangitata Catchment (Tipa & Associates, 2015).

ii. Ecology.

There was significant controversy regarding the biodiversity of braided rivers. Earlier studies classify braided rivers as "ecological deserts" (Ward, 1998; Sager, 1983; Tockner et al., 2006), whereas current literature recognises them as significant ecological landscapes with diverse microecosystems (Tockner et al., 2006, Gray, 2005; Gray et al., 2006; Ward, 1998). As current literature has a higher relevancy, it was assumed that braided river ecology is expansive. To rank this, multiple common ecological ranking systems were assessed for suitability, which included macroinvertebrate community index (Stark, 1998; Callisto et al., 2005), index of biotic integrity (Kerans & Karr, 1994; Miller et al., 1988), and quantified rankings based on key factors (Rossi & Kuitunen, 1996; Hanson & Hargrave, 1996; Mykrä et al., 2012). Both macroinvertebrate community index and index of biotic integrity measurements require accurate data specific to individuals rivers; as such, these methods were discarded as options for the ecological ranking systems due to lack of data availability. Further study showed that higher diversity and species stability was proportional to the higher natural character of the river (Elosegi et al., 2010; Sambrook Smith, 2009; Peat et al., 2016; Gray, 2010), as well as being host

to a multitude of significant water bird (DOC, 2009; Pierce, 1996), invertebrate (Sager, 1983), fish (Bonnett, 1990) and vegetation species (Woolmore & DOC, 2011). These identified factors would form the basis for the ecological ranking system.

iii. Hydrology.

The physical characteristics of braided rivers was divided into two sections: hydrology and geomorphology. Formally used hydrological ranking system including methods such as RiVAR (Hughey, 2013), Promethee II (Brankovic et al., 2018) and hydrologic classification (Olden et al., 2012). The focus variables within these methods were flow rate, water quality, area of extent and human interaction. However, current literature within hydrology classification had limited frameworks outlining the importance of each aspect. Special focus was placed on modern articles like Ioana-Toroimac et al. (2017), which looks at the weighting of different hydrologic features on a river environment, and the extensive study of the Nile river system by Melesse (2011). These two articles provided stronger foundations to use the four hydrologic parameters used in other studies, and gave a broad sense of how to weight the hydrology ranking framework in the methodology, in conjunction with the Ramsar and World Heritage site criteria.

iv. Geomorphology.

The geomorphology of braided rivers influence ecosystems operation. Modification of these rivers damages the ecology, hydrology, and how the system operates naturally. Human activity plays a large role for the damage that these rivers have experienced. Therefore, it was critical to consider the geomorphology of these rivers when assessing which river was most suitable for international recognition (BRaid, 2019). Gray (2018) and Gurnell (2016) both highlighted the importance of identifying the human pressures and how this plays a role in the natural character

of the river. Both research articles touch on the importance of separating rivers into reaches to assess river state. Prior to Gray (2018), there was no assessment tool designed to classify and score a braided river's physical characteristics. This report modified the 'Marlborough Tool' originally designed by Hughey & Baker (2010) to suit the braided river's dynamic, multi-channelled nature. Gray's assessment tool was used as the foundation for the geomorphology variables. The assessment tool was simplified to geomorphological variables due to the inclusion of other methods for sections such as ecology and hydrology.

v. Recreation & Tourism.

Establishing the recreation & tourism ranking system involved developing a framework effective in determining the most important recreation & tourism aspects of Canterbury's braided rivers. Previous literature focused on the study of tourism, recreational research frameworks and case studies which explored tourism and recreational potential (Chhetri & Arrowsmith, 2008; Lew, 1987). This literature contributed to a framework which involved identifying the main recreational and tourism parameters, creating a rating scale for each component and then weighting these parameters based on level of importance. The New Zealand Recreational River Survey was identified as an essential resource when investigating recreational activities that depend upon New Zealand rivers, with the exclusion of fishing & shooting (Egarr & Egarr, 1981). The survey provided information on the recreation potential of a large portion of New Zealand's inland rivers and became the basis of the recreation & tourism ranking system. Fish and Game (n.d.) provided key research when making adjustments to the recreational values established by the New Zealand Recreational River Survey. The descriptions surrounding the quality of fishing and wildfowl shooting at each river were used to account for River Wild Recreation, which wasn't included in the survey scope.

IV. Methods.

i. Cultural Significance.

The cultural framework was based on five key elements: 1) cultural significance, identity and relationship; whakapapa & atua, 2) governance and environmental guardianship; kaitiakitanga, 3) experiences, aesthetic value, tranquillity and inspiration; makoha & ranga wairua, 4) cultural heritage values and knowledge systems; tikanga, and 5) resource use and food; mahinga kai. These factors were ranked from 1 – 5, where 1 to 5 represented very low significance, low significance, neutral, significant, highly significant and sustainable respectively.

Ranking each of these factors significance levels relied on the availability of data for each factor. Mahinga Kai specifically looked at the diversity of species and unique species to a river. For cultural significance and governance, the proximity of Hapū to a river was a key factor as this meant they had a greater connection to the river and usually had an environmental management plan for these rivers. The cultural heritage values were usually based around traditional travel routes and significant events.

ii. Ecology.

The basis of the ecological framework used multiple variables, which were then quantified and added together to generate a score for each river. The variables measured were native bird species, wetlands significance, key animal inhabitants, conservation management, and ecosystem stability. Primarily these variables were measured using GIS shapefiles, where each shapefile was quantified, as seen in table 1. In conjunction with this, external individual factors found through research were added if deemed significant, such as a National Water Conservation Order.

Table 1: The framework of the ecological methodology, showing the key variables measured, the data used to do so, and how this data was quantified into a rankable score. The majority of data was supplied by Environment Canterbury (ECan) and the Department of Conservation (DOC).

Variable	Data Used: (Canterbury Maps, 2019).	Qualitative Measurements.	Quantitative Rank
Native Bird Species	ECan Shapefile: River and open water habitats for indigenous birds.	Outstanding High Moderate – High Moderate Potential	The preordained ranks were quantified; a river received a 5 if classed as outstanding, and a 2 as potential.
Significant Wetlands	DOC Shapefile: Wetlands of Representative Importance (WERI).	Not applicable.	If identified as a contributing area, 1 point is given.
Key Inhabitants	ECan Shapefile: Roosting habitat of long-tailed bat	Not applicable.	If identified as a contributing area, 1 point is given.
	ECan Shapefile: Significant vegetation of water bodies.	Areas of swamps, rivers, terraces, gorges & lagoons associated with rivers.	Presence of each was given a score of 5, 4, 3, 2 and 1 respectively, based on the ecological values associated.
	NZFFD Excel Table: Non-migratory galaxiids distribution.	Not applicable.	If identified as a contributing area, 1 point is given.
	NZFOA Excel Table: Canterbury Mudfish	Not applicable.	If identified as a contributing area, 1 point is given.
Conservation Management	ECan Shapefile & DOC reports: Biodiversity Projects Locations	Not applicable.	If identified upon a braided river, 1 point is given for each project.
	New Zealand Legislation: Water Conservation Orders.	Not applicable.	If identified as a contributing area, 1 point is given.
Ecosystem Stability	ECan Shapefile: Effluent Dairy Discharge	Not applicable.	If identified as a non-contributing area, 1 point is given.
	ECan Shapfile: High Naturalness Water Bodies.		If identified as a contributing area, 1 point is given.

iii. Hydrology.

Hydrologic methods varied in their approach, and centred around gathering quantitative data into tables to generate a valuing system for each river (Benito et al., 2015., Keegan, 2009). The four factors of flow rate, water quality, area extent and

human interaction were evaluated according to each data source, and ranked using a variety of local New Zealand ranking criterion. Flow rate was measured in m^3s^{-1} and ranked on a scale of 1-10, with 10 being the highest flow rate (Tom Cochrane, personal communication, 2019., NIWA, 2016). This was collected from the ECan data service (2019) from employee Kerrie Mears (personal communication, 27/09/2019). Water quality was calculated on a scale of 1-10, with 10 being the most ideal conditions according to NIWA (2016) and LAWA's (2019) habitat ranking scheme. This incorporated 5 evenly weighted parameters of temperature, bacteria content, phosphorus concentration, water clarity, and nitrogen levels. River extent was weighted as the lowest significance for the Ramsar and World Heritage site criteria, giving it a scale of 1-5 based on Canterbury Maps river catchment area values (2019). Human Interaction was scaled from 1-20, with 20 being the ideal volume of interaction, making it the most significant parameter. Drinking and swimming data had a minor role being scaled from 1-3, with irrigation and gravel extraction being scaled from 1-7. Data was accumulated from LAWA (2019), ECan (2019), and Canterbury maps shapefiles. This included necessary areas and point data (Canterbury Maps, 2019). Data for each river was compiled, as seen in figure 2. Spatial data analysis was conducted in ArcGIS Pro to reveal additional patterns of the data through hotspot analysis and Getis-Ord Gi* analysis.

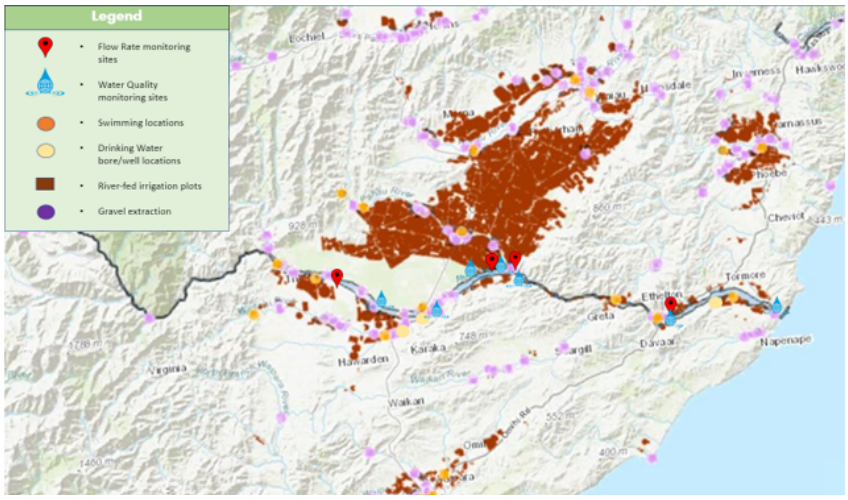

Figure 2: Components of the hydrologic ranking system: as seen above on the Hurunui river, where each factor is spatially represented across the river catchment.

iv. Geomorphology.

The geomorphological section of the physical methodology was based on three variables: braidplain width, human modification, and extended landscape character. Each of the 13 rivers were split into reaches, that is, homogenous stretches of river. For the purposes of this method, the natural terraces were used to define the braidplain as described by Gray (2018). The natural terracing for each reach was identified using elevation profiles and indicative river bank lines mapped by ECan (Table 2). Once completed, numerous cross sections were taken of the reach to establish representative width, inferring the current braidplain. The representative braidplain was used as a proxy for the reach which was then assessed using the 5 point score system (Table 2).

Table 2: Simplified version of Gray's (2018) assessment scale, as used in the geomorphological ranking system.

Variable	Considerations	Score description
Braidplain width	Unnatural constriction of braidplains, typically from human pressures	1 = Highly modified with little or no braiding 2 = Highly modified but exhibits some braiding 3 = Braidplain shows natural characteristics but is influenced by modification, which impacts its natural braiding 4 = Highly natural braidplain with a small amount of modification, which has a small bearing on its width 5 = Overwhelmingly natural braidplain with little or no change to its width
Presence of Human structures or modification	Dams, stop banks, groynes, and bridges	1 = Braidplain is almost surrounded by structures and modification 2 = Large section of the braidplain is surrounded by structures 3 = Presence of some structures and modification 4 = Occasional structures and modification

		5 = Overwhelmingly natural braidplain with little or no structures or modifications
Extended landscape character	Change of surrounding landscapes within a 5-kilometer radius	1 = Highly exotic surroundings such as intensive agriculture or large urban centers 2 = Exotic surroundings with small amounts of natural areas 3 = A mix of indigenous and cultivated landscape 4 = Indigenous landscape with some rural patches 5 = Untouched, indigenous landscapes

The presence and level of human modification and structures was ranked as seen in table 2, using data retrieved from Land Information New Zealand (LINZ). Stopbank location data was retrieved from Canterbury Maps. Presence of urban centres were also considered for this assessment. Each reach was then assessed using the 5 point score system. The extended surrounding landscape character was based on the area's state of modification. Reaches found on the plains typically scored lower due to intensive agriculture as opposed to the mountainous area, which retained indigenous character.

v. Recreational & Tourism Value.

The New Zealand Recreational River Survey acted as the basis of the recreational and tourism ranking system. The survey effectively measured the recreational potential of New Zealand's rivers by establishing values for the recreational and scenic characteristics of the river. The factors measured for determining the recreational value of each river included suitability of use for each recreational group, access, obstacles, proximity to urban settlements and skill or challenge factor for recreationalists. The scenic value is related to tourism activities which involve using the river environment for its visual attraction. This value was measured by considering the vegetation, vista and naturalness of each river. The survey

effectively established an extensive ranking system for measuring the recreational potential of New Zealand rivers. This was done with greater depth and more consideration of varying factors than what would've been able to be achieved with the time period and resources available for this project. Adjustments were made to the recreational value of each river when considering the importance fishing and shooting had on the particular river system. Scenic values weren't affected by the exclusion of fishing and shooting recreational activities and therefore remained unchanged from the surveys original value. The scenic and recreational values were weighted equally and then added together to give the final recreational and tourism score.

vi. Combined Methodology.

Individual ranking system scores were then added together. In order to make each comparable, the totals of each river for each factor was given as a percentage decimal. The cultural and ecological methods were applied to the majority of rivers within the Canterbury area. A natural break within the data provided a point where the higher ranked rivers were further ranked by the final three factors, and the lower ranking rivers were discarded. Scores were then weighted, where the cultural and ecological scores where multiplied by 25, and the remaining three factors multiplied by 16.67, in order to give a final score out of 100.

V. Results.

The highest ranked rivers vary across the different sectors (Table 3). The highest ranked rivers for cultural significance were the Hurunui, the Ashley and the Rakaia respectively. The highest ranking ecology score was the Waitaki at 20, followed by the Ahuriri and the Waimakariri. In both systems, the highest ranking rivers have scored highly across all the measured variables; within the ecological variables, this translates to high populations of key inhabitants such as native water birds and

vegetation, high naturalness, and significant conservation efforts such as Water Conservation Orders and biodiversity projects.

Table 3: The results of the individual ranking systems, showing the ten highest ranking rivers within each system.

River:	Cultural Score	River:	Ecology Score:	River	Hydrology Score	River	Geomorphology Score	River	Rec & Tourism Score
Hurunui	25	Waitaki	20	Rakaia	34.5	Ahuriri	13.25	Ahuriri	7.14
Ashley	25	Ahuriri	20	Wilberforce	33	Wilberforce	13.0.2	Rangitata	6.93
Rakaia	25	Waimakariri	19	Ahuriri	32.5	Hurunui	11.91	Waimakariri	6.18
Wilberforce	25	Orari	18.25	Rangitata	32	Conway	11.22	Hurunui	5.87
Ashburton	25	Rakaia	17.5	Hurunui	32	Rakaia	10.77	Rakaia	5.61
Rangitata	25	Ashburton	16.75	Waimakiriri	29	Ashley	9.74	Waitaki	5.58
Waitaki	25.	Rangitata	16.25	Conway	29	Rangitata	9.74	Ashley	4.97
Conway	16.67	Hurunui	15.75	Waitaki	28.5	Waimakariri	9.20	Ashburton	4.56
Waimakariri	16.67	Tekapo	15.75	Ashburton	28	Waitaki	8.67	Wilberforce	4.14
Selwyn	16.67	Cass	15.75	Ashley	26.5	Makikihi	8.54	Orari	3.37

In terms of hydrologic factors, the Rakaia river had the highest score of 34.5 out of 45 with the highest flow rate, a large area and an ideal amount of human interaction. This was closely followed by the Wilberforce river with a score of 33, and the Ahuriri river with 32.5. These two rivers varied in their hydrologic values, where they both displayed high water quality and human interaction scores, but lacked in flow rate. Worth noting, the Waitaki scored a 28.5 overall. Having extensive gravel and irrigation extraction, along with a dam declined its human interaction score to a 7 out of 20, which severely hindered its chances of scoring highly in the hydrologic section despite its exquisite flow rate and water quality scores. Within the geomorphology rankings, Ahuriri, Wilberforce, and Hurunui ranked highest with scores of 13.2554, 13.0185, and 11,9058 respectively. These rivers generally scored higher in their lower reaches compared to other rivers. The highest recreation &

tourism ranked rivers were the Ahuriri, followed by the Rangitata and the Waimakariri. The top three rivers scored 7.14, 6.93, and 6.18, respectively.

The Rakaia was the highest ranking score overall, followed closely by the Rangitata and the Hurunui (Table 4).

Table 4: The final results of the combined ranking system, once the individual ranking scores have been added and weighted according to their UNESCO World Heritage and Ramsar criteria. .

Rivers.	**Cultural**	**Ecology**	**Hydrology**	**Geomorphology**	**Recreation & Tourism**	**Total**
Rakaia	25	16.8	12.7	11.8	9.3	75.6
Rangitata	25	15.6	12.1	10.7	11.4	74.9
Hurunui	25	15.1	11.7	13.1	9.7	74.7
Ahuriri	16.7	19.2	11.9	14.6	11.8	74.2
Waitaki	25	19.2	10.5	9.5	9.2	73.4
Wilberforce	25	14.2	12.1	14.3	6.8	72.4
Ashley	25	17.5	9.7	10.7	8.2	71.2
Ashburton	25	16.1	10.3	9.3	7.5	68.2
Waimakariri	16.7	17.5	10.6	10.1	10.2	65.2
Conway	16.7	13.7	10.6	12.3	5.5	58.8
Pareora	16.7	12	8.8	8.5	4.8	50.8
Orari	8.3	17.5	9.5	8.6	6.2	50.2
Makikihi	16.7	7.2	8.3	9.4	4.1	45.6

VI. Discussion.

The Rakaia ranks highly on all the cultural values that have been discussed throughout the report; there is a Hapū close to the mouth of the river, Te Taumutu Rūnanga. This would ensure co-management of this area can be achieved between Hapū and government. The Rakaia was part of the traditional travel route that went over Nōti Raureka (Browning Pass), connecting with the Arahura River on Te Tai Poutini (the West Coast). The Rakaia is an important source of mahinga kai to local Hapū and Iwi.

The ecological values of the Rakaia align with the requirements outlined within the UNESCO and Ramsar criteria. This includes a keystone population of wrybill, and is identified as an area of high species diversity and an important breeding habitat for threatened species by the DOC (2009). Key inhabitant include non-migratory galaxiids, which populate both the upper and lower sections of the Rakaia, and the lower river is inhabited by the Canterbury Mudfish. Furthermore, the Rakaia is protected by the National Water Conservation Order 1988, which acknowledges a high level of outstanding natural character, wildlife, and recreational value.

The Rakaia was ranked the highest hydrologically as it displays ideal values of flow rates, area of extent and human interaction. These values align with the UNESCO and Ramsar criteria, as suitable conditions of unique naturalness and exquisite hydrologic systems. The Rakaia received the highest score for flow rate and area, as it covers 59,415.73 Hectares with a flow rate of 203 m^3s^{-1}. The Rakaia had the lowest water quality rating of 6.5 out of the 13 analysed rivers. Methods such as RiVAR (Hughey et al., 2013) and hydrologic classification (Olden et al., 2012) were suitable in establishing a river ranking system, and were adapted to assess hydrology. In order to assess the hydrology, the ranking system components were adjusted to consider hydrology parameters. This will encounter error and includes subjectivity to the ranking system, although using the established ranking systems aided in mitigating this effect, which validates the hydrologic ranking scheme used for this research assignment.

The geomorphology method applied is highly controversial due to high subjectivity exposure (Gray, 2018). The Rakaia river placed 5th within geomorphology due to encroachment and agricultural intensification on the lower reaches. The Rakaia river received the highest overall score despite this. Although not considered in this report, dongas are particular physical landscape features that are present between

the Hinds and Rakaia river, which could increase the extended landscape character of the area. Globally, these are extremely rare and add to the superlative phenomena of this river (DOC, 2016).

The Upper Rakaia and Rakaia Gorge have high scenic value, in conjunction with a high recreational value within the Rakaia Gorge: salmon and trout fishing are prevalent along the river, as well as wildfowl shooting and terrestrial recreational activities along the river banks.

VII. Limitations & Assumptions.

i. Data availability

A major difficulty encountered within this project was the lack of consistent data across the majority of braided rivers within Canterbury. In order to ensure validity and consistency across the research, rankings were limited to data that was inclusive of the majority of rivers across Canterbury. This was easily managed with regards to the cultural and ecological rankings. The remaining three systems were significantly limited to data availability. As such, when a natural break occurred within the data from the combined cultural and ecological ranking systems, the lower ranked rivers were discarded, and the higher ranked rivers analysed further.

The cultural analysis was reliant on information from Ngāi Tahu's interactive map. Although this did not have information on all of the braided rivers within the Canterbury region, this resource provided a substantial amount of the necessary information to complete the cultural ranking system. Due to the time constraints and sensitivity of this project, primary interviews with local Iwi members in order to collect primary and inclusive data on each river was unable to be achieved. It is recommended that further study include this in order to gain insight and

understanding into the significance of each braided river, as well as which river they believe would be best suited for World Heritage or Ramsar recognition.

Further, hydrology and geomorphology data was inconsistent. For some river systems, there is one or no monitoring sites able to collect data. With a reliance on ECan (2019), a considerable amount of flow rate and water quality data was covered, but lacked a complete database suitable for research of this scope. This resulted inaccurate data. As this is an unavoidable limitation throughout the method, further studies should seek to acquire a greater dataset for braided rivers, to gain insight into the hydrology of the Canterbury catchment.

ii. Subjectivity

Subjectivity is an issue prevalent within the majority of qualitative research, as this requires human evaluation of data which introduces personal bias. This report was no exception, with emphasis on the cultural and social framework methodologies. When rating the different characteristics involved in the scenic and recreational values, there was significant subjectivity as there is no quantifiable basis to measure scenic attractiveness and enjoyment levels associated with different recreational activities. However, this report was based on the comparison of river values. However, retaining consistency within qualitative scoring allowed for precise, reliable results.

In order to achieve this, variables were measured within set definitions across each factor: within the recreation & tourism system, vista was defined as "…the more distant views beyond the immediate river bank area." (Egarr & Egarr, 1981). Vistas with far off landscapes and dramatic nearby landforms were more highly regarded than vistas including only river bank scenery. There is a current problem with a braidplain is defined, which can have a significant change on how the elevation

profiles and the width of the braided river is perceived. How the braided rivers are defined have come under much scrutiny due to opposing values of different parties (Ministry for the Environment, 1991; BRaid, 2019; Environment Canterbury, 2015). This affects the management of braided rivers (BRaid, 2019). Within this report, the braid plain is defined by the natural river terracing and indicative river bank lines (Canterbury Maps, 2019).

With regards to the cultural system, use of previous literature and interviews within the Ngāi Tahu Research Centre at the University of Canterbury were used to gain knowledge to make accurate decisions. However, to avoid all cultural subjectivity consultation with Maori would be needed to gain an understanding of key cultural values and the significance of each braided river within Canterbury.

iii. Reusability

Due to the nature of the project, lack of data availability and exposure to subjectivity was significant. To combat this, the project methodology was designed to be reusable; where interested parties could alter the weighting of a factor at their discretion. This applies to the individual ranking systems as well: variables can be added and removed at a parties discretion to achieve their aim, as well as adjusting values and rankings based on the addition, removal, or adjusting of data. Within the cultural framework, the community partner may be able to gather information from Hapū and Ngāi Tahu, and recalculate the final result as such, thus altering the final cultural score. This design is applicable across all of the ranking systems, where access to additional data can be used to recalibrate the final scores. This is significant within the natural sectors of ecology and physical character; the variables used within these systems have been chosen in accordance with the UNESCO and Ramsar criteria. As such, for a party such as Fish & Game, ecology may be a priority,

which may result in an adjustment in the weight of the overall methodology to favour the ecological, hydrological and natural character ranking scores.

VIII. Conclusion.

This study nominates the Rakaia for international status recognition, under either UNESCO World Heritage or Ramsar criteria. This is due to high significance calculated throughout the ranking system, where the Rakaia ranks highly among all five factors: cultural significance, ecology, hydrology, geomorphology, and recreation & tourism. Furthermore, the Canterbury Aoraki Conservation Board will be able to utilise research for future preservation of braided river systems within the Canterbury catchment. This research can be used for further implementing plans and milestones set in the 2016 Canterbury Management Strategy to achieve international recognition for at least one of the Canterbury braided rivers.

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X. Appendices.

i. Appendix 1: UNESCO World Heritage Site and Ramsar Criteria.

The criteria highlighted in bold was the applicable material used to define the ranking systems within this project.

Table 5: UNESCO World Heritage Selection Criteria (World Heritage Centre – UNESCO, 2019).

I	to represent a masterpiece of human creative genius
II	to exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design
III	**to bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared**
IV	to be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history
V	**to be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change**
VI	to be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. (The Committee considers that this criterion should preferably be used in conjunction with other criteria)
VII	**to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance**
VIII	to be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features
IX	**to be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals**
X	**to contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.**

Table 6: Ramsar Site Criteria (Ramsar, 1975;2019).

	Ramsar Site Criteria (Ramsar, 1975;2019).
I	**Should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region**
II	**Should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.**
III	**Should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.**
IV	**Should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.**
V	Should be considered internationally important if it regularly supports 20,000 or more water birds.
VI	**Should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of water bird.**
VII	Should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
VIII	Should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
IX	Should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

ii. Appendix 2: Top Results of the Individual Ranking Systems.

Table 7: The variables measured within the cultural ranking system.

Cultural Variables	Ranking Scores
Cultural significance, identity and relationship	5 - Highly significant and sustainable
	4 - Significant
"Whakapapa, Atua"	3 - Neutral
	2 - Low significance
	1 - Very low significance
Governance and environmental guardianship	5 - Highly significant and sustainable
	4 - Significant
"Kaitiakitanga"	3 - Neutral
	2 - Low significance
	1 - Very low significance
Experiences, aesthetic value, tranquillity and inspiration	5 - Highly significant and sustainable
	4 - Significant
"Makoha, Ranga Wairua"	3 - Neutral
	2 - Low significance
	1 - Very low significance
Cultural heritage values, knowledge systems	5 - Highly significant and sustainable
	4 - Significant
"Tikanga"	3 - Neutral
	2 - Low significance
	1 - Very low significance
Resource use and food gathering	5 - Highly significant and sustainable
	4 - Significant
"Mahinga Kai"	3 - Neutral
	2 - Low significance
	1 - Very low significance, diminishing the resource

Table 8: The top 13 results of the ecological ranking systems, showing the individual scores of each river through each measured variable.

River:	WERI	Effluent Discharge	Bio Proj.	Naturalness	Significant Vegetation	Water Bird Habitats	Long-tailed Bat	Total
Waitaki	5	3	2	0	5	5	0	20
Ahuriri	5	4	2	1	4	4	0	20
Ashley	5	3	2	0	1	5	3	18
Waimakariri	5	3	1	0	4	5	0	18
Orari	5	4	1	2	3	3	0	18
Rakaia	5	1	1	0	6	5	0	18
Ashburton	5	3	2	2	2	3	0	17
Rangitata	5	1	2	0	4	2	2	16
Hurunui	5	4	0	0	3	4	0	16
Tekapo	5	4	1	0	2	4	0	16
Cass	5	2	1	0	4	4	0	16
Dobson	5	4	1	1	1	4	0	16
Opihi	5	3	0	0	1	3	3	15
Tasman	5	3	1	0	3	3	0	15

Table 9: Hydrology parameters and collated data: whilst the flow rate and area data is raw, the water quality and human interaction are the evaluated scores, as they both involve multiple variables.

River Names	Flow Rate/Volume (m^3s^{-1})	Water Quality	Area (Ha)	Human Interaction	Totals
Rakaia	10	6.5	5	13	34.5
Wilberforce	6	9	2	16	33
Ahuriri	4	7.5	4	17	32.5
Rangitata	10	7	5	10	32
Hurunui	6	7	4	15	32
Waimakariri	10	7	2	10	29
Conway	2	8	2	17	29
Waitaki	10	8.5	3	7	28.5
Ashburton	4	7	5	12	28
Ashley	2	8.5	2	14	26.5
Orari	2	9	2	13	26
Paeroa	2	9	1	12	24
Makakihi	2	7.5	1	12	22.5

Table 10: The results of the top 13 ranked rivers ranked by the different parameters used to establish the final values within the recreation & tourism ranking system.

Rivers	Scenic (1 - 6)	Intital Recreation (1 - 4)	Fishing (1-4)	Wildfowl Shooting (Yes/No)	Total
Ahuriri	4	3	3.25	Yes	7.14
Rangitata	3.75	3	3.25	Yes	6.93
Waimakariri	3.6	3	1.75	Yes	6.18
Hurunui	3.1	2.25	3.5	Yes	5.87
Rakaia	3.7	2	2.16	Yes	5.61
Waitaki	3	2.5	2.5	Yes	5.58
Ashley	3.3	1.7	2	Yes	4.97
Ashburton	3.75	1	1.5	No	4.56
Wilberforce	3	1	2	No	4.14
Orari	3	1	1	No	3.73
Conway	3	1	0	No	3.32
Pareora	3	0	1	No	2.90
Makikihi	3	0	0	No	2.49

Table 11: The results of the geomorphological ranking system, inclusive of the measured variables; the top 13 highest ranking rivers are displayed.

Rivers	Reach	Braidplain width	Modification	Landscape character	Total	Weighted Total
Ahuriri						13.2554
	Reach 1	3	3	2.5	8.5	
	Reach 2	4.5	4	3	11.5	
	Reach 3	4.5	4.5	4.5	13.5	
	Reach 4	5	5	5	15	
	Reach 5	5	5	5	15	
Wilberforce						13.0185
	Reach 1	5	5	4.5	14.5	
	Reach 2	5	3.5	4	12.5	
Hurunui						11.9058
	Reach 1	3.5	3.5	2.5	9.5	
	Reach 2	3.5	2.5	3.5	9.5	
	Reach 3	3.5	3.5	1.5	8.5	
	Reach 4	4	5	4	13	
	Reach 5	5	5	5	15	
Conway						11.2221
	Reach 1	3	2.5	3	8.5	
	Reach 2	4	4	4.5	12.5	
	Reach 3	4	5	3.5	12.5	
Rakaia						10.7724
	Reach 1	2	3	2.5	7.5	
	Reach 2	2.5	3	2.5	8	
	Reach 3	3.5	4.5	3.5	11.5	
	Reach 4	4.5	4.5	4	13	
	Reach 5	5	5	5	15	
Ashburton						8.42
	Reach 1	2	2	2	6	
	Reach 2	2	2	2.5	6.5	
	Reach 3	5	5	5	15	
Ashley						9.74125
	Reach 1	3	2	2	7	
	Reach 2	2.5	2.5	2	7	
	Reach 3	5	4.5	5	14.5	
	Reach 4	3.5	2.5	3.5	9.5	
	Reach 5	5	4.5	5	14.5	
Waimakariri						9.202
	Reach 1	1	1	1	3	
	Reach 2	3	2	2	7	
	Reach 3	3.5	5	5	13.5	
	Reach 4	4.5	3.5	4	12	
	Reach 5	3.5	2.5	3.5	9.5	
Waitaki						8.66842
	Reach 1	3.5	2	3.5	9	
	Reach 2	1	1	1	3	
Makikihi						8.54369
	Reach1	2.5	3	2	7.5	
	Reach2	3	3	4	10	
Ashburton						8.42
	Reach 1	2	2	2	6	
	Reach 2	2	2	2.5	6.5	
	Reach 3	5	5	5	15	
Orari						7.85981
	Reach 1	1.5	2	1.5	5	
	Reach 2	4.5	5	4.5	14	
	Reach 3	3	2.5	3.5	9	
Pareora						7.7305
	Reach 1	2	1.5	2.5	6	
	Reach 2	1.5	2	2.5	6	
	Reach 3	2.5	2	3	7.5	
	Reach 4	5	5	5	15	