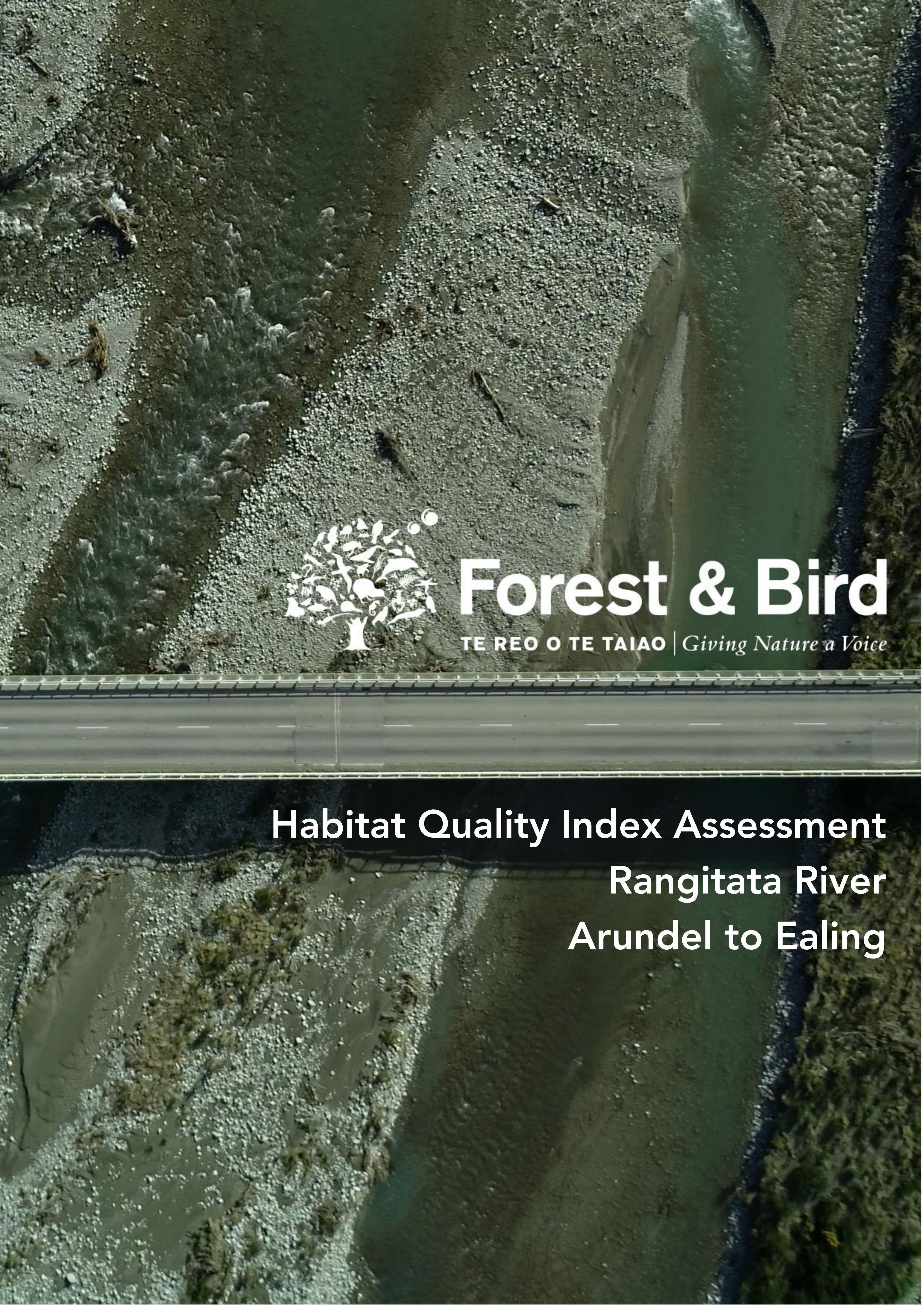

Forest & Bird

TE REO O TE TAIAO | *Giving Nature a Voice*

Habitat Quality Index Assessment
Rangitata River
Arundel to Ealing

Rangitata River Habitat Quality Index (HQI) Assessment

Arundel to Ealing

Prepared by Thomas Kay

Forest & Bird | Te reo o te taiao

May 2020

Acknowledgements

Forest & Bird acknowledge the substantive work of Dr. Russell Death and Dr. Ian Fuller at Massey University Innovative River Solution and their colleagues from various organisations in the development of the Habitat Quality Index—this assessment is a merely re-application of their work to a different river. We also acknowledge Oriane Etter for her work geo-referencing the historical imagery of the river. Finally, acknowledgments to Massey Innovative River Solutions for the use of their drone to capture the cover photo of this report and Victoria University staff Dugal McKinnon, Mo Zareei, and Jim Murphy for their role in capturing the photo. Forest & Bird also acknowledge Dr Ian Fuller for his feedback on an early draft of the report.

Cover photo

Looking down over the Rangitata riverbed and State Highway 72 bridge at Arundel from an altitude of 120m above ground level, July 2019. Photo: Thomas Kay.

Executive Summary

1. The modification of rivers for flood management, irrigation, and agriculture has resulted in a decline in the geomorphic condition and habitat quality of river systems.
2. Death et al. (n.d.a., n.d.b., in prep.) developed the Habitat Quality Index (HQI) as a method to identify and quantify changes in river habitat quality over time. Their method allows for a river's 'current' physical condition to be assessed against its historical, or 'near natural' condition. It presents a measure of the change in condition from 'then' to 'now'.
3. Forest & Bird undertook an HQI assessment of the Rangitata River between Arundel and Ealing in order to quantify any changes in habitat quality from 1937 to 2016-2018.
4. Parameters measured were active channel width, natural and permitted floodplain width, and mid-channel bar length, which was used to calculate a braiding index.
5. Resultant HQI scores are presented in the table below:

REACH	a	b	c	d	e	f	$HQI_{overall}$
Active channel	0.67	0.88	0.57	0.41	0.39	0.52	**0.55**
Floodplain	0.53	0.55	0.85	1.00	1.00	1.00	**0.92**
Braiding index	1.85	0.95	0.76	2.46	0.91	1.00	**0.98**
$HQI_{overall}$	**0.67**	**0.88**	**0.76**	**1.00**	**0.91**	**1.00**	

6. Overall HQI scores, either for each reach or each parameter measured, are calculated as the median of all component scores. Pratt, Neverman, Fuller, & Death (2018) state that a decline of more than 15% in an overall score, or 40% in any single component score should be cause for concern and would indicate a potential need for mitigation activity.
7. The overall HQI scores for reaches a (0.67), and c (0.76), and the overall score for active channel width (0.55) are therefore cause for concern, indicating a significant reduction in the physical condition of the river through the a and c reaches and of the active channel width through all reaches. These low scores are likely a result of the reduction in flows that has occurred with increased water takes for irrigation, and the 'development' of vegetated bars and the floodplain along the edges of the river by farmers.
8. Flooding in December 2018 illustrated the impacts of these changes when the river temporarily reclaimed previously flowing channels and again resembled its condition in 1937.

9. The component floodplain scores for reaches a (0.53) and b (0.55) are also cause for concern. Construction of the storage ponds for the South Rangitata irrigation scheme appears to be the cause of this reduction.
10. The extension of this HQI assessment to the coast and to additional reference years would assist in illustrating more clearly the extent and cause of changes in habitat quality along the Rangitata River through time.

Introduction

Despite an increasing recognition of the importance of river and stream systems in providing life supporting services to communities and biota, the condition of these environments continues to decline (Maddock, 1999; Death, Fuller, & Macklin, 2015; Vaughan et al., 2009). With the frequency of extreme climatic events increasing there is a perception that further modification to river systems will be required as communities attempt to alleviate resultant effects on agriculture, health, or infrastructure (Death, Fuller, & Macklin, 2015; Vaughan et al., 2009). While there has been some recognition of the effect of these changes on biota, attention has generally been directed towards measuring the impact of changes in water quality, water quantity, or the biotic assemblages themselves (Death, Fuller, & Death, in prep.; Harding et al., 2009; Maddock, 1999; Raven, Fox, Everard, Holmes, & Dawson, 1997). It has, until relatively recently, been ignored by many—including regulators—that the maintenance and protection of physical habitat is vital to ensuring the health of river systems does not continue to degrade (Death et al., in prep; Elosegi, Díez, & Mutz, 2010; Elosegi & Sabater, 2013).

In response to this lack of attention towards the importance of physical habitat in riverine ecosystems, Death et al. (n.d.a, n.d.b, in prep.) developed the 'Habitat Quality Index' (HQI) as a method for assessing the current condition of a river's physical habitat against its historic condition. It allows for the quantification and assessment of those habitat variables most relevant for assessing the ecological health, or geomorphological condition, of a river, and presents them as simple ratio scores of current to natural condition. It also allows for the measurement of any number of parameters and measurement at any scale, provided sufficient historic data from which to form a reference condition can be obtained.

Forest & Bird considered the Rangitata River to be in desperate need of such an assessment given that substantial modification to the river has occurred in recent decades. In particular, water takes and diversions for irrigation, construction of water storage ponds, the cessation of flows down the south branch of the river, and reclamation of vegetated banks/bars by neighbouring farmers appear to have had a gross negative effect on the character of the river—perpetuated by a lack of regulation or a suitable management framework for the protection of the river. We have undertaken this assessment for a section of the Rangitata in an attempt to quantify the consequences of these actions and issues on the physical condition of the river and illustrate the application of the HQI in future river management.

Rangitata River Context

The Rangitata River is located in New Zealand's South Island and flows from the Eastern edge of the Southern Alps, near Erewhon, to the Pacific Ocean, between Ashburton and Geraldine (see Figure 2). Beginning at the confluence of the Clyde and Havelock Rivers, the Rangitata's upper catchment is largely unmodified, dominated by alpine and sub-alpine ecosystems and braided river valleys. Except for the impact of some agricultural activity at Erewhon and Mesopotamia (grazing of the riverbed through LINZ agreements, etc.), the river is largely unmodified through this section. However, following its emergence from the Rangitata Gorge at Klondyke, the river is subject to a substantial number of takes and diversions for irrigation, including the large Rangitata River Diversion Race, completed in 1944 (RDR, n.d.), and the Rangitata South irrigation scheme (Piddington, 2013), before emerging on to the Canterbury Plains, the most intensely irrigated area of land in the entire country (Statistics NZ, 2017).

The Rangitata was granted a Water Conservation Order in 2006 to protect a range of remaining 'outstanding characteristics' throughout the length of the river, from the sources of the Clyde and Havelock Rivers all the way to the coast. This included the protection of geomorphological characteristics noted in the order as "Scientific - braided river" from upstream of the Arundel bridge to the coast (Rangitata WCO, 2006). The Rangitata River has only one flow monitoring station, located on the final reach of the Rangitata Gorge at Klondyke (ECan, n.d.).

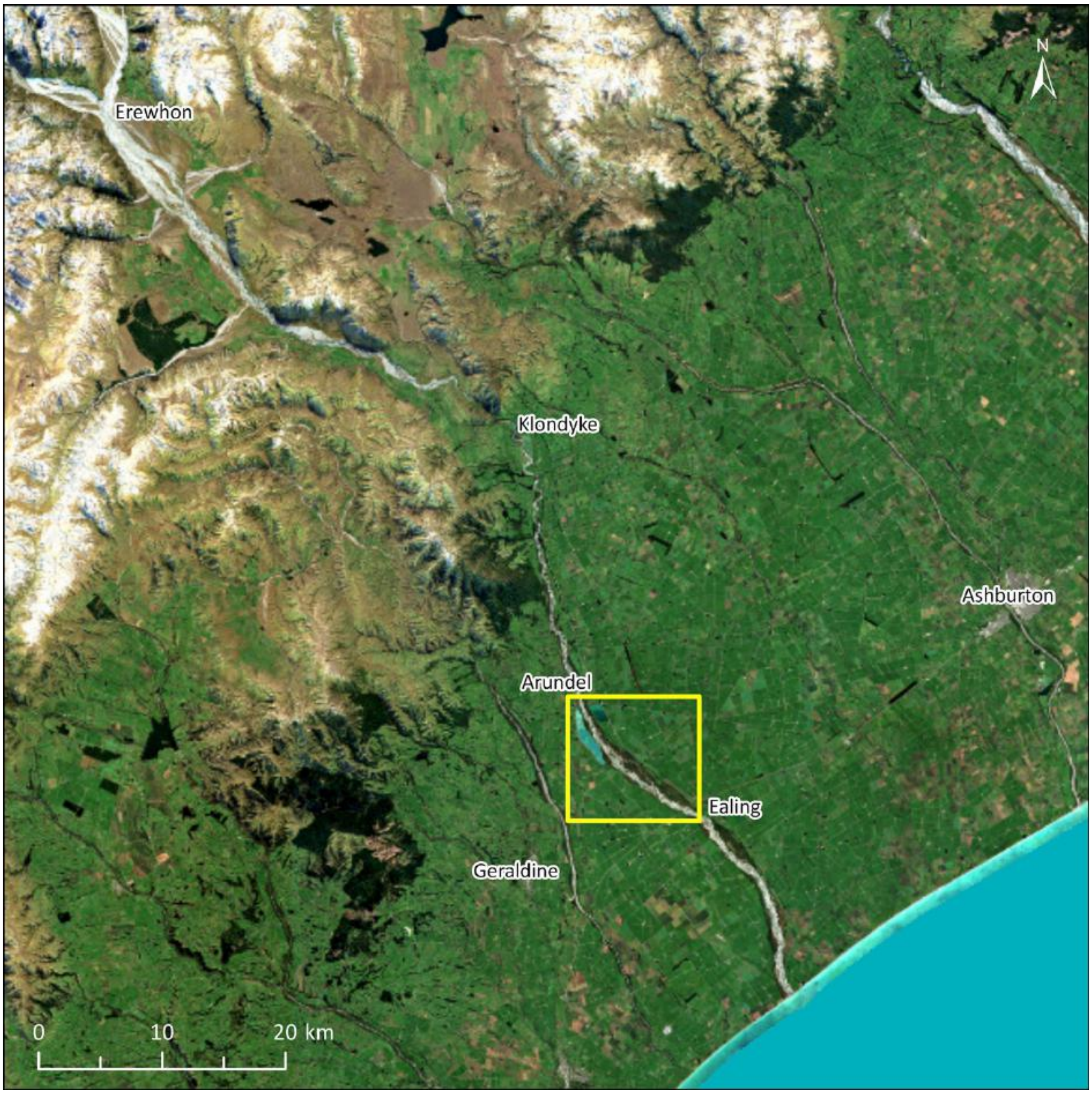

Figure 1: The Rangitata River, flowing from the top left to the bottom right of the map. The area assessed in this report is contained within the yellow box and reproduced in figures 2 and 3 below.

Measured Parameters and Data Sources

The assessment of the Rangitata River's 'current' (2016-2018) habitat quality against its pre-modification habitat quality was limited by the availability and quality of historical data (in the same way that Death et al.'s (n.d.a., in prep.) assessments were limited). Historical black and white aerial imagery of the Rangitata obtained from 1937 was considered a sufficient and near-natural 'baseline' on which to form an assessment of some key habitat parameters, particularly as it was captured before any major water diversions were operational. Coincidentally, work on the 'Rangitata Diversion Race', which was "New Zealand's first major river diversion and largest irrigation scheme" (ENZ, n.d.)—and which has likely had an adverse effect on the Rangitata's habitat quality—was started in 1937 but not completed until 1944 (RDR, n.d.).

Parameters measured in this assessment were active channel width, natural and permitted floodplain widths, and total length of mid channel bars (which was used to calculate a braiding index) as these were readily measurable from historical and LiDAR imagery and were considered appropriate to inform a relatively comprehensive picture of changes in physical habitat over time. Other relevant finer-scale parameters (such as substrate composition, deposited sediment (Death et al., in prep.)) are, at this time, not able to be accurately estimated from aerial imagery obtained at these resolutions (Woodget, Fyfe, & Carbonneau, 2018) and would need to form part of a shorter-term assessment.

Geo-referenced aerial photographs from 1937 and 2016-2018 were used to measure channel characteristics, with 'Light Detection and Ranging' (LiDAR) imagery and NZ Topo50 maps used to inform measures of floodplain width. Imagery from 1937 was obtained from the 'RetroLens' website (http://retrolens.nz/map/) while all other data was obtained through the LINZ Data Service. Parameters were assessed for a series of reaches (a-f as illustrated in Figures 2 and 3), each approximately 2km long, in order to simplify subsequent analysis.

Active Channel and Floodplain Widths

Active channel and floodplain widths were measured in ArcGIS Pro 2.3.1 using aerial and LiDAR imagery and a New Zealand Topo50 topographic map (LINZ, 2020). Both were defined and measured in line with the methodology of Death et al. (in prep.). That is—active channel width was defined as the width of the wetted channel, active gravel bars, and mid-channel islands combined (including those with vegetation where it wasn't mature enough to limit reworking); natural floodplain width was defined as the width between the two youngest river terraces; and permitted floodplain width was defined as the width of floodplain still accessible to the river during a flood. Widths were measured using the line tool ArcGIS Pro on transects at approximately 200 metre intervals running perpendicular to the channel's flow. The assessment of natural floodplain width was supplemented with the use of a topographic map as comprehensive LiDAR imagery was not available for the Arundel-Ealing reach and substantial engineering works on the true right bank have destroyed any remnant river terraces that may have otherwise been visible with LiDAR. An example of active channel width measurement is illustrated in Figure 4.

Braiding

Braiding was assessed using Brice's Index, as defined in the work of Death et al. (in prep.), which states the extent of braiding is twice the total length of mid-channel bars in a reach divided by the mid-channel length of that reach. Bar length for each reach was measured in ArcGIS Pro using the line tool, multiplied by two, and then divided by the reach length as measured with the ruler tool. Given that the Rangitata River has many thalwegs, the mid-channel length was considered to be the length down the centre of the riverbed from the start to the end of each reach and was identical in 1937 and 2017/2018. An example of how braids were measured is illustrated in Figure 5.

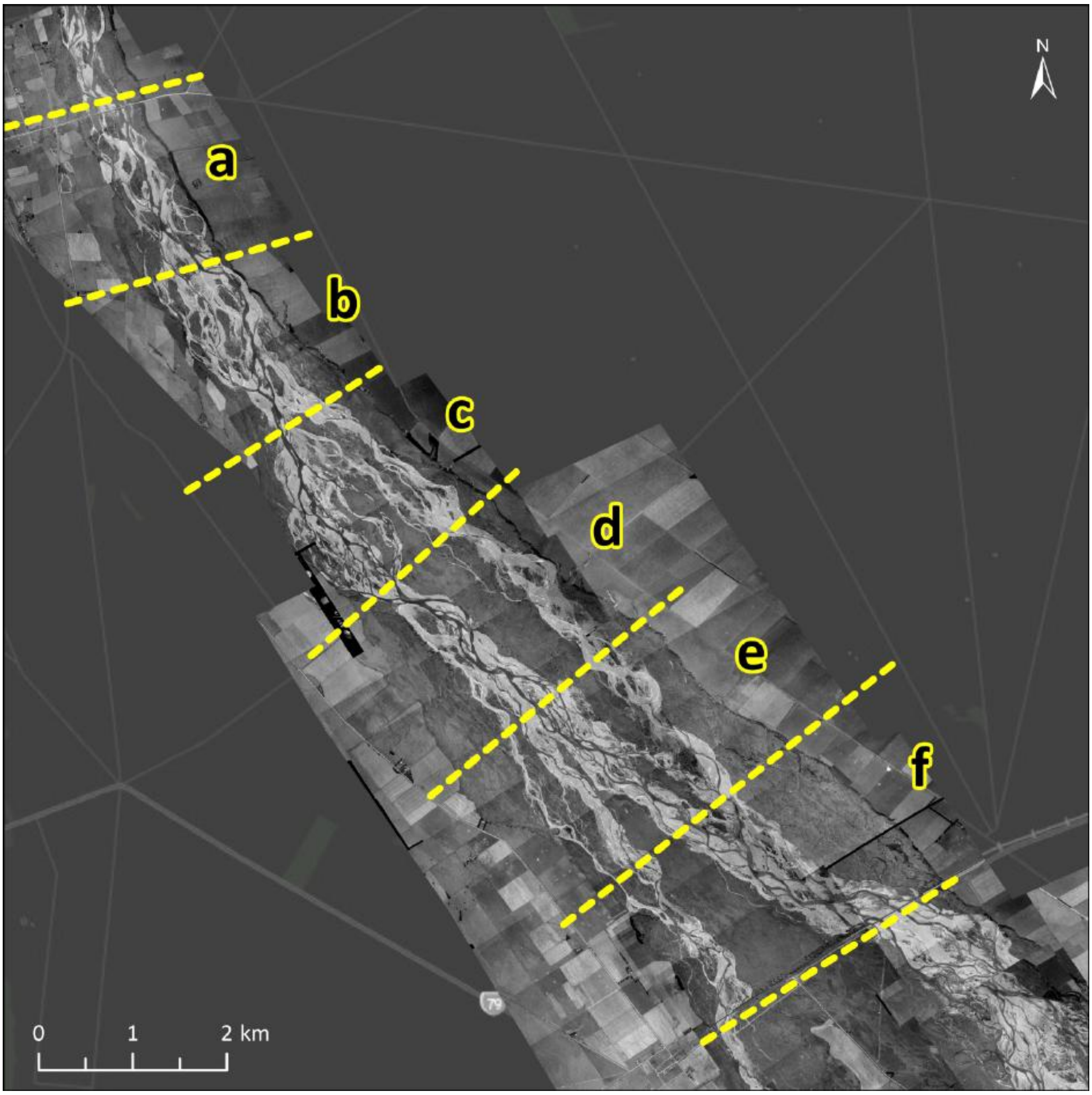

Figure 2: Rangitata River from Arundel to Ealing in 1937. The river has been divided into reaches (a-f) for analysis. Arundel is at the top left of the map, while Ealing is at the bottom right. The first and last yellow lines overlap approximately with the two State Highway bridges.

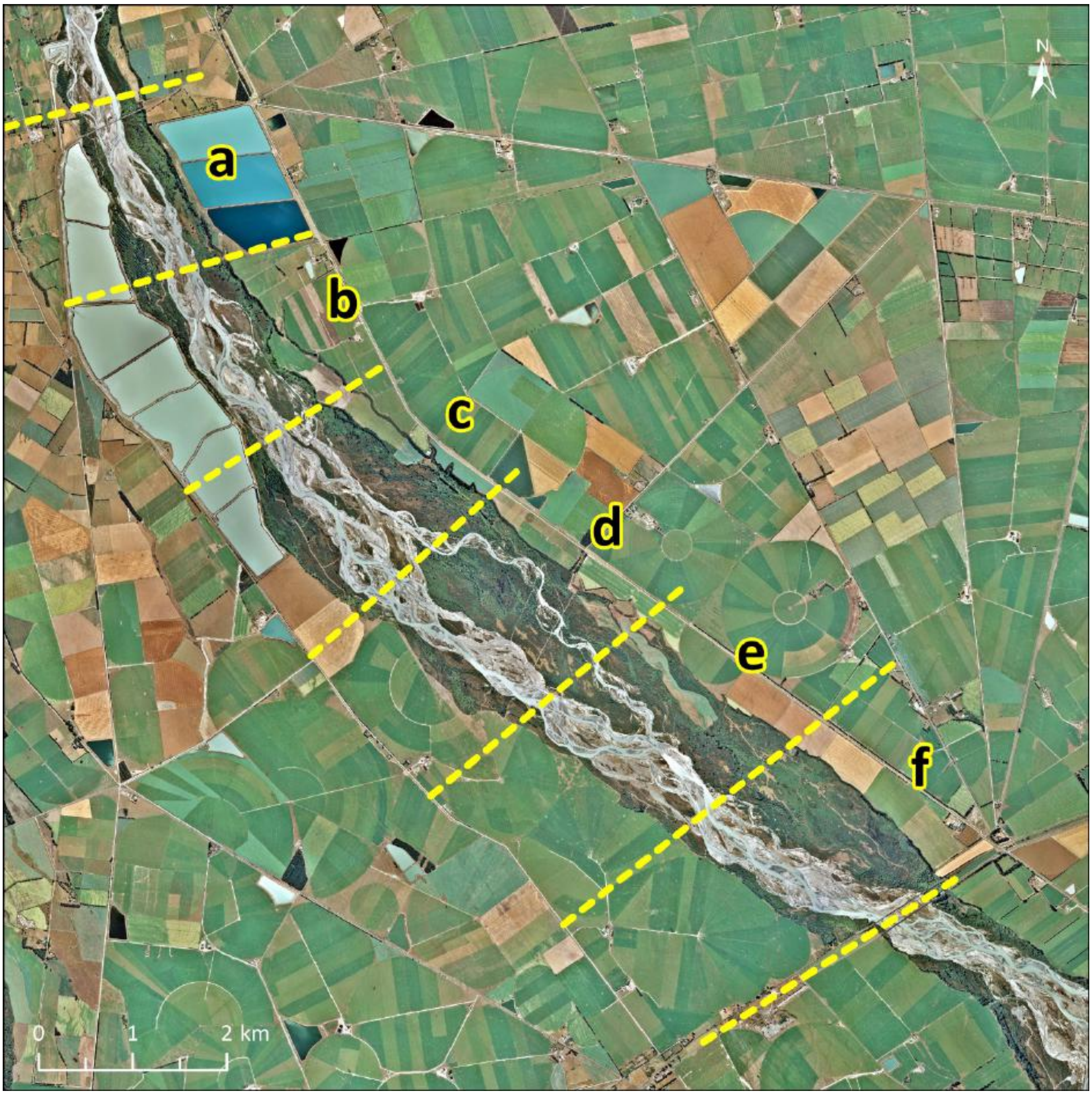

Figure 3: Rangitata River from Arundel to Ealing in 2016-2018. The river has been divided into reaches (a-f) for analysis. Arundel is at the top left of the map, while Ealing is at the bottom right. The first and last yellow lines overlap approximately with the two State Highway bridges.

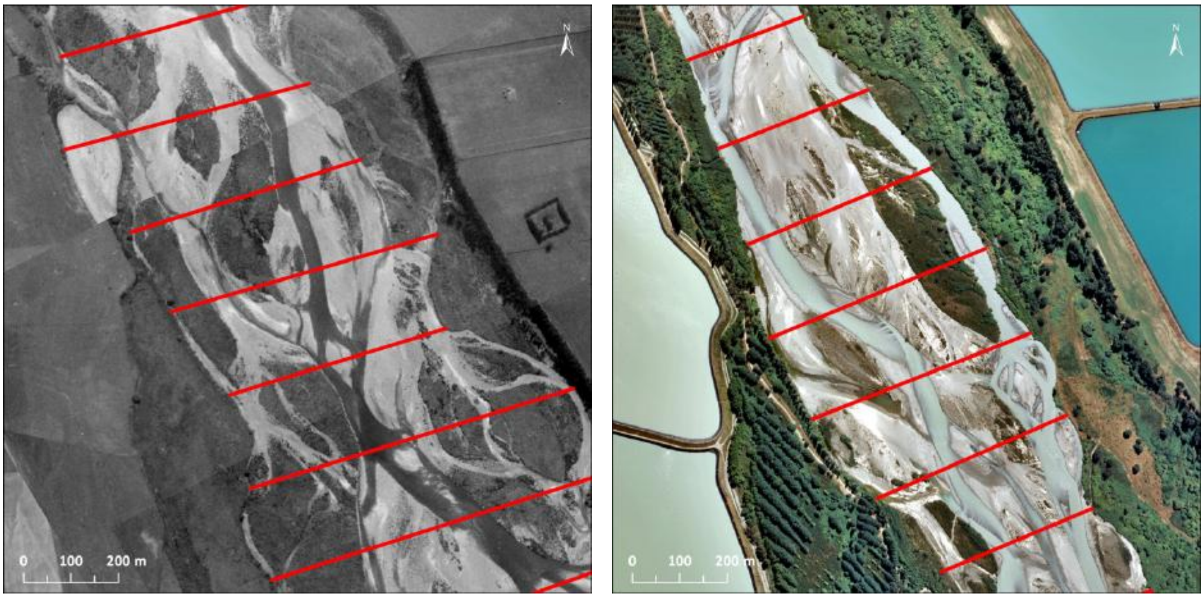

Figure 4: An example of how lines were drawn in ArcGIS Pro to measure the active channel width in 1937 (left) and 2016-2018 (right). The total length of all lines in a reach was divided by the number of transects in the reach to calculate an average width. Imperfections, lower clarity, and a lack of colour in the 1937 imagery made accurate assessment more difficult. Note that the two images here are the same location and scale.

Figure 5: Lines drawn in ArcGIS Pro following the long axis of mid-channel bars in 1937. The total length of all lines in a reach was multiplied by two and then divided by the reach length to obtain a braiding index. The end of reach f can be seen at the bottom right of the image. Accurate assessment in some parts of the riverbed was difficult as a result of discontinuities (from the orthomosaic), lower resolution, and a lack of colour in the 1937 imagery, and over-exposure in some of the 2016-2018 imagery.

Results

HQI scores are presented as a ratio of the current condition of each parameter over its historical (or 'natural') condition (Death et al., in prep.). As an example, the average active channel width of reach a in 2016-2018 was 382m, while its average width in 1937 was 569m. The HQI score for active channel width in reach a is therefore expressed as:

$$HQI_{\text{active channel}} = \frac{\text{Width in 2017}}{\text{Width in 1937}} = \frac{382}{569} = 0.67$$

Measurements for active channel and floodplain width, mid-channel bar length, and braiding indices are presented in Table 1 with resultant HQI scores. Table 2 summarises these HQI scores and includes an 'overall' median HQI score for each reach and parameter. The median is used as the overall HQI score as it avoids any skewing in the assessment that may occur as a result of using the mean (Death et al., in prep.).

Table 1: Component HQI scores for each reach and each parameter measured.

REACH	a	b	c	d	e	f
Active width 1937 (m) (avge)	569	689	1271	1388	1559	1098
Active width 2016-2018 (m) (avge)	382	604	727	569	605	571
$HQI_{\text{active channel}}$	**0.67**	**0.88**	**0.57**	**0.41**	**0.39**	**0.52**
Natural floodplain (m) (avge)	1836	1963	2480	3310	3723	4428
Permitted floodplain (m) (avge)	978	1072	2107	3310	3723	4416
$HQI_{\text{floodplain}}$	**0.53**	**0.55**	**0.85**	**1.00**	**1.00**	**1.00**
Mid-channel bars 1937 (m) (total)	2007	4017	8775	3445	9681	6655
Mid-channel bars 2016-2018 (m) (total)	3716	3831	6628	8484	8764	6688
Braiding index 1937	2.02	4.04	8.98	3.37	9.74	6.35
Braiding index 2018	3.74	3.85	6.79	8.30	8.82	6.38
HQI_{braiding}	**1.85**	**0.95**	**0.76**	**2.46**	**0.91**	**1.00**

Table 2: Component and overall HQI scores for each reach parameter measured.

REACH	a	b	c	d	e	f	HQI overall
Active channel	0.67	0.88	0.57	0.41	0.39	0.52	**0.55**
Floodplain	0.53	0.55	0.85	1.00	1.00	1.00	**0.92**
Braiding index	1.85	0.95	0.76	2.46	0.91	1.00	**0.98**
HQI overall	**0.67**	**0.88**	**0.76**	**1.00**	**0.91**	**1.00**	

Active channel width was the only parameter with HQI values lower than 1.00 across all reaches and had relatively consistently values from Arundel to Ealing. It also had the lowest HQI score (0.39 in reach e). Floodplain width also had some low scores (0.53 in reach a and 0.55 in reach b) but values increased to 1.00 by reach d and were then consistently 1.00 through to reach f. Braiding scores were variable with some scores greater than, and others less than, 1.00. Braiding was the only parameter with HQI scores greater than 1.00.

Discussion

Pratt, Neverman, Fuller, & Death (2018) state that a decline of more than 15% in an overall HQI score or more than 40% in any single component score (i.e. HQI scores below 0.85 and 0.60 respectively) should be cause for concern and would indicate a potential need for mitigation activity. The overall HQI scores for reaches a (0.67) and c (0.76) are therefore cause for concern, indicating a significant reduction in the physical condition of the river through these sections of the river (approximately 4km in total). Notably in these reaches all component scores—except the braiding index in reach a—were 0.85 or less. These low scores appear to be primarily a result of the encroachment of the storage ponds for the South Rangitata irrigation scheme on to the floodplain and the reduction in flows that is likely to have occurred with the increased water takes for irrigation (Stats NZ, 2020). Specific analysis of the floodplain immediately before and after the construction of the storage ponds and analysis of flow trends would be needed to confirm this.

The overall HQI score for active channel width (0.55) is also cause for concern. It is likely that a substantial increase in water takes since 1937 to service intensive farming on the Canterbury Plains is the main driver for this score, along with the reclamation by farmers of vegetated bars and the floodplain along the edges of the river (most clearly illustrated by the disappearance of the 'south branch' of the river).

Interestingly, the overall HQI score for floodplain width is relatively high at 0.98. This indicates the river is largely still connected to its floodplain and in a relatively 'natural' condition (although it should be noted that many aspects of the floodplain, such as its vegetation, are not in a natural condition). This high score appears to be a result of the relatively limited presence of any flood control measures or stopbanks along the river, allowing the river to spill on to its floodplain in times of high flow, and should be commended for preserving its floodplain connection. The connection of the river to its floodplain was emphasised by the 'reclamation' of the south branch of the river during floods in December 2019, as shown in Figures 6, 7, and 8. Figure 8 shows how the maintained floodplain connection allowed the river to temporarily reclaim its south branch during flooding in December 2019, resembling a more natural condition illustrated in the 1937 imagery. It also illustrates the floodplains role in energy dispersal during a large flood (note this lower section was not assessed for its HQI).

Braiding index HQI scores were lower than 1.00 in some reaches, significantly higher than 1.00 in other reaches, and close to 1.00 in others. The reason for this is beyond the scope and expertise of this report, however it is suspected that a potential difference in flow between aerial surveys (with the 1937 survey undertaken in spring (October) and the 2016-2018 survey undertaken over two summers), a difference in the resolution of the images (which may affect the accuracy of judgement between a wet and dry channel and the size of braids), and potential interactions with channel width would explain some of this difference.

Figure 6: Rangitata River from Arundel to Ealing before (left) and during (right) flooding on the 9th of December 2019. Note the 'reclamation' of the south branch of the river. (ECan, n.d.).

Figure 7: Orthomosaic image of the Rangitata River in flood, December 2019. Note the 'reclamation' of the south branch of the river.

Figure 8: The lower Rangitata River in 1937 (left) and in flood in December 2019 (right). The flood allowed the river to temporarily reclaim its south branch and greatly resemble its 1937 condition.

Limitations and Opportunities

While the HQI is a useful tool for the summary of geomorphic variables, it is not an absolute measure of habitat quality (Death et al., in prep.). It simply expresses the relative change in those variables of river character that are relevant and readily measurable based on the data available—it assigns a value to the degree of 'improvement' or 'degradation'. In this assessment the desire to measure against a reference condition as close to 'natural' as possible limited the meaningful variables we could readily measure to three. As mentioned earlier, measurement of additional variables may be achievable from additional aerial imagery at intermediary timeframes.

In measuring parameters there is a somewhat arbitrary nature in the judgement of an assessor in analysing aerial imagery (e.g. when is a braid/mid-channel bar no longer sufficiently separated from the bank or another bar? Is that over-exposed section of riverbed a result of bright boulders or the reflection from a wetted channel?). While in this assessment the potential for these judgment calls to introduce error has been minimised through the use of a single assessor undertaking all of the analysis (utilising the same 'rules of judgement' to map the parameters of the 1937 and 2016-2018 features), there is always room for errors of human judgement to creep in. Reductions in the accuracy of assessment may also occur as a result of the differences in resolution and continuity of the imagery—e.g. that of 1937 had to be mosaicked together from historic 'slides' and was limited to a grayscale band, while that of 2016-2018 was in full colour and a higher resolution, but still had over-exposed sections. Despite this, we are confident that for the purposes of this analysis any cumulative error would be minimal and the scores in this report can be considered as robust as is realistically achievable.

There are numerous opportunities for further assessment of the Rangitata River with the HQI. As a start this assessment against the 1937 baseline could be continued downstream to the coast. Further assessment could be completed against data from intermediary years (i.e. between 1937 and 2016-2018) to draw out rates of change or moments when change was most apparent or at significant times, such as when the Water Conservation Order was gazetted, to determine whether management actions had any effect on preventing the degradation of physical habitat. Additional parameters, such as the area of bars or percentage of pools, could also be introduced where reference imagery is more detailed.

Conclusion

The physical habitat condition of the Rangitata River between Arundel and Ealing in 2016-2018 is lower than it was in 1937. Overall habitat quality in two of the six reaches assessed has declined by an amount worthy of concern and mitigation/remediation, while in the other reaches the condition had dropped only slightly or remained stable. Habitat quality scores within a number of reaches, and for a number of parameters are, however, worryingly low. It is suspected that this is primarily a result of the encroachment of the storage ponds for the South Rangitata irrigation scheme on the floodplain, the likely reduction in flows that has occurred with increased water takes for irrigation, and the reclamation by landowners of vegetated bars and the floodplain along the edges of the river. The extension of this HQI assessment to the coast and to additional reference years would assist in illustrating clearly the extent and cause of changes in habitat quality along the Rangitata River.

Note:

2016-2018 Orthophotography was taken in the Canterbury Region in the flying seasons (summer period) 2016-2018. Imagery was captured for the Canterbury Regional Council by Aerial Surveys Ltd, Unit A1, 8 Saturn Place, Albany, 0632, New Zealand.

1937 imagery was obtained from http://retrolens.nz/ and licensed by LINZ CC-BY 3.0. Images were captured on the 6/10/1937, survey number: SN62, at an elevation of 9000 feet.

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