Projecting river names onto a national digital network

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Executive summary

Digital Networks (DNs) are virtual representations of the placement and spatial connections between river channels, lakes, and the ocean. DNs are used by many different institutions for a variety of purposes. DNs are intermittently revised following improvements to DN generation algorithms and availability of higher-resolution or more accurate topographic data.

Projection of river names onto a DN is useful for purposes such as emergency management, river management, searching for places within a DN, assisting to match sites to DN segments, and helping users to communicate that part of the DN is correctly or incorrectly represented when checking network connectivity. Land Information New Zealand (LINZ) and the Ministry for the Environment (MfE) requested that Earth Sciences New Zealand (Earth Sciences NZ) devise a process to automatically project river names onto a DN. They also requested that the process be easily repeatable so that it could be rerun after a river name change or if a DN was regenerated due to updated input data or user-requested modifications. This report describes the process for projecting river names onto a DN, the data we used to develop and test the process, and the outputs produced by the process.

We used text describing river names from an official government source (LINZ Topographic 1:50k maps; Topo50). Topo50 includes blue lines/polygons representing river channels and text specifying river names but does not express associations between lines/polygons and each river name. We used information about the position of the river name and its font size to project each name onto a nearby DN segment. For this work, we projected names onto a pilot version of New Zealand's national digital network, version 4. The process was designed to assign names with larger font sizes to larger river segments as indicated by higher Strahler orders[1]. The process routed river names downstream whilst giving preference to river names with larger font sizes. Where lake outflows were unnamed, the process was capable of routing river names upstream within the same Strahler order or routing river names downstream through the lake. The process prohibited changes to spellings of river names or creation of new river names because the New Zealand Geographic Board is responsible for policies, standards and guidelines for place naming. The process did incorporate some flexibility by allowing user input via a manual input file to remove, replicate, reposition and ensure downstream routing of river names present in Topo50.

We tested the results of our process in two selected catchments. We found that the process performed very well in many situations but could produce assignment of river names to segments that we judged to be inappropriate following inspection of Topo50. In most cases, inappropriate assignments of river names were associated with an artefact of the DN or the way in which the DN interacted with Topo50 data rather than a deficiency in the logic of our automated process. We were able to resolve all assignments of river names that we initially deemed to be inappropriate by altering our manual input file to remove, replicate, or reposition those river names relative to the DN.

Users of river names projected onto a DN should note the presence of many common river names across several parts of the country when searching for river locations by name (e.g., there are many separate river reaches named Stony Creek).

[1] Strahler ordering (Strahler 1957) is a method of stream ordering often used as a proxy for river size or distance from headwaters (Booker et al. 2026).

Results from our process allowed single river names to be linked to entire catchments, where a catchment is defined as all segments draining to a single terminal segment, typically located at the sea. We first identified the river name associated with each catchment's terminal segment. We then applied a process for labelling all catchments with unique interpretable labels that are independent of the DN they are projected onto. This process generated a label for each unnamed catchment (those with a terminal segment that did not have a river name routed from upstream) by identifying the distance and bearing of its terminal segment relative to its nearest named terminal segment (i.e., a terminal segment that had a river name routed from upstream).

1 Introduction

1.1 Background

Digital networks (DNs) are virtual representations of spatial connections across freshwater-land systems, including rivers, lakes, wetlands, estuaries, and land. The National Institute for Water and Atmospheric Research (NIWA) produced three main versions of a national DN between 1998 and 2018. These previous DNs have often been referred to as digital river networks because they explicitly represented rivers while not explicitly representing lakes or overland flow pathways. These networks have been widely used, but were time-consuming to produce, were generated from now out-of-date topographic data, used a fixed DN density selected at the time of DN production, and did not explicitly represent lakes, artificial channels, or downstream flow-splitting bifurcations.

Several advancements have occurred since 2018 when the previous national DN was generated that impact how a national DN might currently be generated for Aotearoa New Zealand (NZ).

- High resolution topographic data has been collected for most of the country.
- DN users have clarified that different DN purposes may require DNs with differing densities (e.g., flood modelling purposes may need much finer density than river management purposes).
- Improved computing resources and availability of open-source software have made automated DN generation more viable.
- A method for incorporating and distinguishing overland flow pathways, river channels, and lakes within river networks has been devised.
- A method that extends the traditional Strahler ordering system to use zero and negative numbers has been devised, allowing order 1 streams to begin at mapped locations as per topographic maps rather than relying on an upstream contributing area threshold for stream initiation which produces a fixed DN density. See Booker et al. (2026) for further details.
- Access to geographic data such as place names has improved[2].

Between July 2025 and June 2026, Earth Sciences New Zealand[3] (Earth Sciences NZ) devised a process for automatically generating a national DN that incorporates the advancements above. The process was designed to be repeatable such that a new DN can be generated following updates to input data (e.g., topographic data) or requests for changes from users. The DN-generation work was carried out for the collective of Regional and Unitary Councils (Te Uru Kahika). Funding for the DN-generation work was provided by the Ministry for the Environment (MfE).

In addition to funding development of a DN generation procedure, MfE also funded development of a process to project river names set by the New Zealand Geographic Board (NZGB) and

[2] Improvements to the LINZ Topo50 series are continuously being released. See [Topo50 release notes and update history | Toitū Te Whenua - Land Information New Zealand](#) for update and version histories.
[3] Earth Sciences New Zealand was established 1 July 2025 by the merger of GNS Science and NIWA.

supplied by Land Information New Zealand (LINZ) onto segments of a DN. This report therefore describes and tests a “names-to-rivers” process that needed to be repeatable and independent of the DN onto which names are being projected. Thus, the process could be applied to project river names onto any network including a newly generated DN following updates to topographic data.

LINZ and other users of the DN (e.g., regional councils) have indicated that projection of names onto the national DN would be useful for a variety of purposes.

- Emergency management coordination purposes such as quick identification of an area that is forecasted to flood.
- River management purposes such as naming of Freshwater Management Units (FMUs).
- Searching within a network to inspect or extract named catchments or locations.
- To assist in matching sites to DN segments when conducting water accounting.
- Allowing users to indicate that a named river is correctly or incorrectly represented when checking network connectivity.

Aligned pieces of work to automatically generate a national DN and project names onto that DN represent a coordinated effort to produce a nationally consistent DN that can be used by different organisations for different purposes.

1.2 A brief description of digital networks

A DN must contain: a) nodes (points) that represent headwater, terminal, or confluence locations; b) segments (lines) that describe surface flow pathways; c) routing that informs spatial connections between surface flow segments; and d) watersheds (polygons) that represent the areas of land that contribute to each segment.

Segments, watersheds, and routing provide information about relationships across freshwater-land systems. When analysed together, these data can be used to identify: a) whole catchments (e.g., collections of segments upstream of a specific segment such as a terminal segment that flows to the sea); b) upstream and downstream flow pathways; and c) local, upstream or downstream properties such as local slope, upstream dominant landcover, or distance to sea. Thus, DNs can be associated with topographic, hydrological, geological, or other spatial data to draw connections across land and freshwater throughout a catchment.

DNs are key inputs for water quality/quantity modelling, reporting, planning, and policy development. DNs can be used to assess and describe: a) the movement or routing of water, sediment, contaminants, or nutrients through a catchment; b) potential movements of aquatic and riverine species (fish, birds, algae, vegetation); c) classifications of catchment planning zones, conservation planning, and urban planning; and d) hydraulic modelling for flood forecasting.

1.3 Existing national digital networks

DNs are used by many organisations for different needs and purposes across NZ. As a result, multiple DN versions exist at the regional and national scale. Many regional councils have produced bespoke DNs or have modified national DNs for their regions. Some councils have more than one DN for different purposes.

The first national-scale DN for NZ was generated in the early 2000s by NIWA. DN version 1.0 was released in association with a national river classification system known as the REC (River Environment Classification). A DN is required to calculate REC classes and then project those classes onto a map. Rules used to define REC classes (e.g., warm-dry-lowland; cool-wet-mountain) have stayed the same since its initial release, but there have been numerous iterations of the national DN (Table 1-1).

Table 1-1: Major version and sub-version history of NZ's national DN (note that various minor sub-versions of each version have also been released). From Booker et al. (2024); updated.

DN Version	Approximate Release Dates
1.1	1998
2.3	2008
2.4	2012
2.5	2015
3.1	2018
4.0 (pilot)	2026

As of June 2026, Earth Sciences NZ has devised an automated, repeatable DN generation process (version 4.0 (pilot); Table 1-1). This DN generation process incorporates the advancements to DN generation processes highlighted in Section 1.1 and builds upon an extensive body of existing work developing DNs for national purposes (e.g., Snelder and Biggs 2002; Whitehead and Booker 2019; Shankar et al. 2022; Booker 2023; Booker et al. 2024; Booker et al. 2026).

Previous attempts were made to project river names onto DN versions 1 and 2. Those attempts suffered from several disadvantages:

- Manual assignment of names to segments was time consuming.
- Names could not be easily re-projected onto a newly generated network.
- The information source of each name was not traceable.
- Names could not be automatically updated following official name changes by the NZ Geographic Board, even when those updates appeared in information published by government organisations such as LINZ.
- The process included a degree of subjectivity relating to the segments that each name might be associated with.

1.4 Aim, objectives, and report structure

The aim of the work described in this report was to create a process for automatically projecting river names onto a national DN. The work had several associated objectives.

- River names in NZ are set by the New Zealand Geographic Board. Names being projected onto a national DN by a government-affiliated institution should only originate from an official government source. No alterations to names or spellings were to be made as part of this work.
- The process for projecting names onto the DN should be flexible to allow users to alter the way in which the official names were projected onto the DN. This flexibility relates only to the position of names and does not allow for users to alter official names or spellings. This step requires a detailed documentation of any alterations to name positions and the ability to include or exclude user inputs.
- The process for projecting names onto the DN should be automated to allow for quick recalculation following updates to names or the DN.
- The process for projecting names onto the DN should be transparent to allow users to understand how each name has been projected onto the DN and why there may be cases where a name is not projected onto the DN.
- Projection of river names onto the DN should also facilitate naming of catchments (i.e., naming of collections of segments upstream of a specific segment such as a terminal segment that flows to the sea).

This report describes the process developed for meeting the above objectives as well as testing the outputs, challenges encountered, and possible solutions for future refinements. Section 2 of this report outlines the methodology used to project names onto the DN, including input data, the process for projecting names onto DN segments, verification of names, and output format. Section 3 shows key findings related to the Topo50 data that influenced development of the naming process and results of river names projected onto DN segments and catchments. Section 4 provides a brief discussion of the naming process and identifies next steps for further refinements of the DN naming process and data.

2 Methodology

2.1 Input data

The main input data used to project names onto a DN are described in Table 2-1. These inputs include river names extracted from 1:50k topographic map layers supplied by LINZ (referred to here as Topo50), a manually created input file that allows users to ignore, replicate and/or adjust the position of names, a look-up relationship between font size and Strahler stream order, and a DN.

Table 2-1: Data used to project names onto a digital network. The digital network must comprise routing information, Strahler stream order, polylines representing rivers, and polygons representing lakes.

Input	Description	Source	Purpose
River names	Text, font sizes, and point coordinates for names of rivers.	Topo50: LINZ 50280; nz-geographic-names-topo-150k; desc_code = STRM.	A government source of gazetted river names, including official spellings and use of macrons, as determined by the NZGB.
River name positional adjustments	Manual input file describing Topo50 river name occurrences to be ignored and/or have their positioning adjusted. No changes to naming or spelling from Topo50 river names was possible.	User defined input. Initially populated by Earth Sciences NZ staff but can be updated following user requests or for bespoke purposes.	Allows user to ignore a name that has no corresponding segment in the DN. Allows the user to move or replicate a name to increase its chances of being associated with an appropriate DN segment. Explanation of the reason why a name might be moved is required for documentation purposes, and must only be used for projecting names onto appropriate segments of a DN.
Font size to Strahler relationship	An ideal Strahler stream order for each font size used to display river names in Topo50.	User defined input.	To assist in assigning river names with larger font sizes to DN segments with larger Strahler orders.
DEM_DN v4.0	A network whose routing follows DEM slopes and whose network density mimics LINZ 1:50k.	LINZ supplied LiDAR data that has been projected onto an 8 m grid and hydro-corrected as described by Earth Sciences NZ Geofabrics (Pearson et al. 2023).	A multi-purpose nationally consistent DN that river names can be projected onto.

River names

We downloaded several data layers from LINZ in March 2026. We used one-time downloaded LINZ data rather than live links to LINZ data so that we could synchronise our inputs to those

LINZ data. We used river names from the LINZ data layer called NZ Geographic Names 1:50k[4] which provides text, font size, and point coordinates in New Zealand Transverse Mercator 2000 (NZTM2000) for each occurrence of a river name. River names held within this data layer are determined by the NZGB. A single piece of river name text can have multiple occurrences, with each occurrence having different point coordinates and possibly different font sizes. We assumed that any changes to river names set by the NZGB would be reflected in the river names supplied by LINZ. We assumed that river names were signified by the description code "STRM" (stream). We used text stored in the field called "name" as river names, which included text with macrons. We tracked the source of each occurrence of a river name by retaining its associated identifier (t50_id) throughout our process.

River name positional adjustments

We devised a manual input file (called "River name positional adjustments" in Table 2-1) to allow users to alter results that would be produced if our automated process was run using all Topo50 river names without any changes to their point coordinates. The input file exists to aid in extending river names to locations where the existing LINZ data do not reach, or to remove instances of river names that do not have a corresponding digital segment. The input file allows occurrences of river names to be removed or have their point coordinates duplicated and moved. The input file does not produce new names, change river name text or change font sizes that were associated with each occurrence. Any Topo50 identifier (t50_fid) that occurred in the input file but did not exist in the Topo50 database being used in our process was recorded and then ignored by our process. Thus, a user could check whether they had mistyped a t50_fid or if that t50_fid had been removed from Topo50 by LINZ. Updates to Topo50 identifiers are possible at any time.

The input file has five columns:

- t50_fid: an attribute identifier from Topo50.
- X- and Y-coordinates (NZTM2000): numeric coordinates to indicate a new position of a river name occurrence. "NA" for coordinates indicates removal of a river name occurrence. Note that multiple rows with the same t50_fid can be used to remove a river name from one location and add a placement of that river name in other (possible multiple) locations.
- TraceToTerminal: a Boolean (true/false) indicating whether a river name occurrence should be traced downstream from its assigned segment to the terminal segment for the catchment.
- Description: optional description not used in the automated process that can be used to record a reason or a date of entry.

The manual input file was used to achieve the following outcomes.

- Removal of river name occurrences that could not reasonably be associated with any blue (river) lines showing on Topo50 (e.g., Figure 2-1).

[4] https://data.linz.govt.nz/layer/50280-nz-geographic-names-topo-150k/

- Moving point coordinates of a river name to be nearer to the river segment with which it should be associated because:
  - the river name point plotted in the sea (e.g., Figure 2-2);
  - the river name point happened to be very near to two (or more) river segments (particularly necessary when nearby segments are of similar Strahler order); or
  - the DN segment most appropriate to the river point had diverged from its equivalent blue line in Topo50.
- Replication of names of major rivers near to lake outflow locations (e.g., Waikato River near to the outflow of Lake Taupo/Taupōmoana).
- The possibility of overriding all other river names along the downstream route between the segment that the river name occurrence is assigned to and the terminal segment for the catchment which is often located at the coastline. This functionality can be used to guarantee that river names for large rivers (e.g., Waikato River) are not disrupted by inappropriate assignment of river names (usually associated with nearby small tributaries) along their downstream flow path.

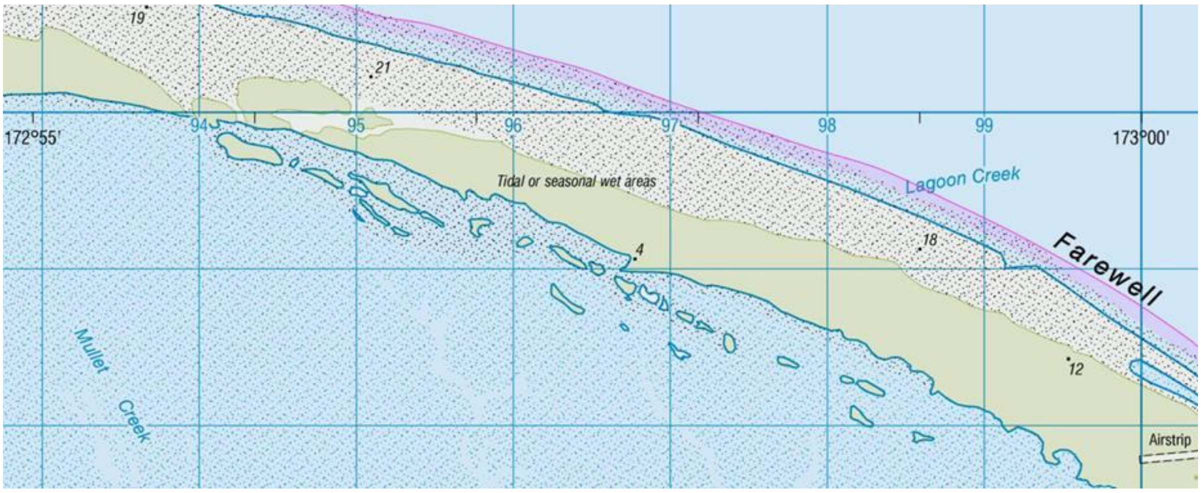


Figure 2-1: Examples of river names removed because they could not reasonably be associated with a blue (river) line in Topo50. For example, blue river lines do not occur near the text 'Mullet Creek' and 'Lagoon Creek' in this example.

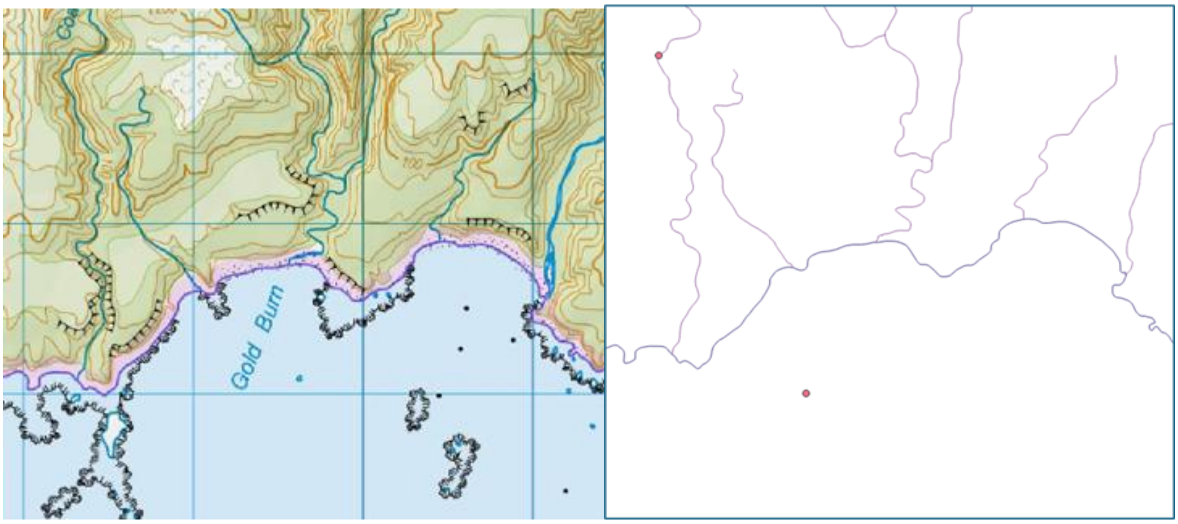


Figure 2-2: An example of a river name point that was moved to be nearer to the river which it should be associated with. The point coordinates for the text of 'Gold Burn' (right plot; orange dot in ocean) were far away from the river. The left plot shows where the text appears in Topo50.

To address issues with routing names through lakes, we identified and isolated unnamed DN segments flowing out from lakes of ≥1 km^2. There were 146 segments that fit these criteria. We compared each segment against the Topo50 basemap to assess whether it would be appropriate to assign the lake outlet segment a river name. Forty-four of the segments were identified as appropriate to have a name assigned to them, while 102 were not. Segments were considered inappropriate to name if there was no river name displayed on the Topo50 basemap near to the segment. Of the 44 segments that could have a name assigned to them, we identified the appropriate name by inspecting the Topo50 basemap. We assigned a confidence score of High, Medium, or Low to each segment to document segments that clearly could have the name extended to the lake outlet versus others that were not so clear (Figure 2-3). These confidence scores were based on proximity of displayed names on the Topo50 basemap to the lake outlet segment or how well-known a river is.

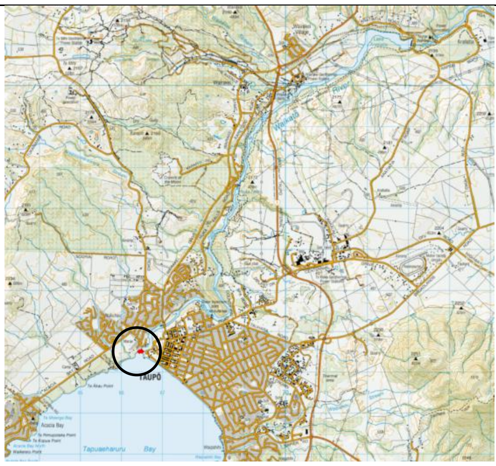
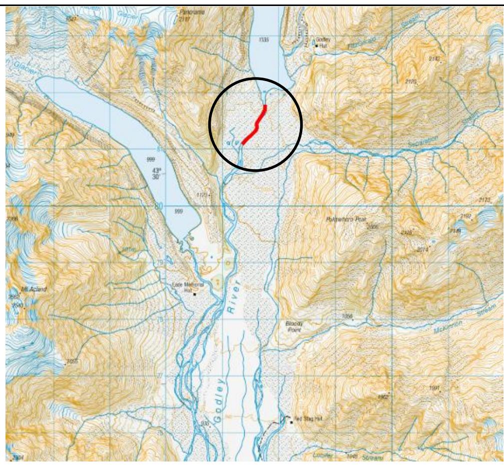
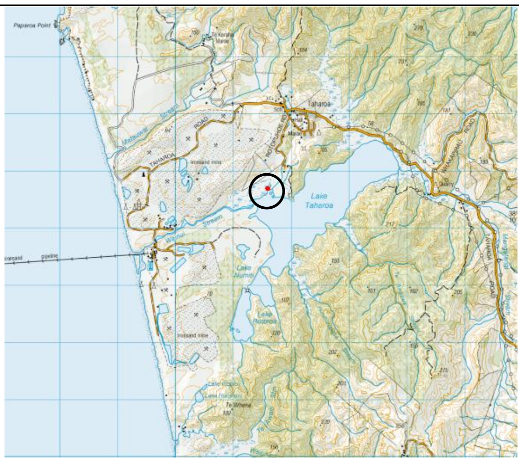
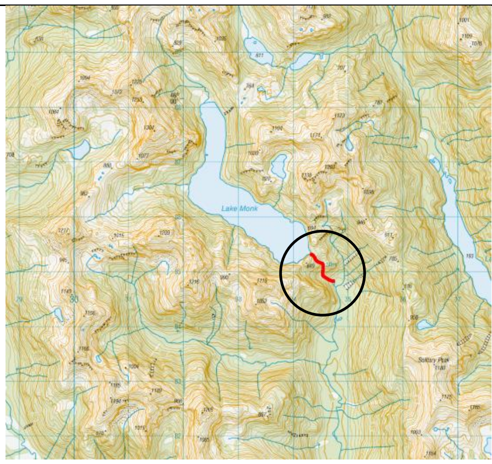
High confidence	Medium confidence
	
Low confidence	**Inappropriate to name**
	

Figure 2-3: An example of each confidence category when applying a name to a lake outlet segment. Lake outlet segments are coloured red within the black circles. The potential river name for the medium and low-medium confidence levels are also circled in black.

High confidence scores were assigned to lake outlet segments that had displayed names on the underlying Topo50 associated with continuously connected Topo50 river lines between the lake and the name and are well known to be associated with a name, such as the Waikato River at the outlet of Lake Taupō. The confidence score was increased if it was possible to corroborate the name with a secondary source (e.g., [Land, Air, Water Aotearoa (LAWA) - Waikato River]). It is well known that the Waikato River emerges from Lake Taupō, but the location of the Topo50 point corresponding to the first iteration of the Waikato River name appears about 9 km downstream of the lake outlet, leaving the upstream segments without a name. We therefore had high confidence that it would be appropriate to associate the outlet segment at Lake Taupō with the Waikato River to ensure naming of those segments from the start of the river. Twenty-eight lake outlet segments were assigned a name with high confidence for similar reasons.

Medium confidence scores were assigned to lake outlet segments that had displayed names on the underlying Topo50 associated with continuous river lines between the lake and the name but could not confidently be associated with a river name due to distance or the presence of intervening features such as dams, wetlands or other smaller lakes. For example, the Godley River was identified as medium confidence because there is a continuous line from the lake to the river name, but it is unclear if it is appropriate to extend the name to the lake outlet. In one case of the Mangaharakeke Stream, a lake outlet segment flowing into a wetland before joining the main river was assigned a medium confidence score because it could be corroborated with LAWA (Land, Air, Water Aotearoa (LAWA) - Lake Rerewhakaaitu). Under normal conditions, the lake does not have permanent outflow, but the Mangaharakeke Stream is the only outlet and flows when the lake level is high. Twelve lake outlet segments were assigned a name with medium confidence.

Low confidence scores were applied to lake outlet segments flowing into wetlands or that flowed out of one lake and into another large lake before encountering an iteration of a river name. Four lake outlet segments were assigned a name that was associated with a low confidence score.

After identifying the appropriate name for the lake outlet segments, we generated a list of t50_fid and easting/northing coordinates that could be included in the manual input file for updating the lake outlet segments. The t50_fid (and therefore the river name) was taken from the closest iteration of the appropriate name from the nz-geographic-names-topo-150k point layer. The easting/northing coordinates was the upstream end of each lake outlet segment. It is recommended that only lake outlet segments with a confidence score of “high” are included in the manual input file.

Thirty-one of the lake outflow segments had names applied successfully without subsequent issues. Four had names applied successfully but revealed some routing issues with the underlying DN (Figure 2-4), implying that it may not be appropriate to apply river names to those segments within the pilot DN we were projecting names onto. Seven segments had names applied successfully, but then those names were not routed downstream as anticipated; in these instances, named side tributaries had their names routed downstream until the first instance of the main river name.

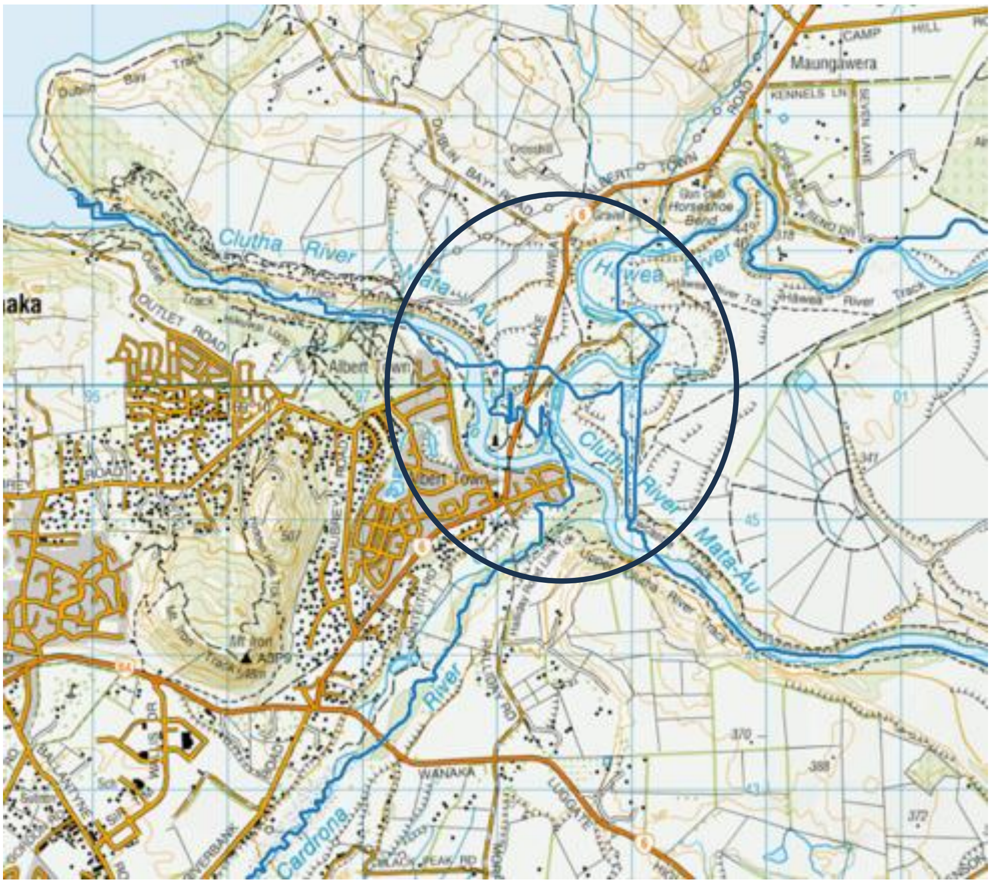


Figure 2-4: Example of issues with the underlying pilot DN that indicate applying a name manually may not be appropriate. The DN – represented by blue lines – does not follow the mainstem of the Clutha River/Mata-Au at the junction with the Hawea River (circled).

We did not systematically explore all names projected onto the entire DN. To explore how alterations to the naming process and manual input files improved or changed the outputs, we iteratively checked the named DN in two case study catchments (see Section 2.4.2), for large rivers across the country, and in locations we suspected might produce inappropriate assignments such as those around the coast of the two main islands of NZ. Following a few iterations of applying the naming process, we devised a manual input file that contained 313 rows reflecting changes to names around the coast, at lake outlets, or that did not have a DN segment to be projected onto. 156 river names occurrences were removed. 121 river name occurrences were moved (their original location was removed and replicated elsewhere once). Three river name occurrences had their original location removed and replicated elsewhere twice. One river name occurrence had its original location removed and replicated elsewhere three times. Twelve river name occurrences had their original location replicated elsewhere twice. One river name occurrence had its original location replicated elsewhere three times.

We specified two river name occurrences to be traced downstream while overriding all other river names to demonstrate this capability. These two occurrences were the most upstream occurrences of Mataura River and Waikato River.

See Section 2.4.2 for further details about how the input file was used to amend positioning of river names in two catchments. Our manual input file will therefore need to be reviewed following changes to a DN or to Topo50 data.

Font size to Strahler relationship

We devised a relationship between Topo50 river name font size and the expected Strahler stream order for that font size (Figure 2-5). The relationship was devised after inspecting font sizes and Strahler orders of nearby river segments for various regions within Topo50. The relationship was devised to recognise that the smallest font sizes used in Topo50 are often associated with either first or second order segments. The relationship assists in assigning river names with larger font sizes to DN segments with larger Strahler orders.

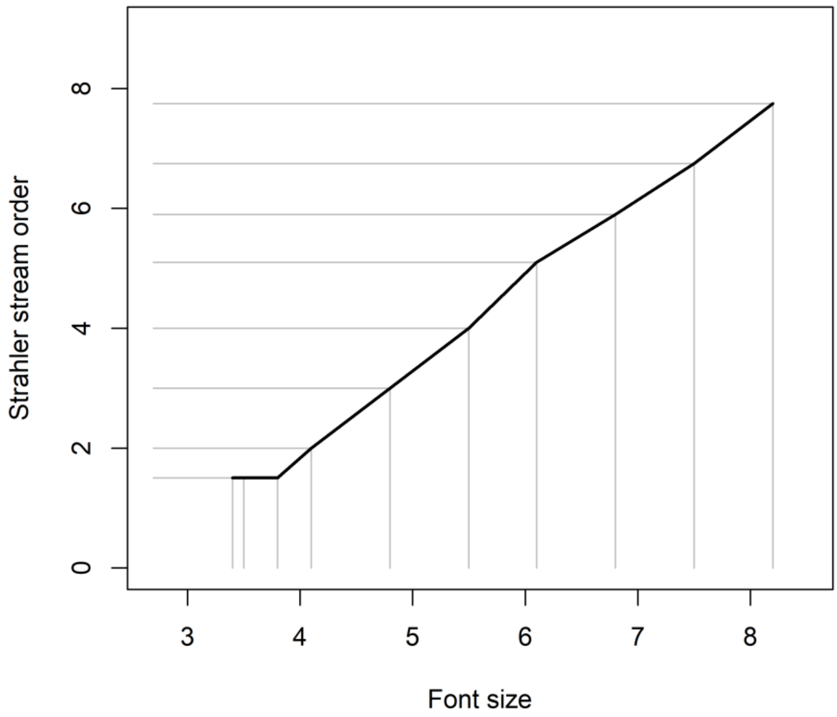


Figure 2-5: Input relationship between river name font size and ideal Strahler stream order. Grey lines indicate font sizes for river names occurring in Topo50. Any font sizes outside of the black line are given the extreme values of the black line.

Digital network

The format of outputs from our automated process for projecting river names onto DN segments is independent of the source or version of the DN. In other words, applying the process will always produce the same output format regardless of DN input. However, the specific results of applying the naming processes are dependent on the DN to which the process is applied.

We applied our process to a pilot version of a national DN for NZ referred to as DN version 4.0. This DN has three aspects that are different to previous NZ DNs and that are important for projection of river names. First, the DN explicitly represents lakes as polygons that can have multiple inflowing segments and multiple outflowing segments. Explicit representation of lakes is important for projection of river names because it may be difficult to discern the name of a lake outflow segment from several named inflow segments. Second, the DN represents river channels that terminate at inland locations due to sinkholes. Surface flow routing continues past sinkholes in the form of segments whose Strahler orders are zero or negative. Segments with zero or negative Strahler orders that are downstream of sinkholes represent overland flow pathways and are labelled as purple segments. Segments with positive Strahler orders represent river channels and are labelled as blue segments. Purple segments are important for projection of river names because it may or may not be appropriate to pass a river name downstream along purple segments. Third, the DN represents bifurcations as well as confluences. Bifurcations are important for projection of river names because they create the possibility that a river name can be routed downstream to more than one segment, and because a segment can be associated with more than terminal segment located at the coast.

2.2 Projecting river names onto DN segments

We used the R programming language to devise an automated process that associated Topo50 river names with segments of a DN. The process consisted of several steps (Figure 2-6). We applied the process to a pilot version of DN version 4.0 generated on 1 April 2026. Our process required some parameter inputs (Table 2-2) in addition to the bespoke input data outlined in Table 2-1.

Table 2-2: Parameters required for our automated process.

Parameter name	Description	Default value	Rationale for default value
Maximum distance	Used to identify and remove river name points that are very far away from any DN segments.	1000 m	A small value would remove too many river name occurrences. A large value would not remove river name occurrences even though they might be very far away from any DN segments. We use 1000 m as a compromise between these two extremes.
Buffer Distance	Search for DN segments nearby to river name points within this buffer.	2000 m	An arbitrary distance that is bigger than the maximum distance which is used to increase computational efficiency when searching for DN segments nearby to each occurrence of a river name.
Number of nearby segments	Find this number of nearby DN segments to each river name point.	5	All river name points were assigned to a segment that was within the five nearest DN segments.
Strahler Difference Multiplier	A multiplier used to weight distances between DN segment and river name point.	100	A value of zero would ignore Strahler order to find the nearest DN segment to each river name point. A value approaching infinity would effectively ignore nearby DN segments if their Strahler order was very different from that which was expected given the font size. We used 100 as a compromise between these two extremes.

In addition to the parameters in Table 2-2, we found some Topo50 "STRM" names that represented names of discrete locations within a river (e.g., the name of a bend in a river or a waterfall) rather than a river name. Our process attempted to find these discrete names automatically by searching for phrases (" Reach", " Loop", " Falls", " Rapids") without other phrases (" Creek, " Stream", " River", " Burn") within each piece of river name text. Note we used spaces within the pieces of text being searched for. These "unwanted phrases" were removed so that they would not be inappropriately projected onto a DN segment.

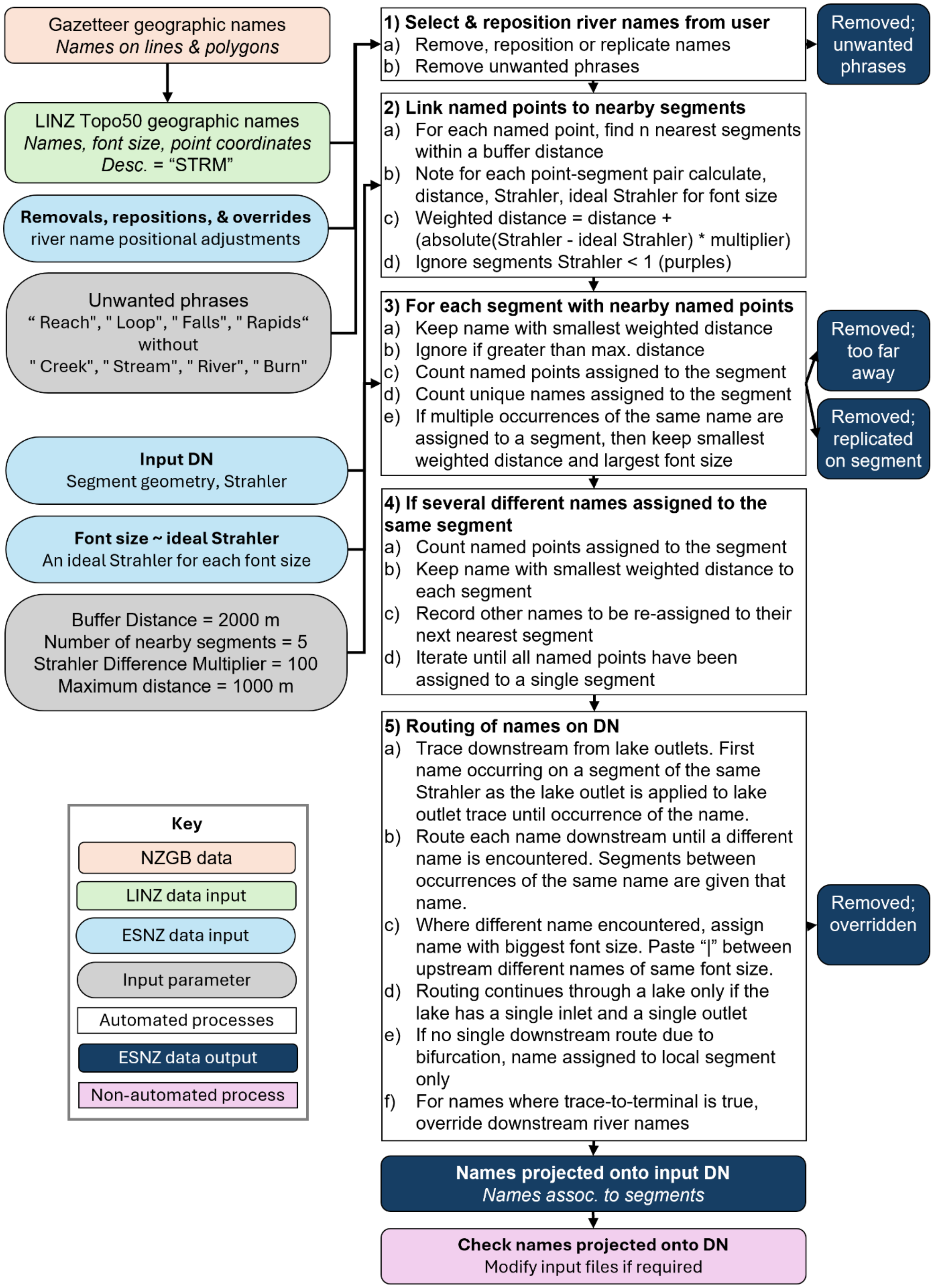


Figure 2-6: Diagrammatical representation of the process for projecting river names onto a digital network.

Our process applied some assumptions.

- Bigger font sizes should be associated with higher Strahler orders (Figure 2-5).
- River names are routed downstream.
- River names cannot be routed downstream through lakes unless the lake has one named inflow and one outflow.
- The only situation in which river names are routed upstream is along segments of the same Strahler order immediately downstream of a lake.

2.3 Projecting river names onto catchments

A catchment is a collection of segments that all route downstream to a common terminal segment. Terminal segments are usually located at the coastline but can be located inland if perched catchments are present within a DN (e.g., inside a volcano, an isolated tarn).

We extracted all terminal segments from our DN. Terminal segments had a projected river name if a river name was projected to any upstream segment that routed to that terminal segment. Terminal segments with no upstream projected river names remained unnamed. We calculated the conditions set out in Table 2-3 for each terminal segment.

Table 2-3: Conditions calculated for each terminal segment. Distance and bearing were 0 for named terminal segments.

Label	Calculation	Representation	Examples
Island	NZTM easting < 1728100 and NZTM northing < 5524000	Main island with which a terminal segment is associated	N = North Island - Te Ika-a-Māui, S = South Island - Te Waipounamu
NameCount	Rank of northing within terminal segments with the same name and on the same Island	Indicates replications of a name and island combination	2 = the second most northerly terminal segment with that name
MaxNameCount	Number of terminal segments with the same name and same Island	The number of catchments with the same name on the same island	3 = a total of three terminal segments have this same name
NearestNamed	The name of the nearest named terminal segment to each unnamed terminal segment	The name of the nearest named terminal segment to each unnamed terminal segment	Esk River = the Esk River is the nearest named terminal segment to the unnamed terminal segment

Label	Calculation	Representation	Examples
Distance	Distance from the nearest named terminal segment to each unnamed terminal segment	How far away from the nearest named terminal segment is an unnamed terminal segment	200m = unnamed terminal segment is 200 m from the nearest named terminal segment
Bearing	Compass bearing from the nearest named terminal segment to each unnamed terminal segment	In what direction is the nearest unnamed terminal segment from the nearest named terminal segment	90deg = the unnamed terminal segment is due east of the named terminal segment
Letter	A capital letter A or B assigned to terminal segments with the same distance, bearing, and nearest name	Allows unnamed terminal segments terminating at the same location to be distinguished	B = the second segment to terminate at these coordinates

We then concatenated the conditions shown in Table 2-3 from top to bottom to produce a unique, interpretable label for each terminal segment. This process generated labels for both named and unnamed catchments. A named catchment is one that has a river name routed from upstream to the terminal segment. An unnamed catchment is one that does not have a river name routed from upstream to its terminal segment.

For example, the label “N_1of2_Waiaua River_137m_288deg_AofA” indicates a terminal segment that is from an unnamed catchment and is:

- Associated with the North Island - Te Ika-a-Māui (“N”).
- Near to the more northerly of two terminal segments associated with the same island with the same name (“1of2”).
- Near to a terminal segment that had “Waiaua River” projected onto it from upstream (“Waiaua River”).
- Located 137 m away from the nearest named terminal segment (“137m”).
- Located in West-Northwest direction from the nearest named terminal segment (“288deg”).
- Only one terminal segment at this location (“AofA”).

The label “N_1of1_Pahi River_0m_0deg_AofB” is an example of a named catchment and indicates a terminal segment that is:

- Associated with the North Island - Te Ika-a-Māui (“N”).
- The only terminal segment associated with the same island with the same name (“1of1”).

- The terminal segment that had “Pahi River” projected onto it from upstream (“Pahi River” and “0m”, “0deg”).
- There was a second segment that happened to terminate at this exact same location (“AofB”).

Labels produced from the process outlined above allowed a single interpretable label to be associated with whole catchments. Furthermore, each label is independent of the DN because it does not contain a DN segment identifier or a DN terminal segment identifier. The independence from DN version is useful because the labels can be used to consistently describe a catchment, even in the event of future DN updates which would change segment identifiers.

2.4 Verification of names

We iteratively refined the naming process. At various times throughout its development, we conducted visual inspections of the named DN outputs to identify any issues with the process and improve its inputs.

We conducted visual inspections of a named DN across the entirety of the country to identify major issues. We also conducted intensive inspections of two river catchments to verify the outputs of the naming process. The visual inspection revealed issues widely encountered across the DN, which we were able to resolve by modifying the naming process or including manual input files (Figure 2-6).

To conduct the visual inspections, we assumed that river names could be correctly associated with Topo50 representations of rivers. We also assumed that human inspection of Topo50 maps could correctly identify a particular stretch of river that should be associated with each river name.

Below, we share some examples of issues found during visual inspections. We include them here because the findings helped us refine the naming process as we iteratively checked outputs.

2.4.1 National-scale inspection

The national-scale cursory inspection involved visually exploring the named DN with a focus on “key” areas. These areas included those of national significance such as large rivers in NZ, lake outlets, coastal areas, or areas of interest identified in aligned DN projects. The national-scale inspection revealed many of the issues that were resolved using the manual input file (described in Section 2.1). We iteratively checked the named DN at the national scale to check how alterations to the naming process and manual input files improved or changed the outputs.

2.4.2 Catchment-scale intensive inspection

The catchment-scale intensive inspection involved a visual exploration of the named DN in the Ngaruroro (Hawke’s Bay) and Selwyn (Canterbury) catchments. Catchment-scale investigations involved generating a list of all river names within the catchment (e.g., items in the nz-geographic-names-topo-150k layer with a description code of STRM) and comparing those names to named DN segments within each catchment. We also performed a visual inspection of how well named segments matched the underlying NZ Topographic basemap.

A visual assessment of named segments in the Ngaruroro and Selwyn catchments revealed local-scale successes or issues with applying the naming process to the DN. There were 164 unique, named rivers in the Ngaruroro catchment and 44 in the Selwyn catchment.

Ngaruroro

Of the 164 unique, named rivers in the Ngaruroro catchment, 119 (73%) were a visual match to the underlying topographic map after applying the naming process to the DN. Thirty-five of the remaining 45 unique, named rivers "mostly" matched the underlying topographic map (Figure 2-7); five "somewhat" matched the underlying topographic map (Figure 2-8A); and five did not match the underlying topographic map (Figure 2-8B).

A visual match was identified if the named segments matched the underlying topographic basemap to a high proportion. For named rivers that "mostly" matched the underlying topographic map, the majority of differences to the underlying map related to the upstream tributaries extending into headwaters. For example, the named segment was in the correct place but could have extended farther upstream for an improved visual match. Rivers that "somewhat" matched the underlying topographic basemap were those that had gaps in what should be a continuously named segment. Rivers that did not match the underlying topographic basemap were those that either had the incorrect name projection or the DN segment was not aligned with the blue river line on the Topo50 topographic map.

For named rivers that "mostly" matched the underlying topographic map, the majority of differences to the underlying map related to the upstream tributaries extending into headwaters. For example, some areas could potentially benefit from having a named segment extend upstream (Figure 2-7A), but we do not anticipate any difference in how the river or catchment would be understood if the name did extend farther upstream. Some other areas where the naming process on the DN "mostly" matched the underlying topographic map was at the confluence of two streams that flow into a river with a different name. It is likely that the name of the river should begin at the confluence of the contributing streams; however, if the underlying data point in the nz-geographic-names-topo-150k layer is some distance downstream, then the name does not get applied to the segment immediately downstream of the confluence (Figure 2-7B). Again, we do not anticipate this difference being a major issue for a user's ability to identify the location of a named river within the DN.

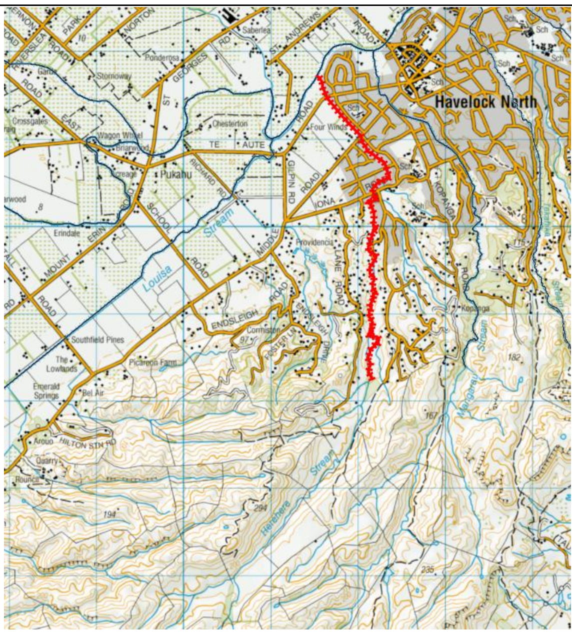
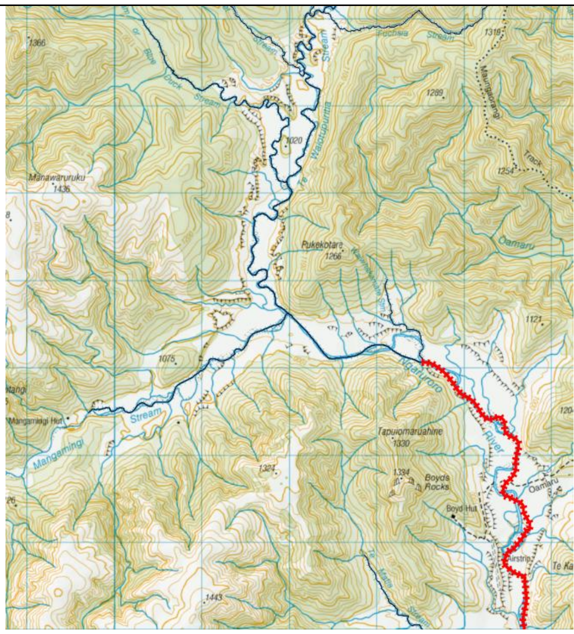
<table>
<tr><td>A) Instance where name could be extended farther upstream, but likely non-critical for emergency management scenarios</td><td>B) Instance where two streams join at confluence of larger river, and the larger river’s name does not begin at confluence</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Figure 2-7: Instances where the named segments "mostly" match the underlying topographic map. Red lines indicate the selected named river. A) The named point associated with Herehere Stream is downstream of the plotted name of the stream. Visually, it might be useful for the name to extend farther upstream, however, it is unlikely to impact any use cases. B) The Ngaruroro River named segment begins about 1.5 km downstream of the confluence of two named tributaries. Currently, the segment downstream of the confluence reflects the names of the two tributaries.

For the cases where named rivers “mostly” matched the underlying topographic map, the most likely cause of the slight discrepancy was the location of the point containing the naming information in the nz-geographic-names-topo-150k layer. Many of these discrepancies could be resolved by adjusting the location of the underlying point data, or by including a duplicated point in the manual input files.

For named rivers that “somewhat” matched or did not match the underlying topographic map, the majority of the causes for these discrepancies were associated with the DN or the naming process. If the naming process encounters two names that are treated similarly mathematically, then there might be a gap in the river (Figure 2-8A). If the DN does not produce a segment within the search radius of the naming process, then a river name will not be applied to any segment (Figure 2-8B). Out of 164 named rivers in the Ngaruroro, only 10 fell into the category of either “somewhat” or “not” matching the underlying topographic map. Gaps in the river can be addressed by overriding all other river names along the downstream route between the segment that the river name occurrence is assigned to and the terminal segment, by activating “TraceToTerminal” in the manual input file (Section 2.1).

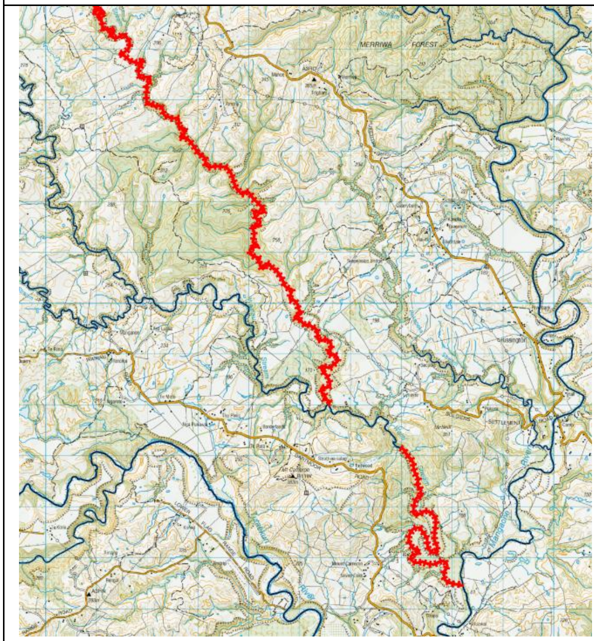
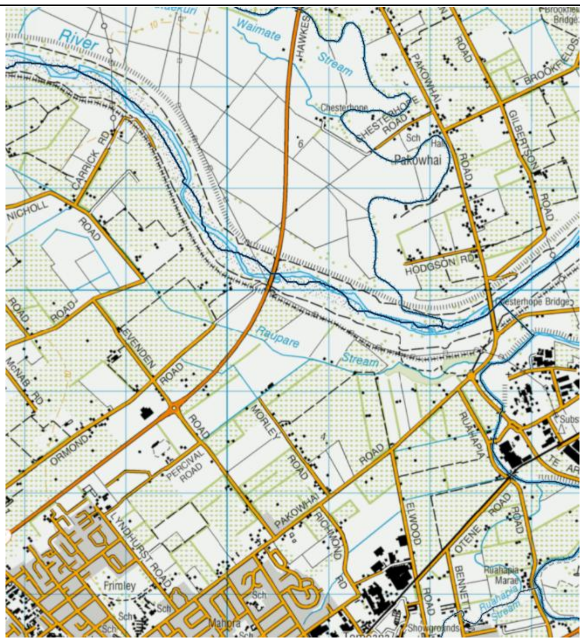
A) Example of a river that “somewhat” matches the underlying topographic map	B) Example of a river that does not match the underlying topographic map
	

Figure 2-8: Instances where the named segments "somewhat" match or do not match the underlying topographic map. Red lines indicate the selected named river. A) There is a gap in the Waiiti Stream where the Waihau Stream joins it. The gap is due the Waihau Stream having a larger stream order and name font size at the confluence, so its name (Waihou Stream) is routed downstream until the next iteration of Waiiti Stream. B) Raupare Stream does not have a DN segment nearby, therefore, the name has not been attached to the DN.

The most significant discrepancy between the named DN and the underlying topographic map identified in the Ngaruroro catchment was the projection of the name for the Clive River (officially renamed Te Awa o Mokotūāraro in June 2023 but labelled Clive River in the Topo50 data we used; Figure 2-9). This is a multifaceted issue. The main issue is that the DN does not generate a segment that flows through the vicinity of the Clive River. Likely due to an issue with sink-filling of the DEM in the DN generation process, the segment that should flow through the Clive River channel is captured by the Ngaruroro River. As such, the Clive River name got projected onto the segment for Muddy Creek. The Muddy Creek name was not projected anywhere, because the Clive River has a larger font size, and receives preferential treatment from the naming process. Following identification of this issue, we reran the naming process utilising a weighted distance calculation. The issue was partly resolved; the name for Muddy Creek was projected onto the correct segment, but the Clive River name, still with no DN segment to attach to, was projected onto the terminal segment of the Ngaruroro River. This issue is a concern for naming the catchment; under the latter scenario, the entire Ngaruroro catchment would be mislabelled as the Clive River catchment. However, once the DN is fixed in this area, the naming process would correctly apply the Clive River name to the corresponding segment.

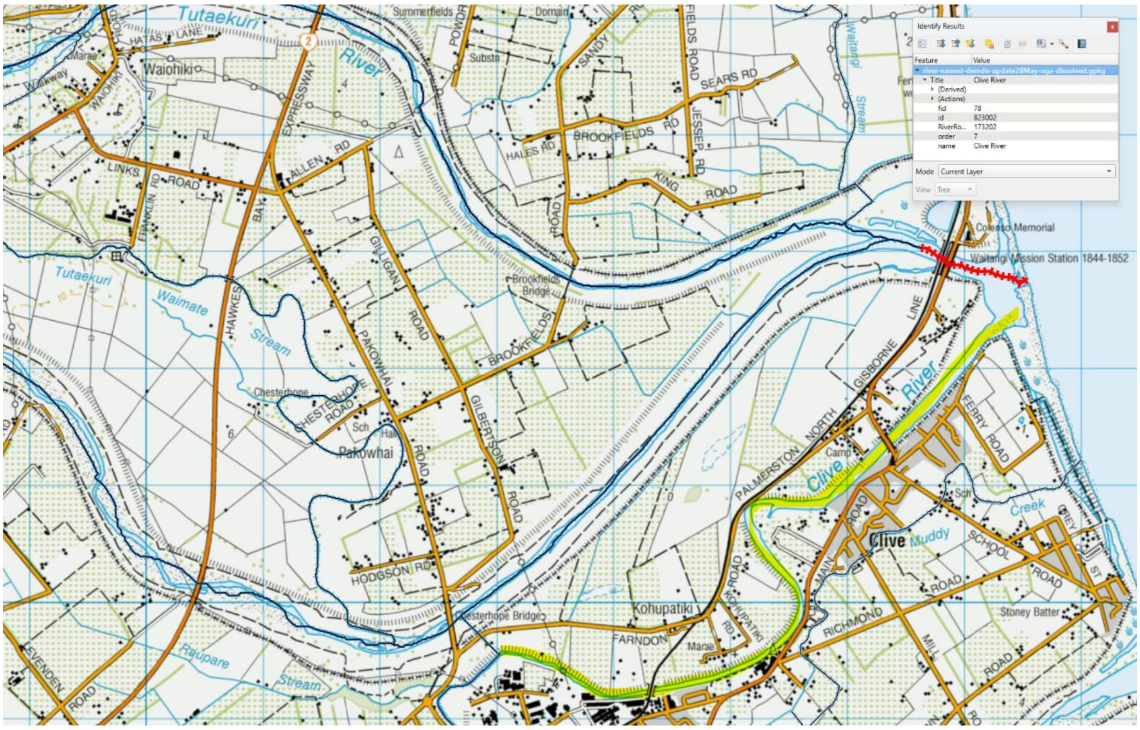


Figure 2-9: Example of inappropriate name projection due to missing DN segment. In this example, the Clive River, which is highlighted in yellow, does not have a DN segment (black lines). As a result, the name "Clive River" is projected onto the nearest eligible segment, which here, is what should be the terminal segment of the Ngaruroro River (red segment). The pop-up box correlates to the selected red segment, showing the name "Clive River".

Selwyn

Of the 44 unique, named rivers in the Selwyn catchment, 31 were a visual match to the underlying topographic map after applying the naming process to the DN. Nine of the unique, named rivers “mostly” matched the underlying topographic map; three “somewhat” matched the underlying topographic map; and one did not match the underlying topographic map.

In the Selwyn catchment, the majority of instances where the named rivers “mostly” matched the underlying topographic map, the issue was predominantly related to named tributaries coming together at a confluence, and the name of the downstream river not beginning for a stretch of distance until it encountered an iteration of the name (like Figure 2-7B in the Ngaruroro). Other issues related to names being assigned to small side streams that likely should not have names.

Like with the Ngaruroro catchment, issues in the Selwyn that resulted in the named segment “somewhat” matching or not matching the underlying topographic map were typically due to issues with the DN segments. For example, there was no DN segment for Wairiri Stream. As a result, the name got projected onto a nearby segment (Figure 2-10).

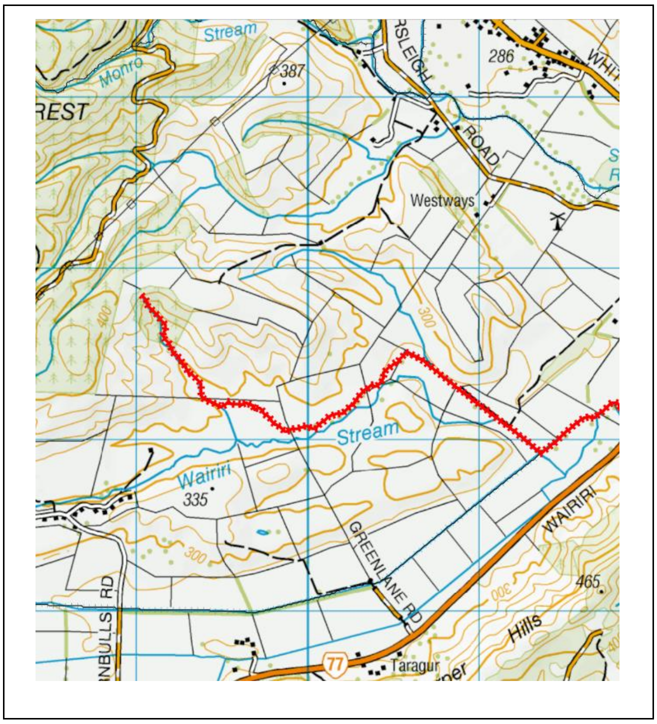


Figure 2-10: Naming issue for Wairiri Stream, Selwyn catchment. Red line indicates the selected named river.

The most significant discrepancy between the named DN and the underlying topographic map in the Selwyn catchment was for the Selwyn River/Waikirikiri. In the initial application of the naming process, the Selwyn River plotted as a continuously named river from just upstream of the confluence with Ford Stream (5187908, 1496438 easting/northing NZTM2000) through to Selwyn Huts (Figure 2-11A). We identified that in the nz-geographic-names-topo-150k layer, there is one iteration of the name “Selwyn River / Waikirikiri”, where there are two spaces either side of the forward slash. This name got attached to a small side creek, because the name “Selwyn River/Waikirikiri” (no spaces either side of the forward slash) took precedence in the main river channel. However, when the naming process was re-run following inclusion of the weighted-distance component, a few other issues arose (Figure 2-11B). At the confluence of the Selwyn River/Waikirikiri with Ford Stream, the name of Ford Stream carried on until the next iteration of the Selwyn River/Waikirikiri name, because Ford Stream has a larger font size at that confluence and receives precedence in the naming process. There is then an issue with the “Selwyn River / Waikirikiri” (two spaces) name, which no longer appears on the side stream, but is routed down the mainstem. This is an issue with the underlying nz-geographic-names-topo-150k layer where the naming convention for the Selwyn River/Waikirikiri is not consistent throughout the dataset. Finally, there is another gap in the Selwyn River/Waikirikiri where the Selwyn River/Waikirikiri and Waiāniwaniwa River come together. They are both the same stream order and font size, so the name that gets projected downstream is “Selwyn River/Waikirikiri | Waiāniwaniwa River” until the next iteration of just “Selwyn River/Waikirikiri” is encountered. This example would be a good candidate for fixing the gaps in the river by overriding all other river names along the downstream route between the most upstream segment with the “Selwyn River/Waikirikiri” name occurrence to the terminal segment, by activating “TraceToTerminal” in the manual input file (Section 2.1). However, users should note that applying “TraceToTerminal” would project “Selwyn River/Waikirikiri” onto the outlet of Lake Ellesmere/Te Waihora.

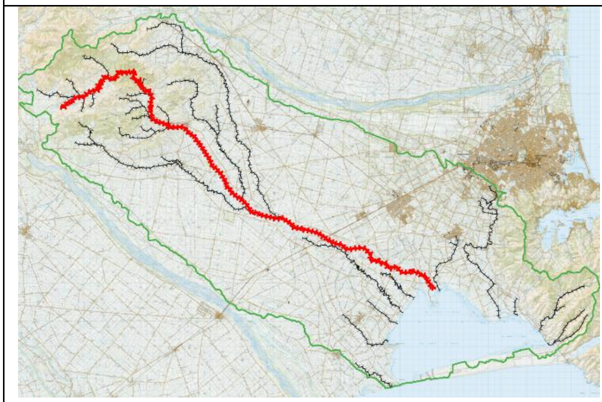
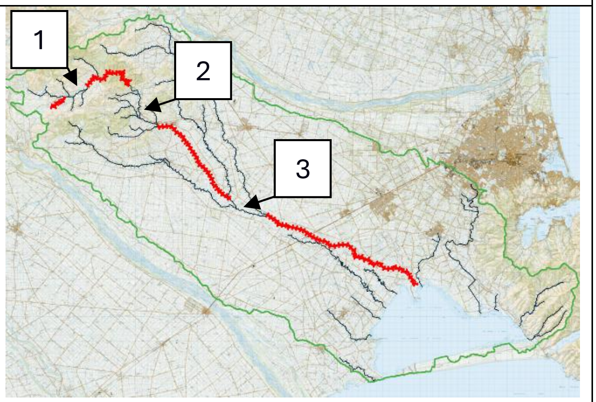
A) Selwyn River/Waikirikiri – first iteration of the naming process	B) Selwyn River/Waikirikiri – second iteration of the naming process using a weighted-distance component
	

Figure 2-11: Complications in the Selwyn River/Waikirikiri. Red lines indicate rivers with the name "Selwyn River/Waikirikiri". The green polygon indicates the extent of the Selwyn catchment. A) Continuous naming of the river. B) Fragmented naming of the river. 1) Gap due to Ford Stream. 2) Gap due to “Selwyn River / Waikirikiri” (spaces). 3) Gap due to Waiāniwaniwa River.

Following several iterations of the naming process, we have arrived at a method that generally produces accurately projected names onto segments and catchments of a DN and has an option where users can address known problems (using the river name positional adjustments input or the TraceToTerminal process).

2.5 Output data

Our process for projecting river names onto DN segments and catchments produces the following outputs.

- An attribute on DN segments which displays the Topo50 river name projected onto that segment. Segments with no river names projected onto them show as Not Applicable (NA).
- A list of t50_fid’s that occur in the input file but did not exist in the Topo50 database being used in the process.
- A list of river names removed from the process because they contained unwanted phrases.
- A list of river names removed from the process because they were located too far away from any DN segments.

3 Results

3.1 LINZ Topo50 data

3.1.1 River name occurrences

Topo50 contains 20,656 individual river name occurrences. These individual occurrences correspond to the individual points in the Topo50 layer that contain "STRM" description codes of river names. Several river names are replicated multiple times within Topo50 (Figure 3-1). Many river names that occur multiple times are English descriptions which possibly reflect the physical settings of small rivers such as Coal Creek, Stony Creek, and Deep Creek. Many river names that occur multiple times contain Te Reo Māori descriptions, which possibly reflect the physical, ecological, or social associations of small rivers such as Mangawhero, Wairere, and Waiau. The most frequently replicated river name occurrence is Waipapa Stream, followed by Mangaone Stream and Coal Creek (Figure 3-1).

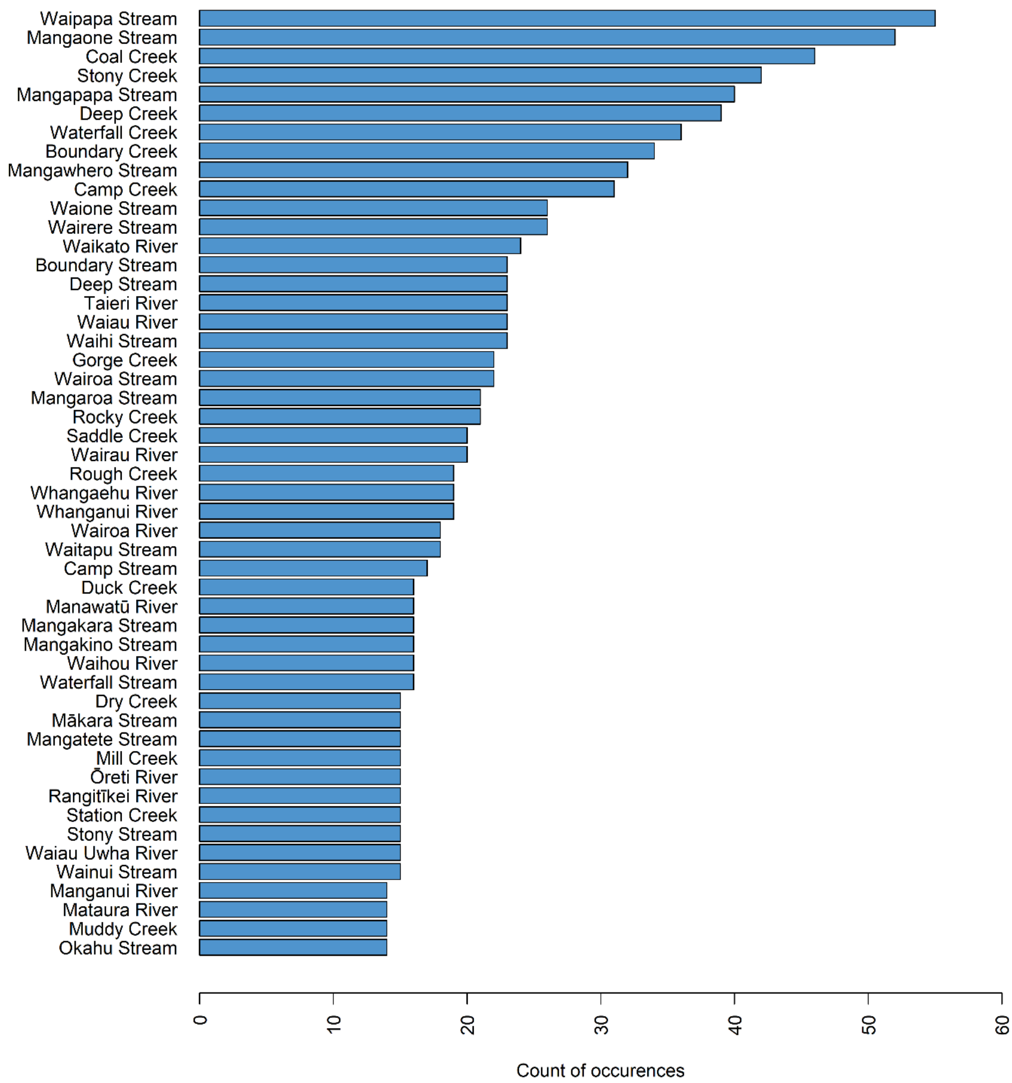


Figure 3-1: Counts of occurrences of the same river names in the Topo50 Geographic names database.

The replication of names can represent one of two possibilities: 1) multiple replications of the same name along the same LINZ blue river line, or 2) multiple replications because there are streams or rivers in different parts of the country that have the same name. It is important to the naming process to be able to identify where river names are replicated along the same river versus where the river names represent different rivers in different parts of the country.

To distinguish between river name replications representing the same LINZ blue river line versus those representing streams or rivers in different parts of the country, we examined the real-world distance between paired occurrences of replicated names. Some pairs of locations sharing the same river name were located close to each other, whereas other pairs were very far apart from each other (Figure 3-2).

The distributions in (Figure 3-2) can help illustrate whether river name replications can be attributed to either, or both, of the two possible reasons for replicated names. A tight, unimodal distribution (such as for the Taieri) likely indicates there is one river nationally with that name, but many recurring occurrences of the name. A broad, unimodal distribution (such as for the Waipapa) suggests that this river name occurs in multiple widely separated locations across the country. This aligns with the fact that Waipapa Stream not only has a wide spatial distribution (Figure 3-2) but is also the most frequently recurring river name in the Topo50 dataset (Figure 3-1). Two occurrences of Waipapa Stream were separated by 1,355 km, confirming the occurrence of the same river name in very different parts of the country. Occurrences of Gorge Creek, Deep Creek, Stony Creek, Waiau River, Coal Creek, Wairere Stream, Camp Creek, and Waipapa Stream were all separated by more than 1,000 km. Bimodal patterns in (Figure 3-2) indicate that at least two catchments containing multiple occurrences of Waiau River and Wairau River are located in different parts of the country. These results demonstrate that the same river name can occur across the country. Each name is not necessarily confined to one region or one catchment.

The 20,656 individual river name occurrences correspond to 12,092 unique river names, which is further evidence that the same river name can occur multiple times. Of the 12,092 unique river names within Topo50, 8,330 occur once, 2,110 occur twice, and 772 occur three times.

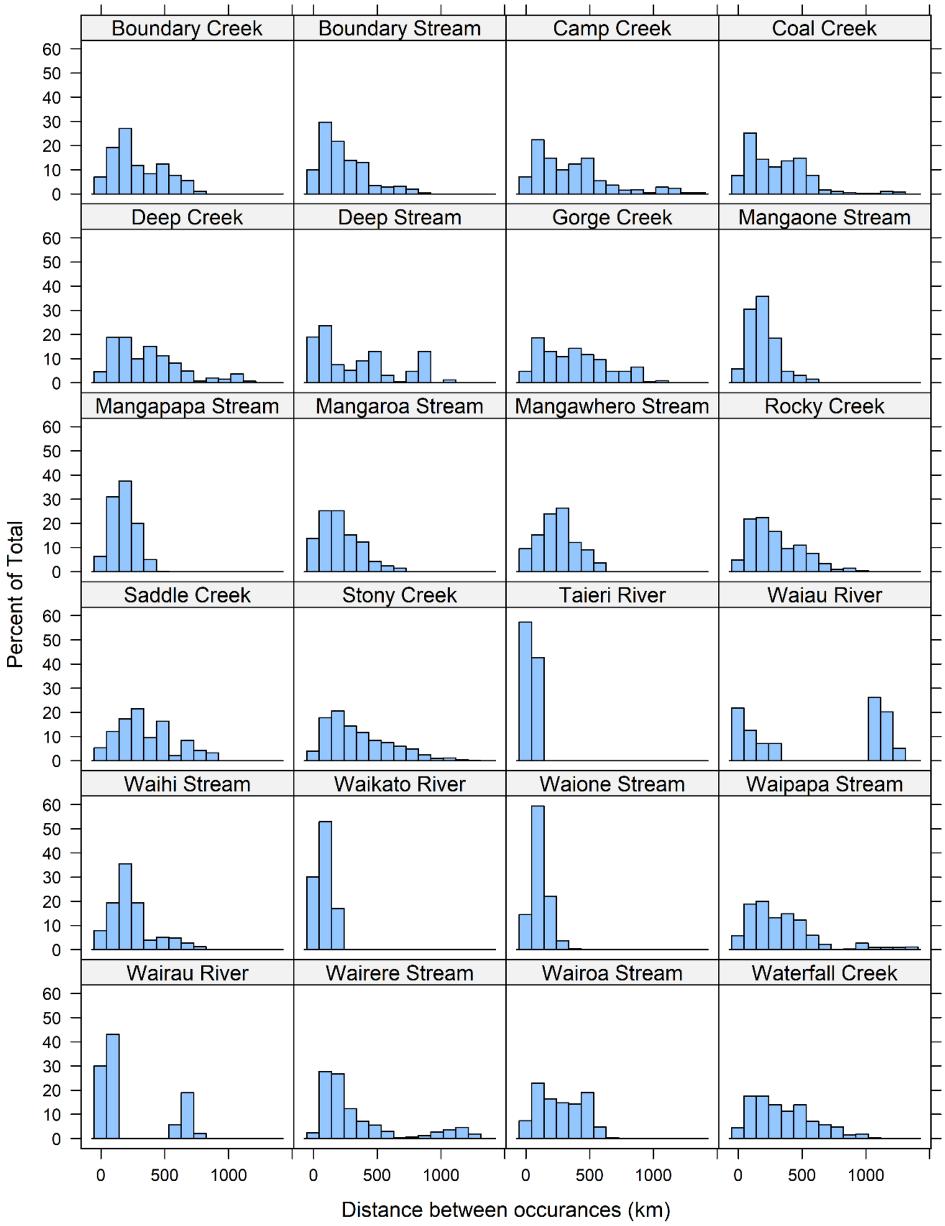


Figure 3-2: Straight line distances between all pairs of points with the same name associated with the 24 most frequently occurring river names within Topo50.

3.1.2 Font size

Many river name occurrences had font sizes of either 4.1, 4.8, or 5.5 (Figure 3-3). Very few river name occurrences had font sizes less than 4. There were only 213 occurrences of river names with font sizes of 8.2.

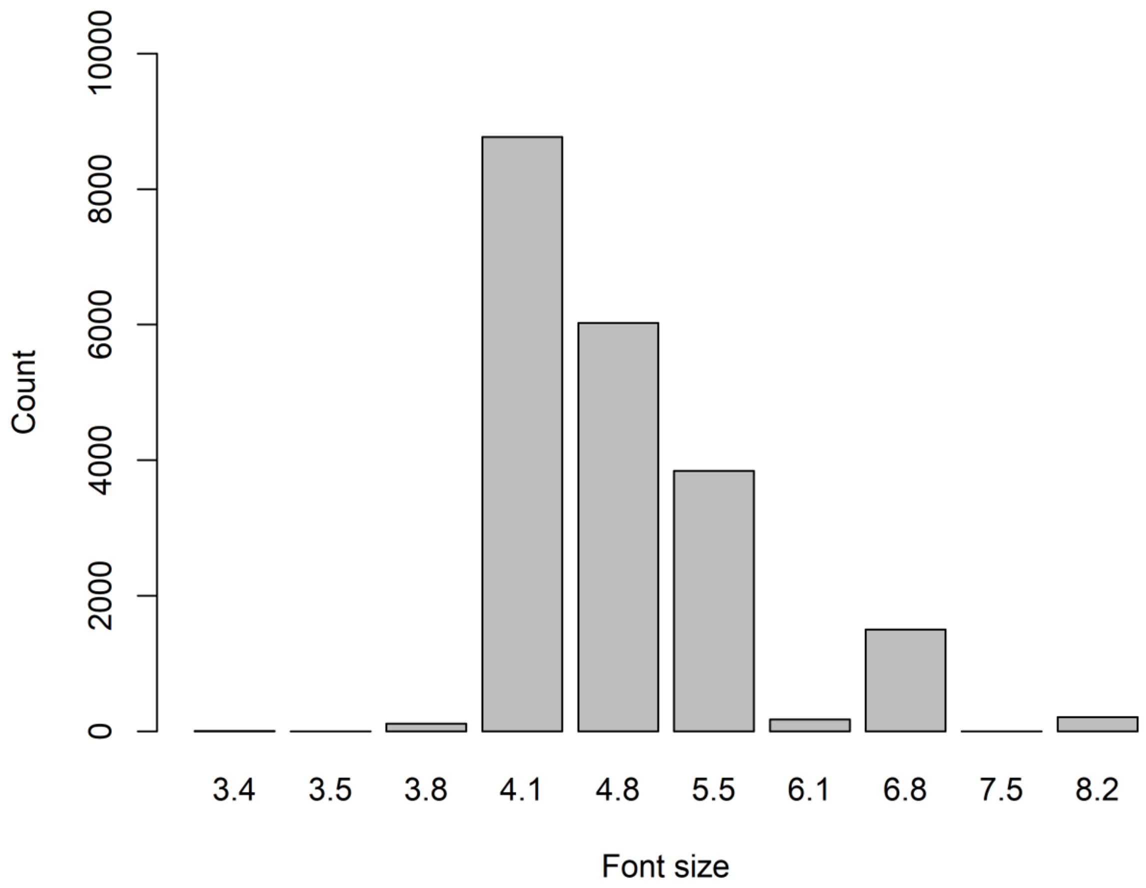


Figure 3-3: Counts of Topo50 river names appearing in each font size.

3.1.3 Repositioning and removal of river names

The naming process can reposition and/or remove river names through the automated process of identifying unwanted phrases and through inclusion of a manual input file (Figure 3-4).

Automated process

Thirteen names were removed with the automated process because they contained unwanted phrases: Balloon Loop; Boulder Reach; Cabin Pass Rapids; Emily Falls; Ngatukuwaru Reach; Otaihanga Reach; Queens Reach; Rainbow Reach; Rata Falls; Reid Falls; Tokakura Reach; Webber Falls; Yerex Reach.

Manual input file

Some names appearing within the LINZ river names data layer were removed using the manual input file because they had no reasonable association with a DN segment, as they were positioned in the sea or an estuary. Many of the removed names were positioned along the coast of the Auckland and Northland regions (Figure 3-4) and contained the phrases “Channel” or “Creek” (e.g., Te Putaaraukai Channel; Tūranga Creek). One name was removed so that it would not be incorrectly assigned to a segment because the DN failed to correctly position a segment in the location where that name should have been assigned to (Clive River, Hawke’s Bay).

Many of the point coordinates that were repositioned were done so because they were associated with a large river (e.g., Waikato River) but originally plotted near to the intersection of two DN segments, which caused the possibility of inappropriate river name projections. These coordinates were often moved a small distance to the midpoint of a DN segment with a high Strahler order to ensure the name was projected onto the appropriate segment.

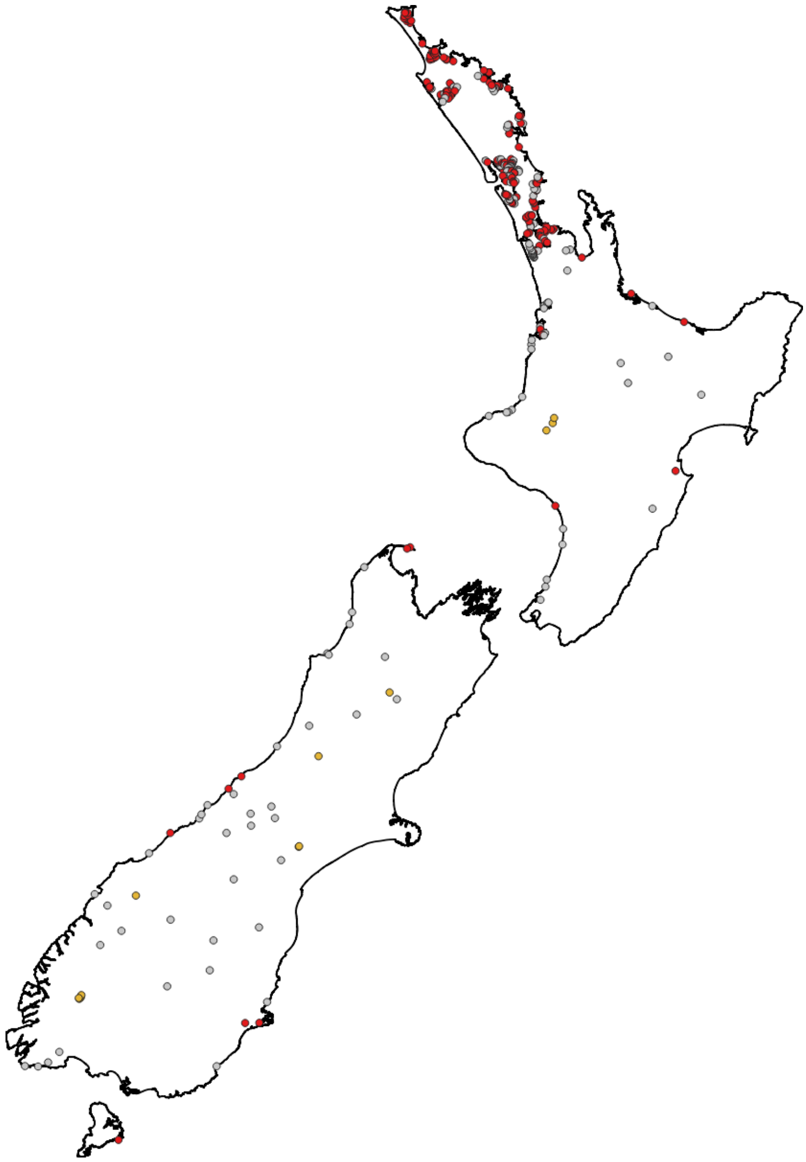


Figure 3-4: Map of repositioned, removed, or unwanted river names. Grey is moved. Orange is unwanted phrases. Red is removed.

The manual input file also enabled identification of river names that should be routed downstream using the "TraceToTerminal" feature. An example of a river name we identified as appropriate for downstream overriding tracing was the Waikato River. Prior to applying the downstream overriding tracing, there were numerous gaps in the river name of Waikato River. After applying "TraceToTerminal" for the Waikato River, the name was continuously routed downstream. (Figure 3-5) shows the river names and Strahler order of named DN segments that were overridden by the "TraceToTerminal" function for Waikato River.

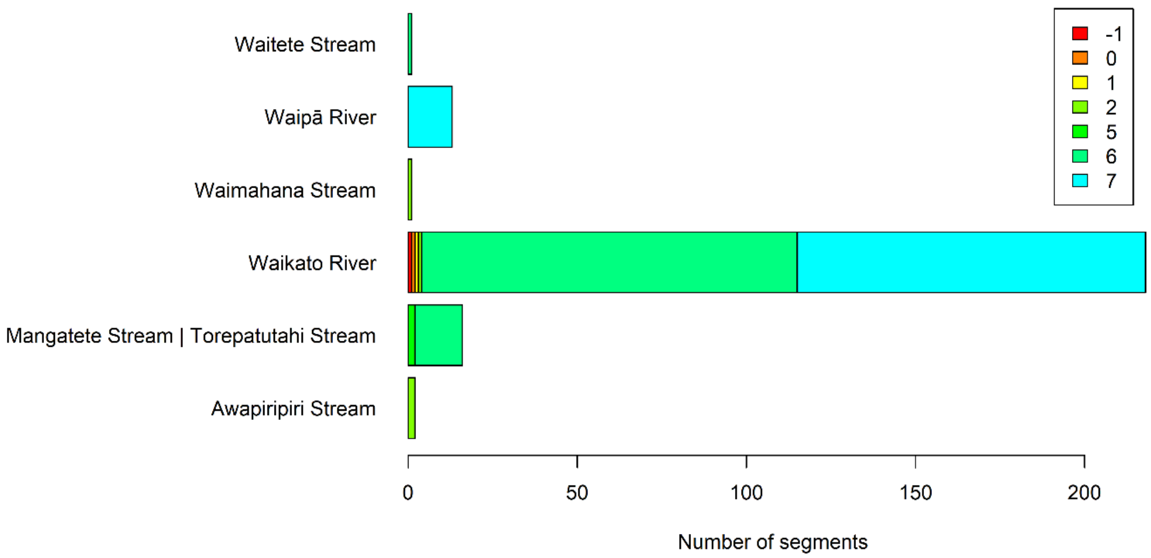


Figure 3-5: Count of DN segments with names that were overridden by "Waikato River".
Note that "Waikato River" was named appropriately for many segments before being overridden by itself. Colours are Strahler order.

3.2 River names on network

Of 740,000 DN segments, 127,000 (17%) had river names projected onto them. Segments of higher Strahler order were more likely to have river names projected onto them (Figure 3-6). For example, only a very small proportion of first and second order segments had names projected onto them. Segments with river names projected onto them were widely distributed across the country and had strong spatial coverage (Figure 3-7).

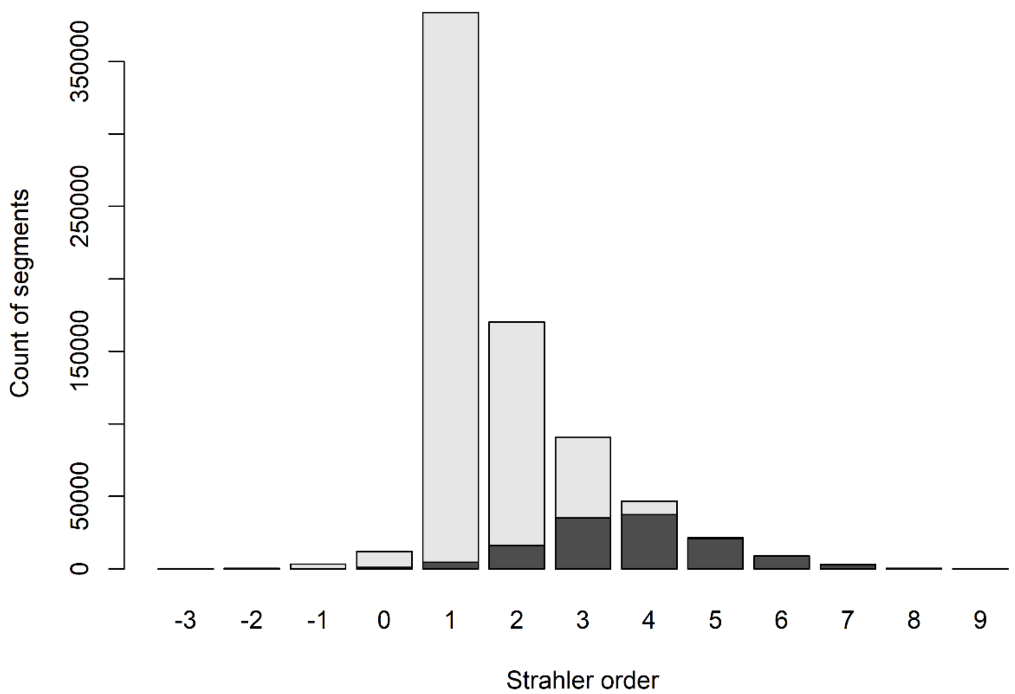


Figure 3-6: Number of DN segments given river names. Dark is with projected river names. Light is without projected river names.

Figure 3-7: A map of DN segments that had river names projected onto them.

The number of individual segments with the same name projected onto them varied greatly (Figure 3-8). Across the dataset of individual segments, the greatest number of segments that all had the same name projected onto them were associated with Whanganui River (the third-longest river in New Zealand).

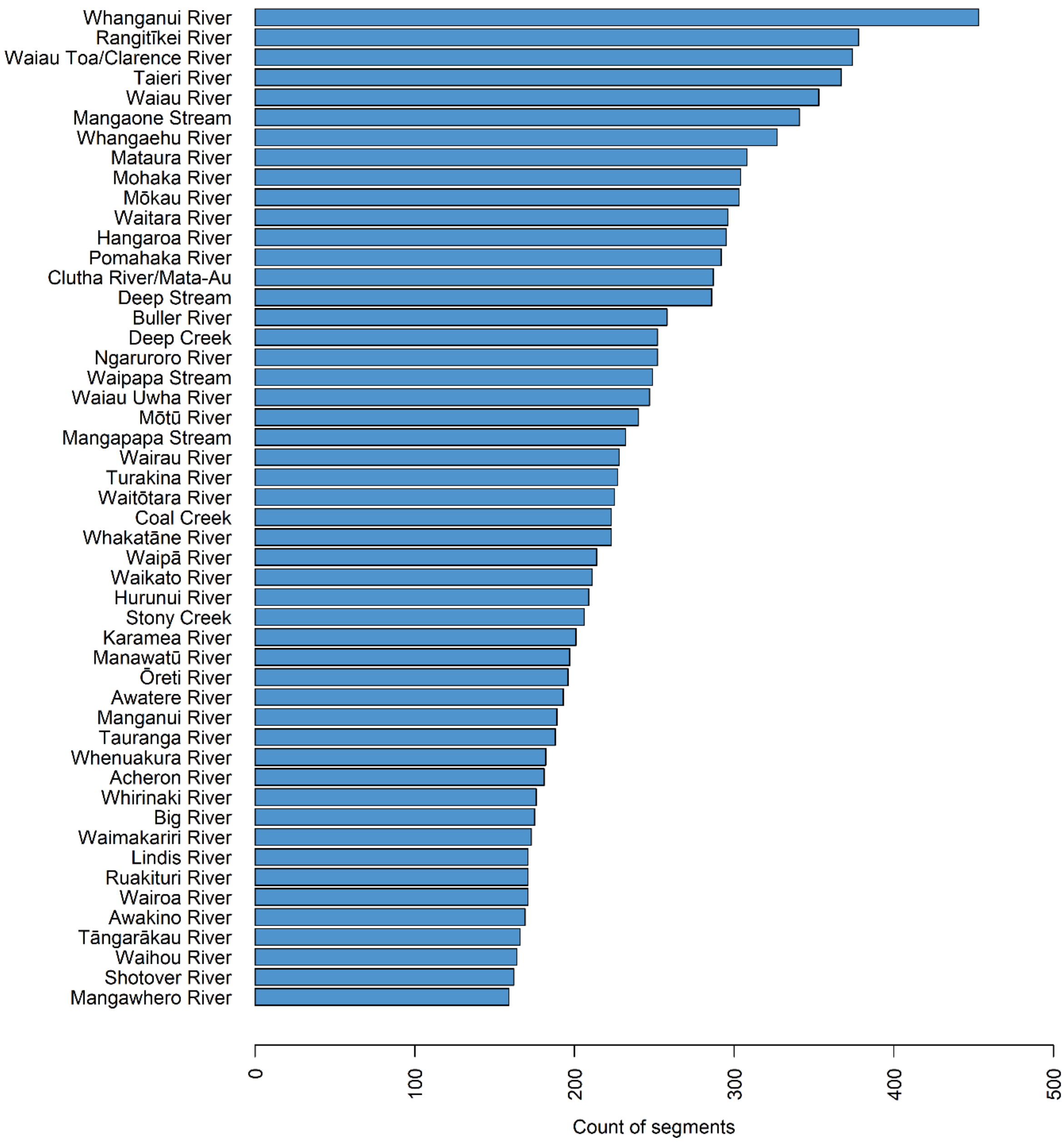


Figure 3-8: Count of river segments associated with the most prevalent river names after being projected onto a national DN. Segment counts are regardless of catchment or adjacency.

3.3 Catchment names

Of a total of 9,751 catchments[5] in our DN, 4,918 (just under 50%) contained one segment, 576 contained two segments, and 1,140 contained three segments. The largest catchment contained 68,810 segments. Approximately a dozen catchments (around 1–2% of all catchments) had more than 10,000 segments (Figure 3-9).

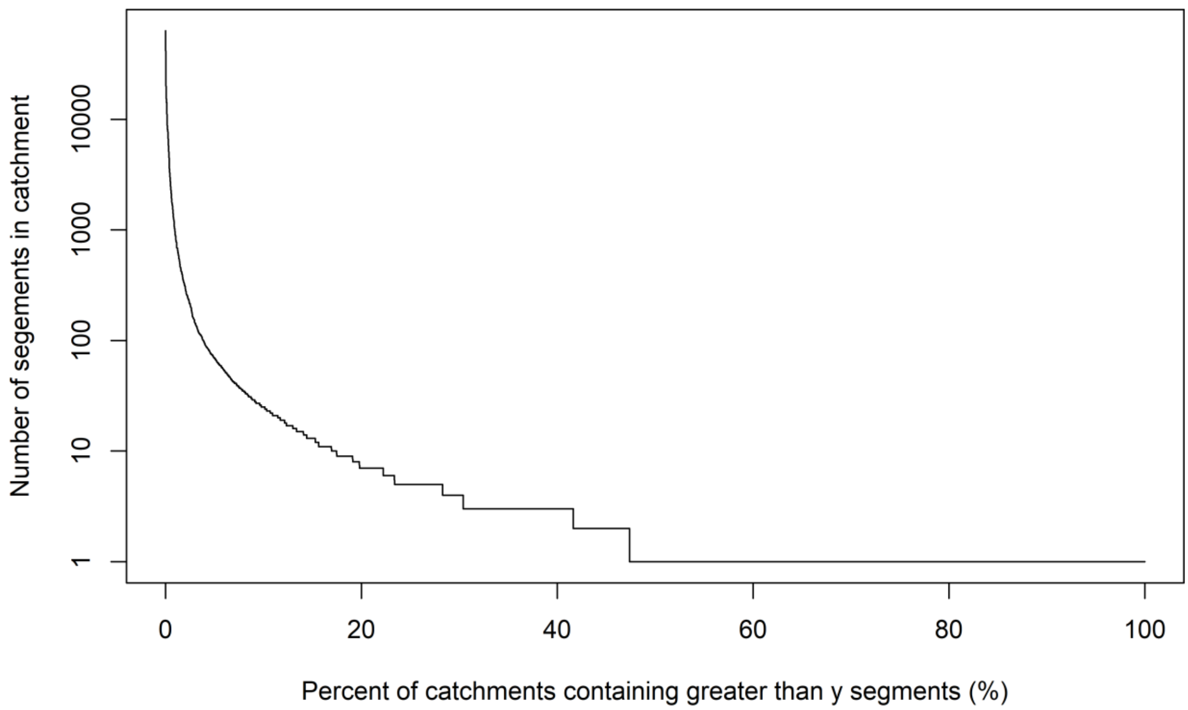


Figure 3-9: Percent of catchments containing a given number of individual segments (indicated on the y-axis).

Catchments flowing to the sea varied greatly in terms of area and number of DN segments (e.g., Figure 3-10). Smaller catchments were present near to the coastline, especially in areas with steeper slopes, such as the West Coast, Banks Peninsula, and the Marlborough Sounds (Figure 3-10). Some catchments that appear to terminate inland, such as the Waiau River in Lake Manapouri, and a small catchment within the Taieri catchment, are due to breaks in projecting names downstream due to lakes.

[5] We have defined catchment as "a collection of segments that all route to a common terminal segment."

Figure 3-10: Membership of South Island catchments. Gaps appear due to presence of lakes (e.g., Lake Wakatipu), ice (e.g., along the main divide of the Southern Alps), or lack of river headwaters (e.g., Canterbury Plains). Note some breaks in this pilot due to inappropriate routing around lakes within this pilot version of our DN. Random colours for each catchment.

Our process has been applied to terminal segments as defined by catchments that terminate at the sea. Therefore, by definition, our process does not capture sub-catchments within these.

Our analysis of river name reoccurrences (Section 3.1.1) revealed that there are multiple recurrences of the same name that represent rivers in different parts of the country. This analysis was useful for identifying distinct catchments with terminal segments containing the same river name. The most commonly named catchment is Waipapa Stream (Figure 3-11), which correlates with Waipapa Stream being the most commonly occurring river name (Figure

3-1) and its broad spatial distribution (Figure 3-2). There are 12 distinct catchments with the name Waipapa Stream.

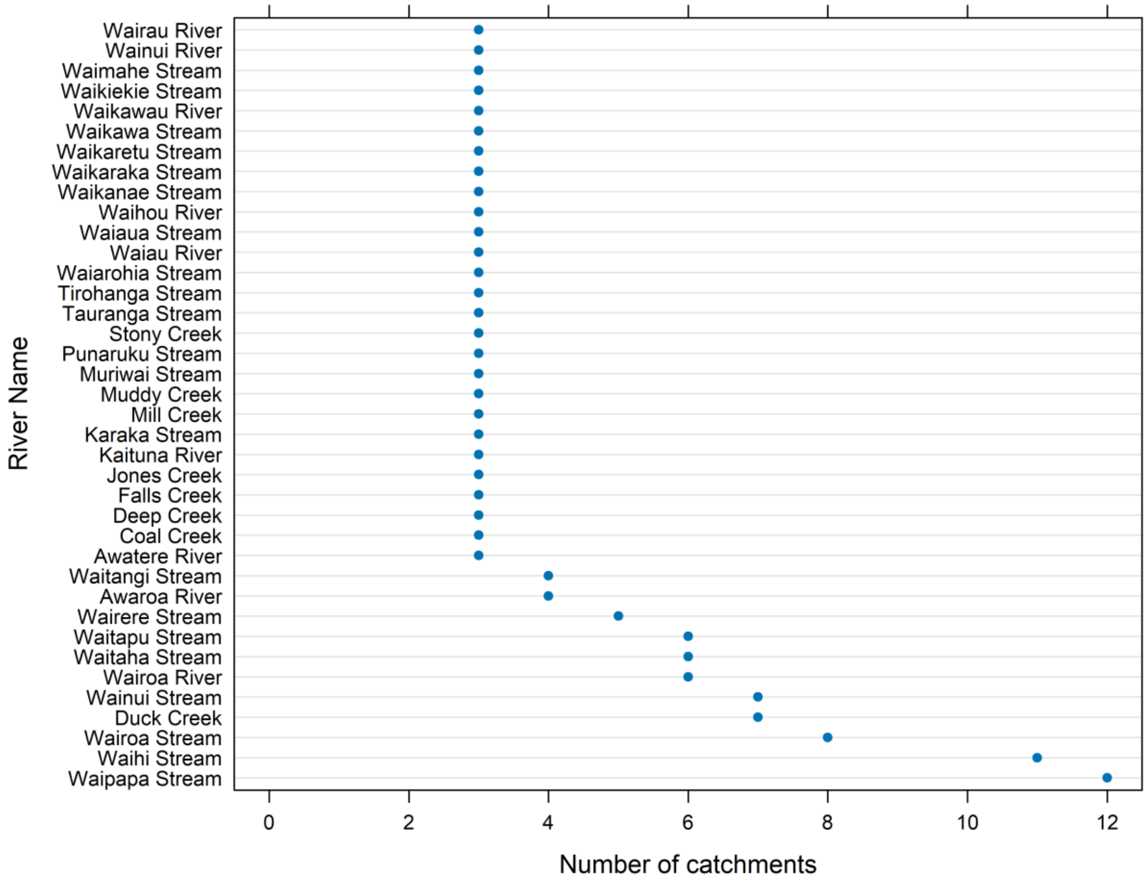


Figure 3-11: Number of catchments with the same river name.

As described in Section 2.3, we devised a method for generating a label for all terminal segments from nearby named terminal segments. In summary, labels of a named terminal segment take the form “N_1of1_[Named River]_0m_0deg_AofA”, where both the distance and bearing values are 0. Unnamed terminal segments take the form “N_1of1_[Named River] _137m_288deg_AofA”, where distance and bearing indicate position relative to the nearest named terminal. Approximately 23% of terminal segments had names projected onto them. Named terminal segments were not evenly spread along the coastline (Figure 3-12). Unnamed terminal segments were more prevalent in locations with numerous small catchments due to steep slopes and intricate coastlines (e.g., Northland, north Marlborough, Fiordland, Stewart Island / Rakiura).

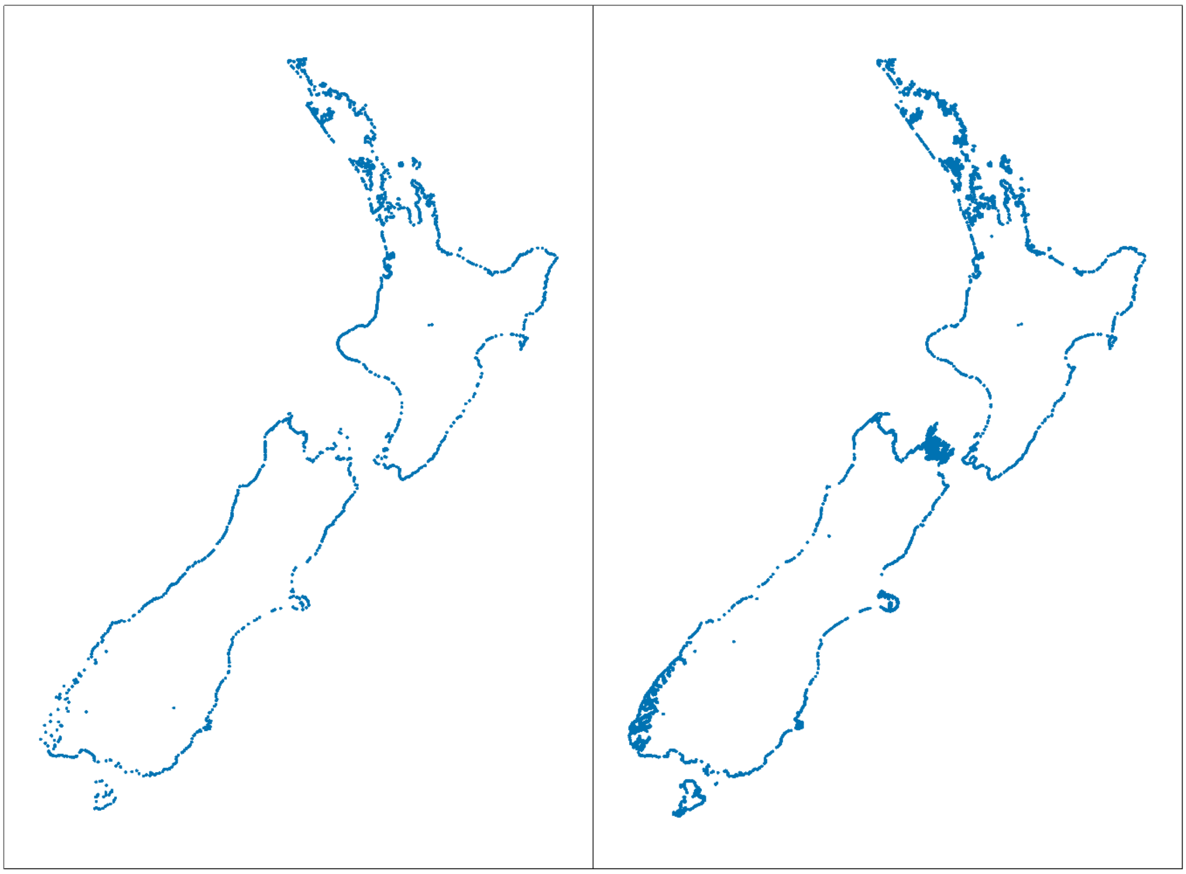


Figure 3-12: Terminal segments with river names (left) and without river names (right).

4 Discussion and next steps

Our automated process to project river names onto a DN generally produced accurate and reliable results. We were able to project river names from Topo50 data onto segments of a DN, including terminal segments of catchments. We devised a method for relating unnamed segments to named segments. Our process is easily repeatable and can be reapplied following any changes to river names in the Topo50 data or to any updates to a DN.

Through development of our process, we identified areas of potential improvement to the process as well as the underlying data. These potential improvements include:

- Improvements to the process:
  - Results produced from our process would be altered by changes to two parameters; the Strahler Difference Multiplier and the Maximum Distance. We did not attempt to optimise these two input parameters because we did not have a source of truth to optimise against.
  - Association of river names downstream of lake outlets proved to be challenging due to our preference to not route river names upstream. We attempted to mitigate this challenge by using the manual input files to replicate appropriate river names at lake outlets and did allow for some upstream routing of river names within the same Strahler order where lake outflows were unnamed. There is potential for improvement within this step of the process.
- Improvements to data:
  - Our process attempted to assign all river names from Topo50 geographic names with the description code of "STRM" to DN segments devised to represent river channels (and not artificial flow pathways such as ditches or drains). We noted that several Topo50 river names were placed near to blue lines belonging to the Topo50 "drains" data layer rather than the Topo50 "rivers" data layer. Ideally, input to our process would exclude names of drains, and only include place names associated with river channels.
  - Tidying of text for names that are almost the same but not quite (e.g., "Clutha River / Mata-Au", "Clutha River/Mata-Au", "Clutha River/Matau Branch" or "Selwyn River/Waikirikiri", "Selwyn River / Waikirikiri").
  - Placement of Topo50 river name point coordinates away from confluences while recognising that there may be differences between the positions of blue lines/polygons representing river channels in Topo50 and segments within a LiDAR-generated DN.

Our naming process comes with some considerations that must be acknowledged:

- Inputs such as river name positional adjustments, the font-Strahler relationship (Figure 2-5) and other parameters (Table 2-2) may become out-dated if changes to the DEM cause changes to the DN, or changes to Topo50 cause changes in the positions or font sizes of river names. It should be noted that changes to Topo50 data may impact the effectiveness of our input file. For example, our process would not be able to move the coordinates of a river name that is specified in our input file if that occurrence of the river name has been removed from Topo50. Our manual input file will therefore need to be reviewed following changes to a DN or to Topo50 data.

- Our results produced non-contiguous names in several cases because river names can change along a main river channel. In some cases, a name appeared, was overwritten by a different name, and then appeared again downstream. This outcome was mathematically correct but may not be ideal for the purposes of identifying continuous stretches of river with a single river name. We have attempted to address this issue by providing the option for a specified river name to override all downstream names. The validity of downstream overriding traces should be double-checked with any future changes to the DN or Topo50 names.
- Most importantly, we applied our process to a pilot DN which was being trialled with end-users at the time of writing. Feedback from end-users indicated that representation of lakes, diversions, and sinkholes in the pilot DN were significant improvements in functionality compared to previous DNs. However, several improvements to channel alignment and routing of the pilot DN are required following requests by end-users.

The naming process will be applied to the NZ national DN version 4 when it is released.

5 Acknowledgements and cautions

River names projected on DNs using the process described in this report are subject to inaccuracies relating to the DN and uncertainties in associating point locations with nearby river segments. The river names automatically projected onto DNs should therefore be used with caution. Earth Sciences NZ takes no responsibility for actions that rely on the river names projected onto the DN for any purpose.

6 References

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