Environment Committee Meeting

1 September 2022

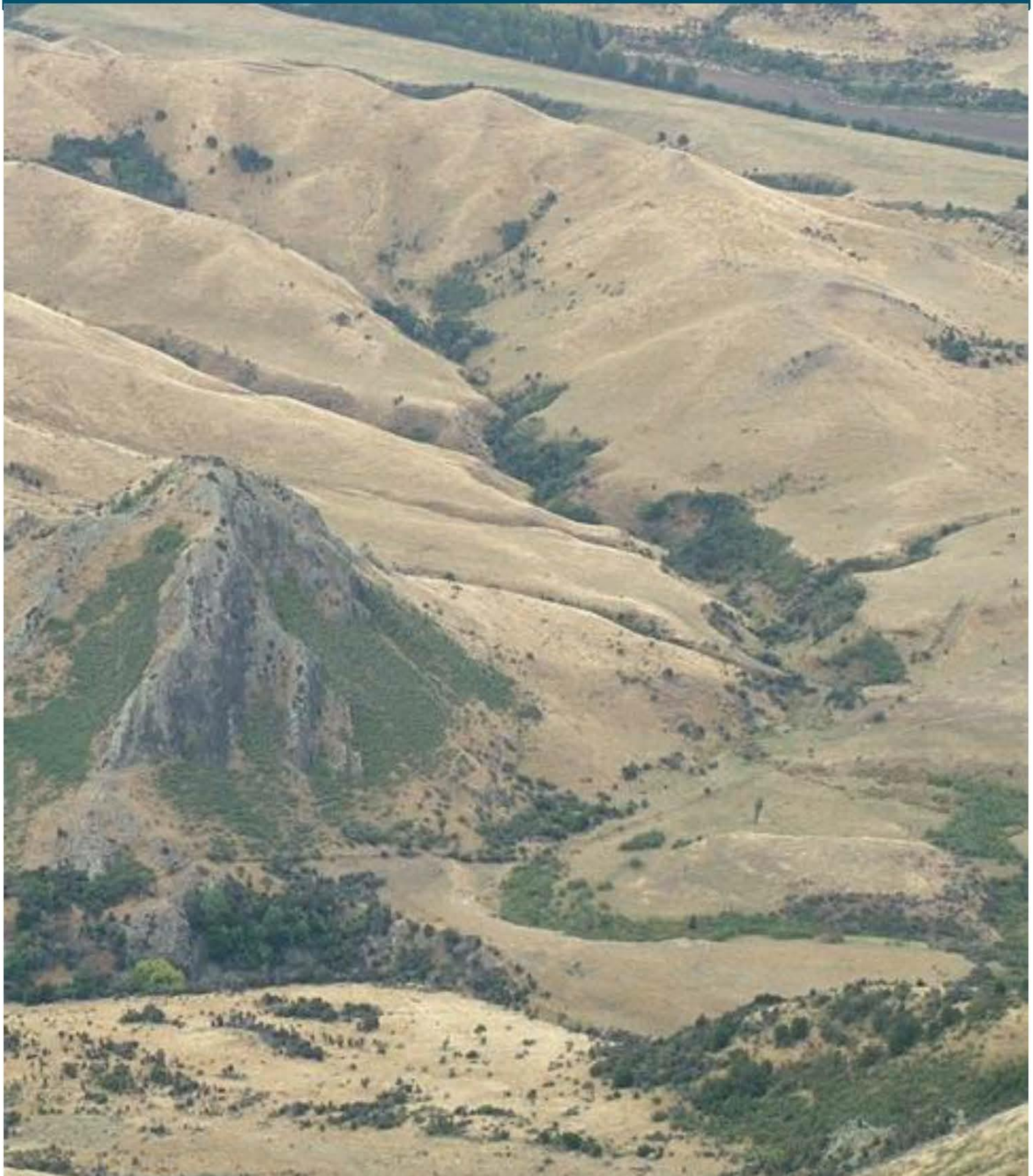
This Report relates to Item 7 in the Agenda

"Surface Water Quality in the Flaxbourne Catchment"

MARLBOROUGH
DISTRICT COUNCIL

Water Quality in the Flaxbourne River Catchment

August 2022



Water Quality in the Flaxbourne River Catchment

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Report Prepared by:
Steffi Henkel
Environmental Scientist - Water Quality
Environmental Science & Monitoring Group

Final Edition approved by
Peter Hamill
Team Leader Land and Water
Environmental Science & Monitoring Manger
Marlborough District Council

Marlborough District Council

Seymour Square

PO Box 443

Blenheim 7240

Phone: 03 520 7400

Website: www.marlborough.govt.nz

Executive Summary

The Flaxbourne catchment is located in the South-East of the region. It receives comparatively little rainfall causing river flows to be low. During dry summers, parts of the river and its tributary streams run dry with flow only continuing within the river gravels.

Very little native vegetation remains in the catchment. More than 80% of the catchment area has been converted to pasture, grazed by sheep and beef cattle. In the lower parts of the catchment, small areas of vineyard and cropping are also present.

The Flaxbourne River has been monitored as part of the State of the Environment programme since 2007. This monitoring has shown that river health is degraded.

In order to better understand surface water quality in the catchment, additional monitoring was carried out on several sites along the Flaxbourne River and the main tributary streams. The sites were sampled during baseflow conditions in 2020 and 2021.

Apart from higher concentrations of phosphorus and nitrogen in some of the tributary streams, the monitoring showed that water quality was comparable at all river and stream sites, including the most upstream location on the Flaxbourne River.

Although signs of regular livestock access were evident at all sampling sites, livestock was generally not present during sampling of the additional sites. Sampling was cut short by a particularly dry weather period in 2021, causing the Flaxbourne River to lose surface flow for several months. This means that the additional water quality monitoring is likely underrepresenting the magnitude of the water quality problem as State of the Environment monitoring has shown livestock stock access to contribute considerably to high E. coli concentrations as well as spikes in nutrient concentrations and turbidity during baseflow.

Still, the study did show that there are very few specific hot spots of poor water quality in the catchment and degraded water quality is a widespread problem. The dry climate and subsequent low flows cause the waterways to be significantly more sensitive to contaminant inputs compared to streams in other catchments. Overall, livestock access and lack of shading riparian vegetation are two of the main causes for degraded water quality in the streams and river of the Flaxbourne catchment, particularly in the lower reaches.

Parts of the Flaxbourne catchment flow into a shallow coastal lake, Lake Elterwater. Although the lake has an outlet that flows into the Flaxbourne River, the outlet very rarely contains flowing water. Lake Elterwater is rarely more than one meter deep and has dried up completely in the past. Water quality of the lake had not been monitored before, so the lake was monitored as part of the additional sampling in 2021. In 2022, the lake was added to the State of the Environment monitoring programme.

The monitoring results show that the health of the lake is severely impacted, with several parameters below the national bottom line of the NPS-FM. These include Total Nitrogen and Total Phosphors concentrations as well as concentrations of E. coli and Chlorophyll-a.

A Catchment Care programme has already been initiated for the Flaxbourne. Two catchment groups, one for the wider catchment and another specifically for Lake Elterwater, are meeting on a regular basis to discuss ways to improve water quality. Restoration action has already started, including the removal of willows and planting of native vegetation around Lake Elterwater.

Table of Contents

Executive Summary i

1. Introduction 1

2. Catchment Characteristics 2

2.1. Geology 2

2.2. Hydrology 3

2.3. Landcover 4

3. Water Quality 5

3.1. State of the Environment Monitoring 5

3.2. Catchment Study 8

3.2.1. Streams and River 8

3.2.2 Lake Elterwater 11

4. Summary and Discussion 14

Acknowledgements 16

References 16

Abbreviations

DIN	Dissolved Inorganic Nitrogen
DRP	Dissolved Reactive Phosphorus
NPS-FM	National Policy Statement for Freshwater Management
MCI	Macroinvertebrate Community Index
MEP	Marlborough Environment Plan
SoE	State of the Environment

1. Introduction

The Flaxbourne River catchment is located in the South-East of the Marlborough region and covers an area of 150.6 km^2 (15,060 ha). The catchment is situated in the rain shadow of the Southern Alps, resulting in comparatively low rainfall and loss of surface flow in sections of the river during the summer months. Approximately 10% of the catchment drains into Lake Elterwater, which on rare occasions flows into the Flaxbourne River.

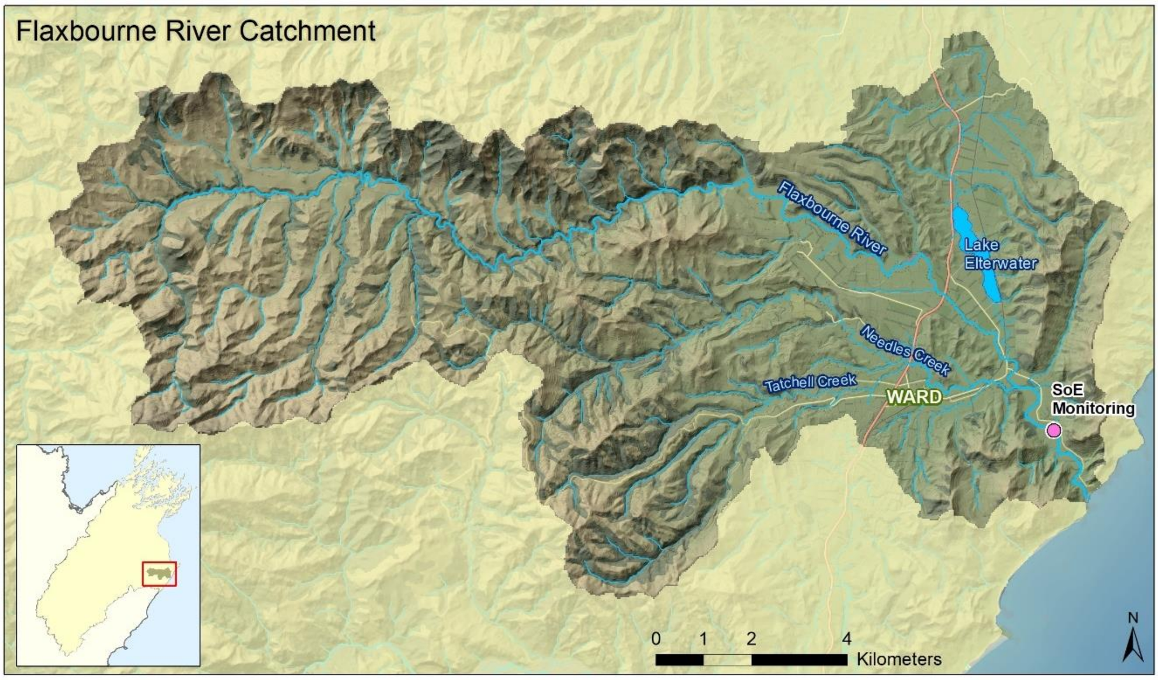

Figure 1: The Flaxbourne Catchment and location of SoE monitoring.

The Flaxbourne River is monitored as part of the State of the Environment (SoE) programme (Figure 1). Council monitors streams and rivers across the region to determine the state of Marlborough's waterways. Monitoring consists of monthly field measurements and taking of water samples that are send to an accredited laboratory for analysis. The results of this monitoring are summarised every year by calculation of a Water Quality Index.

The Water Quality Index for the Flaxbourne River is consistently within the "marginal" category, which indicates that the health of the river is degraded. This is reflected in the exceedance of guideline values and limits for a number of parameters, which include E. coli and nutrient concentrations as well as water temperature and turbidity.

The Marlborough Environment Plan as well as the National Policy Statement for Freshwater Management (NPS-FM) require improvement of rivers and streams that are shown to be degraded. To achieve this, an initial Catchment Study is carried out. This involves monitoring tributary streams and different sections of the river to gain a better understanding of the causes for poor river health. This report summarises study findings within the Flaxbourne catchment.

Following the Catchment Study, actions to improve river health are initiated through a Catchment Care programme. This programme aims to achieve better water quality through voluntary cooperation with land owners in the catchment.

In the Flaxbourne catchment the Catchment Care process has already been initiated. Catchment groups are meeting on a regular basis and this report aims to aid their efforts in improving the health of waterways within the Flaxbourne area.

2. Catchment Characteristics

The following sections provide a short summary of the geology, hydrology and landuse of the Flaxbourne catchment as these have a significant influence on water quality.

2.1. Geology

The surface geology of the Flaxbourne River catchment is dominated by sedimentary rock that has been folded. The majority of the upper catchment consists of Pahau basement sandstone (Figure 2), formed in the early Cretaceous. This sandstone contains mudstone, basalt and limestone.

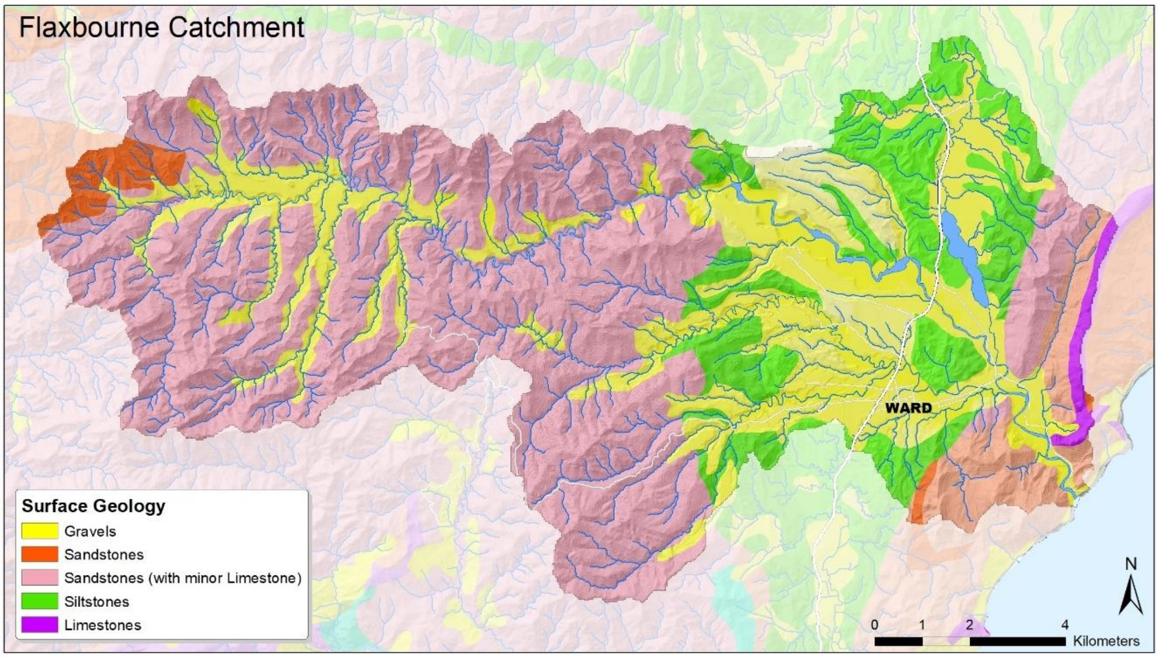

Figure 2: Main rock types within the surface geology of the Flaxbourne catchment.

The Flaxbourne river and its tributary streams have cut deep into the sandstone, forming incised valleys which contain thin layers of alluvial gravels. Towards the coast, the river valleys widen, and the surface geology becomes dominated by quaternary alluvial gravels among pockets of exposed siltstone.

Furthest to the East, sandstone and limestone surface in narrow bands parallel to the coast. The limestone is mined near the mouth of the Flaxbourne River

The predominance of limestone within the geology means that pH and conductivity of the streams and rivers in the Flaxbourne catchment are naturally elevated.

2.2. Hydrology

The Flaxbourne catchment is located in the rain shadow of the Southern Alps, resulting in very low rainfall. A recorder in the lower catchment has been monitoring rainfall since 2007. Median annual rainfall at the site is 774 mm, but in some years, such as in 2015, less than 400mm of rain fell.

The rivers and streams in the Flaxbourne catchment generally flow in a West to East direction. As a result of the low rainfall, flows in the Flaxbourne River are comparatively low despite a large catchment area of 150 km^2. Tributaries and sections of the main river frequently dry up during the warmer months, with flow continuing within the river gravels only. In 2003, a Flow recorder was established on the Flaxbourne River at Corrie Downs, approximately 1 km upstream of the State Highway 1 bridge. Median flow at the recorder is 0.104 m^3/s (104 L/s). The highest flow was measured during a flood event in 2008 with 133 m^3/s.

As part of a MfE funded community project, low flow gaugings were carried out in 2019 and 2020 at a number of sites along the Flaxbourne River and on the main tributary, Needles Creek. This was the first significant investigation of surface flows within the wider Flaxbourne catchment. The flows at the gauging sites, calculated as medians of the five gauging runs conducted, are shown in Figure 3.

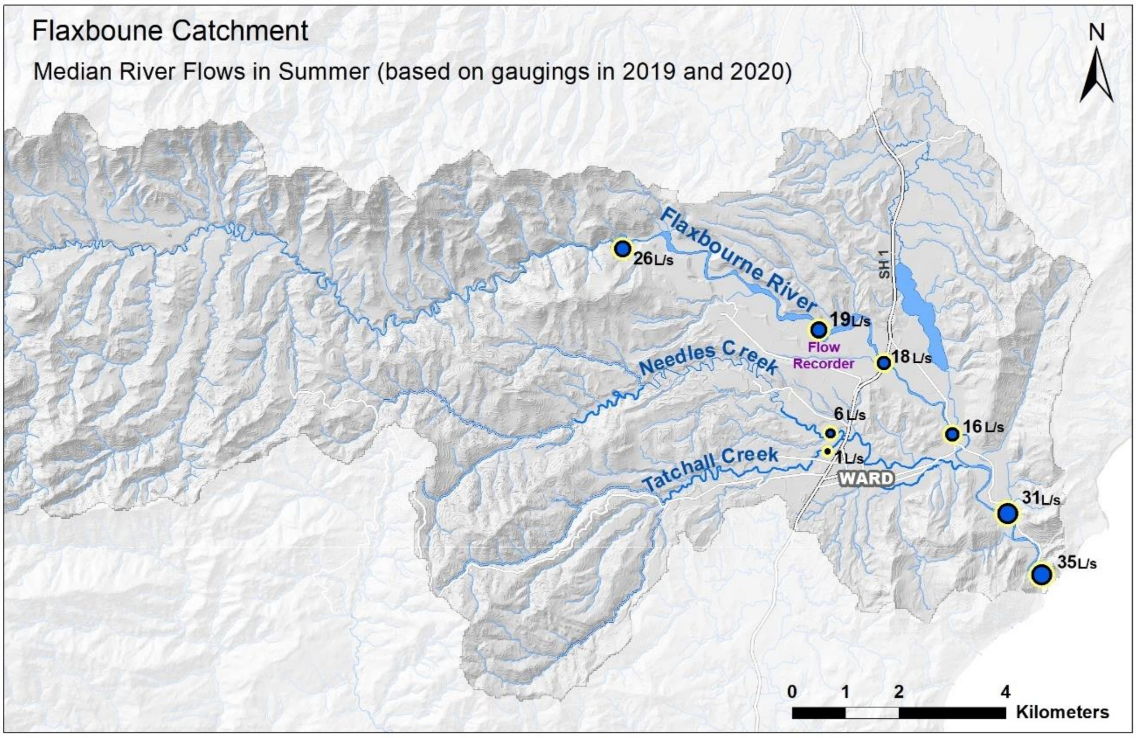

Figure 3: Median flows in the Flaxbourne catchment during summer base flow measured during five gauging runs in 2019 and 2020.

The gaugings show that the river is losing surface flow in the mid reaches around State Highway One but is gaining flow downstream of the confluence with Needles Creek. Not all of the gain can be attributed to the flow in Needles Creek, which indicates groundwater inflows.

Although, there are extensive areas of alluvial gravels in the mid reaches (see Section 2.1), the gravel layers are shallow, mostly no more than 10 meters deep. This means that there is no substantial aquifer that could provide sufficient groundwater storage for irrigation purposes. Most groundwater abstractions are near rivers and streams and are therefore mostly fed by surface flows. Groundwater samples taken as part of a GNS study had mean residence times of less than five years.

2.3. Landcover

Before humans settled in New Zealand, the majority of the Flaxbourne catchment was covered in forest which included totara, black beach, mahoe and matai. By the arrival of European settlers, almost all trees had already been destroyed by Polynesian fires and fire continued to be used for vegetation clearance.

Today, only small areas of native vegetation remain in the natural shelter of steep slopes within incised valleys in the upper catchment. These include some very important forest remnants, which contain plant species that have become rare in South Marlborough, such as lowland totara, leafless clematis, lancewood and ongaonga.

The large areas of harakeke/flax that gave the area its name have all but disappeared, together with wetland areas around Lake Elterwater.

Currently, more than 80% of the catchment area is covered in pasture grasses with small areas of cropping. Pastures are grazed by sheep and beef cattle, which usually have unrestricted access to waterways. In the lower reaches, only small sections of the river and its tributaries are shaded by tall riparian vegetation. Where riparian trees are present, they are generally dominated by willows.

Small areas of pasture have been converted to vineyards in the lower parts of the catchment, and it is likely that further conversions will occur in the future.

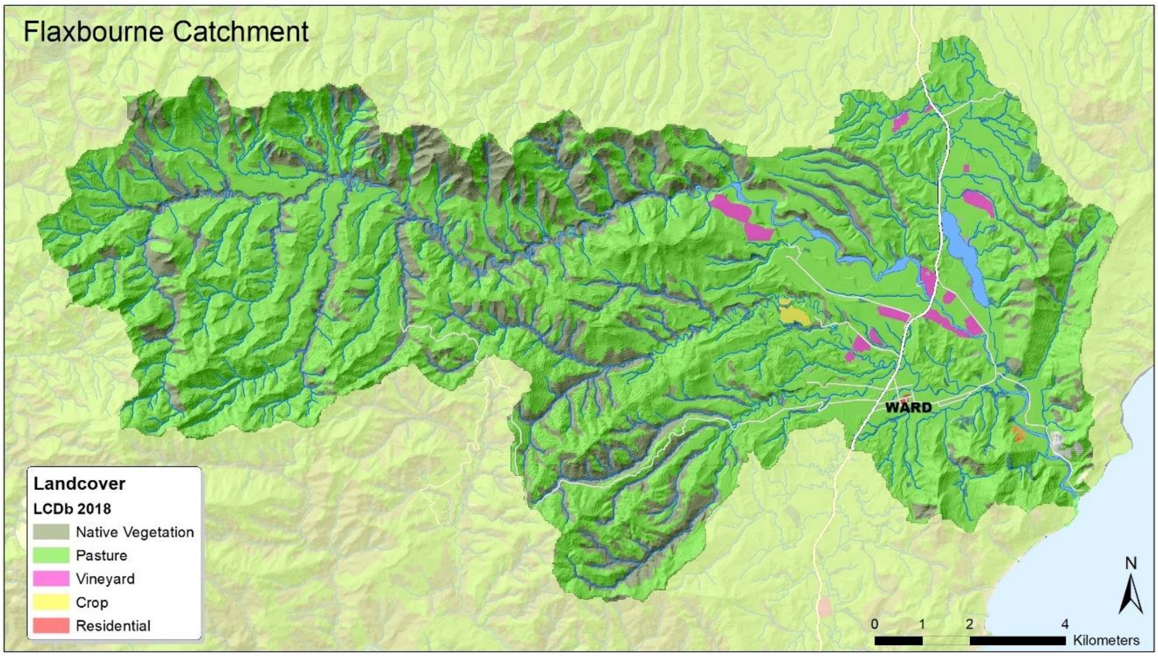

Figure 4: Landcover in the Flaxbourne catchment based on the Land cover database (LCDb) version 5.

3. Water Quality

3.1. State of the Environment Monitoring

Monthly monitoring of the Flaxbourne River as part of the State of the Environment (SoE) programme began in 2007. Monitoring is carried at the bottom of the catchment, approximately 1.5 km upstream of the river mouth.

The results of the SoE monitoring are reported using a Water Quality Index which summarises data from nine parameters over a period of three years. Water quality in the Flaxbourne River has been consistently in the marginal category, which indicates that the health of the river is degraded.

There are a number of parameters that show degraded water quality. One of the most significant is elevated E. coli concentrations. This is confirmed by an E. coli state within the D-band based on the National Policy Statement for Freshwater Management (NPS-FM).

Although E. coli concentrations are generally used as an indicator of the risk to human (and animal) health from contact with the water, high E. coli concentrations are also an indicator for the input of organic material contained within animal droppings. High concentrations of organic material reduce the oxygen available to fish and other aquatic animals as bacteria and fungi use up oxygen to break the material down.

In many other rivers within the Marlborough region, high E. coli concentrations are mostly associated with higher flows when rainfall run-off carries animal droppings into waterways. In the Flaxbourne River, high E. coli concentrations are observed during all flow conditions but are particularly common during lower flows (Figure 5). This indicates that animals entering the waterways are a main source of faecal contamination.

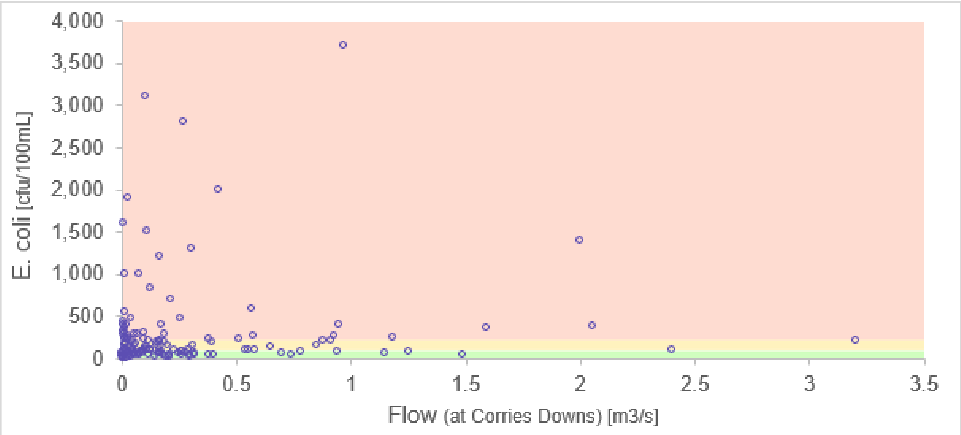

Figure 5: E. coli concentrations in the Flaxbourne River at different flows. The Background shows the NPS-FM bands for E. coli median concentration.

Nutrient concentrations in the Flaxbourne River are relatively low when compared to other pastural catchments. Still, concentrations do exceed guideline levels and NPS-FM limits on a regular basis. Dissolved Reactive Phosphorus (DRP) concentrations are in the B band of the NPS-FM. There are no Dissolved Inorganic Nitrogen (DIN) limits in the current NPS-FM but based on preliminary limits DIN concentrations would also be in the B band.

There is a very weak seasonal pattern for DIN with slightly higher concentrations in winter, while DRP shows no seasonality (Figure 6).

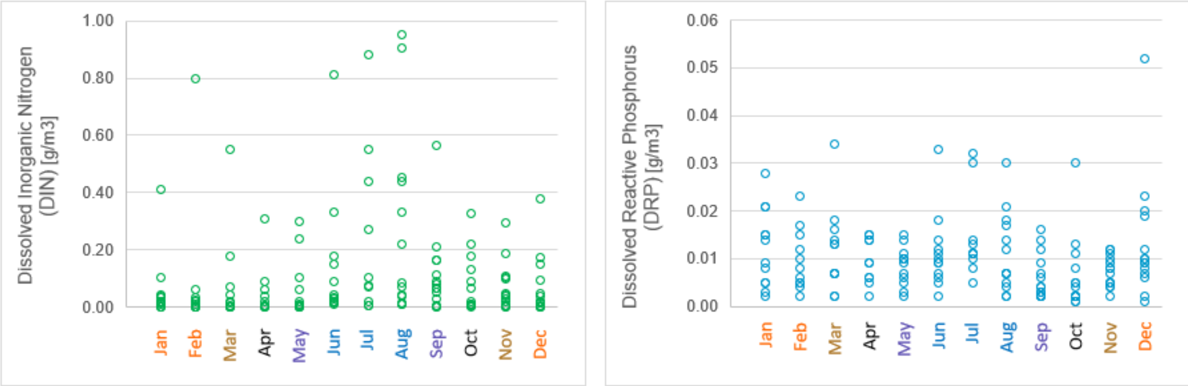

Figure 6: Dissolved nutrient concentrations in the Flaxbourne River in different months.

The purpose of managing DRP and DIN concentrations is to manage the growth of algae on stream beds. High nutrient concentrations cause algae to grow thick mats and dense stands of long filamentous algae. Excess algae growth smothers habitat for aquatic animals and can cause detrimental fluctuations in Dissolved Oxygen levels and pH.

The community of algae and bacteria growing on the stream bed is referred to as Periphyton. Periphyton monitoring is labour intensive and is therefore only carried out at a small selection of the SoE monitoring sites, but it is done on the Flaxbourne River. Of the regional monitoring sites, the Flaxbourne River has the highest amount of Periphyton. It is the only monitoring site with an NPS-FM Periphyton state in the D band and is therefore below the national bottom line for this attribute.

The Flaxbourne river is more susceptible to excessive algae growth due to the dry climate within the catchment. Flood flows are a significant factor controlling periphyton as the algae are scraped off when the stream bed becomes mobilised during higher water velocities. Due to the low frequency of flood flows in the Flaxbourne, algae have longer time to grow and accumulate biomass.

Although some reduction in nutrient concentrations would slow the growth of algae, algae growth is also fuelled by ample sunlight reaching the stream bed. Most of the lower reaches of the Flaxbourne River and its tributaries lack continuous tall vegetation along the riverbanks, which would reduce the amount of sunlight available to algae. Control of periphyton will therefore be best achieved through a combination of nutrient reduction measures and the establishment of riparian vegetation to shade the stream bed.

Figure 7: Filamentous algae growing on the bed of the Flaxbourne River.

The lack of shading by riparian vegetation also results in higher water temperatures. Most New Zealand animals living in rivers and streams prefer cooler temperatures and many sensitive species cannot survive if water temperatures are high.

Another parameter exceeding guideline levels in the Flaxbourne River is turbidity. Turbidity is a measure for the amount of sediment in the water. Measurements are obtained using a sensor that emits light and measures the scattering of that light by particles suspended in the water column. Turbidity measurements are expressed in Nephelometric Turbidity Units (NTU). High turbidity is usually associated with flood flows during which sediment enters rivers and streams as a result of erosion of soil from surrounding land and erosion of stream banks. This is also the case for the Flaxbourne River, in which turbidity usually increases with flow.

However, at times turbidity is also elevated during low flow conditions in the Flaxbourne River. At lower flows sediment in the water is more likely to settle on the stream bed where it can significantly impact the habitat of aquatic animals. The most likely reason for higher turbidity at low flows is animal access to waterways. The animals damage streambanks, moving bank material into the stream as well as remobilising sediment already on the stream bed.

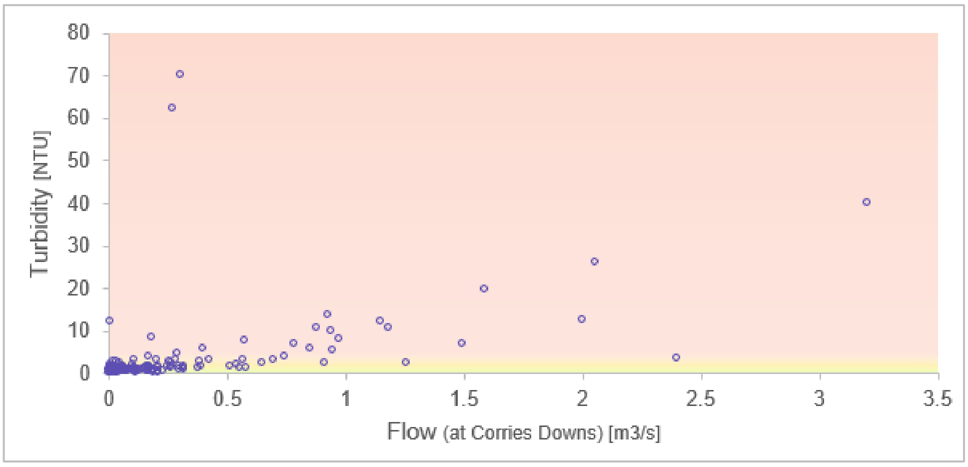

Figure 8: Turbidity in the Flaxbourne River at different flows.

Excessive Periphyton growth, high water temperatures and turbidity as well as organic material from animal droppings ultimately affect the survival of aquatic animals, such as fish. A measure for the health of the aquatic ecosystem is the Macroinvertebrate Community Index (MCI). Macroinvertebrates are small animals living in the water that can be seen with the naked eye. They include aquatic insects, snails and worms and are the food source for fish. Macroinvertebrate samples are taken roughly every year during the summer months. The MCI for the Flaxbourne River is in the D band of the NPS-FM and therefore below the national bottom line. This means that the health of the river is significantly impacted, and council is required to take action to improve river health.

3.2. Catchment Study

This section presents the results of additional water quality monitoring within the Flaxbourne catchment. The majority of the monitoring was carried out in 2020 and 2021, but also included is additional sampling of Lake Elterwater in 2022. The results for the lake and the streams are presented separately as different limits apply to the two distinct types of waterbodies.

3.2.1. Streams and River

Eight additional stream locations were monitored as part of the study, four additional sites on the Flaxbourne River and four sites on tributary streams. All samples were taken during baseflow conditions. Some of the streams, including sites on the Flaxbourne River did not flow during some of the summer sampling rounds. In fact, sampling was somewhat cut short as surface flow in the Flaxbourne River dried up in 2021 for the longest period since monitoring started in 2007. Still, sufficient data was collected in 2019 and 2020 to provide some indication of water quality in the different reaches of the main river and the major tributaries.

Figure 9 shows the E. coli concentrations measured during the catchment study. Also shown are E. coli concentrations measured during baseflow conditions at the SoE site (F2). The SoE site was monitored on different dates, but the results from this site provide a good indication of the range of values usually observed in the Flaxbourne River.

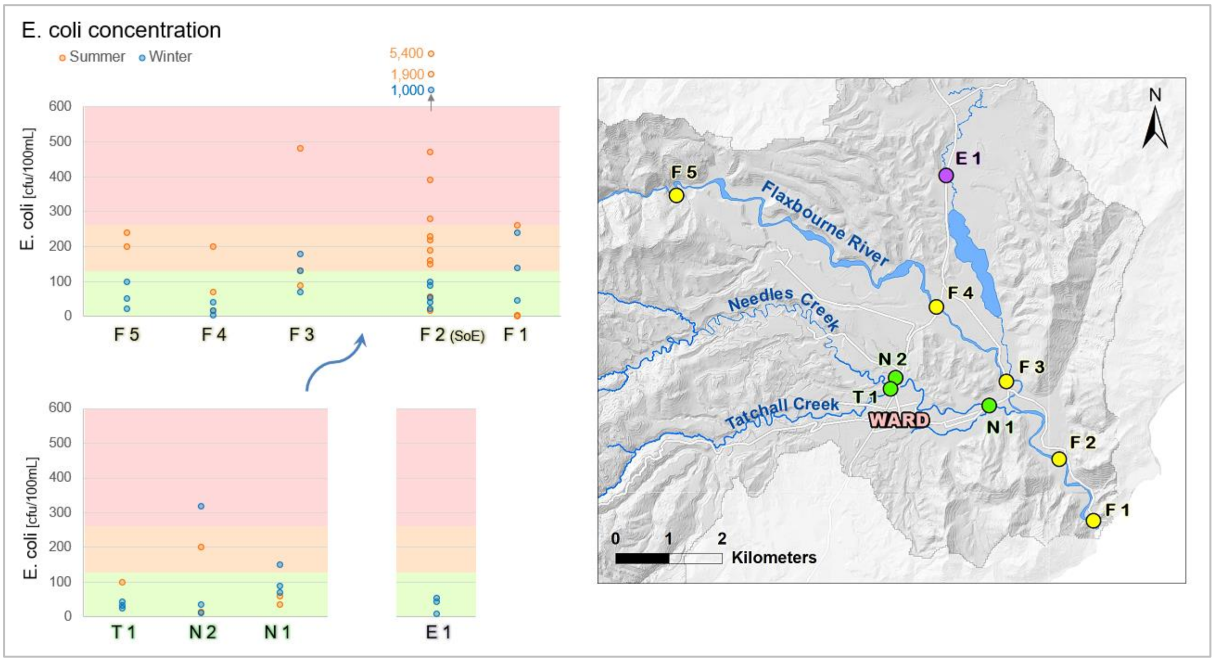

Figure 9: E. coli concentrations in the Flaxbourne River and some of its tributaries at baseflow conditions. The background colour in the graphs is representative of the NPS-FM Band limits for median concentrations (green = A-C Band, orange = D Band, red = E Band).

It can be seen that E. coli concentrations at the SoE site are sometimes significantly higher than at the sites sampled as part of the catchment study. However, this should not be taken as evidence that water quality at the SoE site is generally worse compared to the other sites. Higher E. coli concentrations at the SoE site are usually linked to the presence of livestock at the location samples are taken or somewhat upstream. Livestock was rarely present when samples were taken from the sites sampled as part of the catchment study, but signs that livestock had access to the waterways were visible at all sites sampled (animal droppings, trampling of streambanks, hoofprints etc.). It is therefore likely that E. coli concentrations at all sites occasionally reach levels similar to those observed at the SoE site.

In general, E. coli concentrations were highest in summer. The reason are lower flows and subsequently less dilution of contaminants from animal droppings. Of the study sites, F3 had generally the highest E. coli concentrations, but E. coli levels in Needles Creek were also elevated. Overall, E. coli concentrations were higher in the lower parts of the catchment.

Periphyton, the community of algae and bacteria growing on the stream bed, could not be measured directly as part of the study as the monitoring method is too labour intensive to allow inclusion. Nitrogen and Phosphorus are important drivers of periphyton growth, in particular, the dissolved fraction of these nutrients. Figure 10 shows the Dissolved Inorganic Nitrogen (DIN) concentrations in the streams and river of the Flaxbourne catchment. Due to the dry climate, streams are more susceptible to excess algae growth and DIN concentrations limits are therefore comparatively stringent (background colouring of the graphs).

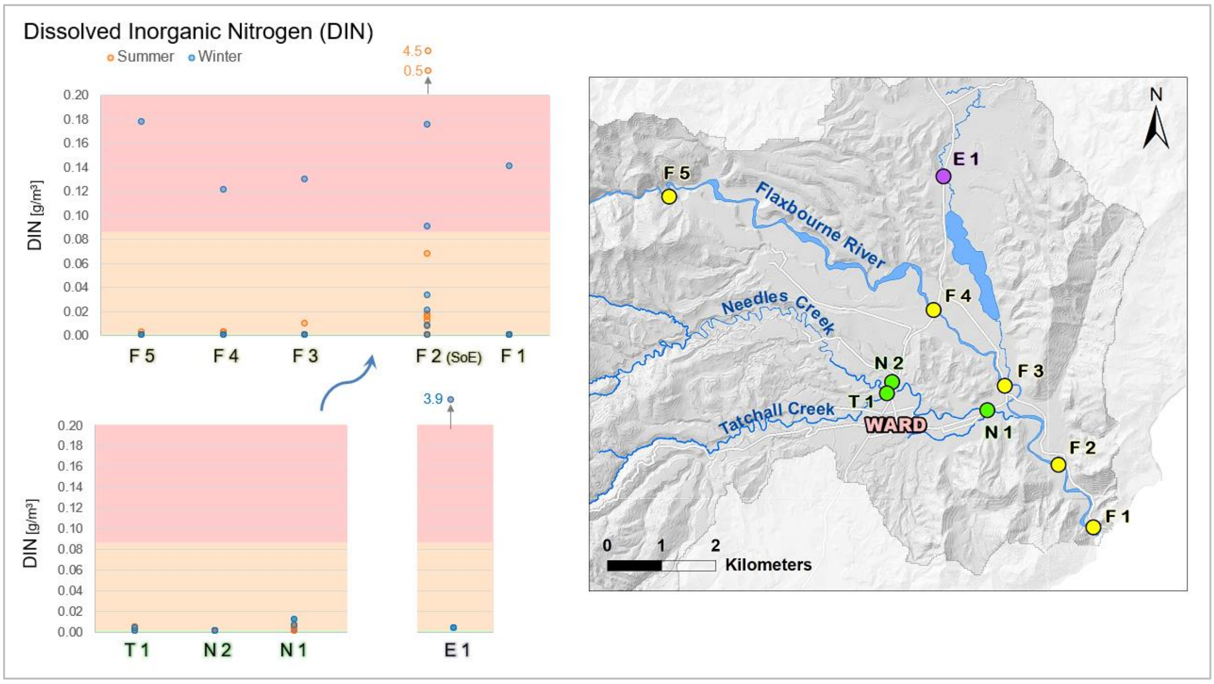

Figure 10: Dissolved Inorganic Nitrogen (DIN) concentrations in the Flaxbourne River and some of its tributaries. The background of the graph is based on default band limits for unshaded streams.

DIN concentrations in samples taken as part of the catchment study were mostly quite low. The highest DIN concentrations were observed during one of the sampling runs in winter. Most notable, DIN concentrations were already high at the most upstream site (F5). Elterwater Stream (E1) had the highest DIN concentration measured as part of the study. The much more frequent monitoring at SoE site shows occasional, very high DIN concentrations also in summer. These were generally associated with direct inputs from animal droppings.

Although, the single high DIN concentrations in winter as part of the study might appear to be a one-off occurrence, the long-term monitoring at the SoE site shows that higher winter DIN concentrations are not particularly uncommon and are affecting algae growth. Some of the highest Periphyton measurements at the SoE site were observed during the colder months.

At very high concentrations, nitrogen has a second, more acute effect on aquatic life. The main form of dissolved nitrogen in the streams of the Flaxbourne catchment is nitrate. Nitrate becomes toxic at high levels and the very high concentration in Elterwater Stream was well above toxicity levels. Again, the occasional high values observed at the SoE site are likely an indication that toxic concentrations of Nitrate are also occurring at other sites.

Figure 11 shows the Dissolved Reactive Phosphorus (DRP) concentrations at the monitoring sites. Similar to DIN, DRP fuels algae growth and the NPS-FM contains limits based on that effect (background colouring of the graphs).

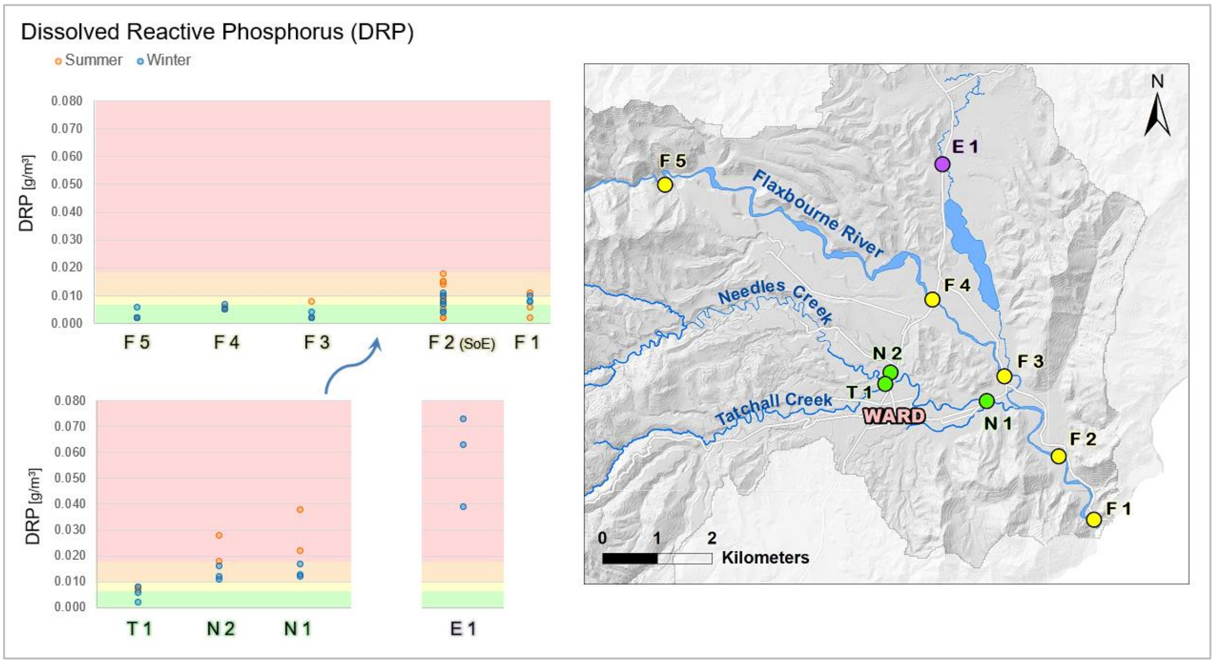

Figure 11: Dissolved Reactive Phosphorus (DRP) concentrations in the Flaxbourne River and some of its tributaries at baseflow. The background of the graph is based on NPS-FM band median concentration limits (green = A-Band, yellow = B-Band, orange = C-Band, red = D-Band).

DRP concentrations are highest in Needles Creek (N2 & N1) and Elterwater Stream (E1). In these tributary streams, DRP concentrations were consistently above the B-Band limit and the higher concentrations in Elterwater Stream were well within the D-Band.

In the Flaxbourne River, DRP concentrations were usually lower. Particularly the two most upstream sites (F5 & F4) had DRP levels consistently within the A-Band. DRP concentrations increased in a downstream direction with the highest levels at the two lower sites (F2 and F1). The higher concentrations at F2 compared to F1 are a result of greater sampling frequency at the SoE site rather than actual differences between the two sites.

Other parameters monitored as part of the catchment study were turbidity and pH. Turbidity was generally low with most values below 1 NTU, meaning that water was very clear. The exception was Elterwater Stream, which was consistently somewhat cloudy with turbidity ranging between 4.4 and 6 NTU.

PH values were consistently in the alkaline range at all sites monitored. Values ranged between 7.5 and 9, with only slightly lower pH values during one sampling run in summer. The high pH is not surprising given the presence of limestone in the underlying geology (see Section 2.1). The dominating influence of the geology is further confirmed with slightly lower pH values within the reaches of the river where river gravels are lying over siltstone that does not contain limestone.

3.2.2. Lake Elterwater

Lake Elterwater is located in the lower catchment, north of the main stem of the Flaxbourne River. It is a shallow coastal lake that has dried out at least 10 times over the past 1000 years, four of which occurred in the last 20 years. In the past, large parts of the dry lake were planted in fodder crop and occasionally grazed, however, this practice is now discontinued

At its fullest, the lake has a maximum depth of 1.8m and an area of 73.5 ha, holding 568,000 m^3 of water. An outlet at the southern end of the lake connects it to the lower Flaxbourne River, however, the lake is very rarely full and the outlet mostly dry. The lake is filled by rainfall and streams from the lake catchment. The largest stream is Elterwater Stream, which collects rainfall from more than half of the 1600 ha of lake catchment before flowing into the lake at the northern end. More than 90 dams within the lake catchment reduce the amount of rainfall run-off available to fill the lake. Most of the dams are small and serve to supply stock water, but three larger irrigation dams also exist.

The lake outlet was artificially lowered in the 1950s decreasing the volume of water the lake can hold. The 2017 Kaikōura earthquake resulted in a tilt of the land, lifting the outlet by 0.24 meters in relation to the northern end of the lake, restoring some of the original lake capacity.

The lake capacity has also decreased due to accumulation of sediment on the lakebed. This is an ongoing process. The lakebed is a mixture of fine clay and silt as well sand and small gravel. In some areas of the lake, the lakebed is quite firm with a greater proportion of sand and gravel, while other areas are covered in a deep layer of fine mud.

It has been estimated that 4mm of sediment accumulates on the lakebed per year. This is more than double the sediment rate that would occur if the lake catchment was still covered in native forest but is less compared to many other lakes within the country. A reason for the comparatively low sedimentation rate, is likely the dry climate and a subsequently small number of heavy rainfall events that cause surface run-off, carrying soil from the surrounding land into the lake. Still, sediment input into the lake needs to be reduced to slow the loss of lake depth, but also to reduce the amount of nutrients that are carried into the lake with the sediment.

Sediment is also introduced from erosion of the lake edge. The low hills around the lake provide little protection from wind. Although there is no wind data available for the lake, it is local knowledge that calm days without wind are rare. The predominantly north-westerly winds cause significant wave action on the lake, which result in comparatively high erosion potential along the lake edges.

As part of the restoration efforts by local landowner, willows have been removed around the lake edge and replaced with plantings of native vegetation. Once established, a thick cover of native vegetation along the lake edge will reduce sediment inputs. However, in the transition phase when new plantings are still young, additional protection of the lake edge from erosion might be needed to prevent plantings from eroding away.

The native plantings will also increase the ecological value of the lake. Lake Elterwater is visited by a large number of waterfowl, as well as shags, crebes and waders. It is a designated wildlife refuge.

Prior to the Flaxbourne catchment study, there was very little information available on the water quality of the lake. Five water quality samples were taken from the lake during the study in 2020/21. Additionally, since the beginning of 2022, the lake has been included in the monthly State of the Environment monitoring programme to provide a much more detailed picture of lake health.

Although, there is yet not sufficient data to assign attribute states as required by the NPS-FM, the information so far paints a rather sombre picture

Both, Total Nitrogen and Total Phosphorus concentrations are consistently above the national bottom-line limits of the NPS-FM. The NPS-FM limits are for median concentrations, which means that exceedance of the limit is allowed fifty percent of the time. However, total nutrient concentrations in Lake Elterwater are consistently two to three times above the NPS-FM limit (Figure 12).

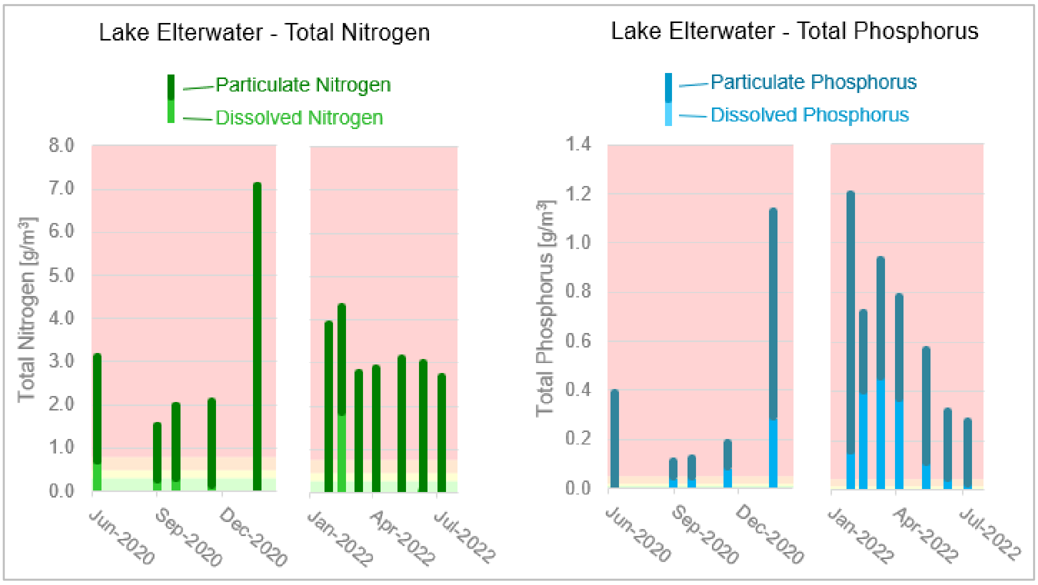

Figure 12: Total Nitrogen and Total Phosphorus concentrations in Lake Elterwater measured during the Catchment Study and as part of the SoE programme. The background colours of the graphs show the NPS-FM bands for median concentrations (green = A-Band, yellow = B-Band, orange = C-Band, red = D-Band). Shown are also the dissolved and particulate fractions of the total concentrations.

Most of the nutrients are bound in particles, which are mainly algae. Often, all of the nitrogen is bound in algae, while in most samples some of the phosphorus remains in dissolved form. The low concentrations of dissolve nitrogen mean that despite the high total concentrations of nitrogen, the toxic forms of dissolved nitrogen, Nitrate and Ammonia, are generally below toxic levels.

However, the high nutrient concentrations do fuel algae growth. As in rivers, excessive algae growth leads to fluctuations in dissolved oxygen and pH that are detrimental to many aquatic animals. Particularly, algae die-off can lead to severe oxygen depletion.

Algae are now sampled on a regular basis as part of the SoE monitoring of Lake Elterwater. Samples are analysed for the concentration of Chlorophyll-a, which is the green pigment used by algae for photosynthesis. It is a good indicator for general algae abundance. Not surprisingly, Chlorphyll-a concentrations in Lake Elterwater are consistently above the NPS-FM limit for the national bottom line (Figure 13).

Excessive algae growth also allows proliferation of potentially toxic algae, which make the lake water dangerous for livestock and humans, but also wildlife. Figure 13 shows the total biovolume of potentially toxic Cyanobacteria (blue-green algae). Fortunately, Cyanobacteria biovolumes have been comparatively low and were within safe levels in all samples taken. In samples with higher Cyanobacteria concentrations, Picocyanobacteria make up the majority of the biovolume. As the name suggests Picocyanobacteria are very small, with diameters of less than one micrometer.

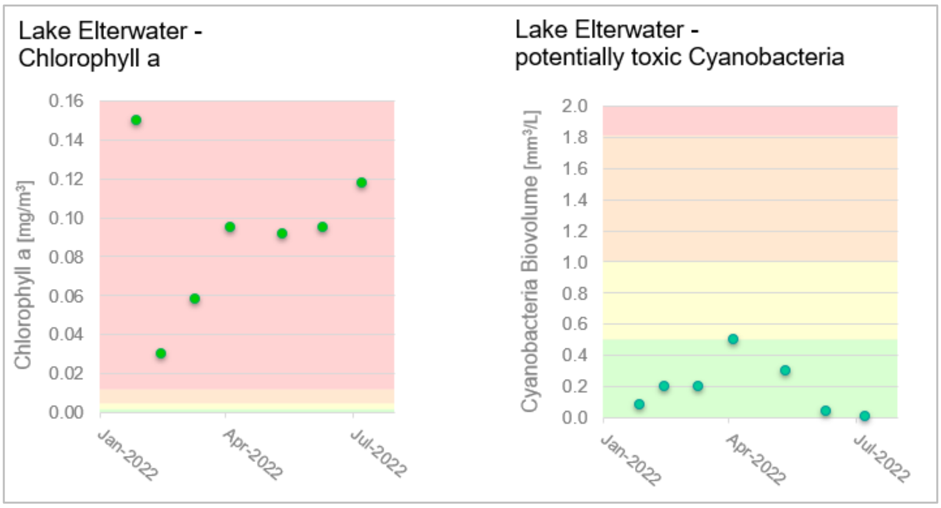

Figure 13: Chlorphyll-a concentrations and Total Biovolume of potentially toxic Cyanobacteria in Lake Elterwater. The background colours in the graphs are based on NPS-FM bands – annual medians for Chlorophyll-a and 80th-percentile for Cyanobacteria Biovolume (green = A-Band, yellow = B-Band, orange = C-Band, red = D-Band).

The high abundance of algae causes the water in the lake to appear very turbid. Additionally, turbidity is increased through disturbance of the lakebed by wave action and bird life. Turbidity in samples taken from the lake range between 13 and 113 NTU.

Another parameter monitored are E. coli concentrations. NPS-FM limits for E. coli concentrations in lakes are the same as those for rivers.

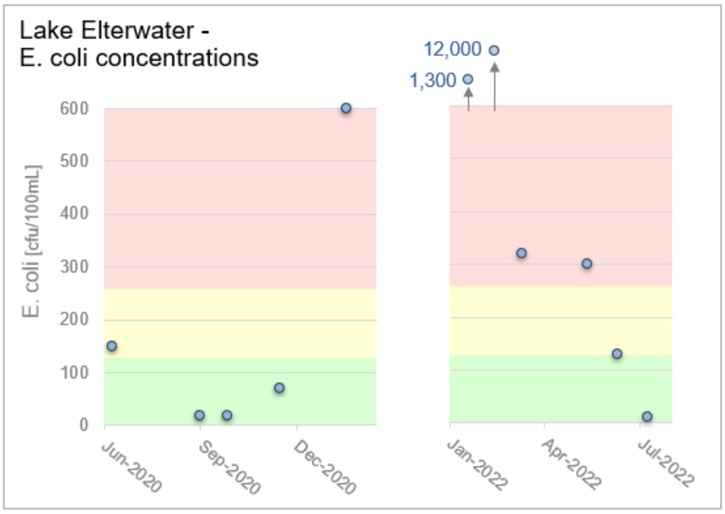

Figure 14: E. coli concentrations in Lake Elterwater. The background colour in the graph represents the NPS-FM Median Bands (green = A-C Band, orange = D Band, red = E Band).

E. coli concentrations in Lake Elterwater are very variable with a range of several orders of magnitude (Figure 14). The highest value of 12,000 cfu/100mL was associated with significant rainfall in the catchment. Surface run-off from the surrounding catchment is therefore a significant source of E. coli in the lake. As E. coli can survive for long periods in turbid water, the effects of the rainfall run-off can impact water quality in the lake for extended periods. Another source of E. coli is the large number of birds on the lake. Overall, E. coli concentrations are likely a function of rainfall events, lake volume (dilution capacity) and the number of birds present on the lake.

4. Summary and Discussion

The Flaxbourne catchment receives comparatively little rainfall and stream flows are subsequently low. The lower flows provide little capacity for dilution. As a result, streams are significantly more sensitive to contaminant inputs than waterways in catchments with higher rainfall.

Most of the catchment has been converted to pasture, which is grazed by sheep and beef cattle. The livestock has mostly unrestricted access to waterways. Very little native vegetation remains.

State of the Environment (SoE) monitoring of the Flaxbourne River has shown river health to be degraded and in need of improvement. Parameters indicative of degraded water quality include E. coli concentrations, Periphyton growth and turbidity.

To better understand the extent and causes of degraded water quality within the catchment, additional reaches of the Flaxbourne River as well as the main tributary streams were monitored at baseflow condition. Although the monitoring period was cut short due to an extended period of loss of stream flows in 2021, the data collected provide sufficient indication of the state of waterways within the catchment.

Dissolved nutrient concentrations were somewhat higher in some of the tributary streams, particularly in Elterwater Stream. Within the Flaxbourne River, water quality was slightly worsening in a downstream direction. Still, overall, water quality was comparable all sites monitored. This means that degraded water quality is not caused in any particular area of the catchment but is instead a catchment-wide issue.

One of the main causes of degraded water quality is livestock access to waterways. Although, livestock was rarely encountered at the additional monitoring sites during sampling, the number of site visits was low, and signs of regular livestock were visible at all of the sites (Figure 15). The more frequent monitoring at the SoE site showed that high nutrient and E. coli concentrations as well as high turbidity during baseflow conditions was predominantly linked to the presence of livestock at the site or upstream when samples were taken.

Figure 15: Examples of signs of livestock access to the additional monitoring sites of the Flaxbourne Study.

Fencing off livestock would therefore significantly contribute to improvements in water quality within the Flaxbourne catchment.

The dry climate of the catchment means that flood events are comparatively uncommon. Flood flows are a significant controlling factor for the growth periphyton on stream beds by removing the algae. In the Flaxbourne catchment, periphyton can grow over longer time periods and reach unhealthy coverage at comparatively low nutrient concentrations. Although, some reduction in nutrient concentrations can be achieved, further control of periphyton growth is required to achieve healthy waterways. A sustainable solution which would provide additional ecological benefits is the planting of tall riparian vegetation consisting of native plants that would have grown in the catchment in the past. Fortunately, remnants of native bush remain in some of the incised valleys in the upper catchment. Shading of the streams by riparian vegetation would also keep water temperature in the streams low, enabling the survival of more sensitive aquatic animals.

Overall, the dry climate and subsequently lower stream flows result in a requirement for more stringent management to achieve and sustain healthy waterways when compared to other catchments within the Marlborough region, however, fencing off livestock and planting native riparian vegetation will be important measures to improve the health of streams within the Flaxbourne catchment. Action is particularly required in the lower parts of the catchment as the incised stream valleys in the upper catchment provide a certain amount of natural protection.

Another important waterbody located within the Flaxbourne catchment is Lake Elterwater, a shallow coastal lake. Monitoring as part to the Catchment Study and later SoE monitoring have shown the lake to be highly degraded. Nutrient concentrations are consistently above NPS-FM limits, fuelling the growth of planktonic algae. During the limited time, the lake has been monitored, most of the algae have been non-toxic, but blooms of toxic cyanobacteria have been observed in the past. The lake is an important wildlife refuge for water birds and toxic cyanobacteria present a risk to these birds as well as to other animals and humans. The monitoring of Lake Elterwater has shown that it is one of the most highly degraded lakes within New Zealand and action is required to improve the health of the lake.

Surrounding landowners have already begun the restoration of the lake by removing willows, fencing off livestock and planting native vegetation around the lake edge. The suggested actions to improve stream health within the Flaxbourne catchment will also reduce contaminant inputs into the lake. Still, further actions will be required to restore the health of Lake Elterwater. Lake restoration can be challenging as not only inputs from the surrounding catchment need to be considered. Internal loads, hydrological characteristics and inputs from wildlife also play a part. Although the lake has an outlet that flows into the Flaxbourne River, this outlet is dry most of the time. This means that the lake effectively acts as a sink for contaminants from the lake catchment.

Expert advice on shallow lake restorations will be required. This should then feed into the development of an action plan for Lake Elterwater.

Figure 16: Lake Elterwater.

Acknowledgements

I especially would like to thank the landowners in the Flaxbourne catchment that have allowed me access to their property, which made this report possible. It will be their support and hard work that will make improvements of stream health in the Flaxbourne possible.

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