Central Plains Water Trust

Annual Sustainability Report 2018-19

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- December 2019

Report prepared by

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List of Abbreviations

CCC	Christchurch City Council
CLG	CPW Community Liaison Group
CWMS	Canterbury Water Management Strategy
CPW	Collective reference to CPWL and CPWT
CPWL	Central Plains Water Limited
CPWT	Central Plains Water Trust
ECan	Environment Canterbury
EMF	CPW Environmental Management Fund
EMS	CPW Environmental Monitoring Strategy
FEP	Farm Environmental Plan
GSWERP	Ground and Surface Water Expert Review Panel
GSWMP	Ground and Surface Water Monitoring Plan
LWRP	Canterbury Land and Water Regional Plan
SDC	Selwyn District Council
TWEMF	Te Waihora Environmental Management Fund
TLI_3	Trophic Level Index
ZIP	CWMS Selwyn Waihora Zone Implementation Plan

Executive Summary

The first stage (Stage 1) of the Central Plains irrigation scheme (the Scheme) commenced operations in 2015, with the final stage (Stage 2) being commissioned in October 2018. The completed scheme supplies water to an area of approximately 47,500 hectares between the Waimakariri and Rakaia rivers.

Stage 1 of the Scheme provides irrigation water to an area of approximately 23,000 hectares between the Rakaia and Selwyn rivers. Stage 1 incorporates a 17km long canal to supply water from the Rakaia River to 130km of underground pipes, which in turn deliver water to 125 farm turnouts. The 4,600 ha Sheffield Scheme is a stand-alone project along the western margin of the Central Plains area that commenced operations in November 2017 utilising water from the Kowhai and Waimakariri Rivers in combination with a large storage pond constructed near Springfield. Stage 2 of the CPW Scheme was commissioned in spring 2018 to provide irrigation water to an area of approximately 20,000 ha between the Selwyn and Waimakariri Rivers.

The 2018-19 irrigation season for Stage 1 and the Sheffield Scheme ran from 1 September 2018 to 29 April 2019. Due to a slight delay commissioning, Stage 2 commenced operations on 2 October 2018, becoming fully operational from the 15 October 2018. During this period, the Scheme supplied 63.6 million m^3 of irrigation water to 132 properties in the Stage 1 area comprising 26.7 million m^3 of water taken directly from the Rakaia River and 36.9 million m^3 of stored water supplied by TrustPower from Lake Coleridge. A total of 50.4 million m^3 of water was supplied to 96 properties in the Stage 2 area, comprising 15.0 million m^3 from the Rakaia River intake and 16.9 million m^3 of stored water. The Sheffield Scheme supplied 8.3 million m^3 of water to 33 properties, comprising 5.0 million m^3 from the Waimakariri River intake and 3.3 million m^3 of stored water.

During the 2018-19 year, direct abstraction from surface water totalled 28 and 12 percent of the volume potentially available under resource consents held by CPW for the Rakaia and Waimakariri Rivers respectively. In combination with the use of stored water, this provided a reliable supply of irrigation water to shareholders, while having no measurable effect on naturally occurring discharge in the Rakaia or Waimakariri Rivers during periods of mid to low flows. Due to the use of Scheme water, groundwater usage by CPW shareholders was less than 17% of the total volume authorised by existing water permits.

The 2018-19 irrigation season was interrupted by a period of above average rainfall and soil moisture during late spring/early summer (Oct to Dec 2018) that significantly reduced irrigation requirements during a period when demand is typically near maximum. Reflecting this reduced mid-season demand, total water use for Stage 1 was the lowest since operations commenced in the 2015-16 season. Water use in the Stage 2 and Sheffield Scheme areas during 2018-19 was also below the anticipated longer-term average.

Water quality monitoring results recorded for the CPW monitoring programme during the 2018-19 year indicate surface water quality, groundwater quality and lake water quality exceeded trigger levels established for the Scheme[1] at a number of monitoring sites located both in Stage 1 and Stage 2 areas, as well as down-gradient of the Scheme. The recorded trigger level exceedances are

[1] These trigger levels are consistent with equivalent environmental limits established in the Canterbury Land and Water Regional Plan

consistent with the historical range and/or background trends observed prior to commencement of CPW operations. No obvious effects on water quality, groundwater levels or surface water flows attributable to operation of the Scheme were observed during the 2018-19 year.

Key Statistics for the CPW 2018-19 Irrigation Season

	Stage 1	Stage 2	Sheffield
Number of Properties Supplied	132	96	33
Irrigated area	22,800 Ha	20,000 Ha	4,600 Ha
Total Volume of Water Delivered	63.6 million m^3	31.9 million m^3	8.3 million m^3
Total Volume of Run-of River Take	26.7 million m^3	31.9 million m^3	5.0 million m^3
Total Volume of Water from Storage	36.9 million m^3	16.9 million m^3	3.3 million m^3
Total Volume of Groundwater Used	16 million m^3	18.5 million m^3	0.7 million m^3
Length of 2017-18 Irrigation Season	241 days	210 days*	241 days
Days with partial or full restriction on river take	110	110	84
Available Surface Water Allocation Taken	28%	28%	12%

* Stage 2 did not operate for the full 2017-18 irrigation season

1. Scheme Background

1.1. History

The Central Plains Water Trust (CPWT) was established jointly in 2003 by Christchurch City Council (CCC) and Selwyn District Council (SDC) to implement the Central Plains Water Enhancement Scheme (the Scheme) which was intended to supply irrigation water to an area of approximately 60,000 hectares between the Waimakariri and Rakaia Rivers.

In July 2012, the CPWT was granted resource consents from Environment Canterbury (ECan) and SDC to take and use water for irrigation purposes, as well as to construct and operate the Scheme. Central Plains Water Limited (CPWL) was subsequently established to implement the Scheme, and CPWT has licensed the use of the consents to CPWL. CPWL is responsible for the construction and operation of the Scheme, and for all consent compliance and reporting. For the purposes of this report, CPWT and CPWL are referred to collectively as CPW.

1.2. Scheme Development

As shown on Figure 1, development of the Scheme was undertaken in three stages.

Stage 1 provides irrigation water to an area of approximately 23,000 hectares between the Rakaia and Selwyn rivers and was completed in September 2015. Stage 1 is supplied from the Rakaia River via a 17km headrace that extends from the river intake as far as Leeches Road. Construction of the Rakaia River intake and distribution network for Stage 1 was undertaken between early 2014 and mid-2015, with the first irrigation water supplied on 1 September 2015.

The Sheffield scheme, covering approximately 4,600 Ha commenced operations in November 2017. This component of the scheme is physically separate from Stages 1 and 2, supplying irrigation water, stockwater, firefighting water and supplementary town supply water for Springfield and Sheffield from the Waimakariri and Kowai Rivers. The Sheffield scheme includes a 2 million m^3 pond constructed near Springfield to provide storage during periods of low flow when run-of-river abstraction is restricted.

Stage 2 supplies an irrigable area of approximately 20,000 hectares between the Selwyn and Waimakariri rivers. Construction of Stage 2 commenced in early 2017, with the scheme becoming operational on 2 October 2018. This component of the Scheme is a fully piped network that is integrated with the Stage 1 reticulation, utilising water from the Rakaia River intake (including Lake Coleridge storage).

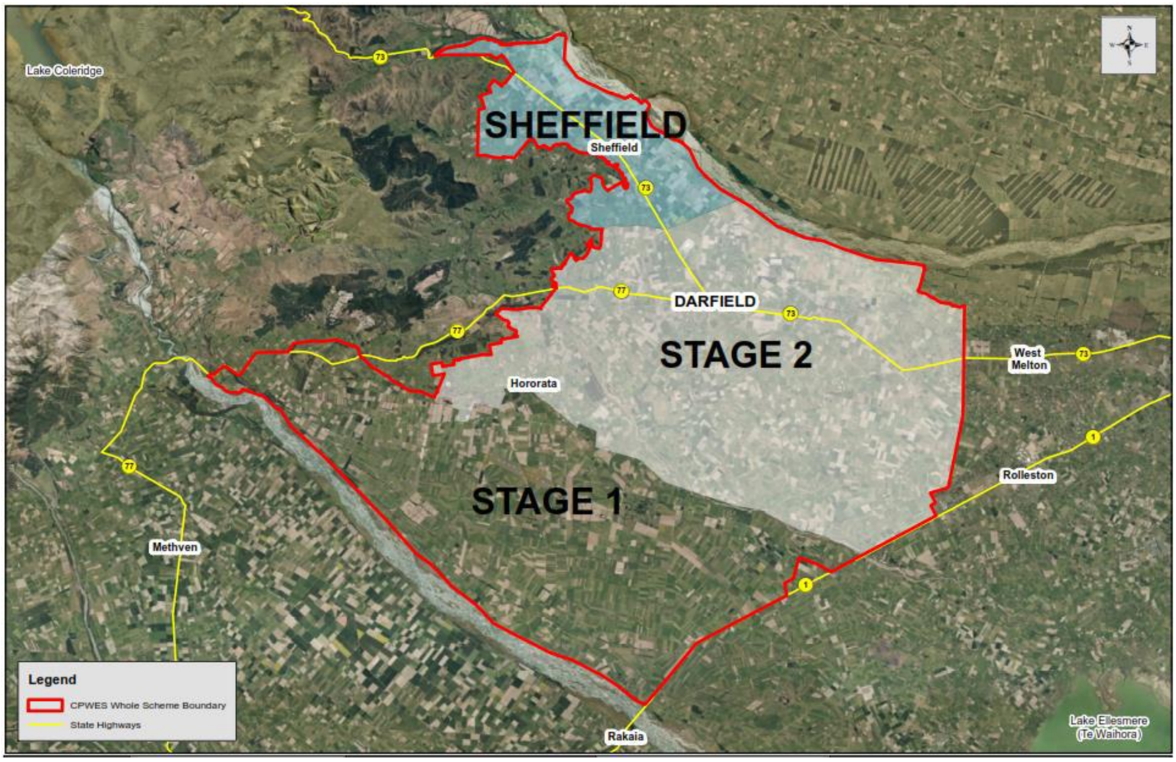

Figure 1. *Layout of the CPW scheme*

1.3. Water Sources

Stage 1 and Stage 2 of the Scheme derive water from the Rakaia River via an intake constructed approximately 8 kilometres downstream of the Rakaia Gorge (SH77) bridge. Conditions of resource consents authorising the taking of water from the river are subject to minimum flow conditions which require the rate of abstraction to progressively reduce as river flows decline.

The Rakaia River Water Conservation Order establishes a minimum flow at Rakaia Gorge which varies depending on the month between 90 cubic metres per second (cumecs) in September and 139 cumecs in December. When flows are below the minimum flow, no water can be taken from the river. When flows are higher than the minimum flow, water can be taken from the river by resource consents assigned to multiple allocation ‘Bands’ which have varying minimum flow restrictions. Water permits assigned to individual Bands can take water on a 1:1 basis above the specified minimum flow (i.e., for every 2 m^3/s of flow above the specified minimum, 1 m^3/s can be taken from the river).

The bulk of allocation held by CPW is assigned to flow Bands which require abstraction to cease when river flow falls to less than 70 cumecs above the WCO minimum flow, resulting in relatively modest supply reliability (i.e., it is cut-off first as river flows decline). Due to constraints imposed by the minimum flow restrictions, the full volume of allocation held by CPW can only be taken for around 63 percent of the time during the irrigation season. In order to ensure an adequate reliability of supply for irrigation, CPW have an agreement with TrustPower Ltd to access water stored in Lake Coleridge. Under this agreement, water is released from Lake Coleridge as river flows decline. This enables CPW to continue to take water from the river without having any adverse effect on natural flows in the river. The use of stored water increases the reliability of supply for Stage 1 and 2 to approximately 98 percent.

The Sheffield Scheme utilises water from the Kowai and Waimakariri Rivers which are subject to similar low flow restrictions to those applying on the Rakaia River. The storage pond constructed for the Sheffield Scheme holds sufficient water to maintain reliability of supply at a similar level to Stages 1 and 2. It is noted that the Waimakariri River intake is only constructed to accommodate a flow of 2 m^3/sec which is equivalent to 8% of the allocation held by CPW. As a result, the maximum rate of take possible under the current Scheme configuration is significantly lower than that authorised by existing resource consents.

Table 1 below provides a summary of the average utilisation of water available to CPW under existing resource consents via the Rakaia River and Waimakariri River intakes since the Scheme commenced operation. The figures show CPW consents represent a small proportion of the total volume of water available for consumptive use from both rivers, and that average usage by the CPW Scheme is only a small proportion (<25%) of the volume authorised by current resource consents.

Table 1. Average w*ater availability and utilisation of CPW consents, 2015-2019.*

Intake	Volume of water available in river (m^3)	Volume of water available under CPW consents (m^3)	% of water available to CPW under consents	Actual volume taken by CPW (m^3)	% of consented volume taken by CPW
Rakaia River (2015-19)	6,053,210,076	394,019,571	6.5%	85,281,339	22%
Waimakariri River (2017-19)	3,713,100,394	51,672,224	1.4%	6,839,925	14%

1.4. Regulatory Environment

The Canterbury Land and Water Regional Plan (LWRP) establishes objectives, policies and rules relating to the management of land and water resources across the Canterbury region. The plan divides the region into ten geographic zones and establishes a set of objectives, policies and rules which apply uniformly across the entire region. In addition, each Zone has a set of specific policies, rules and limits which address localised or sub-regional resource management issues particular to that Zone, which either over-ride or add to the region-wide rules.

The specific management provisions for each Zone are developed and overseen by a Zone Committee comprising a range of community representatives. The Zone Committee is responsible for developing strategies, targets and activities outlined in a Zone Implementation Plan (ZIP) that outlines recommendations for short and long-term water management in each Zone.

The Scheme is located in the Selwyn Waihora Zone and forms an integral part of measures outlined in the ZIP (also referred to as the “Solutions Package”) for delivering the Canterbury Water Management Strategy (CWMS) outcomes adopted by the Selwyn Waihora Zone Committee in October 2013. These measures anticipate that the Scheme will provide additional recharge to the catchment from alpine water, a reduction in the volume of groundwater used for irrigation and provide opportunities for targeted stream augmentation. This is expected to result in increased volumes of water in aquifers and flows in lowland streams, as well as dilution of nitrogen concentrations in Lake Ellesmere/Te Waihora, thereby improving water quality and quantity across the wider Zone.

Recommendations in the Selwyn Waihora Solutions Package were formally adopted by ECan via Plan Change 1 to the Canterbury Land and Water Regional Plan (LWRP) in February 2016. Updated provisions for the Selwyn Waihora zone in the LWRP include:

- Prohibiting new groundwater takes in over-allocated water management zones and reducing the total volume of water allocated within the Zone;
- Revised surface water allocation limits to deliver ecological and cultural flows, particularly in lowland streams;
- Introduction of a fixed allocation or "cap" on nitrogen losses in the catchment (including the Scheme). Progressive reductions in cumulative nitrogen losses are required over time;
- A requirement for all farming properties to prepare a farm environment plan (FEP) and implement a range of good management practices. This includes specific requirements for individual landholdings to reduce nitrogen leaching losses by specific amounts (depending on land use type) by 2022;
- A reduction in legacy phosphorus in Lake Ellesmere/Te Waihora by 50 percent and improved management of lake-level and opening.

The Selwyn-Waihora provisions of the LWRP make specific provision for nitrogen losses from the Scheme. These provisions set a threshold for cumulative losses from the land irrigated from the Scheme which enables conversion of some existing dryland farms to irrigation, while requiring land uses within the scheme to implement good management practice to achieve the overall reduction in nitrogen losses required by 2022.

2. 2018/19 Annual Summary

2.1. Climate

During the 2018-19 year, cumulative rainfall totals were above the long-term average across the Central Plains area. As illustrated on Figure 2, a total of 891 mm of rainfall was recorded at NIWA weather station 4702 (located approximately 4km west of Hororata) between July 2018 and June 2019, 65 mm (8%) above the long-term average of 826 mm. The figure also illustrates cyclical variations in medium-term (5-year moving average) rainfall, with extended periods of above and below-average rainfall observed in the historical record. Since 2000, medium-term average rainfall totals at Hororata have remained close to, or slightly above, the medium-term average.

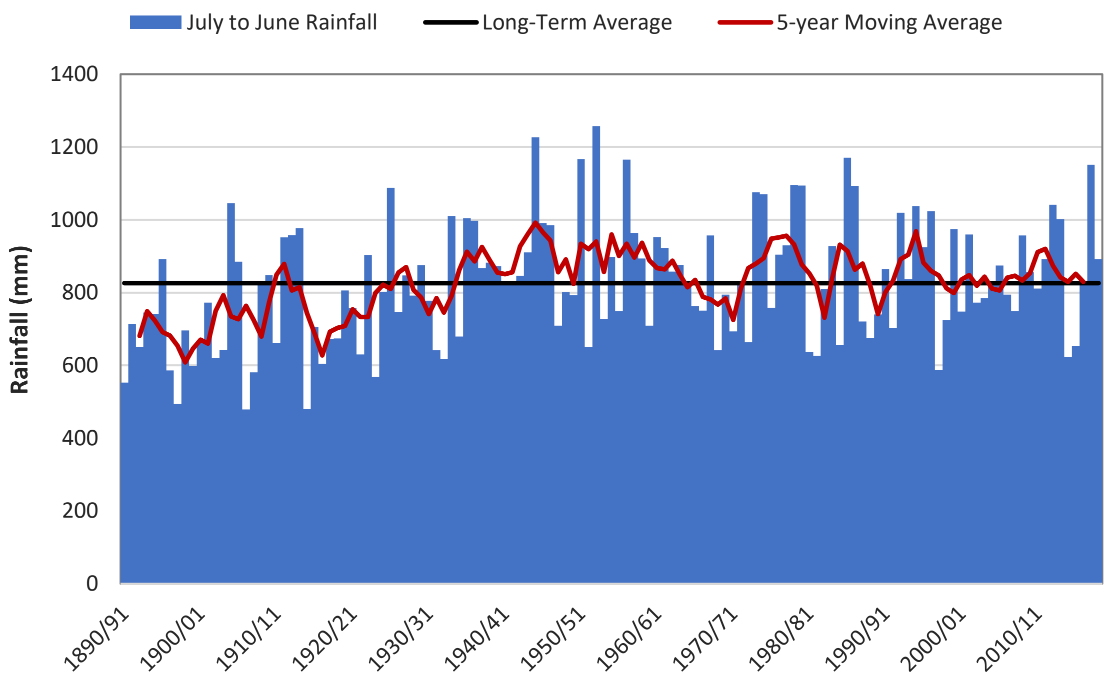

Figure 2. *Historical July to June rainfall at Hororata (4702), 1890-91 to 2018-19 (Data from NIWA CliFlo database)*

As shown on Figure 3 below, monthly rainfall totals exhibited a cyclical pattern during the 2018-19 year. Rainfall totals were consistently below average across the Central Plains area during winter and early spring (July to September) 2018, above average during late spring/early summer (October to December) before returning to below average during summer and early autumn (Jan to March) 2019. Rainfall was variable both spatially and temporally across the Central Plains for the remainder of the 2018-19 year.

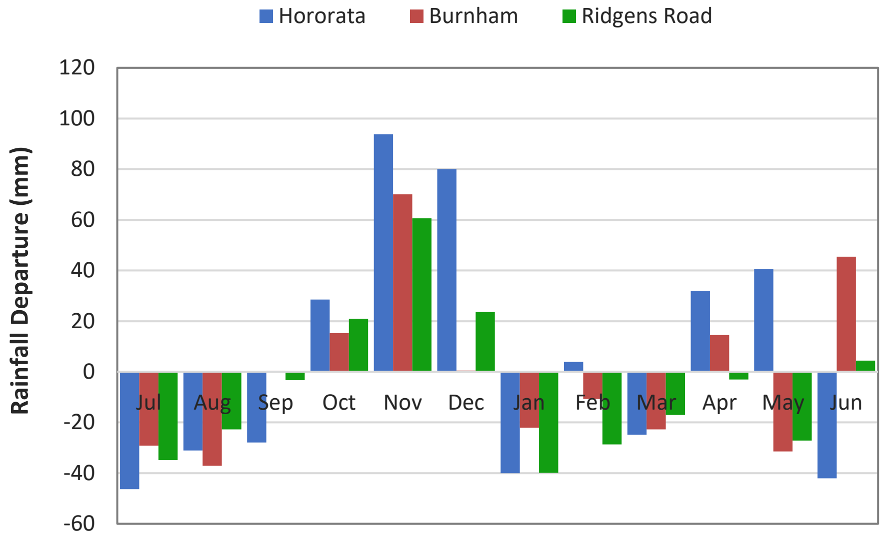

Figure 3. *Departure from average monthly rainfall at Hororata, Burnham and Rigdens Road 1during the 2018-19 year (Data from NIWA CliFlo database and Environment Canterbury).*

Temporal variation in rainfall during the 2018-19 year is reflected in the accumulated soil moisture deficit. As shown on Figure 4, soil moisture deficit was close to average across the Central Plains area from July to October 2018, decreasing significantly from November to January before returning to near average for the remainder of the year. Interestingly, temporal variation in soil moisture during 2018-19 was almost the inverse of that recorded during 2017-18 season when soil moisture generally remained well above average, except during the early summer period. Differences in the timing of soil moisture deficit between individual irrigation seasons significantly influence overall water demand in the CPW Scheme.

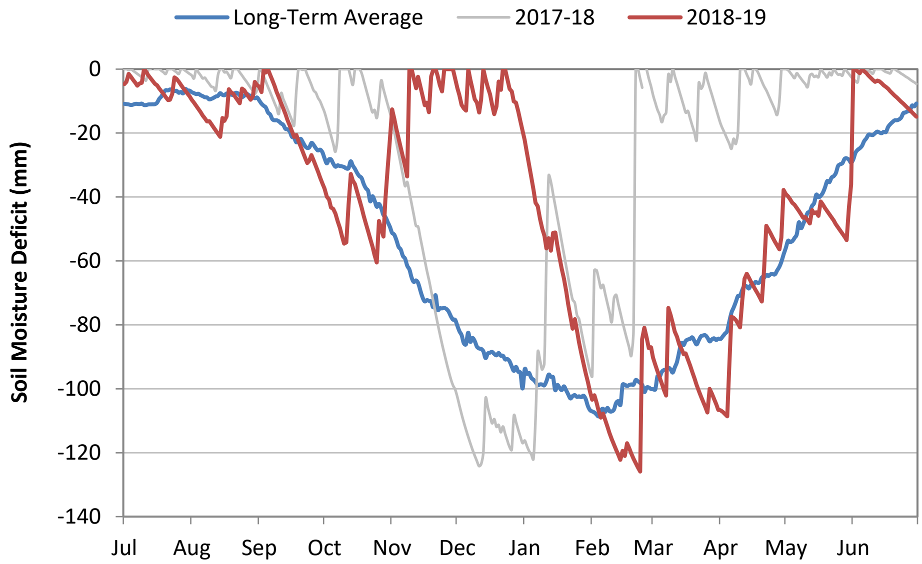

Figure 4. *Soil moisture deficit at Hororata during 2017-18 and 2018-19, compared to the long-term average (Data from NIWA CliFlo database, Station No. 4702)*

While requirements for irrigation reflect short-term variation in rainfall, the overall quantity of groundwater and surface water resources in the Central Plains area generally reflect longer-term trends in climate. As illustrated on Figure 5, cumulative rainfall during the 2018-19 year was below normal for the early part of the season (July to November) before returning to around normal for the remainder of the year. In contrast, cumulative rainfall was consistently above average during the entire 2017-18 season and below average for much the two preceding seasons (2015-16 and 2016-17).

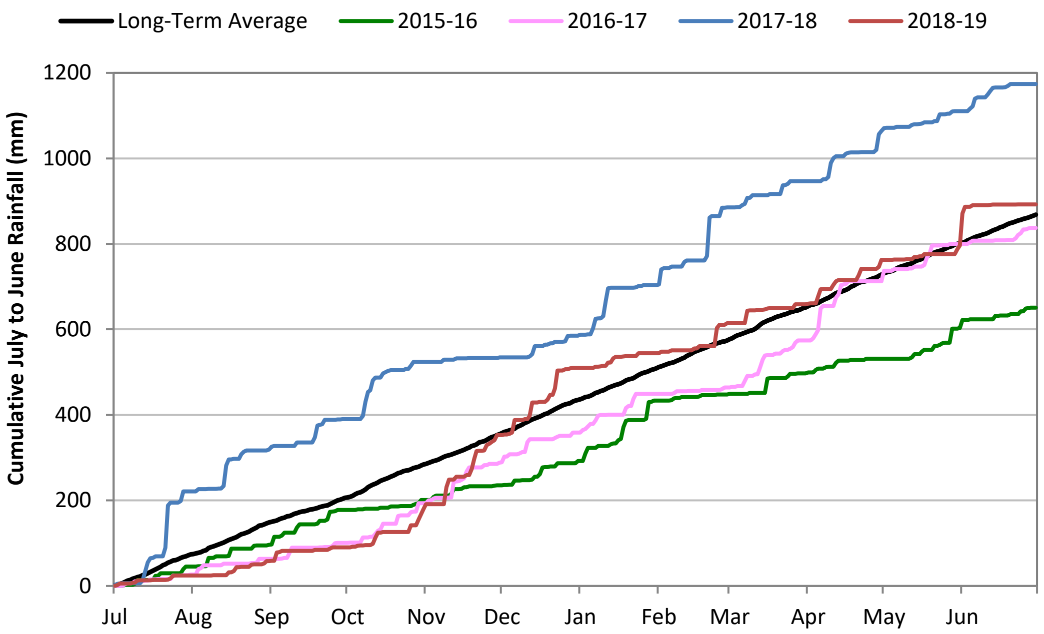

Figure 5. *Cumulative (July to June) rainfall at Hororata, 2015-16 to 2018-19*

Both short and medium-term variations in rainfall departure from average were reflected in groundwater levels and stream flows across the wider Central Plains area during the 2018-19 year. While surface water flows are generally influenced by individual rainfall events over the short-term, variations in groundwater levels and discharge in lowland streams are more strongly influenced by seasonal to inter-annual variations in rainfall.

Figure 6 shows a plot of representative groundwater levels in ECan long-term monitoring wells located in the Central Plains area. All sites exhibited groundwater levels well above the long-term average during 2018-19, following a substantial increase in response to significantly above average rainfall during the 2017-18 year. This multi-year recovery follows an extended period of high groundwater utilisation (prior to commencement of CPW operations) and below normal rainfall from 2013-14 to 2015-16, when groundwater levels at many sites were at, or near, historical minimums.

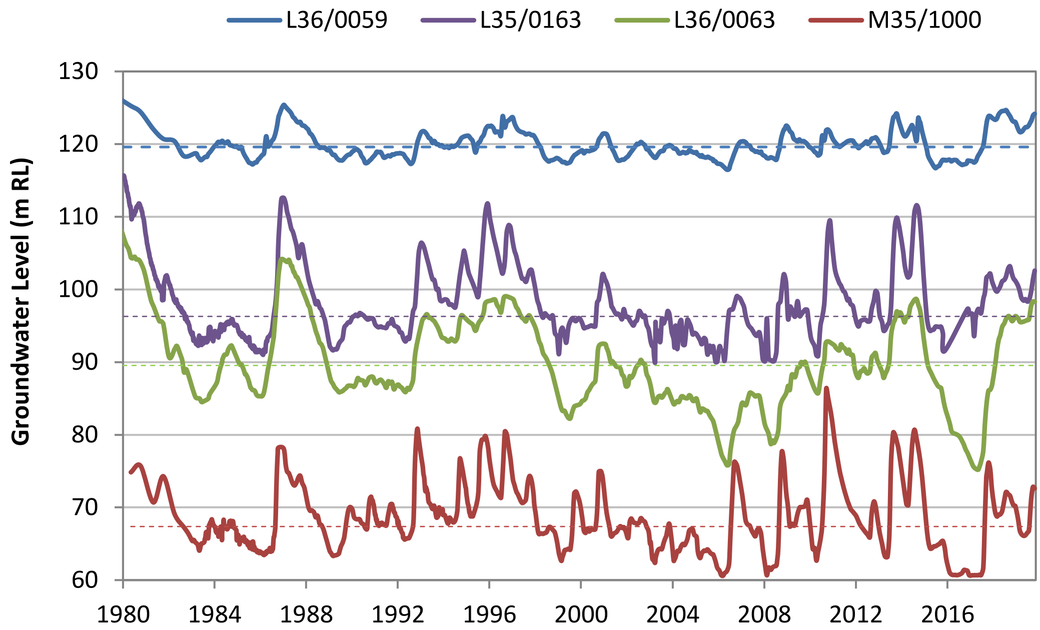

Figure 6. Groundwater levels recorded in L36/0059 (Hororata), L35/0163 (Kirwee), L36/0063 (Greendale) and M35/1000 (West Melton) from 1980 to 2019 (Data from Environment Canterbury). Dotted lines indicate long-term mean groundwater levels at each site.

Flows in rivers and streams draining the Central Plains area are influenced by both rainfall and groundwater levels (particularly during periods of limited rainfall). Figure 7 compares flow in the Selwyn River at Coes Ford during the 2018-19 year with the long-term average for this site. The figure shows flows during winter and spring 2018 were well below the long-term average, increasing to significantly above average during late spring/summer (November to January) reflecting significant rainfall during this period. River flows then declined to generally average to below average for the remainder of the year.

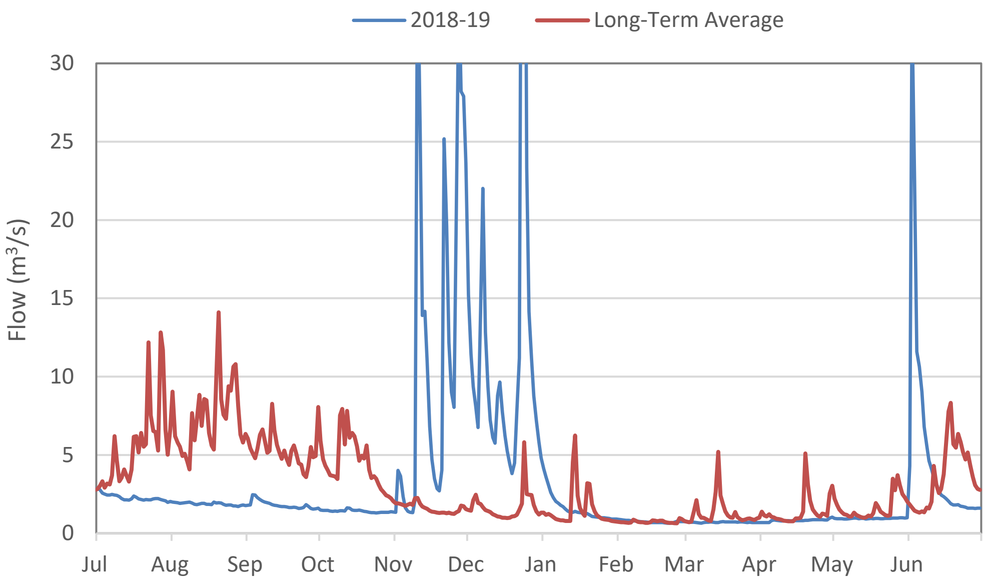

Figure 7. *Mean daily flow in the Selwyn River at Coes Ford during 2018-19 compared to the long-term average. Note: scale only shows flows below 30 m³/s. (Data from Environment Canterbury)*

Large recharge or high flow events following heavy rainfall can have a significant short-term influence on groundwater and surface water quality. Groundwater quality may also be influenced by inter-annual rainfall variability where extended periods of above average rainfall following similar periods of below average rainfall and can act to flush contaminants accumulated in the soil and unsaturated zone into underlying groundwater. Such short to medium-term climate variability can act to obscure underlying water quality trends.

Overall, the 2018-19 irrigation season can be characterised as being average to slightly dry for much of the year except for a period of above average rainfall from mid-October to December.

2.2. Construction Activities

Construction activities for Stage 2, the third and final stage of the CPW Scheme were completed during the 2017-18 year, with Stage 2 commencing operations on 2 October 2018.

2.3. Scheme Operation

Between 1 September 2018 and 29 April 2019, a total of 63.6 million m^3 of water was supplied by the CPW scheme to 105 properties in the Stage 1 area. A further 31.9 million m^3 of water was supplied via the Rakaia River intake to 96 properties in the Stage 2 area between 2 October and 29 April 2019. Of the combined volume of 95.5 million m^3 supplied to Stages 1 and 2, 41.7 million m^3 comprised run-of-river abstraction from the Rakaia River, with an additional 53.8 million m^3 (representing 56% of the total volume supplied) of stored water sourced from Lake Coleridge.

A total volume of 8.3 million m^3 was supplied to 33 properties in the Sheffield Scheme area during 2018-19, comprising 5 million m^3 of run-of-river abstraction from the Waimakariri River and 3.3 million m^3 from pond storage.

CPW scheme shareholders also utilised a total of 16 million m³ of groundwater (16% of available allocation) in the Stage 1 area, 18.5 million m³ (18% of available allocation) and 0.7 million m³ of groundwater (11% of the available allocation) in the Sheffield Scheme area during 2018-19.

Figure 8 provides a summary of water use across the CPW Scheme during the 2018-19 season.

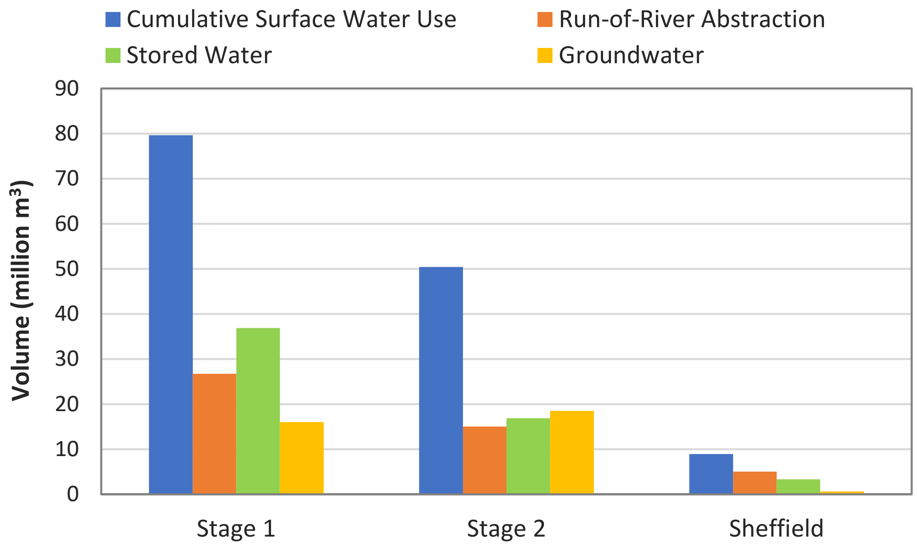

Figure 8. *Water use in the CPW Scheme, 2018-19*

Figure 9 provides a breakdown of seasonal water use for Stage 1 since operations commenced in 2015-16. The figure shows total water use in 2018-19 was the lowest recorded (slightly lower than 2016-17), while use of stored water was the highest (46% of the total volume in 2018-19 compared to 17% in 2016-17). Both run-of-river abstraction and groundwater use in 2018-19 were the lowest recorded.

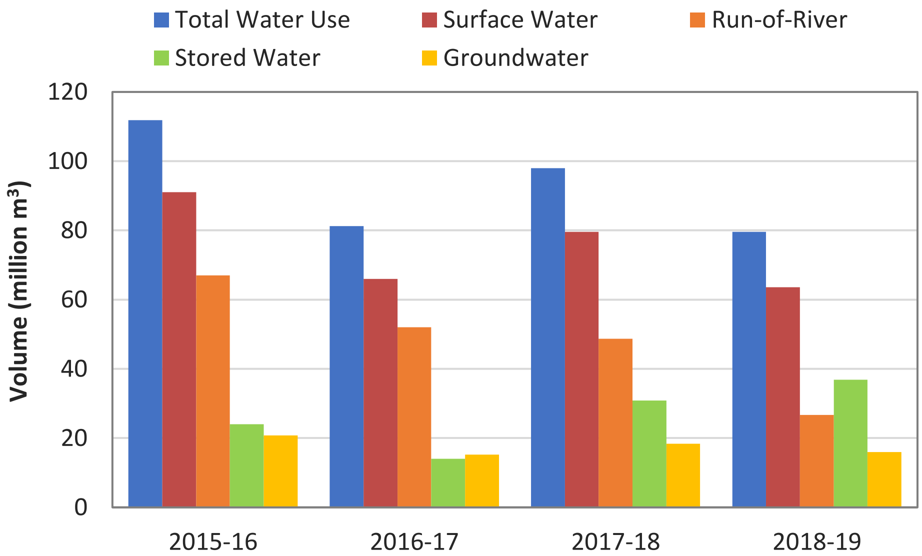

Figure 9. *Water use in CPW Stage 1, 2015-16 to 2018-19*

Figure 10 shows a plot illustrating the combined operation of Stages 1 and 2 of the CPW scheme during the 2018-19 year. The figure shows irrigation demand (blue line) was relatively modest (generally <5 m^3/s) from mid-September through to mid-November 2018. Demand then dropped-off significantly due to above average rainfall and soil moisture levels from mid-November to late December, before increasing to just over 15 m^3/s as soil moisture levels declined in early January. Scheme flows then remained relatively constant through to late February before gradually declining through late summer/early autumn to reach near zero in early April. The figure shows irrigation was supplied by run-of river abstraction from the Rakaia River except for sustained periods of low flows from October to early November 2018 and February to early March 2019 necessitating use of stored water from Lake Coleridge to meet scheme demand (denoted by red bars).

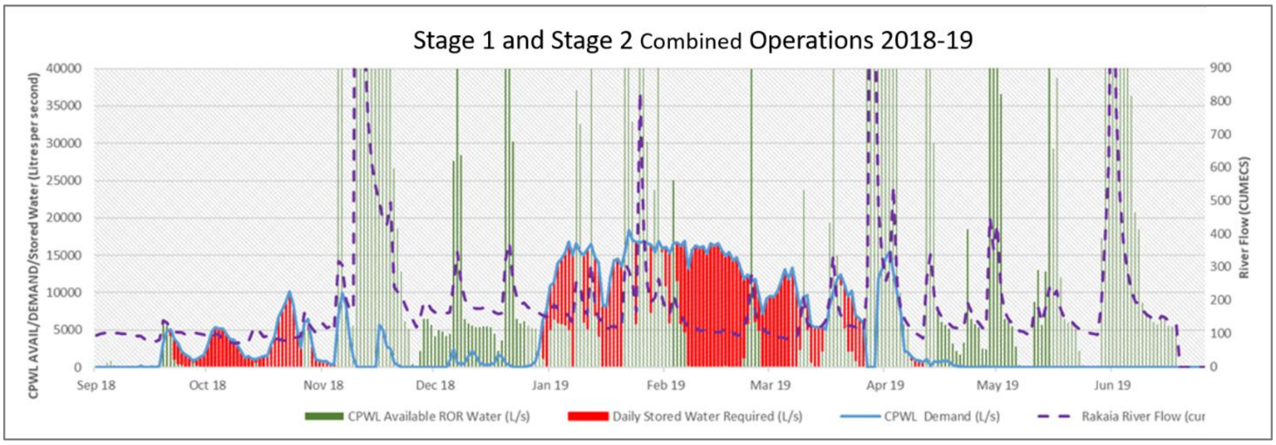

Figure 10. *Schematic illustration of Stage 1 and 2 operations during the 2018-19 year.*

Figure 11 illustrates operation of the Sheffield Scheme during the 2018-19 season. The figure shows brief spikes in demand during October 2018 were supplied from run-of-river abstraction. Following above average rainfall in November and December 2018 when little irrigation took place, demand increased sharply in early January 2019 and continued through to early April. Due to declining river flows storage was utilised to supply a significant proportion of Scheme water requirements from February through to April 2019, with pond storage declining to under 40% in early April.

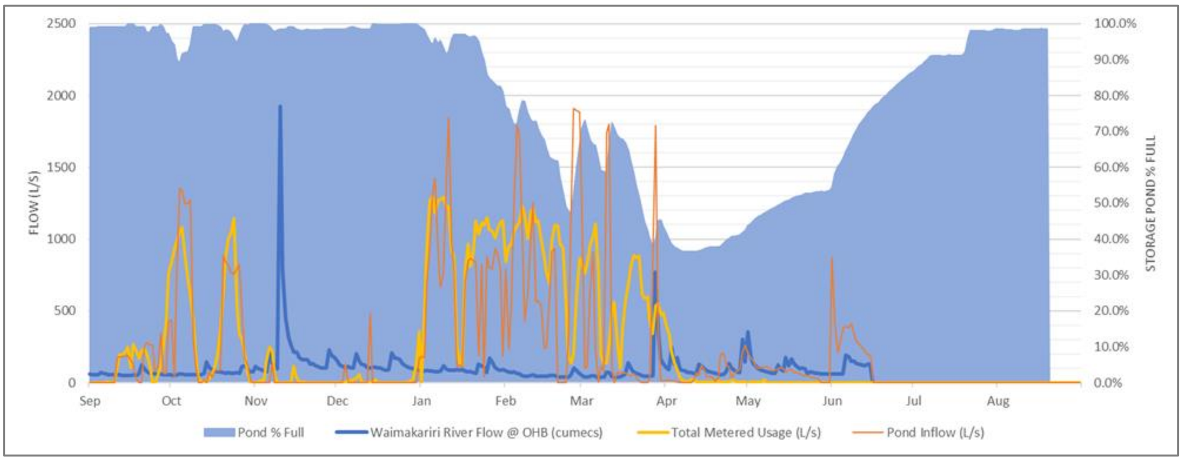

Figure 11. *Schematic illustration of Sheffield Scheme operations during the 2017-18 year.*

2.4. Positive Benefits

Development of the CPW Scheme was forecast to provide a range of economic and social benefits to the wider community. Limited data has been collated to accurately quantify these effects as operation of the full scheme has only recently commenced. Specific positive benefits resulting from Scheme that have been identified to date include:

- Growth in rural communities, school roles;
- Increased business activity and new businesses directly resulting from Scheme operations;
- Approximately 1,000 direct and indirect jobs in the wider Christchurch region as a result of the Scheme;
- Conversion of unsustainable groundwater use to surface water use – to date CPW Shareholders have reduced their usage of groundwater by 66% across the scheme
- A $592M pa increase in agricultural output;
- Provision of supplementary/backup water supplies for the Springfield and Sheffield communities;
- Construction of 20 turnouts (connections to the scheme) to provide contingency for rural fire fighting (8 in Stage 1, 7 in Stage 2 and 5 in the Sheffield Scheme area)

The CPW Scheme has also provided a range of other positive benefits including:

- Long-term security of water supply for Shareholders (given current resource consents expire in 2047);
- Reliable irrigation which has supported cultivation of alternative, high value crops such as chrysanthemum, hemp, sunflower etc;
- Increases in primary production that support ongoing operations and expansion of large food processing plants (e.g., dairy, vegetable, protein) in the surrounding area;
- Long-term environmental funding to ecological projects and programmes in the Selwyn/Waihora catchment;
- Scheme environmental management requirements advantageously positions Shareholders for potential regulatory changes such as the Action for Healthy Waterways policy package.

3. On-Farm Monitoring

Conditions of the CPW consents and provisions of the LWRP require both CPW and individual Shareholder farmers to undertake an extensive range of environmental monitoring, management and reporting activities.

3.1. Environmental Management Strategy

Prior to commencement of operations, CPW developed an Environmental Management Strategy (EMS) which established a range of protocols, policies and procedures for operation and management of the Scheme to ensure it achieves high environmental standards, sustainable outcomes and complies with all consent and Regional Plan requirements.

The EMS outlines specific responsibilities for operation of the Scheme including:

- Ensuring that all water users implement on-farm environmental management requirements related to achieving sustainable irrigation;
- Monitoring and reporting of environmental performance;
- Provision of education and training initiatives; and
- Funding and management of environmental initiatives, including those required by resource consent conditions, such as Community Liaison Group (CLG), the CPW Environmental Management Fund (EMF) and CPW Te Waihora Environmental Management Fund (TWEMF)

To facilitate adoption of best practice land management, the EMS requires a Farm Environment Plan (FEP) to be developed and implemented on each CPW shareholder property supplied with water. Following Plan Change 1 to the LWRP in February 2016, the requirement for FEPs was formally extended to include a majority of agricultural properties larger than 10 Ha where nitrogen loss exceeds 15 kg/ha/year in the Selwyn Waihora zone.

Key components of FEPs include:

- Identification of environmental risks and potential adverse impacts associated with farming activities;
- Development and implementation of measures to avoid or minimise identified environmental risks and implement good management practice farming methods;
- Development and implementation of monitoring to inform good decision making on-farm; and
- Calculation and recording of nutrient loss rates and documentation of management practices to maintain, and where required, reduce, losses over time.

All FEPs are audited by a qualified Farm Environment Plan Auditor to provide an independent check that appropriate systems and practices are in place to minimise environmental risks associated with agricultural land use within the Scheme. Auditing is conducted on-farm and is based on sighting of evidence to document and support how FEP objectives and targets are being met. FEP audit results are reported to CPW, individual water users, and to ECan. After the first two years, audits are conducted based on the last grade received. A property receiving an A-grade is audited every three years, a B-grade every 2 years, a C-grade within one year and D-grade within 6 months of the previous audit.

3.2. Irrigated Area and Types

Use of water under the Scheme is limited by resource consent conditions to a designated area of approximately 60,000 hectares, within a command area of 100,000 hectares.

The total land area managed under CPW in Stage 1 during 2018-19 totalled 33,288 Ha (including Farm Enterprise properties), of which 22,765 Ha was irrigated using water supplied by CPW. Stage 2 properties cover at cumulative area of approximately 32,000 Ha (including Farm Enterprise properties), approximately 20,000 Ha of which was irrigated with CPW water. The total land area managed under CPW in Sheffield Scheme area during 2018-19 totalled just under 7,500 Ha (including Farm Enterprise properties), of which around 4,700 Ha was irrigated using water supplied by CPW.

The distribution of irrigation system types within the Stage 1 area is shown on Figure 12. The figure shows a majority of land is irrigated using either centre pivot irrigators (74 percent of total irrigated area) or travelling irrigators (21 percent of total irrigated area). It is noted a majority of travelling irrigators are used on properties which were irrigated prior to CPW, while new irrigation development predominantly utilises centre pivot irrigators.

Figure 12. *Irrigated area and irrigation types for CPW Stage 1, 2018-19*

Figure 13 shows the irrigated area and distribution of irrigation types within the Stage 2 area. A majority of the area (65%) is irrigated using centre pivot irrigators, with a further 15% using travelling irrigators and the remaining 20% fixed systems.

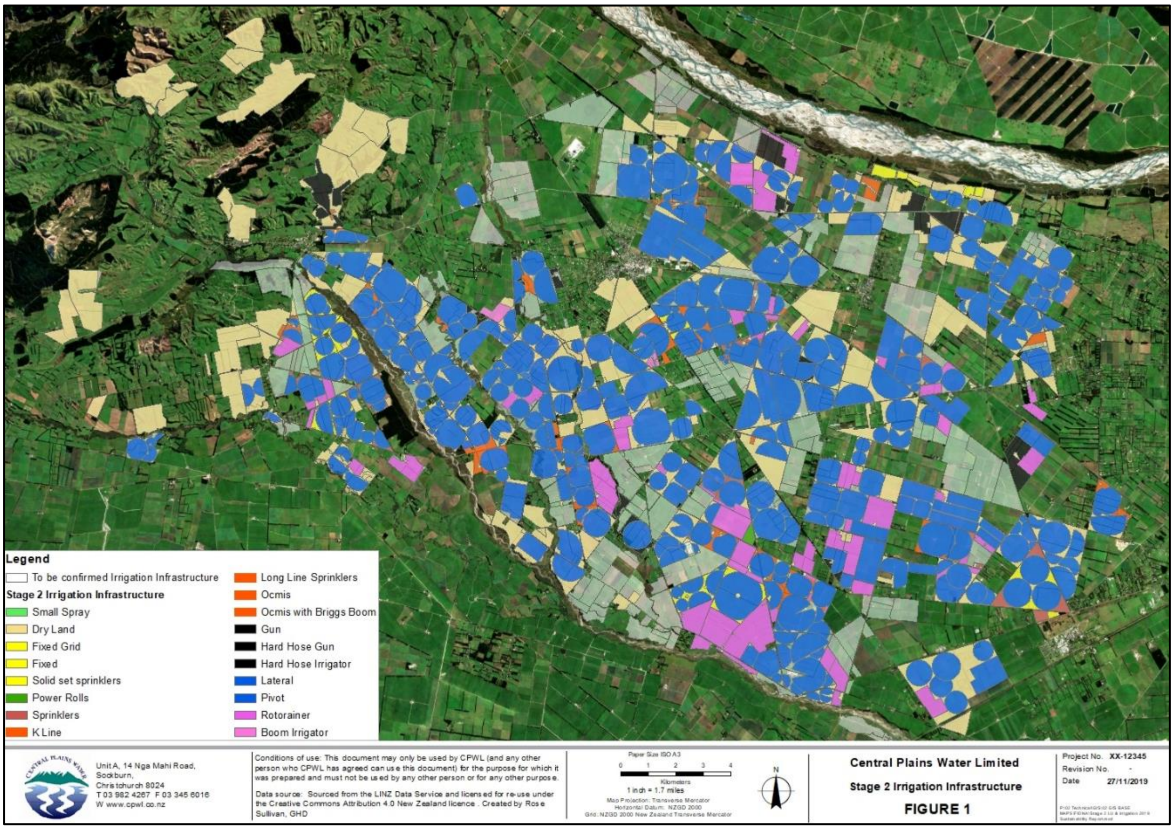

Figure 13. *Irrigated area and irrigation types for CPW Stage 2, 2018-19*

The distribution of irrigation system types within the Sheffield Scheme area is shown on Figure 14 below. The figure shows a majority of land is irrigated using centre pivot irrigators with approximately 15% of the total area irrigated using travelling irrigators or spraylines.

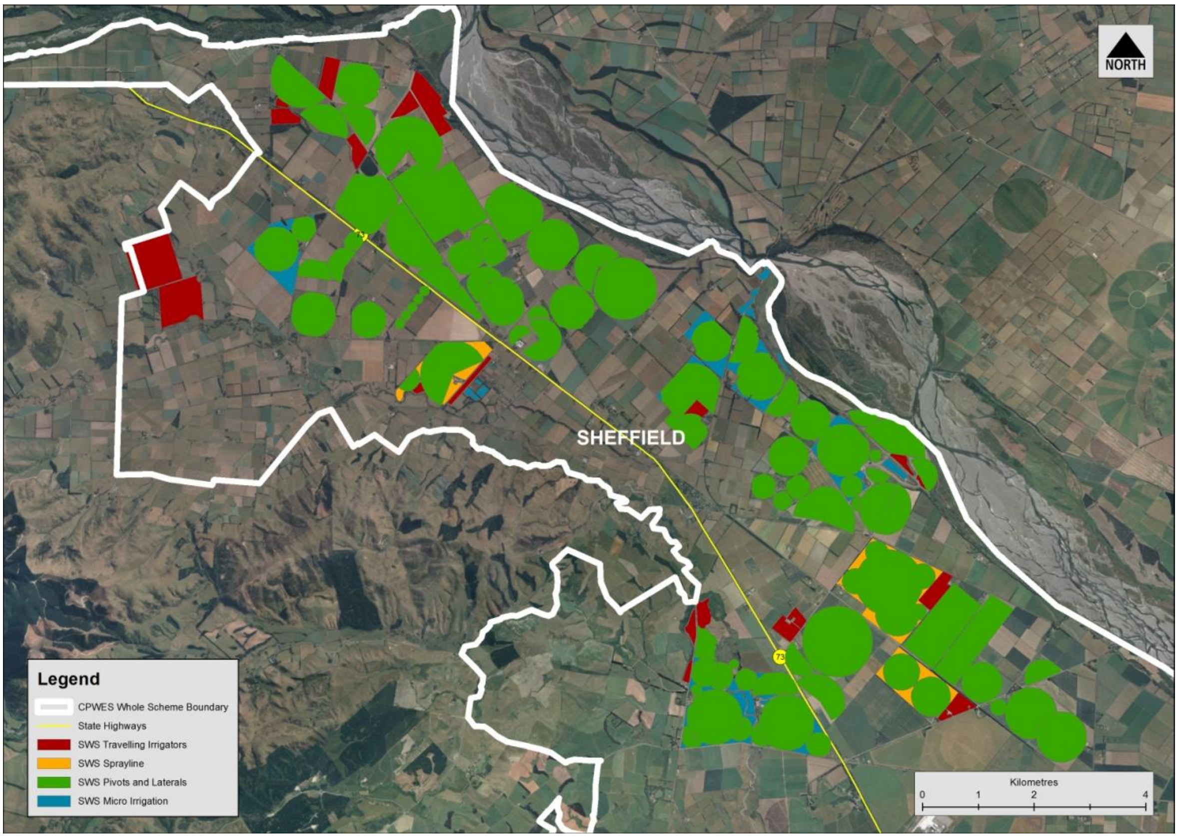

Figure 14. *Irrigated area and irrigation types for CPW Sheffield Scheme, 2018-19*

3.3. Land Use

Figure 15 provides a breakdown of land use (enterprise) types in the CPW Scheme area during the 2018-19 year based on the categories defined in the OverseerFM® nutrient budget model. The data shows that dairy and various combinations of sheep, dairy and beef grazing accounted for a majority of overall land use. From a farm systems perspective these enterprises can be divided into two types: dairy systems, and mixed systems. It is noted approximately 40 % of the total area comprise mixed systems that provide flexibility for farmers to respond to changes in market demand without the higher capital investment required to establish a dairy operation.

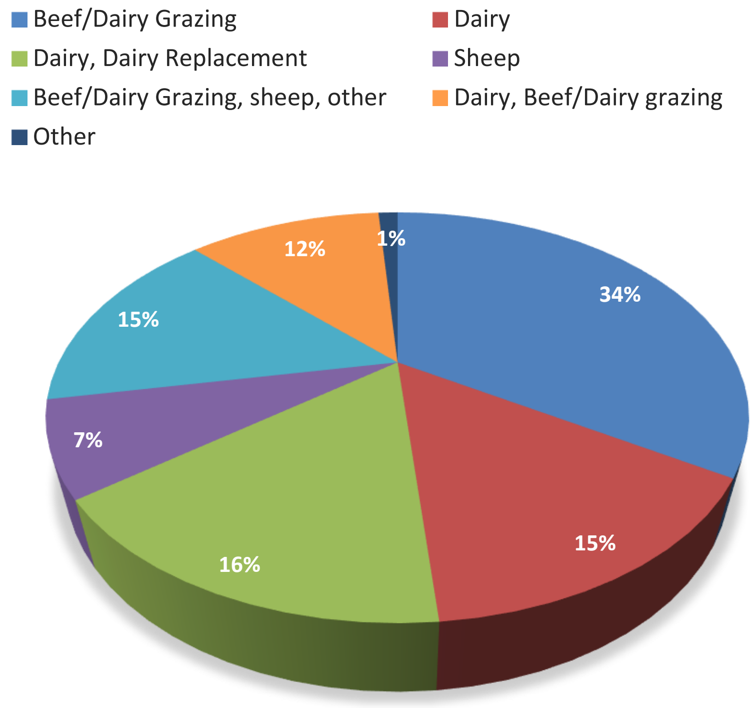

Figure 15. *Land use types in CPW Scheme area, 2018-19*

Figure 16 provides a comparison between baseline land use (i.e. pre-CPW) and 2018-19 land use in the Stage 1 area based on FEPs. The data show that land use has remained relatively constant over the four years since the scheme commenced operations, with the major change being a 34 % (3,290 Ha) reduction in the area of Sheep, Beef/Dairy grazing which has largely been balanced by an increase in Beef/Dairy grazing enterprises (1,670 Ha increase in Dairy, dairy replacements and a 2,193 Ha increase in Beef/Dairy Grazing). The overall expansion of dairy enterprises following commencement of Stage 1 operations equates to around 5% of the total scheme area.

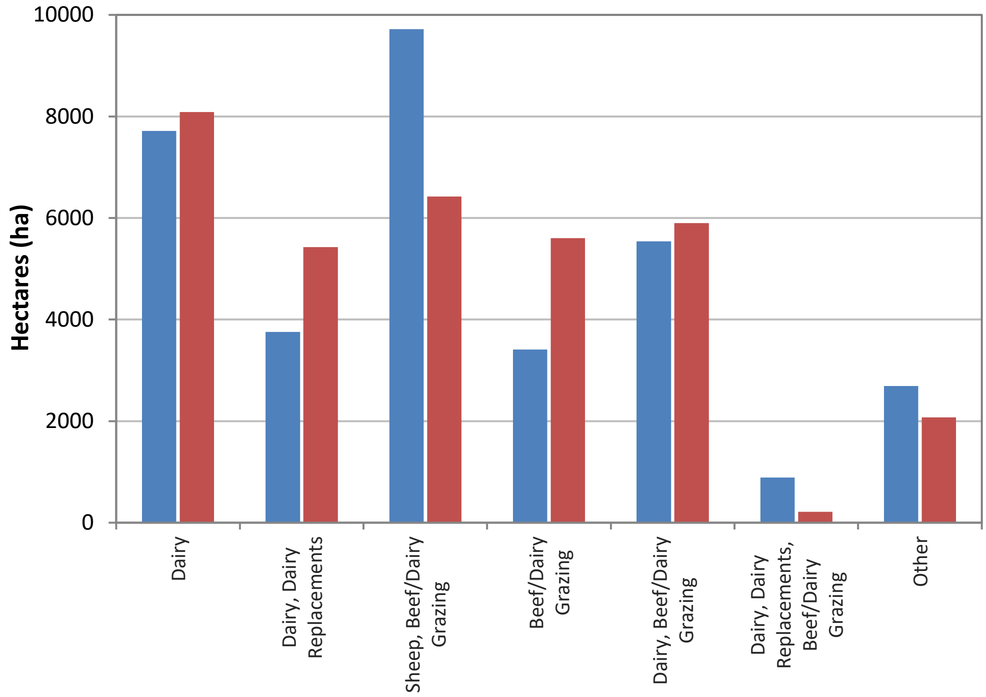

Figure 16. *Comparison of baseline land use (blue bars) and 2018-19 enterprise types (red bars) in the CPW Stage 1 area.*

Figure 17 provides a breakdown of farm enterprise types in the Sheffield Scheme area during 2018-19. The figure shows Sheep, Beef/Dairy grazing is the dominant land use accounting for 61% of the total scheme area, with Beef/Dairy grazing accounting for a further 17%. Again, changes in land use following commencement of Sheffield Scheme operations in 2017-18 have been relatively limited.

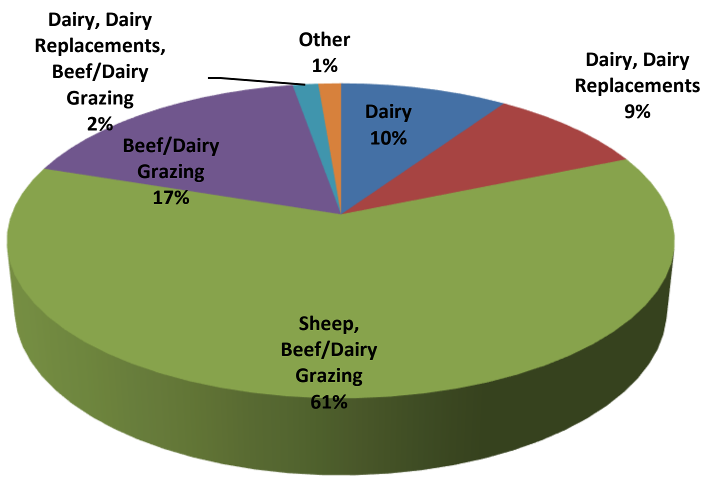

Figure 17. *Land use types in CPW Sheffield Scheme area, 2018-19*

3.4. Irrigation Water Use

The Scheme-wide average maximum application rate during the 2018-19 season was 1.30 mm/ha/day. As illustrated on Figure 18, no individual property exceeded a combined irrigation application rate (including CPW water and groundwater) of 5.18 mm/ha/day, which is the maximum limit specified in CPWs consent to take and use both Scheme water and groundwater[2].

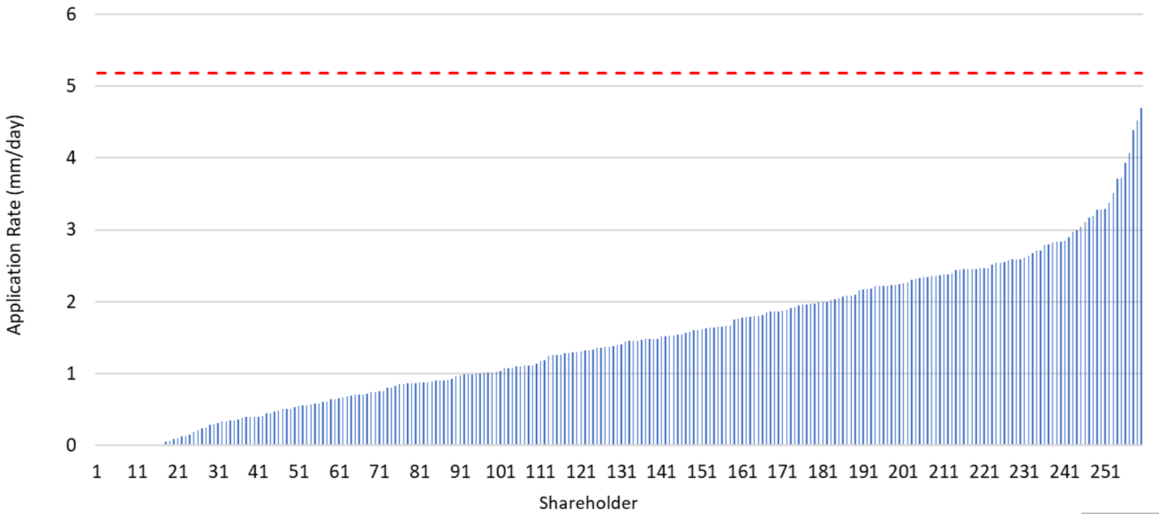

Figure 18. *Combined maximum daily groundwater and CPW irrigation application rate (Reproduced from CPWL, 2019[3])*

Cumulative water use (across the CPW Stage 1, Stage 2 and Sheffield Scheme areas) area during the 2018-19 season totalled 2,930 m³/ha (equivalent to a seasonal application depth of 293 mm), comprising 740 m³/ha of groundwater and 2,190 m³/ha of CPW water. Table 2 provides a summary of seasonal water use across the Scheme for the 2017-18 and 2018-19 years. This comparison shows seasonal water use was appreciably lower during the 2018-19 year due to above average rainfall which significantly reduced water use during November and December 2018, a period when irrigation demand is typically near the seasonal maximum.

Table 2. *Average seasonal irrigation application rates across the Scheme area, 2017-18 and 2018-19*

Year	Water Source	Stage 1 (m^3/Ha)	Stage 2 (m^3/Ha)	Sheffield (m^3/Ha)	Whole Scheme (m^3/Ha)
2018-19	CPW	2,790	1,595	1,797	2,190
	Groundwater	700	925	141	740
	Total	**3,490**	**2,520**	**1,938**	**2,930**
2017-18	CPW	3,486	-	1,513	3,161
	Groundwater	806	-	188	701
	Total	**4,292**	**-**	**1,701**	**3,862**

[2] It is note that some groundwater taken is used for purposes other than irrigation, so the rates shown are considered conservative

[3] CPWL, 2019; Annual Compliance Report – Central Plains Water Limited. Report submitted to Environment Canterbury, August 2019.

3.4.1. Groundwater Conversion to CPW Scheme

One of the key benefits associated with the Scheme identified in the Selwyn Waihora Zone Solutions Package was a reduction in the volume of groundwater utilised for irrigation across the Central Plains area, due to substitution with water derived from alpine sources (i.e. the Rakaia and Waimakariri Rivers (run-of-river and storage). The reduction in groundwater abstraction is expected to result in positive benefits associated with an increase in groundwater storage and correspondingly higher flows in lowland streams. A target of an 80% reduction in the volume of groundwater abstraction across the Rakaia-Selwyn and Selwyn-Waimakariri allocation zones is identified in the Selwyn-Waihora Zone ZIP Addendum.

Figure 19 shows the percentage of total groundwater allocation utilised by farms in the CPW Scheme area between 2015-16 and 2018-19. The data show groundwater use in Stage 1 declined from 21.4% of total allocation in 2015-16 to less than 16% during 2018-19. Cumulative groundwater use on properties in the Sheffield Scheme during 2018-19 reduced to 11% of cumulative allocation from 25% the previous year. Around 18% of total groundwater allocation was used in the Stage 2 area during 2018-19.

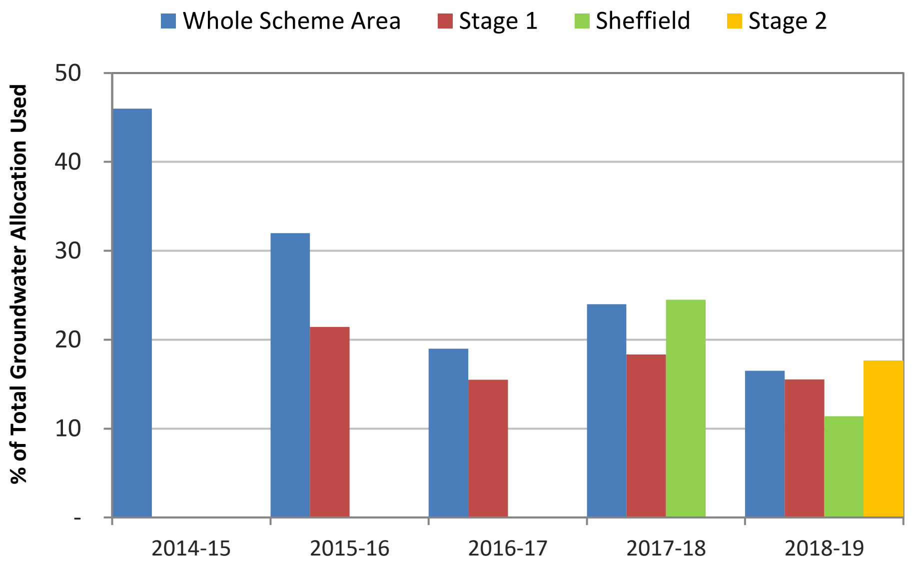

Figure 19. *Percentage of total groundwater allocation used by farms in the Stage 1, Stage 2 and Sheffield Scheme areas, 2014-15 to 2018-19*

Estimates of groundwater use across the whole CPW scheme area are complicated by the quality of historical data but indicate recent usage is significantly below the estimated 46% of total allocation used in 2014-15 (i.e., pre-Stage 1). Representative estimates of the percentage of total groundwater allocation used are also complicated by the expiry, partial replacement or surrender of water permits over time. The volume of groundwater used across the wider CPW scheme area is expected to continue to decline over coming seasons as on-form irrigations systems are modified or replaced and confidence in the reliability of supply for of the CPW Scheme increases.

Figure 20 provides a comparison of actual and consented groundwater use on properties within the Stage 1 area which hold existing groundwater abstraction consents. The figure shows that approximately 25 percent of properties holding existing groundwater consents used no groundwater during the 2018-19 (i.e., irrigation water was derived solely from the CPW Scheme). Across a majority of the remaining properties, groundwater usage was significantly below consented volumes, with cumulative usage less than 17% of the total volume allocated.

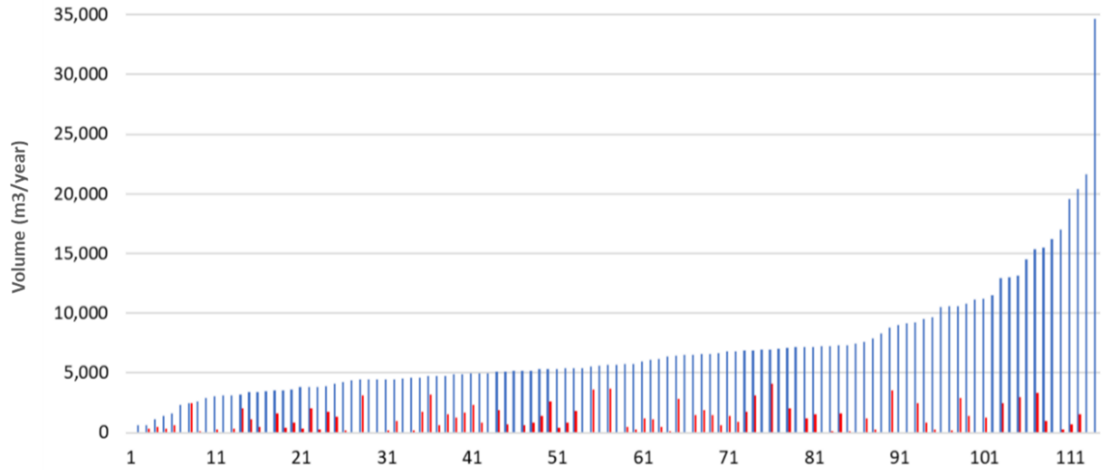

Figure 20. *Comparison of consented and actual groundwater use within the CPW Scheme, 2018-19 (blue bars indicate groundwater allocation volumes per shareholder property, red bars actual volumes used). Reproduced from CPW (2019).*

3.5. Farm Environment Plans

A FEP is the key environmental management tool that helps farmers recognise on-farm environmental risks and sets out a programme to manage those risks. It is also a mechanism which has been adopted in the LWRP to enable water quality objectives in the Selwyn Te Waihora zone to be achieved.

FEPs are unique to a property and reflect the type of farm operation, the local climate and soil type, and the goals of the land user. The FEP covers management areas including:

- Irrigation management, including efficient water use
- Nutrient management
- Soil management
- Point source management (offal holes, farm rubbish & silage pits etc)
- Collected animal effluent management
- Native plants and animals
- Waterbodies - riparian drains, rivers, wetlands and lakes
- Water use (excluding irrigation water)

Under CPWs EMS all irrigators were required to have an FEP in place before they are able to take water from the Scheme. FEPs form a key component of the overall environmental compliance requirements for the CPW Scheme. The FEP must be updated if anything on-farm changes e.g., a farm system or manager.

FEPs are audited and assigned a grade ranging from A (all objectives met) to D (objectives for one or more management areas not met) based on specified criteria. All properties are audited twice on an annual basis, with audit frequency reduced for those achieving A (3-yearly) or B-grades (2-yearly).

3.5.1. Stage 1 FEP Compliance Status

During the 2018-19 year a total of 106 FEPs were in place covering all properties located in the CPW Stage 1 area. Over this period, independent audits were undertaken of FEPs for 11 properties in the Stage 1 area. Properties included in the 2018-19 Stage 1 audits included 5 properties which received a C-grade in audits undertaken in 2017-18, and 6 properties where there had been a change of ownership or farm manager for the 2018-19 season.

Of the Stage 1 FEP audits undertaken in 2018-19, 1 property received an A grade, 9 properties received a B grade and the remaining property received a D grade. The property receiving the D grade had previously received a B grade in the 2016-17 audit and C grade in the 2017/18 audit and would have received a B grade if effluent management objectives had been met in 2018-19. CPW is assisting the landowner to implement the effluent management recommendations outlined in the audit report.

3.5.2. Stage 2 and Sheffield Scheme FEP audits.

During 2018-19 FEP audits were undertaken for the second time on properties in the Sheffield Scheme, with Stage 2 properties audited for the first time. Of the 135 audits completed, 21 properties (16%) received an A-grade, 104 (77%) a B-grade, 7 (5%) a C-grade and 3 (2%) a D-grade.

The 7 properties receiving a C-grade in the 2018-19 FEP audits were all in their first year of audit. Three of the properties received a C-grade due to not meeting effluent management objectives, three for insufficient record keeping, one due to lack of a nutrient budget and location of an offal pit and one due to improvements required in management of new irrigation infrastructure. Two properties received a D-grade in 2018-19. These grades related to lack of records and a current nutrient budget, as well as various management risks associated with management of stock and winter grazing.

Figure 21 compares audit grades received for CPW properties between the 2016-17 and 2018-19 years (noting inclusion of different stages in each year). The figure shows a consistently low proportion of properties (<7%) assigned either C or D-grades, with the largest change being the higher proportion of properties in Stage 2 and Sheffield receiving a B-grades in the 2018-19 compared to Stage 1 properties in previous years[4].

[4] It is noted FEP audit results reported by ECan for the 2017-18 year indicate that 10% of FEPs undertaken across the wider Canterbury Region were assigned C or D-grades https://ecan.govt.nz/reporting-back/farm-environment-plan-audits/

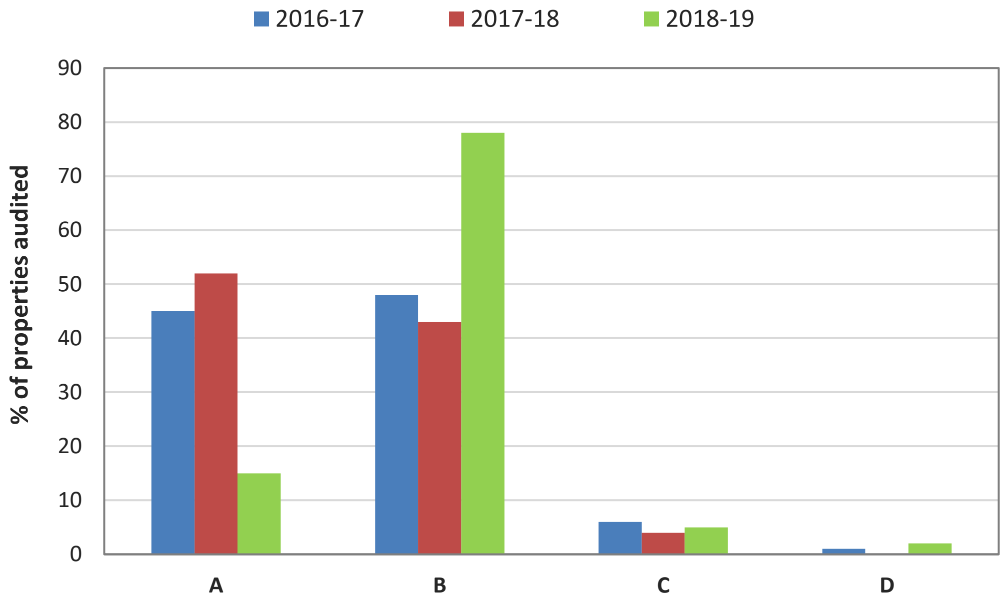

Figure 21. *Comparison of FEP audit grades for the 2016-17 (Stage 1 properties only), 2017-18 (Stage 1 properties only) and 2018-19 (11 Stage 1, all Stage 2 and Sheffield properties) seasons.*

3.5.3. Nutrient Budgets and Nitrogen Allocation

Table 11(i) of the LWRP establishes a limit for nitrogen losses in Selwyn Waihora zone of 5,044.4 tonnes/year by 2037. Of this total, 358 tonnes/year (7% of the total under OverseerFM® version 6.1.3) has been allocated to CPW to provide for the conversion of dryland into irrigated land. This allocation is in addition to the assessed dryland nitrogen baseline of 621 tonnes (OverseerFM® 6.1.3), giving a total Nitrogen Allocation for the CPW scheme of 979 tonnes (OverseerFM® 6.1.3), as specified in Table 11(j) of the LWRP. Under OverseerFM® version 6.2.3 this is equivalent to 1,983 tonnes N/year.

Nutrient Budgets and FEPs have been prepared for all Stage 1, Stage 2 and Sheffield Scheme properties. Calculated cumulative nutrient losses from existing irrigators in the Scheme is 27% less than in the baseline period 2009-13. The entire Scheme (including 19,000 Ha of new irrigation) is achieving a cumulative nitrogen loss approximately 3% lower than that estimated for the baseline period. The year-end nutrient budgets for all new irrigators are approximately 40% below the nitrogen allocation of 1,983 tonnes N/year specified in the LWRP. However, there is still 8,000 hectares available for a nitrogen allocation and, under version 6.3.1 of OverseerFM, 9 properties within Stage 1 and 10 within Stage 2 converted to irrigation within their dryland baseline and therefore may require a nitrogen allocation in the future.

3.6. On-Farm Training

CPW provides ongoing training and assistance to shareholders with regard to a range of irrigation and environmental management issues, including development and implementation of FEP requirements. Additional training is also being provided in terms of irrigation management and FEPs on an ongoing basis via a workshops for all users within the Scheme area (including Stage 1, Stage 2 and Sheffield).

4. Environmental Monitoring

Requirements for extensive monitoring of environmental effects resulting from operation of the Scheme are specified in conditions of CPWs resource consents for the take and use of water. Details of this monitoring programme are outlined in a Ground and Surface Water Monitoring Plan (GSWMP)[5] which consists of two parts:

- Part I: an outline of the CPW monitoring programme (e.g., monitoring sites, parameters measured, monitoring frequency etc.); and
- Part II: specification of trigger levels for the monitoring programme, along with procedures to be followed in the advent that trigger levels are exceeded.

Results and interpretation of environmental monitoring undertaken for the Scheme are provided in the *Annual Ground and Surface Water Monitoring Report*[6] (GSWMP), which forms one component of the overall resource consent compliance monitoring for the Scheme.

Development of the GSWMP and the subsequent monitoring process is overseen by the Ground and Surface Water Expert Review Panel (GSWERP) which was established in 2013. This panel is responsible for overseeing and directing the ground and surface water monitoring program undertaken by CPW, as well as response to trigger level exceedances and/or public complaints. As required by CPW's consents, GSWERP members include representatives from SDC, ECan and Ngai Tahu, alongside independent experts with knowledge and skills specific to hydrogeology and groundwater quality, hydrology and surface water quality, land drainage and cultural values.

4.1. Environmental Baseline

Ongoing operation of the Scheme is anticipated to result in changes to historical land use, recharge and water abstraction patterns across the mid to upper sections of the Central Plains area. These changes have the potential to alter water quality and quantity parameters in downstream receiving environments (groundwater, rivers and streams, and Lake Ellesmere/Te Waihora).

In terms of water quantity, increased recharge from irrigation using water from alpine rivers, coupled with a reduction in the volume of groundwater used for irrigation, are expected to result in an overall increase in groundwater levels and flows in lowland streams. While such effects can have a positive impact on environmental values associated with these waterways, increased groundwater levels and stream flows also have the potential to result in higher water tables and associated drainage issues around the margins of Lake Ellesmere/Te Waihora.

Groundwater flowing through the Central Plains aquifer system is ultimately discharged to lowland rivers and streams around the margins of Lake Ellesmere/Te Waihora so changes to the quality and quantity of groundwater potentially impact on ecological and environmental values associated with these waterways, as well as the lake itself. However, due to the slow rate of groundwater flow (which varies spatially and with depth) it takes between 10 to 30 years depending on location[7] for water

[5] http://www.cpwl.co.nz/environmental-management/ground-surface-water-monitoring-programme

[6] http://www.cpwl.co.nz/environmental-management/environmental-reports

[7] https://cpwl.co.nz/wp-content/uploads/Section-2-Baseline-GW-Quality-2.1-2.2.pdf

recharged on the Central Plains area to drain to Lake Ellesmere/Te Waihora. These variable time lags complicate interpretation of water level, flow and quality monitoring results, particularly when the period of historical information available is short, and monitoring results can also be influenced by factors external to the scheme (such as non-CPW land use and modifications to hydrological environments).

Interpretation of monitoring results is also complicated by climate variability. For example, the above average rainfall recorded during the 2017-18 and 2018-19 seasons contrasts with significantly below average rainfall during the 2014-15 and 2015-16 seasons. Such intra-seasonal variability in rainfall, groundwater recharge and surface water flows can result in short-term effects that obscure longer-term underlying trends in groundwater levels, groundwater quality, streamflow and surface water quality. In addition, as noted in Section 2.1 above, variations in the timing of rainfall during individual seasons may also contribute to short-term variability in water quantity and quality in receiving environments.

Given the Scheme has recently commenced operations in an area with an extensive history of agricultural development, the existing state of water quality and quantity differs significantly from its 'natural' state. Consequently, environmental effects arising from the Scheme are assessed in terms of the pre-Scheme baseline (i.e., the state of water quality and quantity in the absence of the Scheme). In order to better quantify 'baseline' water quality and water quantity prior to Scheme development, a review of all available monitoring data for the Central Plains area was commissioned by GSWERP in 2013[8]. In addition, conditions of consents operated by CPW also required monitoring of groundwater and surface water quantity and quality 2 years prior to individual Scheme stages becoming operational.

4.2. Environmental Monitoring Programme

Full details of the CPW environmental monitoring programme are outlined in Part 1 of CPW's Ground and Surface Water Monitoring Plan (available at http://www.cpwl.co.nz/environmental-management/ground-surface-water-monitoring-programme)

In summary, the monitoring programme consists of four components:

1. 29 surface water quality monitoring sites;
2. 4 lake water quality monitoring sites;
3. 20 groundwater quality monitoring sites; and
4. 12 groundwater level monitoring sites.

As illustrated on Figure 22, the surface water quality monitoring sites include:

- 4 sites upstream of the Scheme (US1 to US4)
- 4 sites within the Scheme area (IS1 to IS4)
- 1 site on downstream boundary of the Scheme (SWSH)

[8] http://www.cpwl.co.nz/environmental-management/ground-surface-water-monitoring-programme

- 8 sites in the headwaters of lowland streams (SF1 to SF8)
- 8 sites near the confluence of lowland streams and Te Waihora/Lake Ellesmere (T1 to T8)
- 4 sites in the SDC stockwater race system at the downstream boundary of the Scheme

Surface water quality sites are monitored on a monthly basis for a range of water quality parameters including dissolved and particulate nutrients, indicator bacteria (*E.coli*) and physical parameters such as pH, temperature and dissolved oxygen concentrations.

The monitoring network also includes 4 sites located in Lake Ellesmere/Te Waihora (3 around the lake margins and one mid-lake site). These sites are monitored on a monthly basis by ECan for a range of parameters including nutrients and chlorophyll-*a* which enable calculation of Trophic Level Index (TLI_3). TLI is an overall measure of lake water quality which allows comparison between individual waterbodies and lake types[9].

As shown on Figure 23, the CPW groundwater quality monitoring network comprises twenty monitoring bores (8 within or down-gradient of the Stage 1 area, 10 within or down-gradient of the Stage 2 area and 2 in the Sheffield Scheme area). These groundwater quality sites are sampled quarterly for a range of chemical and microbial water quality indicators.

It is noted that the CPW groundwater quality monitoring bores are constructed with long screened intervals to enable collection of water quality samples from close to the water table. This aspect of construction is important with regard to interpretation of monitoring results as contaminants associated with overlying land use are typically concentrated near the water table, reducing in concentration with depth (in contrast typical water supply bores are screened at some depth below the water table). Collection of samples from close to the water table in the CPW monitoring bores is therefore inferred to provide a conservative (or 'worst case') assessment of groundwater quality at any given location.

The increased groundwater flow resulting from Scheme operation will result in an increase in groundwater levels in lowland areas of the Central Plains as groundwater flows toward coastal discharge areas. Depending on the magnitude and spatial distribution of groundwater mounding, the increase in groundwater levels has the potential to result in a range of environmental effect ranging from beneficial effects including increased baseflows in lowland streams to adverse effects on land drainage around the margins of Lake Ellesmere/Te Waihora. Trigger levels have been established for 12 lowland groundwater level sites down-gradient of the Scheme. These sites are monitored on a monthly basis as part of the ECan State of the Environment groundwater monitoring network and have a long monitoring history to enable evaluation of current groundwater levels in an appropriate historical context.

[9] see https://www.lawa.org.nz/learn/factsheets/lake-trophic-level-index/ for more information

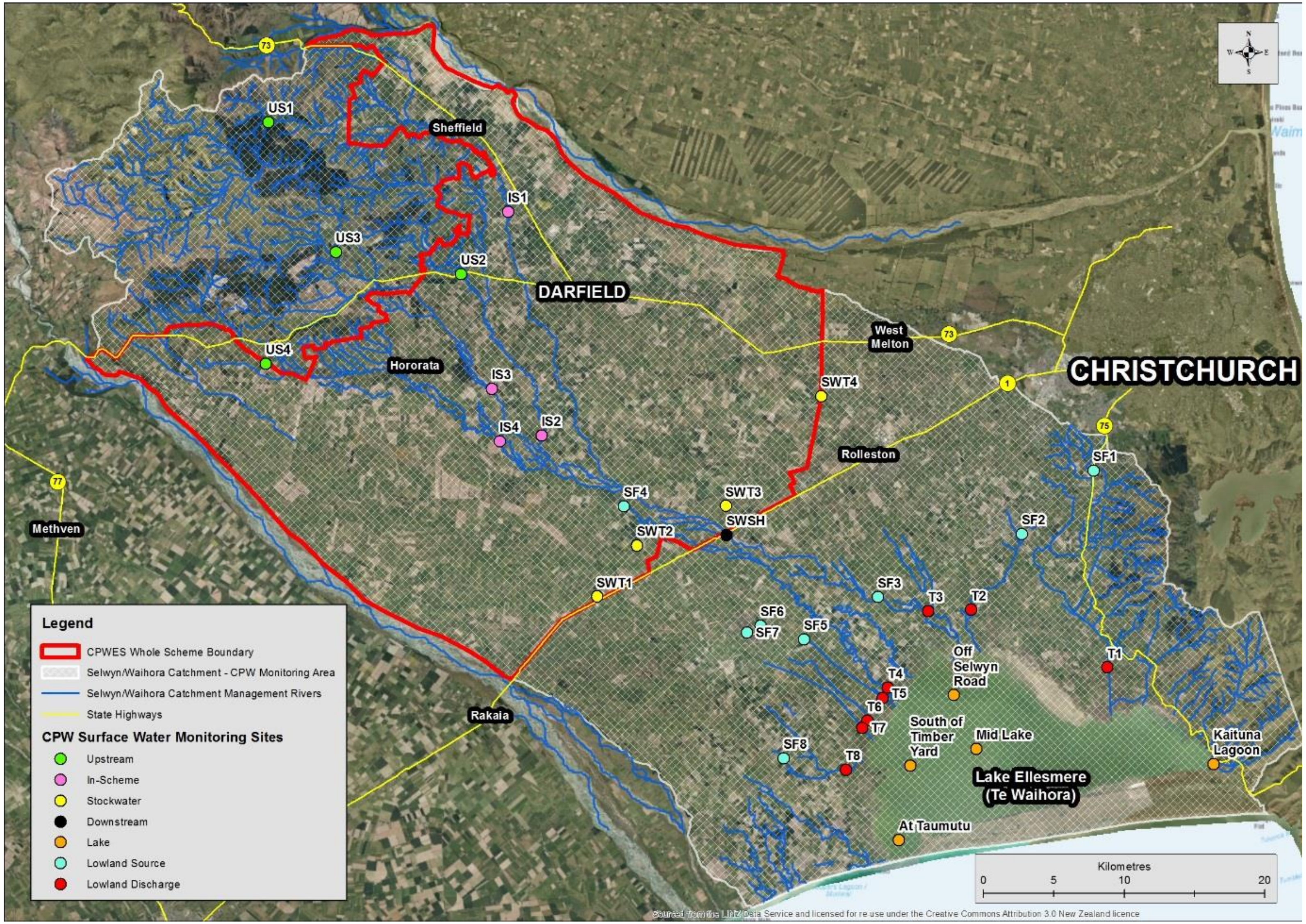

Figure 22. Surface water quality monitoring sites for the CPW scheme

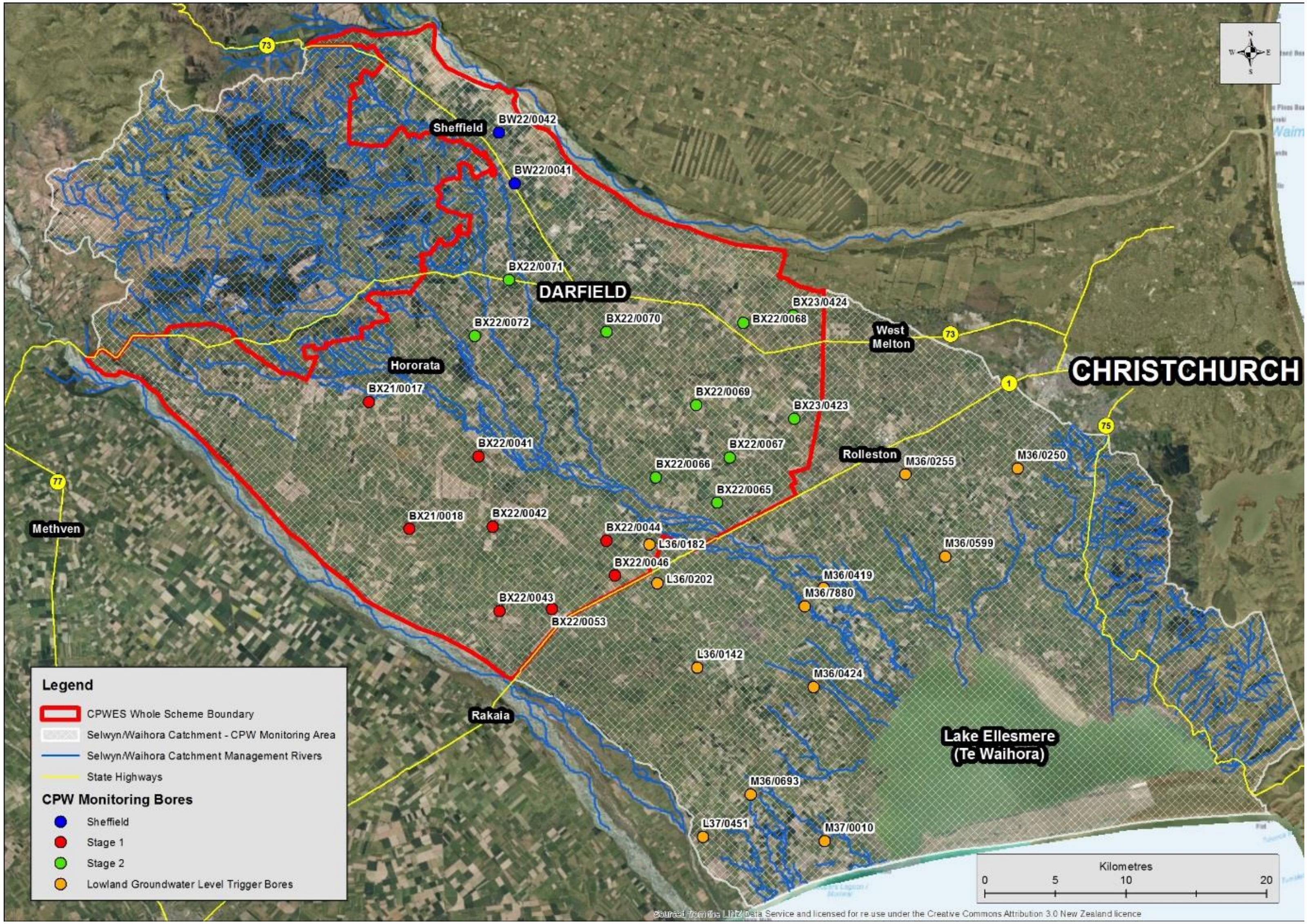

Figure 23. Groundwater quality and level monitoring sites for the CPW scheme

4.3. Environmental Management

Part II of the CPW GSWMP establishes trigger levels for nominated parameters including:

- Nitrate-Nitrogen concentrations at surface water sites;
- Trophic Level Index (TLI_3), Total Phosphorus and Chlorophyll-*a* at lake monitoring sites;
- Nitrate-Nitrogen and *E.coli* concentrations at groundwater quality monitoring sites; and
- Groundwater levels in lowland monitoring wells.

The nominated trigger levels are based on relevant water quality standards established in the LWRP or, in the case of groundwater levels, the range of historical measurements. The triggers provide a basis for evaluation of CPW environmental monitoring results. Once a nominated trigger level is exceeded, the GSWMP establishes a procedure which must be followed to firstly identify if the monitoring results represent a departure from 'background' concentrations or levels and, if they do, specific steps which must be followed to investigate and mitigate the potential cause of the trigger level exceedance. This process is overseen by the GSWERP.

4.4. 2018-19 Monitoring Results

Results from the CPW environmental monitoring programme are summarised in the *Annual Ground and Surface Water Monitoring Report 2018/19* which was reviewed and approved by GSWERP in November 2019.

4.4.1. Surface Water Quality

Trigger levels for CPW surface water quality monitoring are summarised in Table 3 below. These triggers are equivalent to limits for surface water quality established in the LWRP. It is noted the trigger levels differentiate between hill-fed streams (i.e. those predominantly sourced from runoff in upper catchment areas) and spring-fed streams on the lower plains (which derive a majority of flow from groundwater drainage).

Table 3. *CPW Surface water quality triggers for Nitrate-Nitrogen (mg/L)*

River Type	CPW Surface Water Monitoring	
	Annual Median	**Annual 95th Percentile**
Hill-fed Lower	1.8	2.6
Spring-fed Plains	5.2	7.4

Table 4 summarises trigger level exceedances for nitrate-nitrogen concentrations at CPW monitoring sites during the 2018-19 season. The data show both the median and 95th percentile triggers were exceeded at 1 hill-fed site and 5 spring-fed sites, with an equivalent number of exceedances (at the same sites) for the 95th percentile trigger. The number of sites exceeding trigger levels in the 2018-19 year was lower than that recorded during the previous two seasons (2016-17 and 2017-18), including in the Stage 2 area where CPW operations only commenced during the 2018-19 year.

Table 4. *Summary of surface water quality trigger level exceedances for CPW sites, 2016-17 to 2018-19.*

River Type	Year	Sites	Samples*	Sites exceeding annual Nitrate median	Sites exceeding annual 95th percentile
Hill-fed Lower	2018-19	9	80	1	1
	2017-18		93	3	4
	2016-17		71	2	1
Spring-fed Plains	2018-19	16	198	5	5
	2017-18		198	6	7
	2016-17		144	6	6

* The number of samples varies between years due to the presence/absence of flow at individual monitoring sites

During the 2018-19 season surface water nitrate trigger level exceedances were recorded in six waterways including the Hawkins River (IS1), Selwyn River (SF3, T3), Doyleston Drain (SF6) and Harts Creek (SF8, T8) at the locations shown on Figure 24. While a majority of sites exceeding the trigger levels were located in spring-fed streams around the margins of Lake Ellesmere/Te Waihora, the Hawkins River site within the Stage 2 area also exceeded the trigger values. It is noted that sites where trigger levels exceedances were recorded in 2018-19 also exceeded trigger levels during previous years.

One site (T8, Harts Creek downstream) exhibited an annual 95th percentile concentration which was the highest recorded in 24 years of monitoring. However, as illustrated on Figure 27 below, nitrate concentrations at this site during the 2018-19 year were consistent with an overall increasing trend that was established well before the CPW Scheme commenced operations. All other sites recorded annual median and 95th percentile nitrate concentrations recorded in 2018-19 were within the range observed historically.

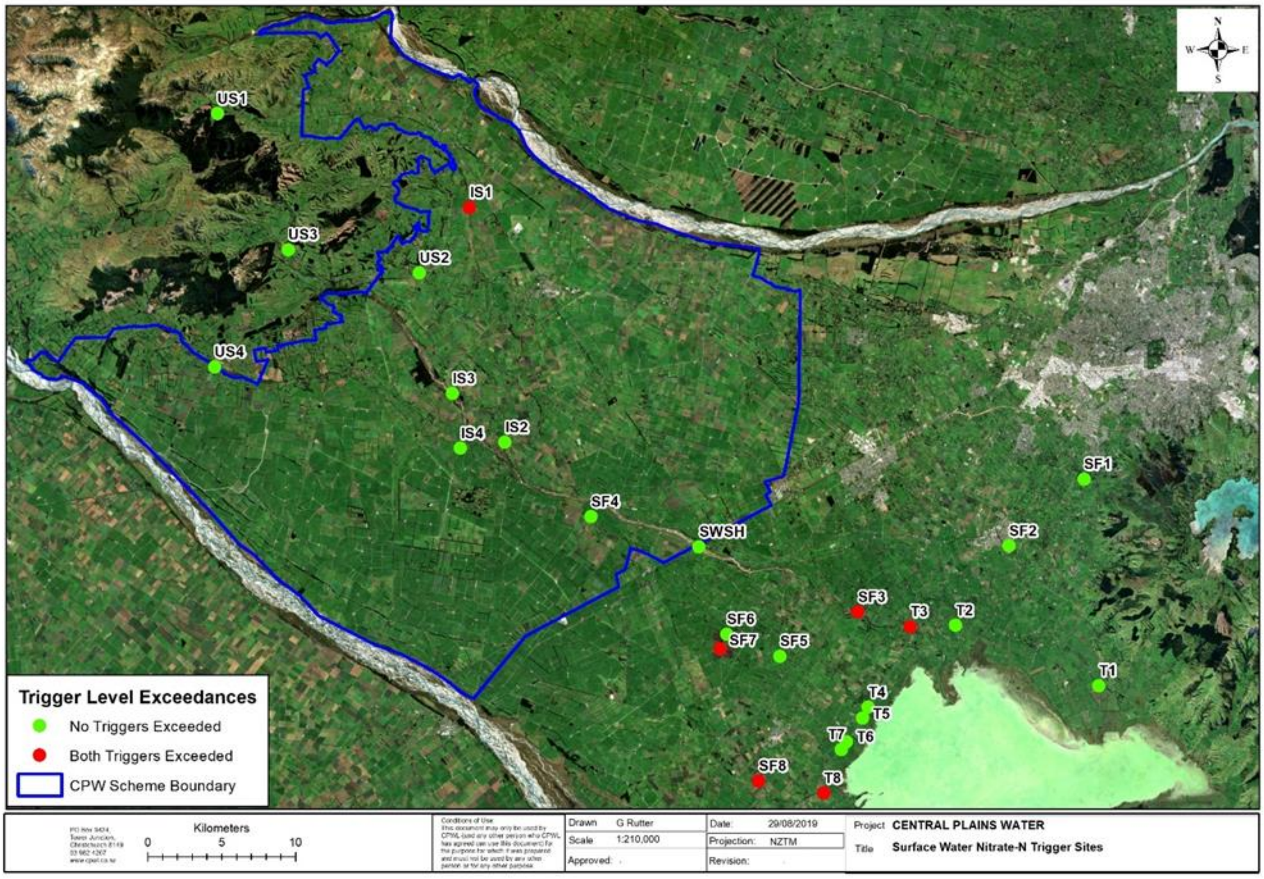

Figure 24. *Surface water nitrate trigger level exceedances during 2018-19*

Figures 25 and 26 below compare annual median nitrate concentrations from the 2015-16 to 2018-19 seasons with the relevant Nitrate-Nitrogen triggers for hill-fed and spring-fed streams. The data show both a wide range in both the magnitude and temporal variation of median nitrate concentrations at individual monitoring sites. For example, while upstream monitoring sites (including US1, US3 and US4) generally exhibit nitrate concentrations well below trigger values, many lowland sites (SF6, SF8, T3) exhibit concentrations consistently above the trigger values. Similarly, while nitrate concentrations are relatively stable at many sites, others either exhibit significant temporal variability between individual years (SF3, SF5, SF6) or indicate consistent increasing (IS1, T2, T8) or decreasing (IS2, SF4, SF3) concentrations over time.

As a result, while surface water monitoring shows an overall increase in median nitrate concentrations from headwater to lowland areas, results from individual monitoring sites exhibit significant variability between individual catchments. This variability is inferred to reflect the complex interaction between multiple factors influencing water quality, including climate, local and upstream land use, time lags in the groundwater system (particularly important in spring-fed streams) as well as instream processes in different waterways. Such spatial and temporal variability will inevitably complicate attribution of observed variations in water quality associated with the Scheme, from those reflecting background (i.e., pre-scheme) water quality or external influences.

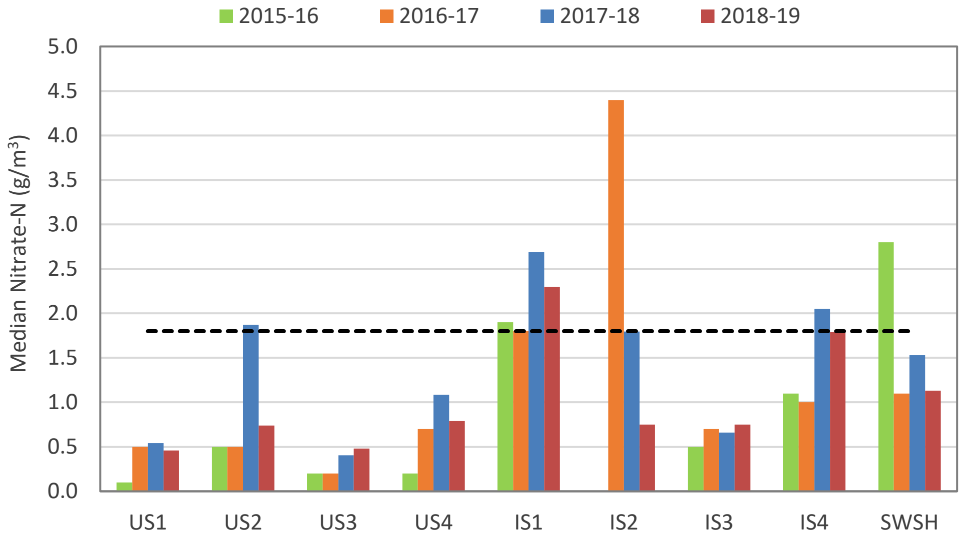

***Figure 25**. Annual median nitrate concentrations at hill-fed lower sites, 2015-16 to 2018-19 (black line denotes trigger level)*

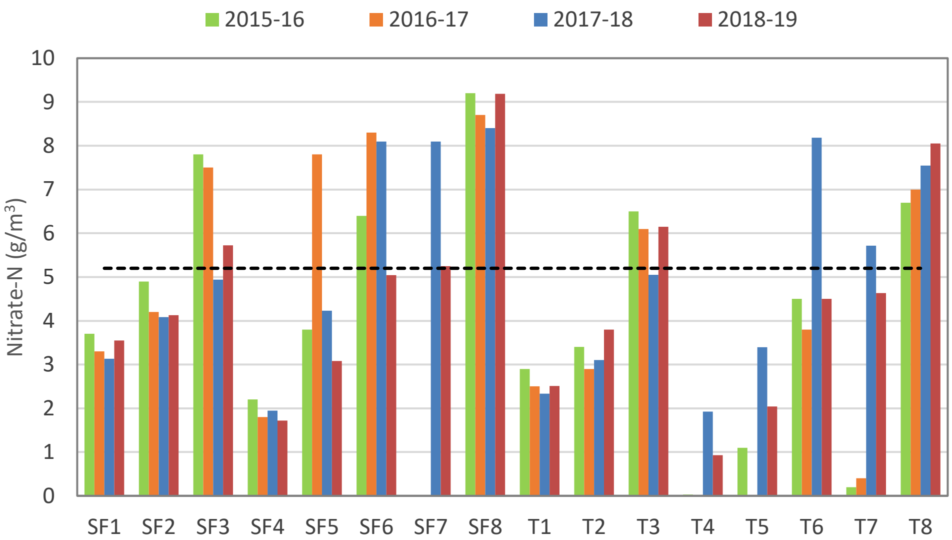

Figure 26. *Annual median nitrate concentrations at spring-fed plains sites, 2015-16 to 2018-19* (black line denotes trigger level)

It is noted that the GSWERP baseline water quality report identified historical nitrate concentrations (i.e., pre CPW) that would have exceeded triggers in the Hawkins River, Selwyn River, Boggy Creek and Harts Creek in. As illustrated in the examples from Harts Creek and the Selwyn River shown in Figure 27 and Figure 28 below, many of these waterways have a history of elevated and/or increasing nitrate concentrations that pre-dates Scheme operations. At both sites, although being the highest (or close to) recorded historically, median and 95th percentile concentrations observed during 2018-19 were consistent with historical trends.

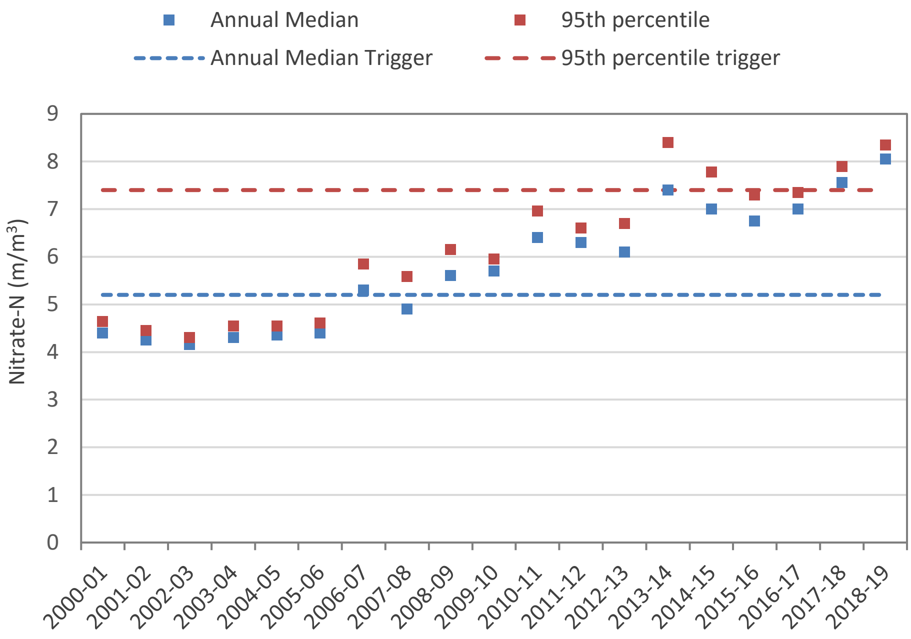

Figure 27. *Annual median and 95th percentile nitrate-nitrogen concentrations in Harts Creek downstream (T8), 2000-01 to 2018-19.*

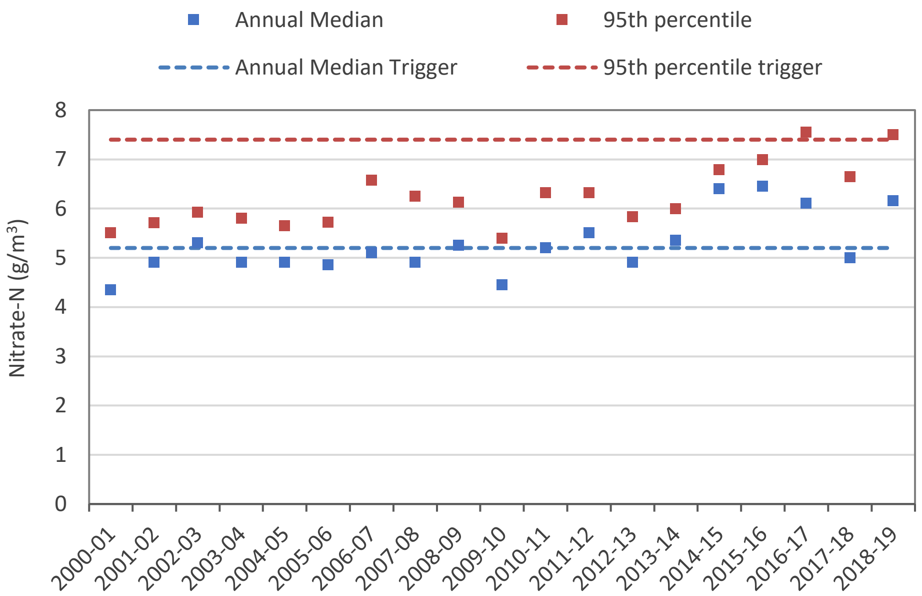

Figure 28. *Annual median and 95th percentile nitrate-nitrogen concentrations in the CPW Selwyn River downstream monitoring site (Coes Ford), 1992-93 to 2017-18*

Overall, although surface water triggers were exceeded at six sites in the CPW monitoring network during the 2018-19 year, observed concentrations are generally consistent with the historical baseline (either the observed range or historical trends). As a consequence, monitoring data collected to date does not show any discernible effects of the Scheme on surface water quality either within, or down-gradient, of the Scheme area. Monitoring results during the 2018-19 year are also likely to be influenced by temporal variations in rainfall and surface water flows, with high flows occurring during the summer months and stable baseflow recorded during much of autumn and early winter 2019.

4.4.2. Lake Water Quality

Lake Ellesmere/Te Waihora is the ultimate receiving environment for a significant proportion of surface water and groundwater flows from the CPW Scheme area. Land use and land management activities in the Scheme area there have the potential to influence lake water quality. Trigger levels established by GSWERP for lake water quality are listed in Table 5. These trigger levels are equivalent to water quality limits contained in Table (l) of the LWRP.

Table 5. Lake water quality triggers

Monitoring Location	Chlorophyll-*a* (□g/L)[(b)]	Total Phosphorus (mg/L)[(b)]	Total Nitrogen (mg/L)[(b)]	TLI_3[(a)]
Mid-Lake	74	0.1	3.4	6.6
Lake Margins	no trigger	no trigger	no trigger	6.0

(a) TLI is calculated as TLI_3 (using TP, TN and chl-a)
(b) As a maximum annual average determined from 12 (monthly) rounds of monitoring results.

Table 6 provides a summary of CPW lake water quality monitoring results for the 2018-19 year. The figures show CPW triggers were exceeded for Chlorophyll-*a*, Total Phosphorus and TLI_3 at the mid-lake site, and for TLI3 at the three lake margin monitoring sites.

Table 6. *2018-19 CPW lake water quality monitoring results (figures in bold denote concentrations exceeding trigger levels)*

Site	Chlorophyll-*a* μg/L	Total Phosphorus mg/L	Total Nitrogen mg/L	TLI_3
Mid-Lake	**89**	**0.19**	2.22	**6.83**
Lake Margin Sites				
- Off Selwyn River Mouth	81	0.16	2.17	**6.72**
- South of Timber Yard	80	0.15	2.16	**6.69**
- Taumutu	71	0.14	1.91	**6.56**

The Trophic Level Index (TLI_3) is an indicator of lake water quality specifically developed for New Zealand lakes. The TLI_3 is calculated from measured concentrations of Total Nitrogen, Total Phosphorus and Chlorophyll-*a*. The average TLI_3 value at the Mid-lake site in 2018-19 year (6.83) was marginally higher than the long-term mean of 6.79. Figure 29 shows TLI_3 values calculated for the mid-lake monitoring site from 2000/01 to 2018/19 and show that, except for a short period between 2010/11 and 2012/13, TLI_3 values at the mid-lake monitoring site have consistently exceeded the CPW trigger level since 2000/01. Values of Chlorophyll-a and Total Phosphorus observed at the mid-lake monitoring site during 2018-19 were also within the range observed historically. Calculated TLI_3 values for the 2018-19 year at the mid-lake site (6.83) were marginally higher than the median value of 6.79

recorded between 2000/01 and 2018/19, and significantly below the maximum of 7.24 recorded in 2000/01.

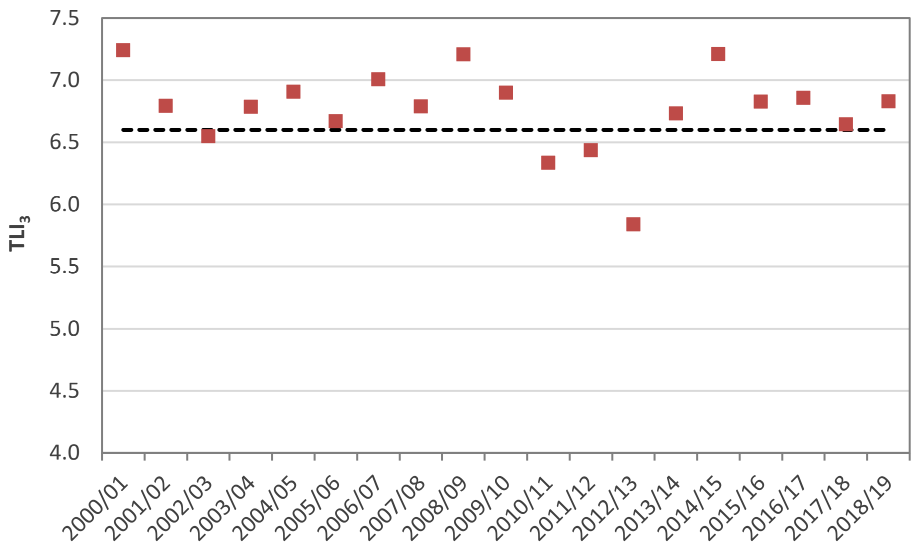

Figure 29. *Calculated TLI3 values at the mid-lake monitoring site, 2000/01 to 2018/19 (black line indicates trigger value).*

As shown on Figure 30 below, TLI_3 values at lake margin monitoring sites are slightly lower than those recorded at the mid-lake monitoring, while exhibiting a similar temporal pattern. However, while recent values recorded at the mid-lake site marginally exceed the relevant trigger (by between 0.05 and 0.26 between 2015-16 and 2018-19), sites around the lake margin remained well above the relevant trigger (0.51 to 0.81) over the same period. Consequently, lake water quality trigger level exceedances are greater for the lake margin water quality sites compared to the mid-lake site.

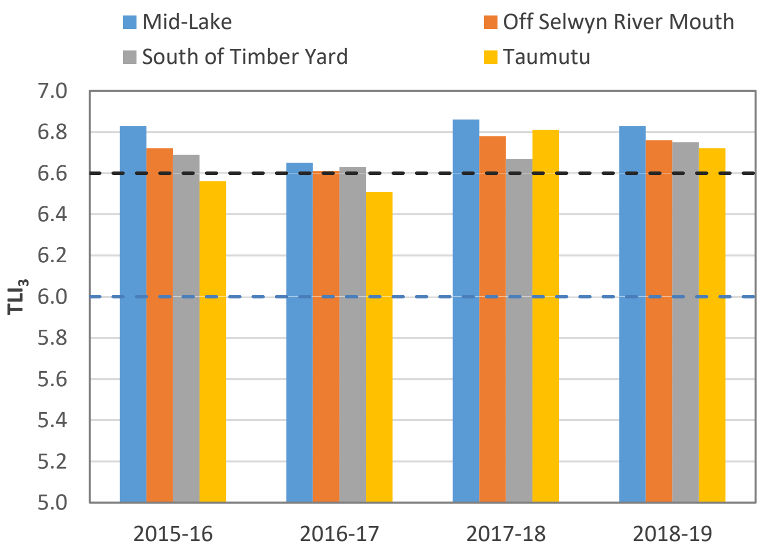

Figure 30. *Calculated TLI3 values at the four Lake Ellesmere/Te Waihora monitoring sites, 2015/16 to 2018/19 (black line = mid-lake trigger, blue line = lake margin trigger).*

During the 2018-19 year, lake water quality triggers in Lake Ellesmere/Te Waihora were exceeded at both mid-lake and lake margin monitoring sites. However, concentrations of indicator parameters and calculated TLI3 values were within the historical range and do not exhibit any readily discernible change that can be related to CPW activities.

4.4.3. Groundwater Quality

Trigger levels for CPW groundwater monitoring are summarised in Table 7 below. It is noted that these triggers are equivalent to the limits for groundwater quality in the Selwyn-Waihora zone established in the LWRP.

Table 7. Groundwater quality triggers for CPW monitoring

Contaminant	Measurement	Trigger
Nitrate-Nitrogen	5-year annual average concentration[(a)]	7.65 mg/L
E.coli	Median concentration[(b)]	<1 organism/100 millilitres

(a) In shallow groundwater <50 metres below groundwater level

(b) Measured over the length of record

Two years of groundwater monitoring data were collected by CPW prior to the commencement of irrigation in each stage of the Scheme. This data (combined with results of historical ECan monitoring) forms the baseline against which future groundwater quality within the CPW Scheme area can be assessed.

4.4.3.1. Nitrate-Nitrogen

Due to the limited period over which the CPW Scheme has been operating (2018-19 was the fourth year of Stage 1 operations), it is not possible to directly compare CPW groundwater quality monitoring results against the trigger level established in the GSWMP (which are based on a 5-year annual average concentration). The 2019-20 season will be the first year sufficient data is available for this comparison (for Stage 1).

However, as shown on Figure 31 below, comparing annual mean 2018-19 Nitrate-Nitrogen concentrations for individual monitoring sites against the trigger level shows concentrations exceeded 7.65 mg/L in:

- 4 of the 8 monitoring sites in the Stage 1 area; and
- 7 of the 10 sites in the Stage 2 area

No monitoring sites in the Sheffield Scheme area exceeded the groundwater nitrate trigger.

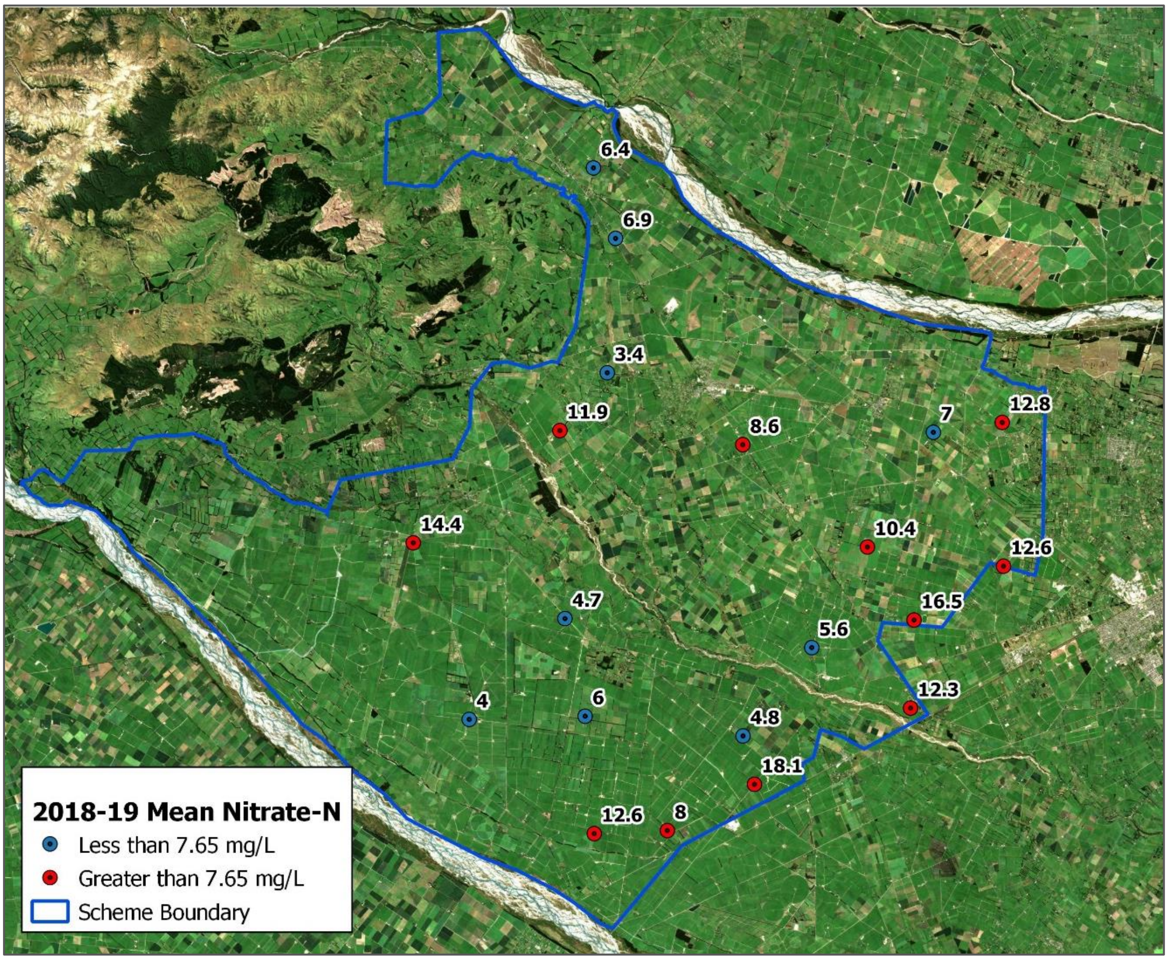

Figure 31. *Mean annual groundwater nitrate concentrations across the CPW Scheme area 2018-19*

Figure 32 shows yearly mean nitrate concentrations in Stage 1 monitoring bores between 2014-15 and 2018-19[10]. The data exhibit significant variability in nitrate concentrations in individual monitoring bores over time. This suggests that localised factors including climate, land use, as well as the hydraulic properties of the unsaturated zone and underlying aquifers exert a significant influence on groundwater quality across the Central Plains area.

[10] Note: this includes 'baseline' data recorded prior to commencement of Stage 1 operations in 2015-16.

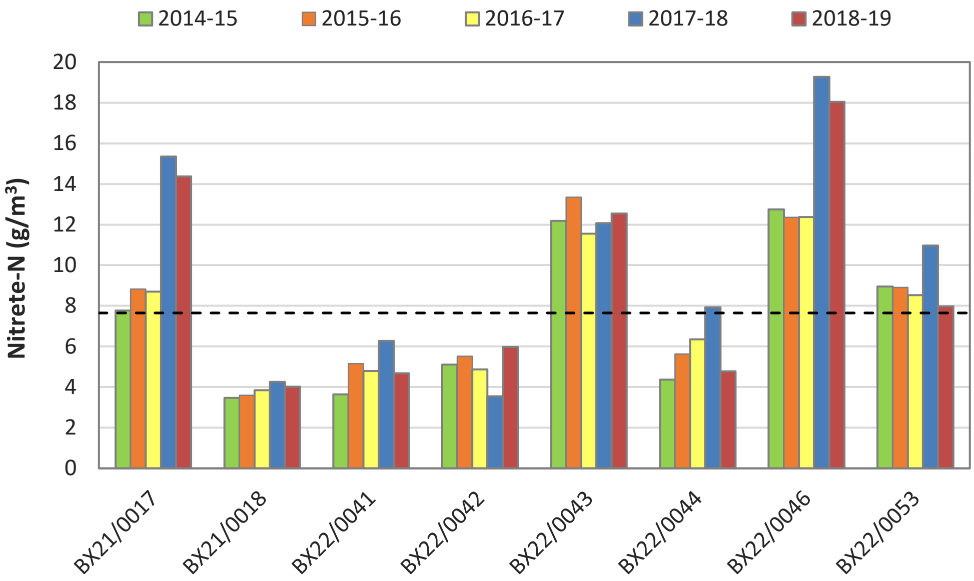

Figure 32. *Mean annual groundwater nitrate concentrations in the Stage 1 area, 2014-15 to 2018-19*

Figure 33 shows a plot of quarterly groundwater nitrate concentrations in the Stage 2 area between 2015-16 and 2018-19. While the data indicate nitrate concentrations have remained relatively low and stable at some sites (e.g., BX22/0071), many others exhibit appreciable temporal variability, particularly following the wet autumn and winter in 2017. The significant increase in nitrate concentrations during 2017 (observed in all three Scheme stages) is attributed to the large volume of recharge mobilising excess nitrogen from the soil and underlying unsaturated zone following 3 years of generally below normal winter recharge.

As illustrated in Figure 34, monitoring data collected by ECan elsewhere in the Central Plains (outside of the CPW scheme area) exhibit a similar relationship with groundwater levels with large increases in groundwater levels (associated with significant recharge events) corresponding to significant increases in groundwater nitrate concentrations

It is also noted that a significant proportion of monitoring sites in both the Stage 1 and Stage 2 areas exhibited nitrate concentrations well in excess of the GSWERP nitrate triggers in baseline data collected prior to commencement of Scheme operations.

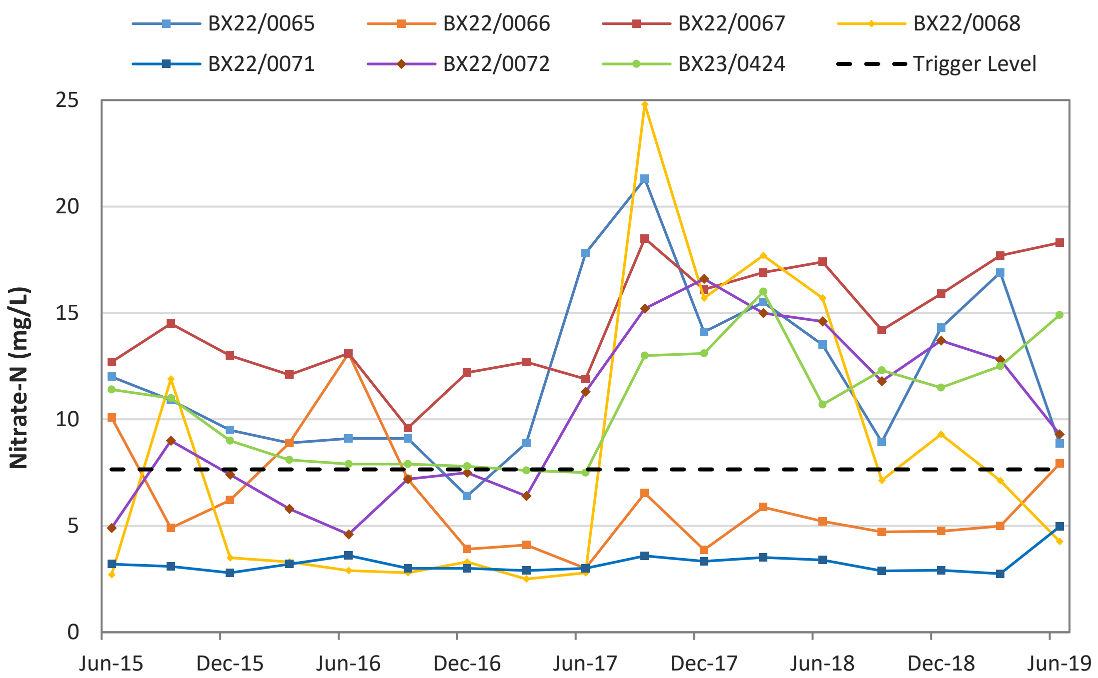

Figure 33. *Mean annual groundwater nitrate concentrations in the Stage 1 area, 2014-15 to 2018-19 (black line indicates CPW trigger)*

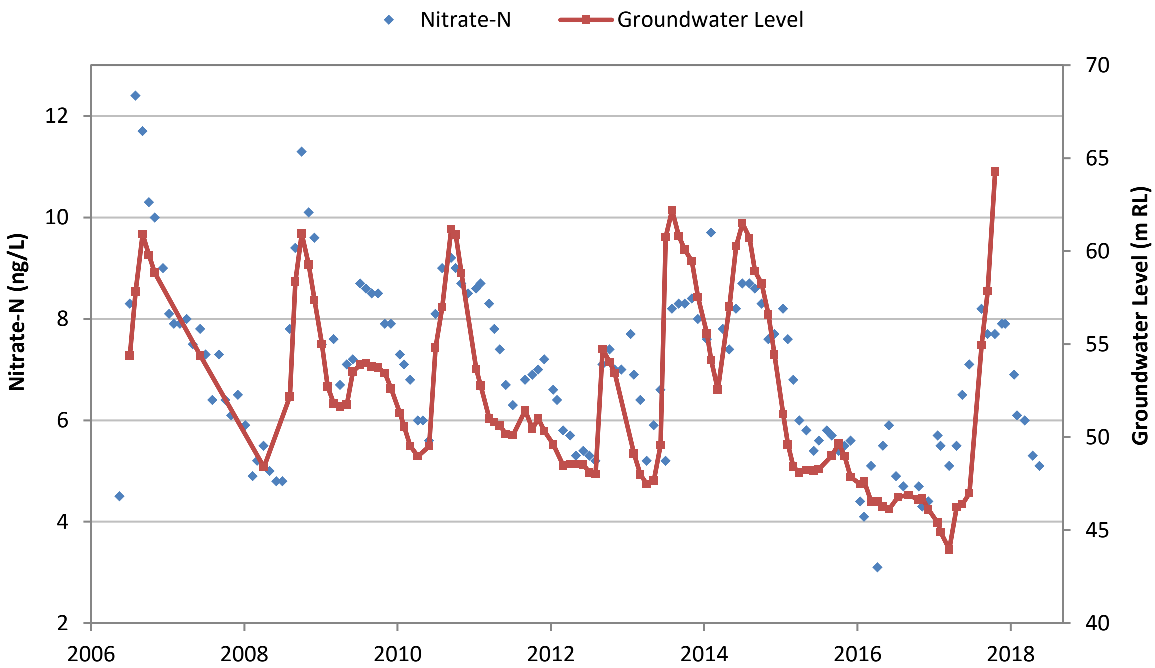

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Figure 34. *Temporal variation in groundwater level and nitrate concentrations in M36/4126 near Rolleston (monitored by ECan), 2006 to 2018.*

Overall, while monitoring data from the 2018-19 year show elevated groundwater nitrate concentrations (in excess of GSWERP triggers) in approximately 50% of CPW monitoring bores, the following points are noted:

- Due to the construction of the CPW monitoring bores and the sampling methodology utilised, nitrate concentration from CPW monitoring likely reflect 'worst case' nitrate concentrations recorded at the top of the water table;
- Insufficient data is yet available to allow direct comparison with GSWERP groundwater nitrate triggers (which are based on 5-year average nitrate concentrations);
- Nitrate concentrations in excess of GWERP triggers were recorded in baseline data from approximately 30% of monitoring bores located in the Stage 1 and Stage 2 areas prior to CPW operations commencing;
- Significant temporal variability in nitrate concentrations is observed between individual monitoring bores. In particular, a significant number of sites exhibit a marked increase in nitrate concentrations (above trigger levels) during 2017. This increase is attributed to a period of above average rainfall during autumn/winter 2017 which mobilised excess nitrogen from the soil and underlying unsaturated zone following 3 years of generally below normal winter recharge.

4.4.3.2. Microbial Quality

As shown on Figure 35 below, the intermittent presence of low levels of indicator bacteria (*E.coli*) was observed in a number of CPW monitoring wells during the 2018-19 year.

Within the operational Stage 1 area *E.coli* were detected in one bore (BX23/0043) on a single occasion, and twice another bore (BX22/0044). These detections did not result in the GSWERP trigger (based on median concentration for entire monitoring record) being exceeded. Positive *E.coli* detections were recorded in 3 out of 32 samples (9.4%) collected from the Stage 1 area during 2018-19 (compared to 15.6% of samples during 2017-18).

Positive detections of E.*coli* bacteria were recorded in 8 out of 10 monitoring bores in the Stage 2 area during 2018-19. Most of these detections were low level (i.e., <6 MPN/100 mL) and similar in magnitude to intermittent detections of indicator bacteria in the same bores during the baseline monitoring period (i.e., samples collected prior to Stage 2 commencing operation in October 2019). Two bores (BX22/0065 and BX22/0067) exhibited elevated E.*coli* concentrations (i.e., >10 MPN/100 mL) during 2018-19, both of which also exhibited positive detections for E.*coli* during the baseline monitoring period (BX22/0065 4 out of 14 samples, BX22/0067 7 out of 14 samples).

No positive detections for E.coli were recorded in the Sheffield Scheme monitoring bores during 2018-19.

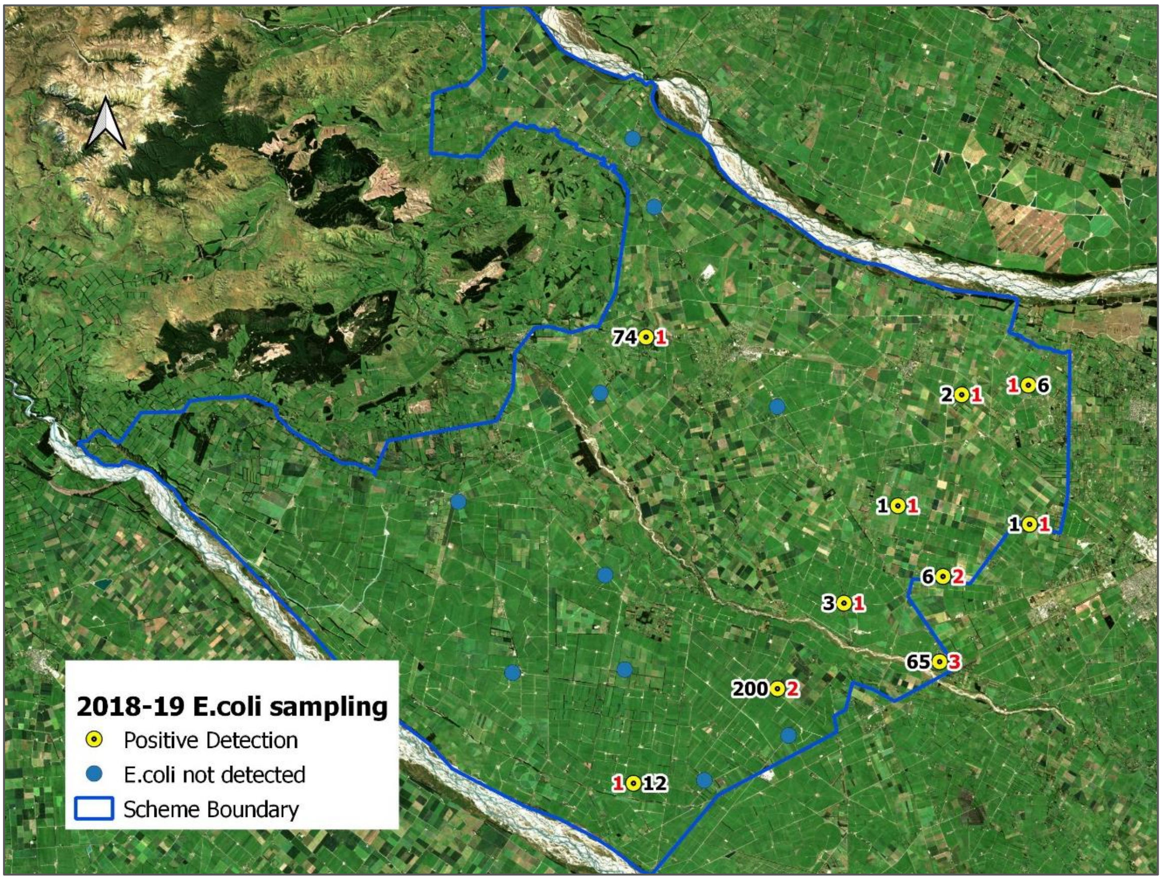

Figure 35. *Positive E.coli detections in CPW monitoring bores, 2018-19 (red numbers indicate number of positive detections (n=4), black numbers indicate maximum concentration).*

Where a positive *E.coli* detection was recorded in the CPW monitoring an assessment was undertaken to identify potential causes. This assessment considered factors such as climate (rainfall) preceding sample collection, land use (stocking) in the vicinity of the bore, irrigation activities as well as the general condition of land surrounding the bore at the time of sampling. The assessment also considered potential water quality risks for nearby bores used for potable or farm supply. While some positive *E.coli* detections correlated with rainfall events and/or land use activities, no obvious cause was identified for a majority of the *E.coli* detections observed.

It is noted that the rate of positive E.coli detections across the CPW groundwater monitoring network in 2017-18 (17.5% of samples) is similar to that observed during previous years (20% 2017-18 and 19% 2016-17). Overall detection rates for indicator bacterial across the CPW monitoring network are similar to those reported for ECan's annual regional groundwater surveys from 2009 to 2018 (3.7% to 14% of bores sampled), particularly given the construction of the monitoring bores and sampling methodology utilised (i.e., long-screen bores with samples collected from immediately below the water table).

No clear relationships were observed between surrounding land use or rainfall events and positive detections of indicator bacteria in CPW monitoring bores, although the relatively high frequency of detection may in part relate to the sampling methodology used (i.e., samples collected from the top of the water table in long-screen monitoring bores), particularly in shallower monitoring bores along the eastern (down-gradient) boundary of the Scheme.

4.4.4. Groundwater Levels

Increased irrigation of alpine-sourced water and decreased abstraction of groundwater has the potential to result in elevated groundwater levels in areas down-gradient of the CPW Scheme. While providing positive benefits in terms of discharge in spring-fed streams, elevated groundwater levels also have the potential to result in adverse effects on land drainage, particularly around the margins of Lake Ellesmere/Te Waihora.

GSWERP established triggers for (high) groundwater levels in 12 bores located down-gradient of the Scheme which are currently monitored either automatically, or on a regular (monthly) basis, by ECan. These monitoring sites, shown in Figure 36 below, were selected on the basis of having a long historical record (>40 years) to account temporal changes in groundwater levels associated with natural climate variability. Triggers for high groundwater levels were established at the 95th percentile of the historical record for individual monitoring sites.

Although groundwater levels remained above the long-term median, only a single lowland groundwater level trigger exceedance was recorded during the 2018-19 year. This compares to 16 trigger level exceedances recorded at 5 sites during the 2017-18 year (reflecting the significantly above average rainfall during 2017). Figure 37 shows groundwater level variations at two representative monitoring sites (M36/0250 and M36/7880) between 2014 and 2019.

CPWL did not receive any complaints concerning elevated groundwater levels or adverse impacts on land drainage or on-site wastewater systems in the Lowland Plains area during the 2018-19 year.

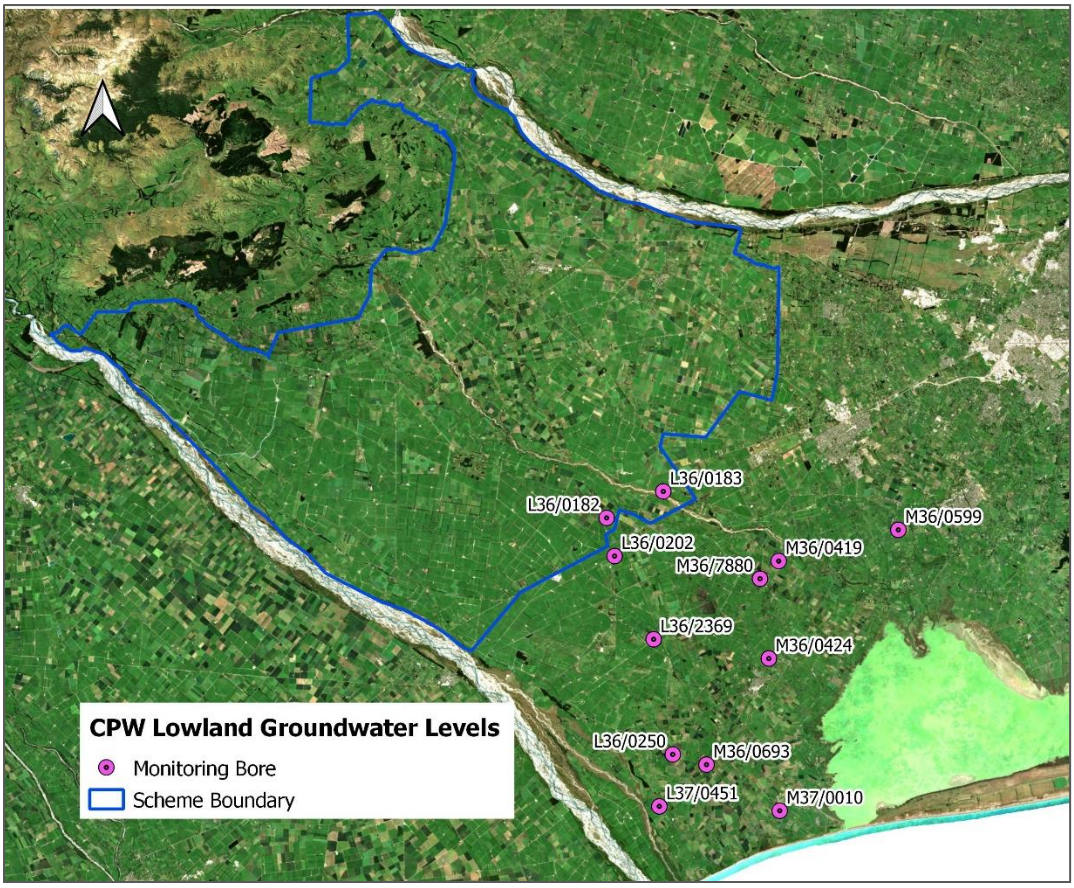

Figure 36. *CPW lowland groundwater level monitoring sites*

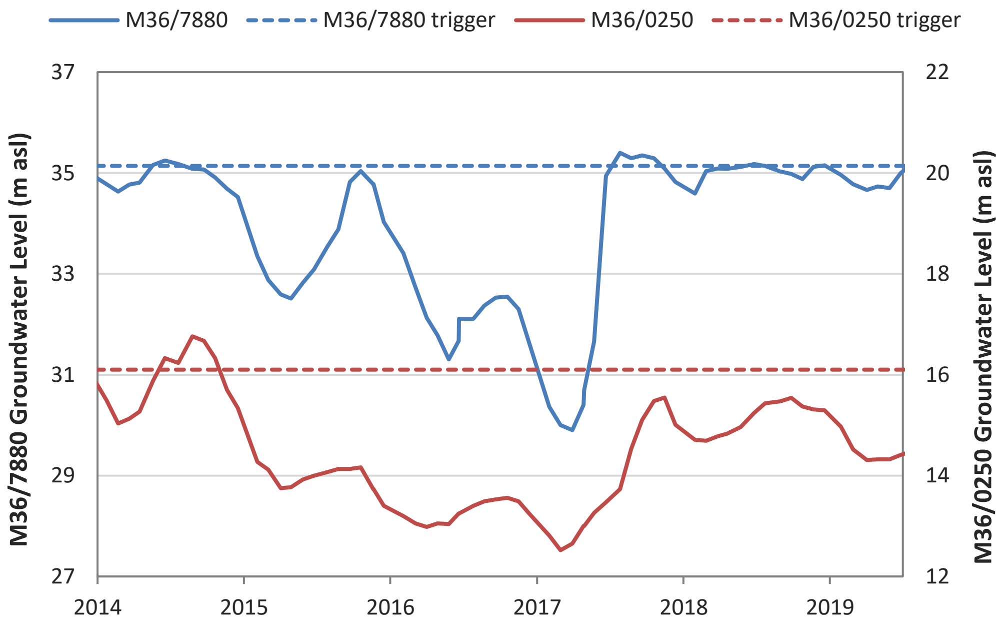

Figure 37. *Groundwater levels (and respective triggers) recorded in M36/0250 and M36/7880, 2014 to 2019*

4.4.5. Summary

Water quality monitoring results recorded in the CPW monitoring network during the 2018-19 year indicate surface water quality, groundwater quality and lake water quality exceeded trigger levels established in Part II of the CPW GSWMP[11] at a number of monitoring sites located both in Stage 1 and the Sheffield and Stage 2 areas of the scheme. Although trigger level exceedances were recorded, monitoring results show groundwater, surface water and lake water quality during 2018-19 was either within the historical (i.e., pre-CPW) range or consistent with long-term trends in baseline water quality. Monitoring results (particularly in terms of groundwater levels and quality) were also influenced by inter-annual variations in rainfall, particularly the significantly above average rainfall recorded during the 2017-18 year while surface water quality monitoring results reflect shorter-term (in-season) rainfall variation.

The *Annual Ground and Surface Water Monitoring Report 2017/18* produced by CPW was approved by the GSWERP in November 2018 as providing a valid interpretation of monitoring results for the 2017-18 year. The report also notes that there were no complaints related to surface water quality, groundwater quality, land drainage or effects on on-site wastewater discharges received by CPW during the 2017-18 year.

4.5. Environmental Mitigation and Enhancement

4.5.1. Environmental Management Funds

In addition to an extensive environmental monitoring programme, part of the mitigation package offered by CPW during the resource consent process involved the establishment of funding for three environmental initiatives:

- The CPWL Environmental Management Fund (EMF)
- Te Waihora Environmental Management Fund (TWEMF); and
- Te Waihora Lake Opening.

The EMF and TWEMF were established during the 2015-16 irrigation season. Contributions to these funds are provided by Scheme shareholders. Due to the staged nature of Scheme development, annual contributions to these funds increased as the area under irrigation increased, with full contribution to the fund (from all three stages) commencing during the 2018-19 year. The fully operational Scheme generates approximately $115,000 annually for the EMF to allocate.

An independent Environmental Management Fund Committee (EMFC) is responsible for managing and allocating distributions from the EMF to environmental initiatives within the Selwyn Waihora catchment. In contrast, the TWEMF fund is provided directly to Ngai Tahu who manage allocation and annual reporting of fund expenditure. To date funding for the TWEMF is held in trust while details and priorities for initiatives associated with the restoration of health/mauri of the environment in the vicinity of Lake Ellesmere/Te Waihora are being determined by iwi.

The primary focus of the EMF is the enhancement of biodiversity across the Selwyn/Waihora catchment. To date funding has been provided for the planting of native species (17%), development

[11] These trigger levels are consistent with equivalent environmental limits established in the LWRP

of wetlands (18%) and research (3%). Since its formation, the EMF has allocated approximately $400,000 of funding to groups and individuals within the Selwyn Te Waihora catchment for environmental enhancement projects. One of the regular recipients of the Fund, Te Ara Kakariki Greenway Canterbury Trust (TAK), have used CPW-sourced funding for their annual Spring plant out days, funding landowner initiatives, school education and maintenance of established sites enrolled in their successful Greendot Programme. The EMFC have elected to continue their ongoing support for TAK as the organisation is now seen as one of the key promoters for biodiversity and narrowing the divide between urban and rural communities, along with the huge success of their work to date.

Figure 38 shows the location of sites in the Selwyn Waihora catchment where EMF funding was utilised to support environmental enhancement and biodiversity projects during the 2018-19 year.

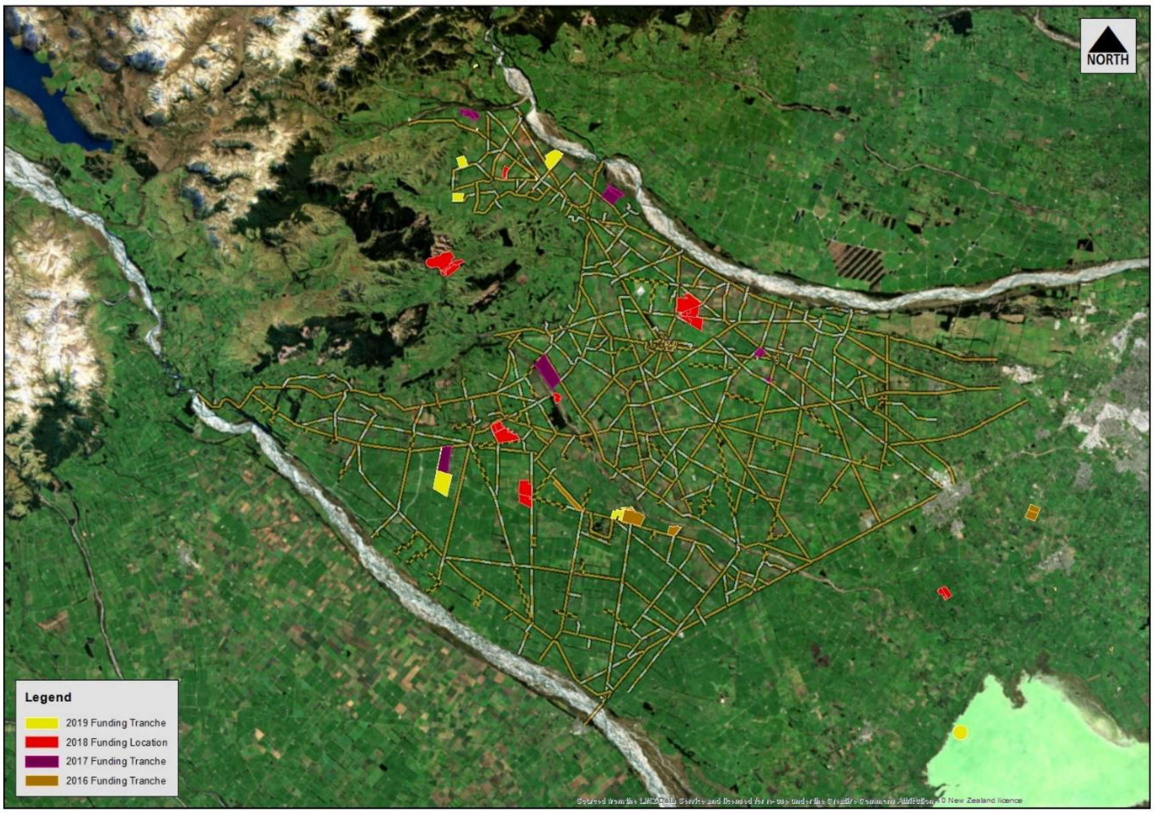

Figure 38. *Location of sites where CPW Environment Management Funds were utilised to support environmental enhancement and biodiversity projects 2015-16 to 2018-19 year.*

CPW also undertakes a range of other environmental initiatives across the scheme area. During the 2018-19 year such initiatives have included:

- Planting at the Sheffield Scheme intake and storage pond;
- Riparian plantings at the Hororata River crossing
- Donations to the Darfield School Social Studies Plant Day Out;
- Establishing, maintaining and monitoring the Stage 1 and Stage 2 lizard habitat areas;

- Applying to the Billion Tree fund on behalf of shareholders
- Providing hi-visibility vests to a local country school.
- Working with ECan to develop an aquifer recharge project.

4.5.2. Targeted Stream Augmentation

A targeted stream augmentation project is being developed by CPW in conjunction with ECan to utilise ‘spare’ CPW water to augment natural flows in the Selwyn River in a manner that provides significant environmental benefits to the river system, while respecting cultural values associated with the mixing of waters.

During the 2016-17 season CPW signed an agreement with ECan to make provision in the CPW Stage 2 infrastructure for a discharge point that will enable up to 3.5 cumecs of water to be released into the Selwyn River at times when the water is not required for irrigation, particularly during shoulder periods of the irrigation season. Infrastructure, including an energy dissipater, wetland soakage area and control system was constructed as part of the Stage 2 development. Final agreements regarding the operation of the scheme are being worked through and it is anticipated that the scheme will commence operation in the near future.

5. Summary

The final stage of the CPW Scheme (Stage 2) commenced operations in October 2018. This development extended coverage of the Scheme to a total irrigable area of approximately 47,500 Ha.

During the 2018-19 year the Scheme delivered a total of 103.8 million m^3 of water to a total of 261 properties. This total comprised 63.6 million m^3 of water taken directly from the Rakaia and Waimakariri Rivers, with the balance (40.2 million m^3) derived from water storage. Properties in the CPW Scheme also utilised 35.2 million m^3 of groundwater (equivalent to 17% of the total volume authorised by existing resource consents). The average seasonal irrigation application rate (CPW Scheme water and groundwater) across the Scheme area was 2,930 m^3/ha (equivalent to a seasonal application depth of 293 mm), comprising 740 m^3/ha of groundwater and 2,190 m^3/ha of CPW water.

Rainfall across the Central Plains area was below average from July to September 2018, significantly above average from October to December and generally average to below average for the remainder of the year. The above average rainfall and soil moisture during late spring/early summer 2018 significantly reduced irrigation requirements during a period when demand is typically near maximum. Reflecting this reduced mid-season demand, total water use for Stage 1 was the lowest since operations commenced in the 2015-16 season. Water use in the Stage 2 and Sheffield Scheme areas during 2018-19 are also likely to be well below the longer-term average.

Water quality monitoring results recorded for the CPW monitoring programme during the 2018-19 year indicate surface water quality, groundwater quality and lake water quality exceeded trigger levels established for the Scheme at a number of monitoring sites located both in Stage 1 and Stage 2 areas, as well as down-gradient of the Scheme. The recorded trigger level exceedances are consistent with the historical range and/or background trends observed prior to commencement of CPW operations. No obvious effects on water quality, groundwater levels or surface water flows attributable to operation of the Scheme were observed during the 2018-19 year