



LINDIS CATCHMENT AND BENDIGO-TARRAS BASIN

**Information sheet
April 2014**

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BACKGROUND

Location

Located east of Wanaka and Luggate, north of Cromwell, west of St Bathans and Omarama, the Lindis catchment includes the areas of Ardgor, Tarras, Lindis Valley and the Lindis Pass. The catchment covers an area of 1,059 km² and is bounded in the north by Breast Hill, Little Breast Hill and Mt Melina, in the east by Dromedary Hill, Old Man Peak and Chain Hills, in the south by the Dunstan Mountains and in the west by the Clutha River/Mata-Au, Trig Hill and Grandview Mountain.

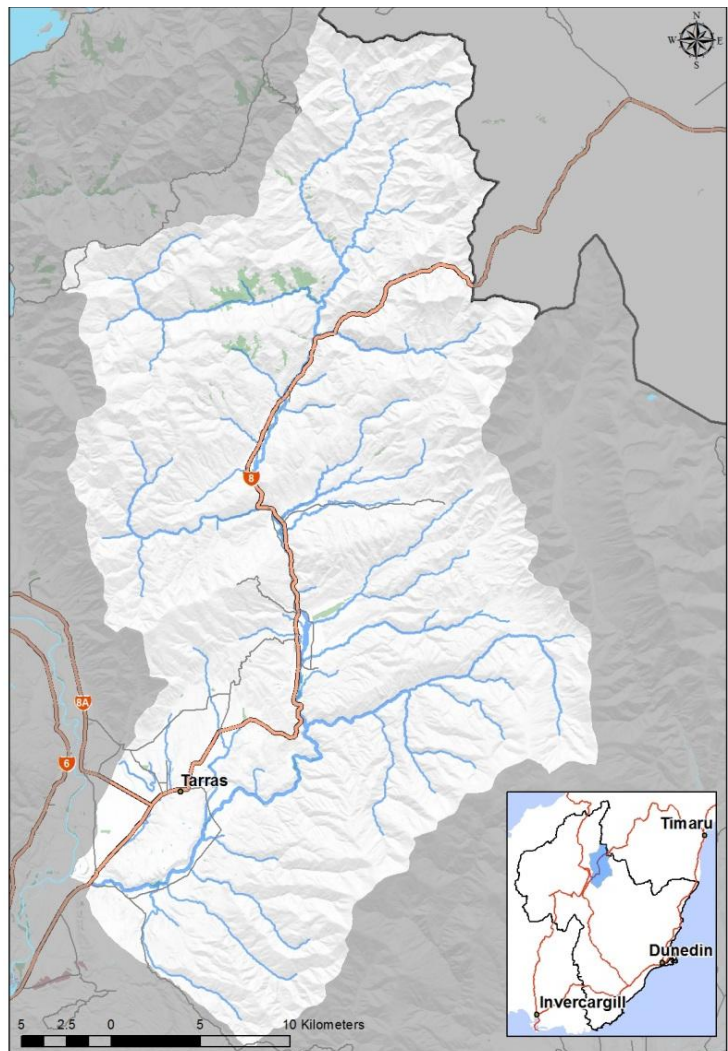


Figure 1. The Lindis catchment

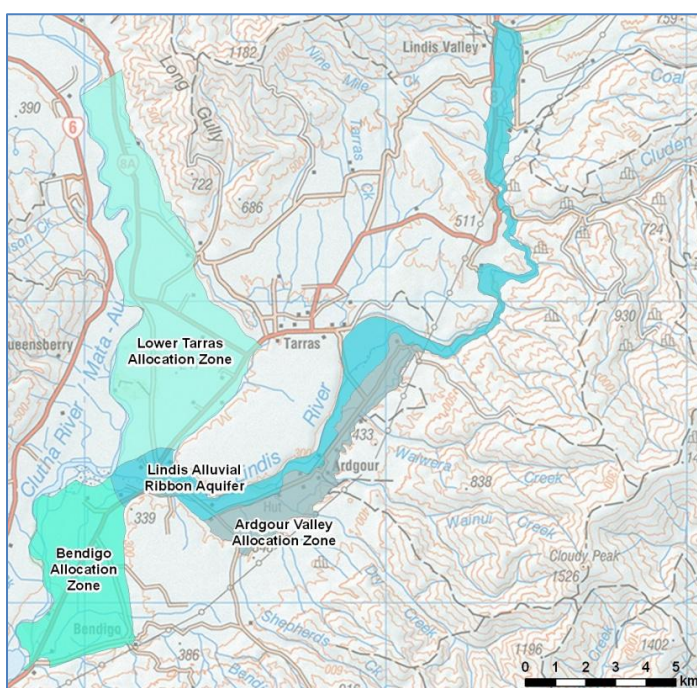


Figure 2. Sub-aquifers of the Bendigo-Tarras basin

The catchment's main water body, the Lindis River, flows 55 km in a south-westerly direction into the Clutha River/Mata-Au, about 6 km upstream of Lake Dunstan. Major tributaries of the Lindis River include Camp Creek, Cluden Stream and Breast Creek.

The catchment consists of a steep river valley, ranging in elevation from 220 m above sea level at the Clutha River/Mata-Au confluence, to 1,925 m at Mount Melina, in its higher reaches.

The lower Lindis catchment overlaps with part of the Bendigo-Tarras basin, a complex groundwater system that is strongly integrated with the flows in the Clutha River/Mata-Au and the Lindis River. The Bendigo-Tarras basin comprises various sub-aquifers, each of which is characterised by distinct hydraulic properties (Figure 2).

Topography, geology and soils

The topography of the Lindis catchment varies from river flats in the lower reaches to gently undulating and strongly rolling hinterland, further up the catchment. The catchment is characterised by its smaller scale to Central Otago's standard pattern of large-scale basin and range topography. The old erosion surface is warped into a set of north-east-trending folds, with elements of the overlying Manuherikia Group sediments. Haast Schist underlies most of the region and is often exposed as tors (rocky outcrops).

Soils throughout the Lindis catchment are sandy and loam-based, with areas of low to moderate fertility. Soil types range from brown-grey earths in the driest zone (less than 500 mm of rainfall) and yellow-grey earths in the lower mountain slopes, to high-country yellow/brown earths above 700 m. Increasing elevation is also associated with decreasing fertility, increasing acidity and leaching. The valley floors contain some areas of recent soils on the alluvium of flood plains and fans.

Morven Hills' pastoral lease, largely encompassed by the Lindis catchment, contains two soil sites of regional importance (Chain Hills and Double Peak) and two of national importance (Dip Creek Beech and Dip Creek Totara).

Climate and rainfall

The headwaters of the Lindis River receive large amounts of rain and snow (800-1500 mm per year) during winter and spring. In contrast, the lower Lindis catchment is one of the driest areas in New Zealand, with low rainfall combined with high temperatures throughout summer. The Tarras rainfall site recorded an average of around 500 mm per year, with the minimum being about 300 mm per year. Figure 3 illustrates the modelled rainfall patterns for the catchment.

Monthly rainfall averages calculated from three local rainfall sites show that although averages differ between sites, the overall monthly rainfall trends are similar: the periods of highest average rainfall occur in the months of May and December, while the periods of lowest rainfall generally occur in February and June-July. The catchment is known for its extremely dry periods, with at least five extreme low-flow events recorded since the collection of records began in 1976 (Figure 4).

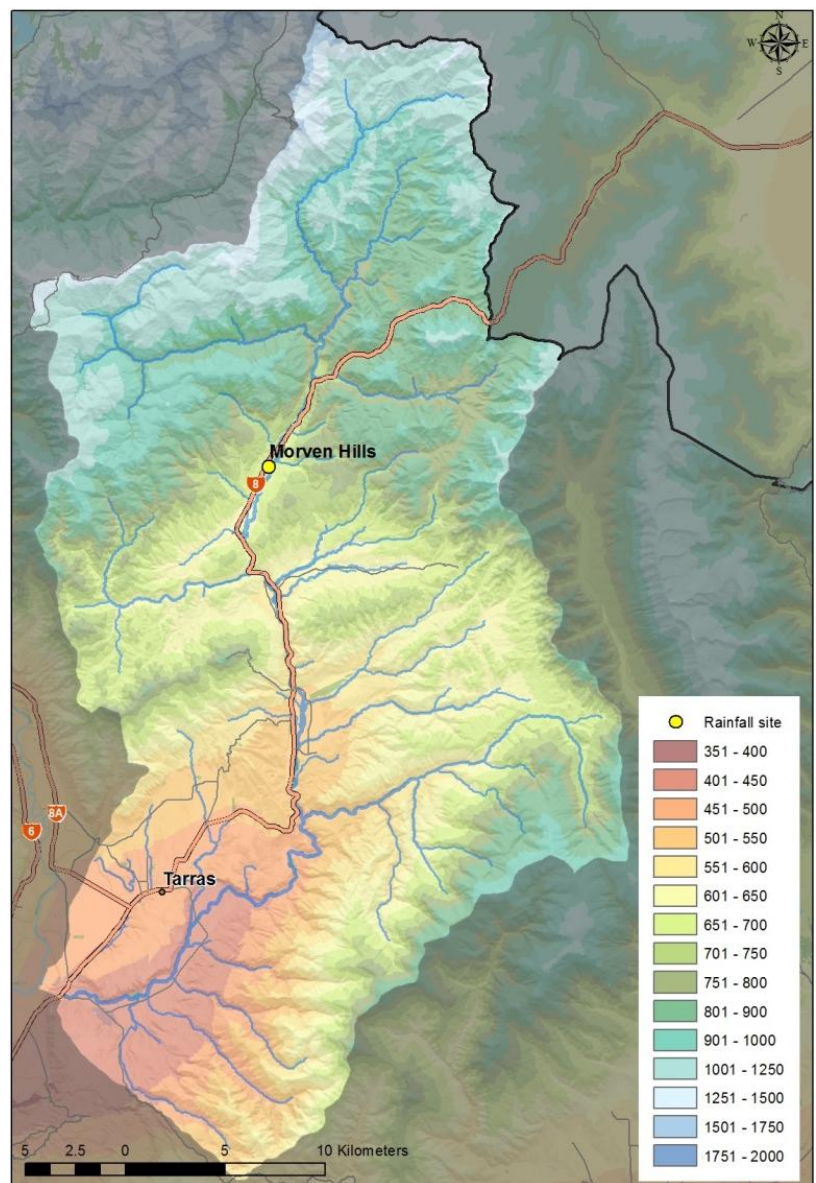


Figure 3. Modelled rainfall in the Lindis catchment

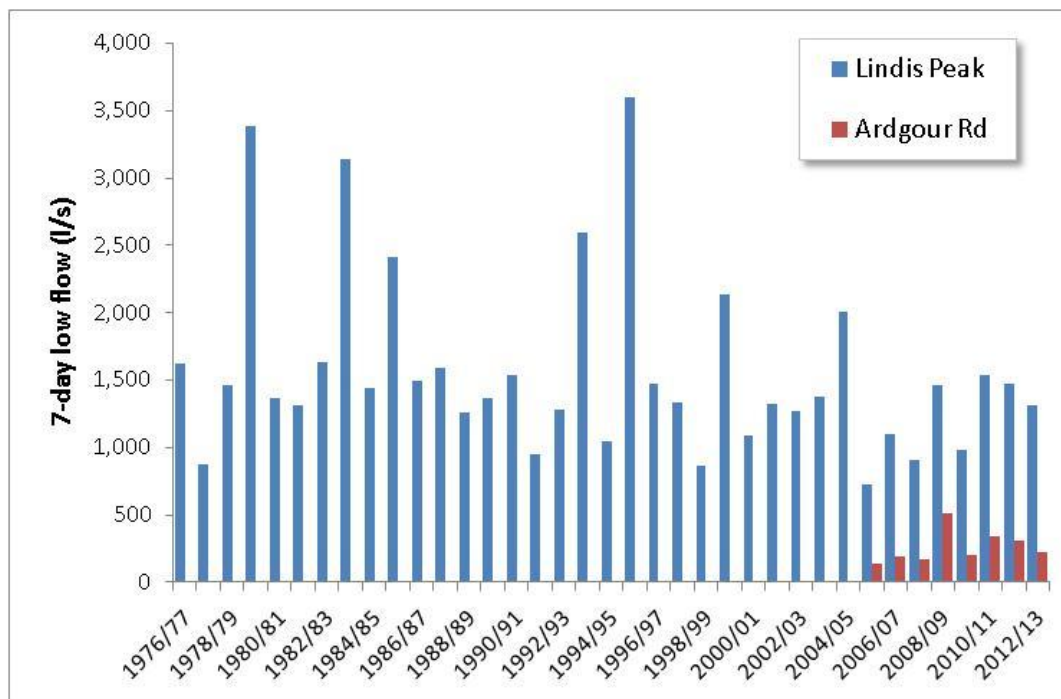


Figure 4. Low-flow patterns in the upper (Lindis Peak) and lower (Ardgour Road) Lindis River

Land uses

With its dry climate and low availability of water, the Lindis catchment has traditionally been dominated by pastoral farming, particularly sheep (including merino wool) and beef farming. Within the area are a number of past and present Crown pastoral leases, including Morven Hills, Cluden, Cloudy Peak, Ardgour, the Lindis group (Shirlmar, Geordie Hills, Nine Mile, Merivale, Longacre and Timburn), Deep Creek, Bargour, Forest Range, Rostrieve, Breast Hill, Lake Hawea and Dalrachney Station.

More recently, the lower catchment and the Tarras and Bendigo areas have witnessed an increase in the number of life-style blocks and dairy-support operations. Deer farming and viticulture are also prominent, with more than 14 wineries located within the area. Other land uses include crop farming and horticulture (e.g. flowers and vegetables).

SURFACE AND GROUNDWATER HYDROLOGY

Hydrology and river-flow data of the Lindis River

The Otago Regional Council (ORC) has collected continuous hydrological information on the Lindis River from the Lindis Peak flow recorder since the mid-1970s. In 2005, a second flow recorder was installed at Ardgour Road. A summary of flow statistics for these sites is given in Table 1.

Table 1. Flow statistics for the Lindis River at the Lindis Peak and Ardgour monitoring sites

Monitoring site	Catchment size (km ²)	Min recorded flow (l/s)	Mean recorded flow (l/s)	Mean annual low flow (l/s)
Ardgour Road ¹	1045	51	5,351	1,560
Lindis Peak ²	542	633	6,181	259

Flows in the Lindis River are generally high during spring, due to rainfall and snowmelt, but are greatly reduced during summer. During the non-irrigation season (May-September), flow patterns at the Lindis

¹ Term of record: 7 years

² Term of record: 36 years

Peak and Ardgour Road flow-monitoring sites are similar, with typically higher flows occurring at Ardgour Road. During the irrigation season, taking water from the river significantly affects its flow in the middle and lower catchment.

Figure 5 compares the flows at Lindis Peak (upstream of most surface water takes) and at Ardgour Road (downstream of most surface water takes) and shows the effects of taking on the river. Although the red line (the Ardgour Road flow) is above the blue line (the Lindis Peak flow) throughout winter and spring, during summer, flows at Ardgour Rd are well below those at Lindis Peak and can drop below 100 l/s in a dry year.

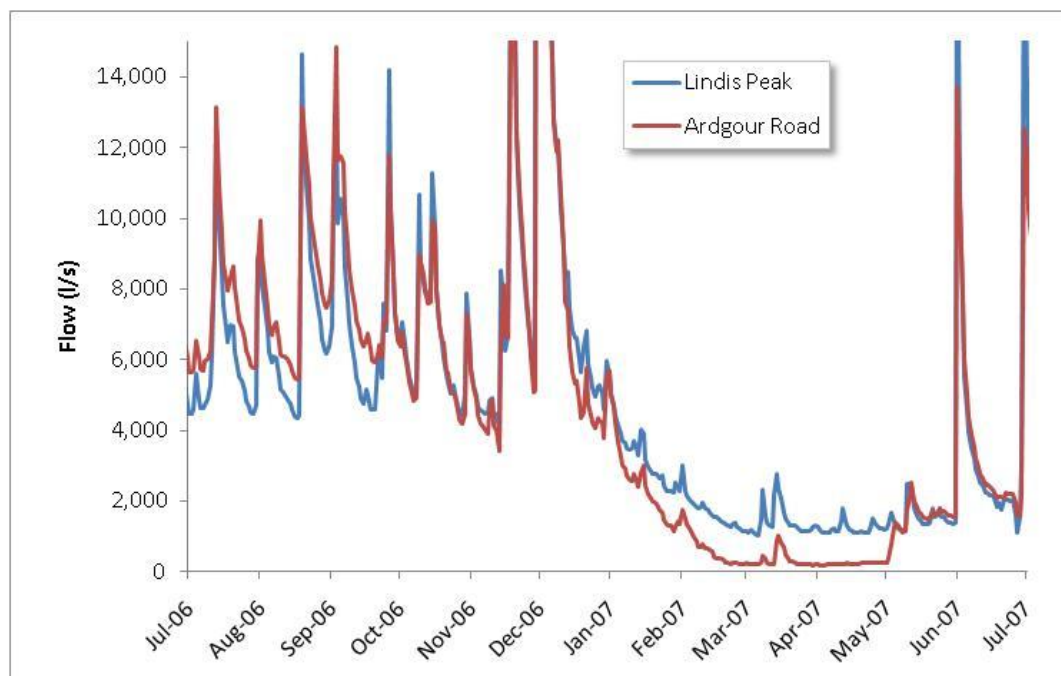


Figure 5. Comparison of the flows at Lindis Peak (upper catchment) and Ardgour Road (lower catchment)

Due to extensive water taking throughout the middle reaches, the Lindis can run dry for up to 10 km upstream of the Ardgour Road flow recorder, as well as in the 3 km between the flow recorder and the confluence with the Clutha River/Mata-Au. Since flow records began in 1976, there has not been an occasion when the Lindis River would have run dry naturally. The lowest recorded summer flow of 635 l/s occurring in February 2006 would still have maintained flows if taking had not occurred.

Groundwater hydrology and interaction with surface flows

Land-surface recharge (rainfall), irrigation returns and surface water contribute to the recharge of aquifers in the Bendigo-Tarras basin. Land-surface recharge occurs sporadically and requires large rainfall events to saturate soils and to create the potential for aquifer recharge. In the summer months, irrigated land contributes significantly more recharge than non-irrigated land, due to irrigated soils having a lower initial moisture deficit when rainfall occurs.

The Clutha River/Mata-Au is the dominant source of recharge in the lower Tarras and the Bendigo allocation zones. The Lindis alluvial ribbon aquifer and the Ardgour Valley groundwater zone receive most of their recharge from the Lindis River. However, at times the aquifer may also lose water back into the Lindis River.

During spring and early summer, the Lindis River between the Ardgour Road monitoring site and Lindis Crossing, is generally a gaining reach as groundwater levels are higher than the river level (Figure 6:A). In summer, when groundwater levels begin to drop, due to lower recharge and increased taking of groundwater, this reach begins to lose water to the aquifer (Figure 6:B). As the groundwater levels in the lower Lindis catchment continue to decline over the irrigation season, this reach becomes disconnected from the aquifer (Figure 6:C).

Between Lindis Crossing and the Clutha River/Mata-Au, the Lindis River is generally either a connected or disconnected losing reach and is unlikely to gain groundwater at any time.

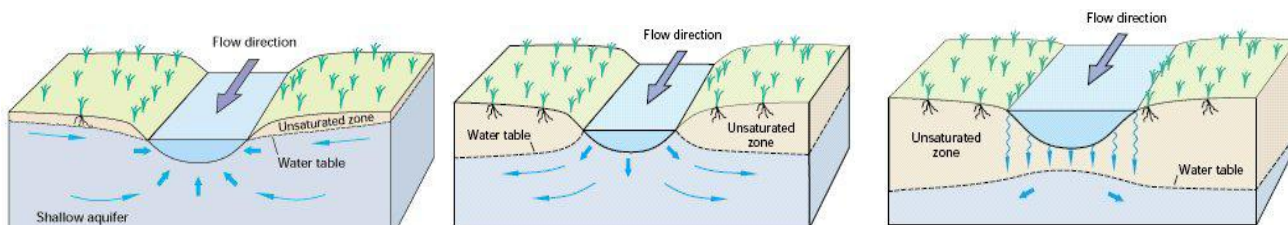


Figure 6. (from left to right): Gaining reach (A) connected losing reach (B) disconnected losing reach (C) (Winter et al., 1998)

Monitoring of the lower Lindis River indicates that at low-stable flows, a loss of about 0.44 m³/s to groundwater in the Lindis alluvial ribbon aquifer occurs between Ardgour Road and the Clutha River/Mata-Au confluence. Flow losses tend to be more variable downstream of Lindis Crossing under moderate flows, due to the broad channel morphology.

Based on a flow loss of 0.44 m³/s between Ardgour Road and the Clutha River/Mata-Au confluence, it is very likely that, without taking, the Lindis River would typically flow the entire way to the Clutha.

Flooding

Flooding occurs in various locations along the length of the river. Mostly it is observed between Morven Hills and Black Bridge, on Goodger Flat and the flats below Elliots Bridge and, further downstream, near Ardgour Road Bridge. In recent decades, flood flows have been experienced in 1983, 1987, 1995, 1999 and 2009.

The Lindis catchment is also subject to thunder plumps. These are short but violent downpours of rain in connection with thunderstorms that usually occur in the early evening and tend to cause extreme damage.

Bank erosion occurs along the entire length of the Lindis River, while fence damage and stock losses during flooding events have also been considerable. One of the main problems associated with flooding in the area is the isolation of private properties and communities due to the inundation of roads or damage to transport infrastructure. Flood mitigation works, such as willow clearing, shoal removal, protection planting and the construction of minor flood banks, have been undertaken in various locations along the river.

NATURAL VALUES AND CATCHMENT ECOLOGY

The Lindis River and its tributaries support a rich ecosystem that provides habitat for a range of native plants and animals. The Lindis River is recognised in Schedule 1A of the Regional Plan: Water for Otago (Water Plan) for its value as a habitat for trout, trout spawning and juvenile retention, its gravel-bed composition and for being free of aquatic weeds, although its lower reaches are now infected with *Didymosphenia geminata* (didymo).

Water quality

Water quality in the Lindis River is monitored at the Lindis Peak and Ardgour Road flow-monitoring sites. The water quality at Lindis Peak is classified as 'excellent', meaning that the river meets all water-quality limits introduced by Plan Change 6A (Water Quality), while the water quality at Ardgour Road is classified as 'good', because it meets all limits except nitrate-nitrate nitrogen. Notable trends in the water quality of the Lindis River (2006-2011) are an increase in total nitrogen and a decrease in total phosphorus in the lower Lindis (Ardgour Road). There has been no significant change in water quality parameters at the Lindis Peak monitoring site over this period.

In the summer of 2011/12, the Ardgour Road monitoring site had a Macroinvertebrate Community Index (MCI) score of 109, which is an indication of 'good' water quality.³

³ The MCI categories are: poor: less than 80; fair: 80–99; good: 100–119; excellent: greater than 119

Fish

The middle and upper reaches of the Lindis River support a locally important brown trout fishery. The river is also the major spawning tributary for the regionally and nationally recognised upper Clutha and Lake Dunstan fisheries.



Figure 7. Fish kill in the lower Lindis River

Native fish species present in the Lindis River and its tributaries include: Clutha flathead galaxias, the common bully, the upland bully, koaro and longfin eel. Of these species, the Clutha flathead galaxias is listed as 'nationally vulnerable', and the koaro and longfin eel are listed as 'in decline'.

An important aspect of the current hydrology of the lower Lindis River is the sudden reduction in surface flows once irrigation begins in the middle reaches. This event has led to annual fish kills such as those observed in February 2008 (Figure 7).

It is likely that the dewatering and subsequent fish kills observed in 2008 have occurred consistently in the lower Lindis River downstream of Lindis Crossing since the time when large surface water takes started to have an impact on the catchment hydrology.

Flora

The vegetation of the Lindis catchment comprises higher-altitude snow tussock, developed mid-altitude short-tussock grasslands, communities of lower-altitude scabweed and high-producing exotic grasslands on the alluvial flats. In the Morven Hills area, the hill-slopes are dominated by exotic grass species, with fescue tussock becoming common as altitude increases. The gullies and some hill-faces contain shrublands, where sweet briar is prominent.

Notable vegetation includes the 'nationally endangered' sedge, *Carex inopinata* and the wetland herb, *Triglochin palustris*, also nationally endangered. The 'nationally critical' forget-me-not, *Myosotis cheesemaniae*, the climbing broom, *Carmichaelia kirkii*, and the dwarf broom, *Carmichaelia vexillata*, in 'serious decline', are found in the Cluden Station area. Within the Lake Hawea pastoral lease, there are also two populations of the 'nationally vulnerable' shrub, *Hebe cupressoides*, and two populations of the tree daisy, *Olearia fimbriata*, in 'serious decline'.

Invertebrates

The Lindis catchment contains a diverse invertebrate community, dominated by mayfly, stonefly and caddisfly, as well as pollution-tolerant taxa such as midges and worms.

The rare moth, *Pseudocoremia n.sp.* "Olearia", which is in 'serious decline', can be found in the Morven Hills area, while the 'nationally endangered' moth, *Asaphodes stinaria*, is present in the Cluden area.

Reptiles

Otago skinks ('nationally critical') have been observed at several sites: Trig. P Dip Creek, lower Farmers Gully, Upper Farmers Gully, Hogget Block and G-Mars, near Deep Creek; Glenfoyle and Sandy Point. Grand skinks ('nationally critical') have also been observed on the Forest Range and Rostreiver properties and the Lake Hawea pastoral lease.

Other reptiles present in the catchment include McCann's skinks, common skinks, cryptic skinks, Southern Alps geckos, common geckos, Cromwell Gorge geckos and Roys Peak geckos.

Birds

A variety of birds have been identified in the catchment, including: rifleman (titipounamu), grey warbler (riroriro), fantail (piwakawaka), New Zealand falcon (karearea), paradise shelducks (putangitangi), black shag (kawau), harrier hawk (kahu), pipit (pihoihoi), black-backed gull (karoro), silvereye (tauhou), South Island pied oystercatcher (torea), spur-wing plover, welcome swallow, sparrow, blackbird, quail, chaffinch, yellowhammer, California quail, starling, magpie and chukor.

Two bird species are of particular significance: wild emus and the eastern New Zealand falcon. Emus have been spotted with their young in the area, which may be the first instance of this species breeding in the wild in New Zealand. The New Zealand falcon ('gradual decline') has been observed in the Morven Hills area.

COMMERCIAL, SOCIAL AND CULTURAL VALUES

Economic/commercial values

Various economic activities in the Lindis catchment rely on the availability of water resources or the physical and aesthetic qualities of the Lindis River.

Farms and wineries make a significant contribution to the regional economy through on-farm employment and by supporting associated industries such as agricultural contractors and primary-processing industries. Reliance of the local primary sector on water for irrigation, frost fighting and stock water is important. Without a reliable supply of water, the economic viability of the agricultural industry in the Lindis would languish and become vulnerable to drought events. In pursuit of greater surety of supply, an increasing number of irrigators are now switching from run-of-the-river water takes to groundwater takes.

The growth of Central Otago as a holiday destination has also stimulated the local tourism industry. The scenic Lindis Pass route (State Highway 8), which follows the Lindis River for a considerable distance, is now a popular tourist route linking the Mackenzie basin with Central Otago and the Lakes region. The route brings many people to the Lindis area, boosting local retail, food outlets, accommodation and recreational providers.

Iwi values

Water occupies a significant role in the spiritual beliefs and cultural traditions of Kāi Tahu, and the health of water bodies and the condition of water is of particular consideration.

The Lindis Pass was particularly important as a trail (sites and water bodies that formed part of traditional routes, including tauraka waka (landing place for canoes)) from North Otago and South Canterbury to the Southern Lakes region for mahika kai (food gathering) and pounamu (greenstone). The usual route is noted as following Longslip Creek from the Ahuriri River, down the Pass Burn to the Lindis River and then over Mount Grandview to Lake Hawea.

Schedule 1D of the Water Plan identifies the spiritual or cultural beliefs, values or uses associated with water bodies of significance to Kāi Tahu. As well as its significance as part of the trail, the Lindis catchment is also important for its wāhi taoka (treasured resources that are valued and reinforce the special relationship Kāi Tahu have with Otago's water resources) and cultural materials (sources of traditional weaving materials (such as raupo and paru) and medicines (rongoa)).

Historic value

The Lindis area was the site of the first gold rush in Otago when gold was found in the Lindis River in 1857. Road builders rediscovered gold in 1861, and about 300 gold-miners flocked to the area. Although the remoteness of the area, the cost of supplies and the opening of more lucrative fields (such as Gabriel's Gully, near Lawrence) meant most miners left the district a few months later, a number of historic sites, buildings and artefacts remain today throughout the catchment as testimony to the area's mining heritage.

The Lindis Pass is also the site of the release of the first red deer (*Cervus elaphus scoticus*) in Otago. The herd flourished due to a lack of predators and competition. These deer, now the only remaining pure British red deer in the world, are widespread, but are under threat from interbreeding with escapee farm deer.

Various heritage sites are scheduled in the Central Otago District Plan, including the historic buildings in Morven Hills, the Cob Stables at Rocky Point, the ruins of the Lindis Pass Hotel, originally constructed in 1873, and the 1,085 ha. Bendigo Historic Reserve, with its wide range of relics from the hard-rock and quartz mining days. There are also many unscheduled, yet identified, historic sites, most of which are protected under the Historic Places Act 1993.

Recreational value

Important recreational uses of the catchment include trout angling, eeling, hunting, motorcycling, four-wheel driving, swimming, horse riding, kayaking, tramping, picnicking, camping, mountain biking and walking.

An angler survey undertaken in 2007/08 (Unwin, April 2009) showed that the number of anglers in the Lindis, between October and January, increased from 150 in the 2001/02 season to 330 in the 2007/08 season. During the same period, the number of anglers recorded fishing in Lake Dunstan increased from 19,480 (2001/02) to 26,140 (2007/08). These results show that fishing is continuing to grow in popularity and remains an important recreational pursuit within the region.

Lake Dunstan has been identified in the Water Programme of Action: Potential Water Bodies of National Importance for Recreation (July 2004) as a valuable water resource for recreation purposes, tourism and scenic value.

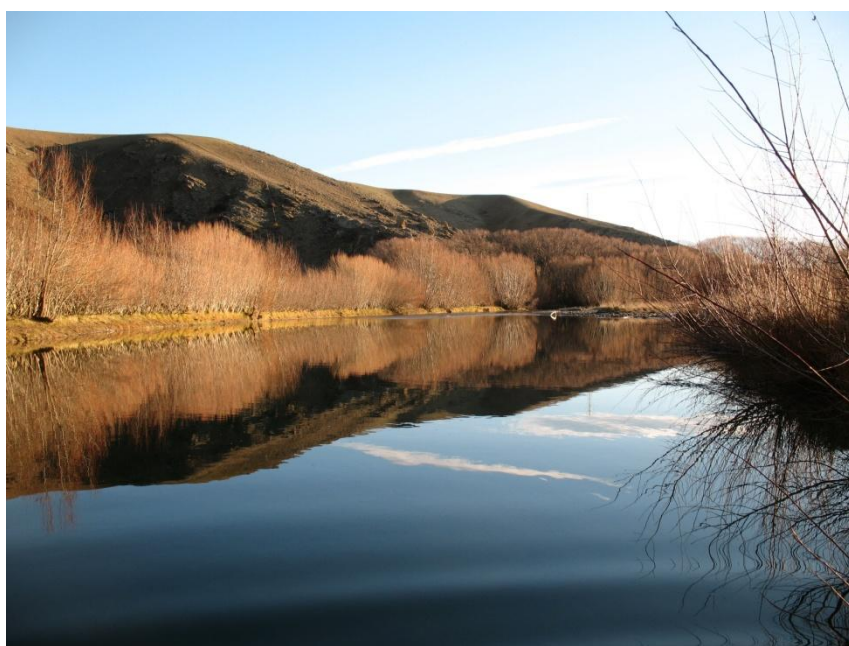


Figure 8. Lindis River in June 2008

Aesthetic value

The Lindis area is well known for its natural beauty, with the Lindis Pass, in particular, being recognised for its iconic, tussock-clad hills. The Water Plan recognises the scenic value of the Lindis Valley and lists the Lindis River in Schedule 1A as an area with a high degree of naturalness above 900 m.

The Department of Conservation's Lindis Pass Scenic Reserve, an area comprising 403 ha of sub-alpine snow tussock grassland, also covers part of the northern section of the catchment.

WATER TAKES WITHIN THE CATCHMENT

Permitted surface water takes

Under the Resource Management Act (RMA) and the Water Plan, water can be taken from the Lindis River and its tributaries for an individual's reasonable household/stock drinking water needs and for fire-fighting purposes. The setting of a minimum flow in the Lindis River will not directly affect these takes. The Water Plan also permits small water takes, subject to meeting the specified conditions. The ORC does not hold information on permitted water takes.

Consented surface water takes (and groundwater takes managed as surface water)

There are 31 surface water takes from the Lindis River and its tributaries as at January 2014. Of these, 19 are deemed permits (see next section), and of the remaining 12 consented surface water takes, eight are primary allocation and four are supplementary allocation takes.

Under the Water Plan, some groundwater takes are also managed as surface water. These include:

- takes from within the Lindis alluvial ribbon aquifer
- takes within 100 m of a connected perennial surface water body in the Lindis catchment
- takes more than 100 m from the Lindis River or its tributaries that affect surface water flows by more than 5 l/s.

Within the Lindis catchment, there are currently seven consented groundwater takes that are subject to the surface water allocation regime and any minimum flow.

Overall, the catchment is over-allocated with a consented instantaneous primary water take of 4,141.33 l/s. Community feedback has indicated that the actual take is about 2,300 l/s. No new primary allocation is available when the instantaneous take is greater than 50% of mean annual low flow (MALF), or a higher primary allocation limit is identified as part of the minimum flow plan change process. As 50% of MALF for the Lindis River has been determined to be 780 l/s, no new primary allocation is available.

Table 2 gives an overview of the consented surface water and connected groundwater takes in the Lindis catchment.

Deemed permits

Deemed permits (also known as 'mining privileges') were issued under very early mining legislation, including the Mining Act 1926, and allowed the taking, damming and discharging of water. As gold mining declined, this water was increasingly used for irrigation. The Crown acquired a number of the higher priority, significant mining privileges, which were used for irrigation schemes, and these were transferred to community irrigation groups.

In 1991, under the RMA, every mining privilege was deemed to become a water permit for the taking or damming of water on the same terms and conditions as the original mining privilege. Deemed permits expire on 1 October 2021 (RMA Section 413(3)). After this date, water permits will need to be sought if water is to be taken or dammed.

Consented groundwater takes

The Clutha River terraces on either side of the Clutha and the Bendigo-Tarras basin are becoming increasingly used for irrigated pasture and grape vines. In particular, the groundwater resources in the lower Tarras and Bendigo allocation zones now provide an alternative and reliable source of water supply for irrigators in the lower Lindis catchment.

There are currently more than 40 consented groundwater takes within the Bendigo-Tarras basin. Most of these takes are located within the lower Tarras and the Bendigo allocation zones. Table 3 provides an overview of the consented groundwater takes (excluding groundwater takes allocated as surface water) in these zones.

Table 2. Consented water takes within the Lindis catchment (as at January 2014)

Water take	Number of consents	Combined monthly volume (m ³)	Combined instantaneous take rate (l/s)	Purpose	Water source
Primary surface water permit ⁴	8	548,937	298.2	Irrigation, stock water, domestic and communal supply, storage, frost fighting	Lindis River, unnamed tributary, unnamed springs
Deemed permits (managed as primary allocation)	19	8,867,765	3,608.3	Irrigation, stock water, domestic supply, wine making	Lindis River, Cluden Stream, Eight Mile Creek, Little Rocky Hill Creek, Long Spur Creek, McKenzie Creek, Nine Mile Creek, Shepherds Creek, Station Creek, Timburn, Wainui Creek and Waiwera Creek
Groundwater permits (managed as primary allocation)	7	562,793	234.83	Communal supply, irrigation	Lindis alluvial ribbon aquifer, Ardgour Valley allocation zone
Total primary permits	34	9,979,495	4,141.33		
Supplementary surface-water permits	4	373,918	185	Irrigation, stock water, communal supply, storage, frost fighting	Lindis River, Cluden Swamp, Dry Creek, Deep Creek

New groundwater allocation is available as long as the combined yearly volume of take is less than 50% of the aquifers' mean annual recharge (MAR), or a tailored allocation limit is identified as part of a plan change process. As 50% of MAR for the lower Tarras and Bendigo allocation zones is estimated to be around 18 Mm³/yr and 28 Mm³/yr respectively, further allocation remains available.

Table 3. Consented groundwater takes from the lower Tarras and Bendigo allocation zones

Water source	Number of consents	Combined yearly volume (Mm ³ /yr)	Purpose of use
Lower Tarras allocation zone	7	2.10	Irrigation, stock water, domestic and communal supply, storage, frost fighting, fire fighting
Bendigo allocation zone	27	11.86	Irrigation, stock water, communal supply, storage

⁴ These do not include water permits 2006.254 (14 l/s) to retake augmentation water and 2003.110 (555.5 l/s) to retake water that has been discharged into the Cluden Stream from the Tarras main race

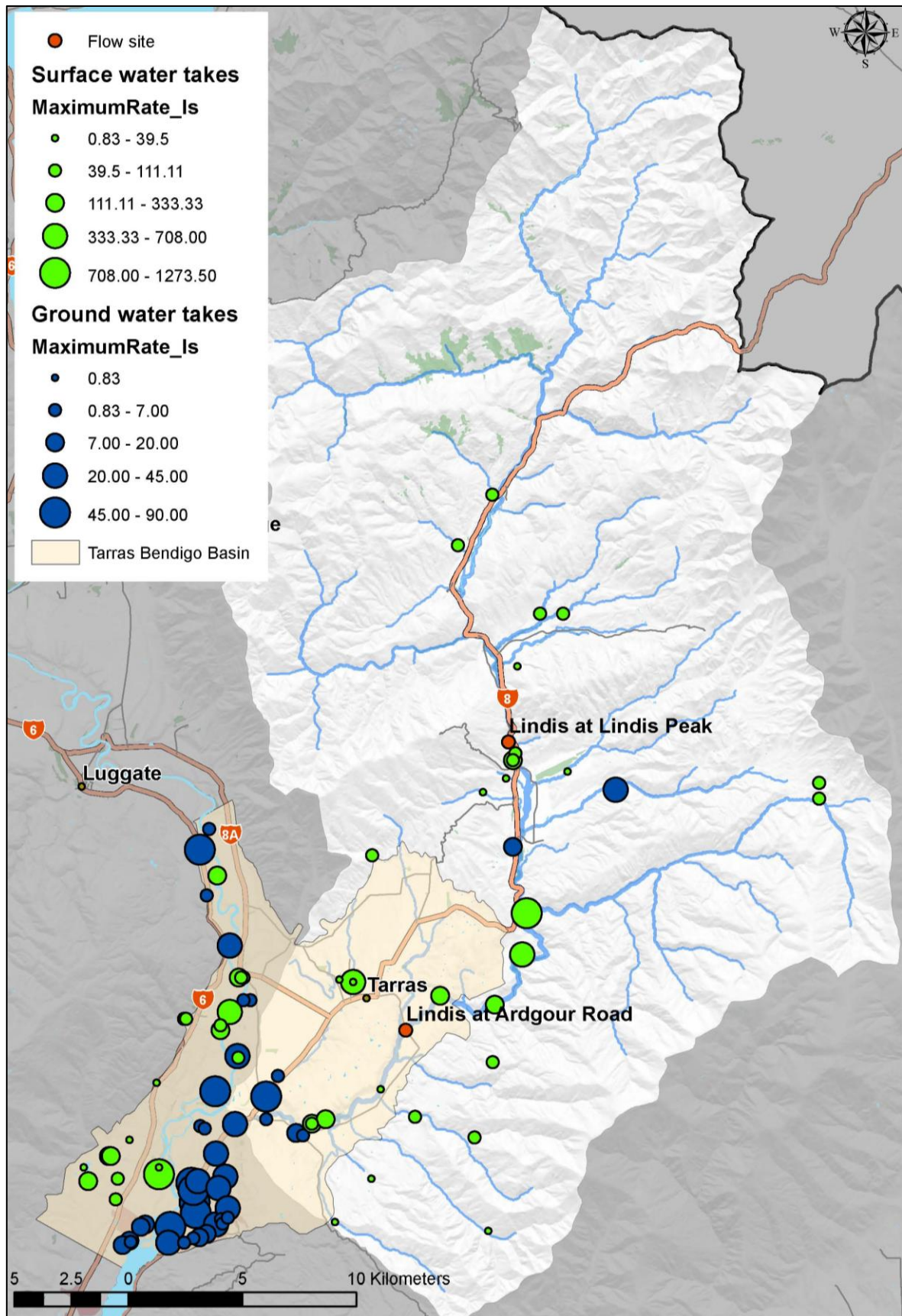


Figure 8. Map of the Lindis catchment and Bendigo-Tarras basin showing points of abstraction (as at January 2014)

FURTHER INFORMATION

Central Otago District Council (2008)	Central Otago District Plan
growOTAGO (2004)	growOTAGO project. www.growotago.orc.govt.nz
Kāi Tahu ki Otago (2005)	Natural Resource Management Plan 2005
Land Information New Zealand (2005)	Conservation Resources Report: Part 1, Lake Hawea Crown Pastoral Land Tenure Review
Land Information New Zealand (2005)	Conservation Resources Report: Part 1, Morven Hills Crown Pastoral Land Tenure Review
Land Information New Zealand (2002)	Conservation Resources Report, Merivale, Long Acre, Geordie Hills, Shirlmar, Nine Mile and Timburn Station Crown Pastoral Land Tenure Review
MAF (July 2004)	Water Programme of Action: Potential Water Bodies of National Importance - Technical Working Paper
Otago Regional Council (2010)	Bendigo and Tarras Groundwater Allocation Study
Otago Regional Council (2008)	Management flows for aquatic ecosystems in the Lindis River
Otago Regional Council (2012)	State of the Environment Report: Surface water quality in Otago
Otago Regional Council (2004)	Regional Plan: Water for Otago
Otago Fish and Game Council (2004)	Resource Report for Morven Hills Station Crown Pastoral Lease, 31 March 2004
Tarras Community Association (2007)	Tarras Community Plan, August 2007
Unwin, M. (April 2009)	Angler usage of lakes and river fishers managed by Fish and Game New Zealand: Results from the 2007/08 National Angling Survey. <i>NIWA Client Report CHC2009-046</i>
Winter, T.C., Harvey, J.W., Franke, O.L. and Alley, W.M. (1998)	'Ground Water and Surface Water: A Single Resource,' <i>U.S. Geological Survey Circular</i>

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