Needles Creek Monitoring Well Trigger Level

Flaxbourne catchment, Marlborough

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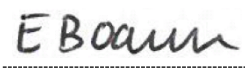

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Contents

1 Introduction

WSP Opus is working with the Flaxbourne Settlers' Association and the Marlborough Research Centre, to identify the changes, and quantify the potential impacts, of the Kaikōura Earthquake on the water resources of the Flaxbourne, Mirza and Waima/Ure catchments.

Needles Creek is a tributary to the Flaxbourne River and lies within the Flaxbourne River catchment. There are a number of water abstraction permits which take surface and groundwater from along Needles Creek. To monitor the groundwater level changes in Needles Creek, there is a monitoring site located near the SH1 bridge (Figure 1.1); 'Needles Creek Gravels Aquifer at SH1/Ward'. The monitoring site is associated with Marlborough District Council's (MDC) well P29w/0169 and has been monitored since 2003.

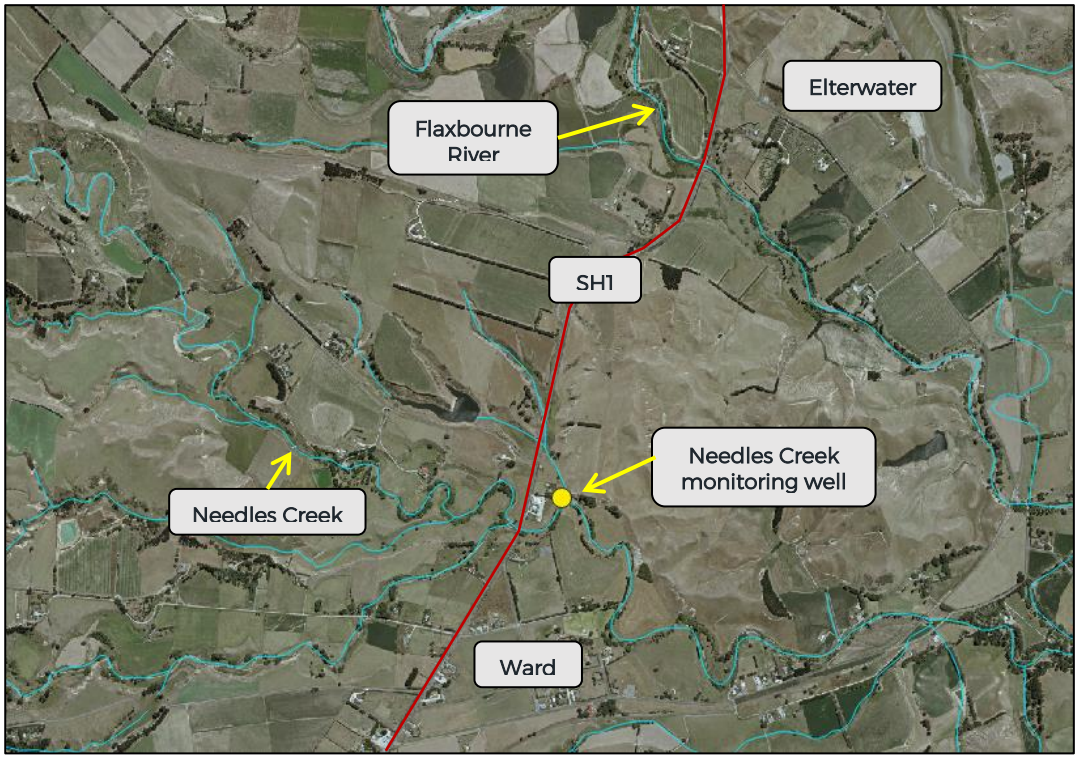

Figure 1.1: Location of Needles Creek monitoring well, near SH1. Streamlines shown in blue.

This report discusses the potential impacts of the Kaikōura Earthquake on the flow regime of Needles Creek, the monitoring well, and the associated 'trigger' level whereby restrictions are imposed on water abstraction.

2 Local Setting

2.1 Geological setting

The Needles Creek monitoring well is located in southern Marlborough, approximately 500m north of the Ward township. The vicinity of the well is underlain by recent river gravel and sand which has been eroded to form a suite of degradational terraces. Local outcrops of Starborough Formation bedrock have also been mapped, which consists of poorly bedded sandstone and siltstone. The monitoring well is located between the Ward Syncline and the London Hill Fault (WSP Opus, 2019a).

The log from the Needles Creek monitoring well confirms the local geology and indicates a general stratigraphic profile of ~4m of alluvial gravel underlain by mudstone or 'papa' (MDC, 2003). This log is provided in Appendix A.

2.2 Hydrological setting

All known groundwater in the Flaxbourne catchment is restricted to shallow alluvial gravel deposits associated with the Flaxbourne River or its tributaries Tachalls and Needles Creeks (Figure 2.1) Very little information is available to quantify any permanent groundwater system in the catchment. However, it is thought that the relatively thin alluvial gravel deposits are recharged from rainfall and, the Flaxbourne River and its tributaries. The gravel deposits act as unconfined riparian aquifers i.e. the rivers and adjacent groundwater are hydraulically connected and can be considered as one system. In the wider Flaxbourne catchment, the gravel deposits are generally thin, i.e. less than 10m thick, and the storage capacity of the aquifers is likely to be limited (Davidson & Wilson, 2011).

At the Needles Creek monitoring well, the alluvial gravels are ~4m thick and extend laterally north and south of the river. These gravels are associated with the youngest river terrace of Needles Creek. During dry periods, Needles Creek loses surface flow. However, flow is maintained in the gravel system below and adjacent to the river channel, below the surface. This was confirmed through a series of low-flow gaugings undertaken in the Flaxbourne catchment over the 2018-2019 summer. The flows recorded in Needles Creek reduced through the reach between SH1 and Seddon Street (where the monitoring well is located), indicating a 'loss' of water to the underlying gravel (WSP Opus, 2019b).

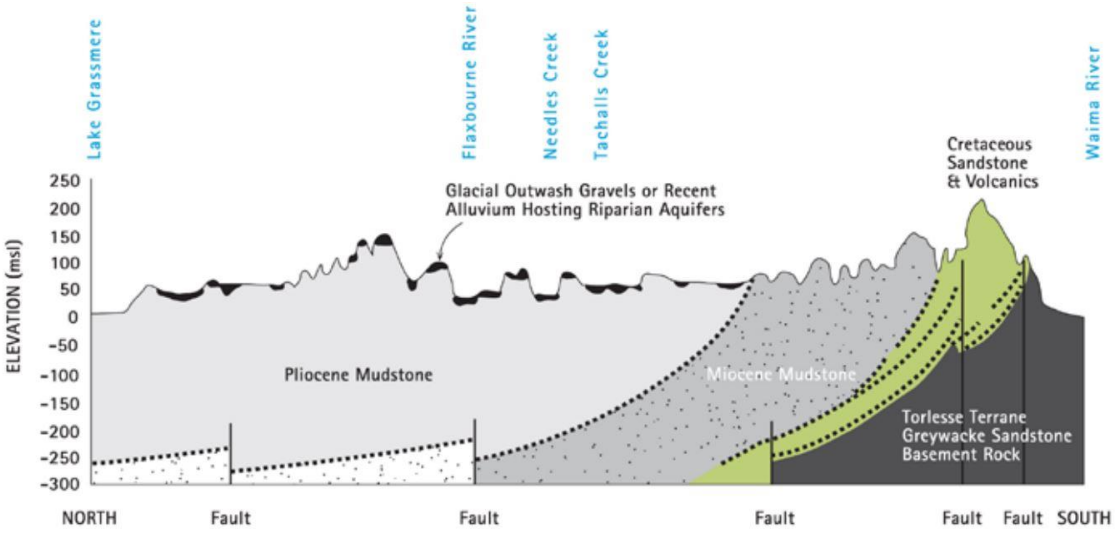

Figure 2.1: Cross-section through the Ward Syncline indicating the limited nature of alluvial deposits near Needles Creek (Davidson & Wilson, 2011).

2.2.1 Resource Management

As discussed above, all known groundwater in the Flaxbourne catchment is restricted to shallow alluvial gravel deposits associated with the Flaxbourne River or its tributaries Tachalls and Needles Creeks. As such, Needles Creek and the adjacent groundwater within the alluvial gravels are hydraulically connected and can be considered as one system.

Needles Creek can lose surface flow during the summer months and it can be difficult to accurately measure such low-flows. To manage this, water levels are measured within the Needles Creek

monitoring well, adjacent to the river. When the water level drops past a 'trigger' level, water restrictions are put in place for associated water users.

The quantity allocation rules for water takes associated with Needles Creek are outlined in Table 2.1.

Table 2.1: Quantity allocation rules for water takes (MDC, 2016)

Freshwater Management Unit	Minimum Flow or Level	Monitoring site or method	Management purpose
Needles Creek (including Tachalls)	Minimum level RL 22.8m amsl at Needles Creek.	MDC Monitoring well P29w/0169.	Fully restricted when water level at or below RL 22.8m amsl.

** amsl – above mean sea level.*

3 Potential Impacts on the Needles Creek Monitoring Well

3.1 Pre - earthquake

Prior to the Kaikōura Earthquake in November 2016, the water levels in Needles Creek were monitored through MDC monitoring well P29w/0169, also referred to as the Needles Creek monitoring well. A minimum water level of 22.8m above mean sea level within the monitoring well was used to trigger restrictions of water takes (Table 2.1). The 'trigger' level of 22.8m was linked to the cessation of surface flow in Needles Creek at the monitoring well location (Figure 3.1). Observations of the cessation of surface flow are shown in the well record at 22.8 ±0.1m (MDC, *pers. comm., 2019*).

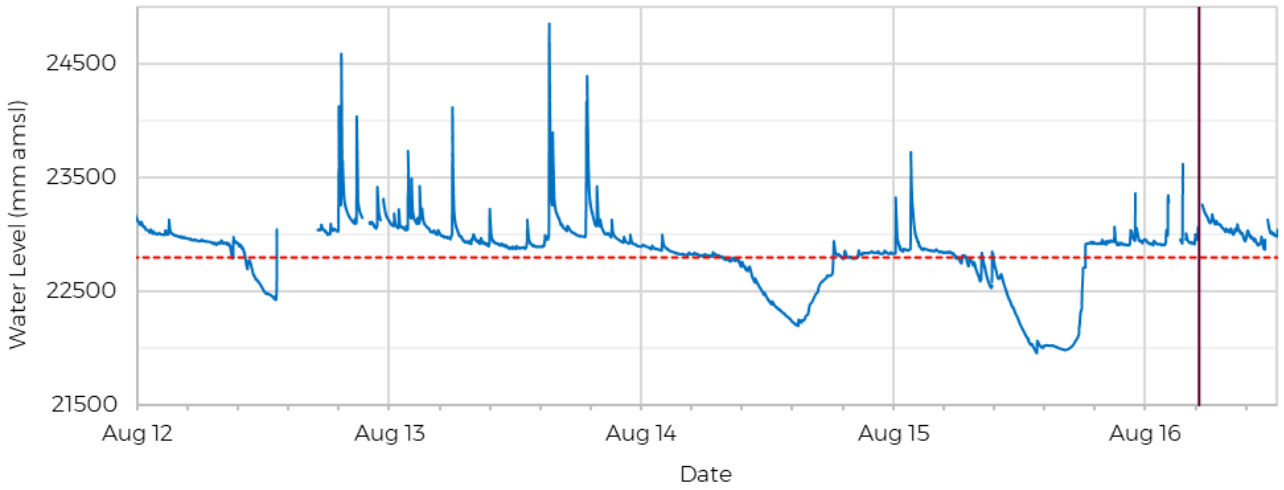

Figure 3.1: Water level record from Needles Creek monitoring well. The red dashed line represents the trigger level. The Kaikōura Earthquake is represented by the brown line.

3.2 Post – earthquake

The 14 November 2016 Mw 7.8 Kaikōura Earthquake occurred in the north-east of the South Island, at the boundary between the Australian and Pacific tectonic plates. It initiated near Waiau in North Canterbury at 12:03am. Rupture propagated south–west to north–east and terminated offshore in Cook Strait. Surface rupture occurred on at least fourteen faults, including displacements of >10 m on the Kekerengu Fault (WSP Opus, 2018).

3.2.1 Topographic displacement

Extensive topographic change occurred across the northern Canterbury and Marlborough regions during the Kaikōura Earthquake. Lateral displacement of the wider Marlborough Region occurred to the north-east with a maximum of ~6m around Cape Campbell (WSP Opus, 2018).

In Ward, approximately 500m south of the Needles Creek monitoring well, the ground was vertically displaced between 1.7m and 1.82m upward, and 4.65m to 4.77m horizontally to the north-east (Figure 3.2). The largest vertical and horizontal movements were recorded along Seddon and Duncan Streets in southern Ward. Smaller movements in both directions were recorded at the Ward War Memorial along SH1 to the north (Figure 3.2).

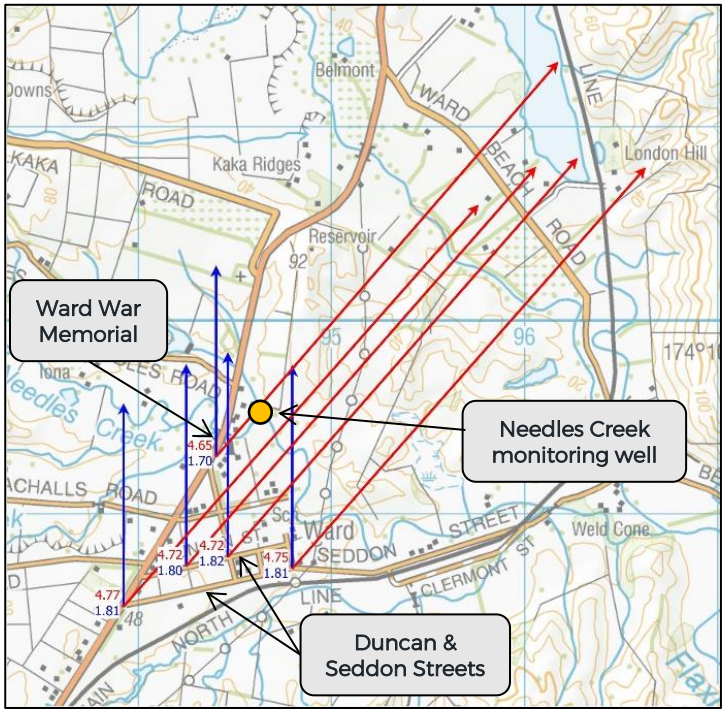

Figure 3.2: Land movement maps for Ward - Kaikoura Earthquake 2016. Blue arrows indicate vertical movement, red arrow indicate horizontal movement (LINZ, 2016).

The Needles Creek monitoring well was significantly damaged during the earthquake as a result of both significant ground shaking and displacement. To appraise the potential vertical movement experienced at the monitoring well, the differences in the elevations of pre- and post-earthquake geodetic benchmarks in the Ward area have been assessed.

Geodetic benchmarks used in this study were obtained through the LINZ geodetic database. Marks within the Ward area with a height order of 5 or below were chosen. Orders are based on the quality of the coordinate in relation to the datum, and to other surrounding benchmarks (LINZ, n.d.). Orders 0-8 are survey accurate, with accuracy decreasing with increasing order.

The closest geodetic benchmark to the monitoring well is the Ward War Memorial (~300m south-west of the monitoring well), where uplift of 1.7m was measured (Figure 3.2). The next closest benchmarks are located 350m and 550m further south, along Seddon Street. The Seddon Street benchmarks have recorded uplifts of 1.80m and 1.82m. This indicates that there is a 0.10m to 0.12m reduction of uplift between Seddon Street and the Ward War Memorial; a decreasing rate of uplift from south to north.

Following the direction of recorded ground movements, towards the north-east, and using the rate of uplift derived between the benchmarks in Ward, it is reasonable to expect a further 0.06m to 0.10m reduction in uplift in the vicinity of the Needles Creek monitoring well, i.e. a total upward elevation change of 1.60m – 1.64m. The relationship between this change in elevation and the consequential effect on the trigger level set for water restrictions is further discussed in Section 3.2.3 below.

3.2.2 Needles Creek flow regime

Water resources are most stressed during summer and periods of prolonged low-flow. It is known that reaches of the Flaxbourne River and associated tributaries go dry for extended periods, although this has not occurred since the Kaikōura Earthquake. To better understand how the Kaikōura Earthquake may have influenced water resources in the Flaxbourne catchment, a low-flow monitoring programme was implemented in 2018. This is detailed in WSP Opus, 2019b.

The results of the low-flow gauging identified that flows recorded in Needles Creek reduce through the reach between SH1 and Seddon Street, indicating a 'loss' of water to the underlying gravel (WSP Opus, 2019b). This confirmed previous observations and assessment of the catchment, and particularly at the Needles Creek monitoring well site, where the set trigger level is associated with the cessation of surface flow. However, insufficient gaugings are available, both pre- and post-earthquake, to identify any change in the overall low-flow regime of the Flaxbourne catchment.

3.2.3 Trigger level

As the original Needles Creek monitoring well (P29w/0169) was severely damaged during the Kaikōura Earthquake, a new recorder site was installed as a replacement. The original monitoring well was replaced with well P29w/0257 in late 2018.

Water level data was recorded in the original well from 6th August 2003 through to the date of the Kaikōura Earthquake (November 14th, 2016). Level data was also collected after the earthquake; however, it is not calibrated to account for the significant ground movement and damage to the well, and therefore is not considered reliable. Water level measurements in the new well began recording in October 2019 (Figure 3.3).

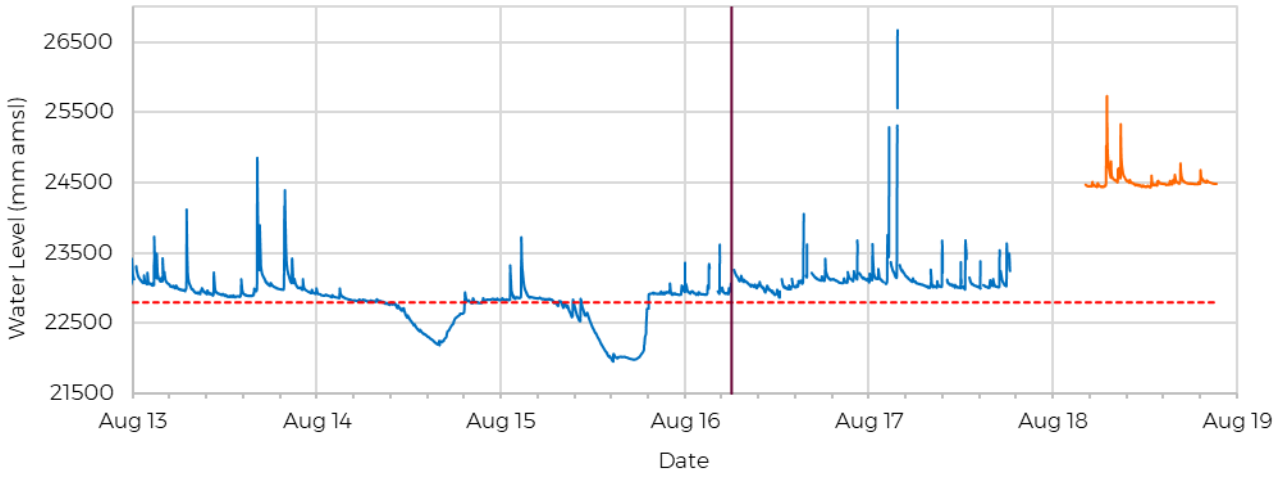

Figure 3.3: Water level data from the original Needles Creek monitoring well (P29w/0169) (blue) and the new well P29w/0257 (orange). The trigger level set for the original well is shown as a red dashed line and the Kaikoura Earthquake is marked by a vertical brown line.

It is apparent in the data from the new monitoring well that the water levels recorded are significantly different to those recorded before the earthquake. The water levels are considerably

higher, likely in response to the uplift and ground displacement experienced throughout the catchment (Section 3.2.1), and potential changes in the flow regime. The difference in elevation between the original and replacement monitoring well is of the order of 1.60m – 1.64m.

Given the significant uplift experienced at the monitoring well site, and the possible changes to the low-flow regime of Needles Creek, the original trigger level set for water restriction is no longer likely to be an accurate or reliable indication of when allocation should be restricted (Figure 3.3). The trigger level should therefore be updated to reflect the new datum at the monitoring site, as well as any changes to the flow regime of the wider Flaxbourne catchment.

New trigger level

The water level record from the new monitoring well is relatively short and has only covered one summer period i.e. 2018/19. During the recorded period, higher flows than normal were identified in the wider catchment, as well as an uncharacteristically wet April (WSP Opus, 2019b). MDC field staff indicated that during this period surface flow was maintained in Needles Creek, and no significant drops in water level were recorded.

Given that the trigger level within the monitoring bore is linked to the cessation of surface flow in Needles Creek, and this has not occurred within the recording period of the new well; a new trigger level can therefore not currently be determined in this way. However, given that surface flow was still observed during the lowest recorded water level of 24.43m above mean sea level, the new trigger level should be at, or lower than this value.

A minimum level of 24.43m corresponds well with the uplift experienced at the well site. Without taking into account any changes to the flow regime, if the current trigger level was raised by the expected vertical elevation change of 1.6 – 1.64m, the trigger level would be 24.4m to 24.44m (Figure 3.4).

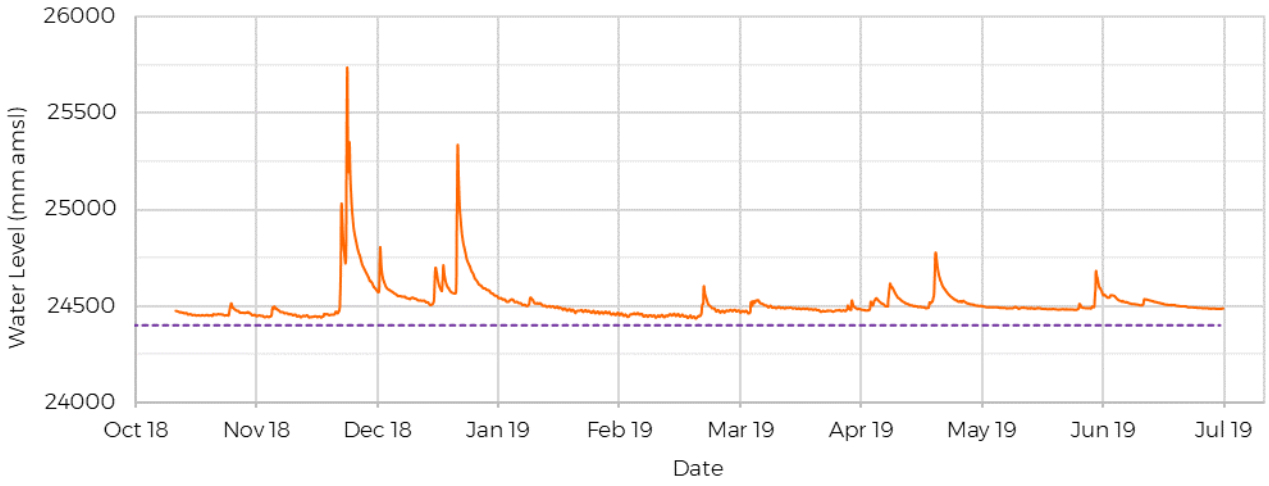

Figure 3.4: Water level data from new Needles Creek monitoring well (post-earthquake) and allocation restriction line raised by expected topographic uplift at the well (1.6m).

While a new trigger level could be based on the elevation change at the site at ~24.4m, there is currently insufficient information available to identify any change in the low-flow regime of the Flaxbourne catchment following the Kaikōura Earthquake. The water level at which surface flow ceases in Needles Creek has previously been used to manage water allocation restrictions, however this has not occurred since the Kaikōura Earthquake.

4 Conclusions

- All known groundwater in the Flaxbourne catchment is restricted to shallow alluvial gravel deposits associated with the Flaxbourne River; or its tributaries Tachalls and Needles Creeks. As such, Needles Creek and the groundwater within the adjacent alluvial gravels, are hydraulically connected and can be considered as one system;
- During periods of low flows, Needles Creek loses surface flow. However, flow is maintained in the gravel system below and adjacent to the river channel, below the surface. Gaugings undertaken along Needles Creek confirm that flows reduce through the reach between SH1 and Seddon Street (where the monitoring well is located), indicating a 'loss' of water to the underlying gravel;
- Needles Creek can lose surface flow during the summer months and it can be difficult to accurately measure such low-flows. To manage this, water levels are measured within the Needles Creek monitoring well, adjacent to the river. When the water level drops past a 'trigger' level, water restrictions are put in place for associated water users consented for takes within the catchment;
- A trigger level of 22.8m asml was previously set for the monitoring well, which corresponded to observations of when surface flow ceased in Needles Creek at the monitoring well location. Observations of the cessation of surface flow are apparent in the water level record at 22.8 ±0.1m.
- The Kaikōura Earthquake significantly impacted the Flaxbourne catchment and wider Marlborough region. The Ward area was subject to vertical ground displacements between 1.7 – 1.82m and horizontal movements of 4.65m to 4.77m.
- It is likely that the monitoring well experienced vertical displacement of the order of 1.6m – 1.64m during the earthquake. The installation of a replacement well indicated that the water levels recorded are significantly different to those recorded before the earthquake.
- Given the significant uplift experienced at the monitoring well site, and the possible changes to the low-flow regime of Needles Creek, the original trigger level set for water restriction is no longer likely to be an accurate or reliable indication of when allocation should be restricted;
- Throughout the duration of the water level record in the new monitoring well, higher flows than normal were identified through the Flaxbourne catchment and the cessation of surface flow in Needles Creek has not occurred;
- Given that the trigger level within the monitoring bore is linked to the cessation of surface flow in Needles Creek, and this has not occurred within the recording period of the new well; a new trigger level can therefore not currently be determined in this way. However, given that surface flow was still observed during the lowest recorded water level of 24.43m above mean sea level, the new trigger level should be at, or lower than this value;
- A minimum level of 24.43m corresponds well with the uplift experienced at the well site. Raising the original trigger level by the vertical elevation change at the well site would result in a level of 24.4m to 24.44m; and
- The new trigger level should be confirmed following additional low-flow gaugings to identify any changes to the flow regime in the wider Flaxbourne catchment.

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Appendix A
Well Log P29w/0169

Marlborough
District Council
P.O. Box 443, Blenheim.
Phone (03) 578 5249, Fax (03) 578 6866

WELL P29w/0169

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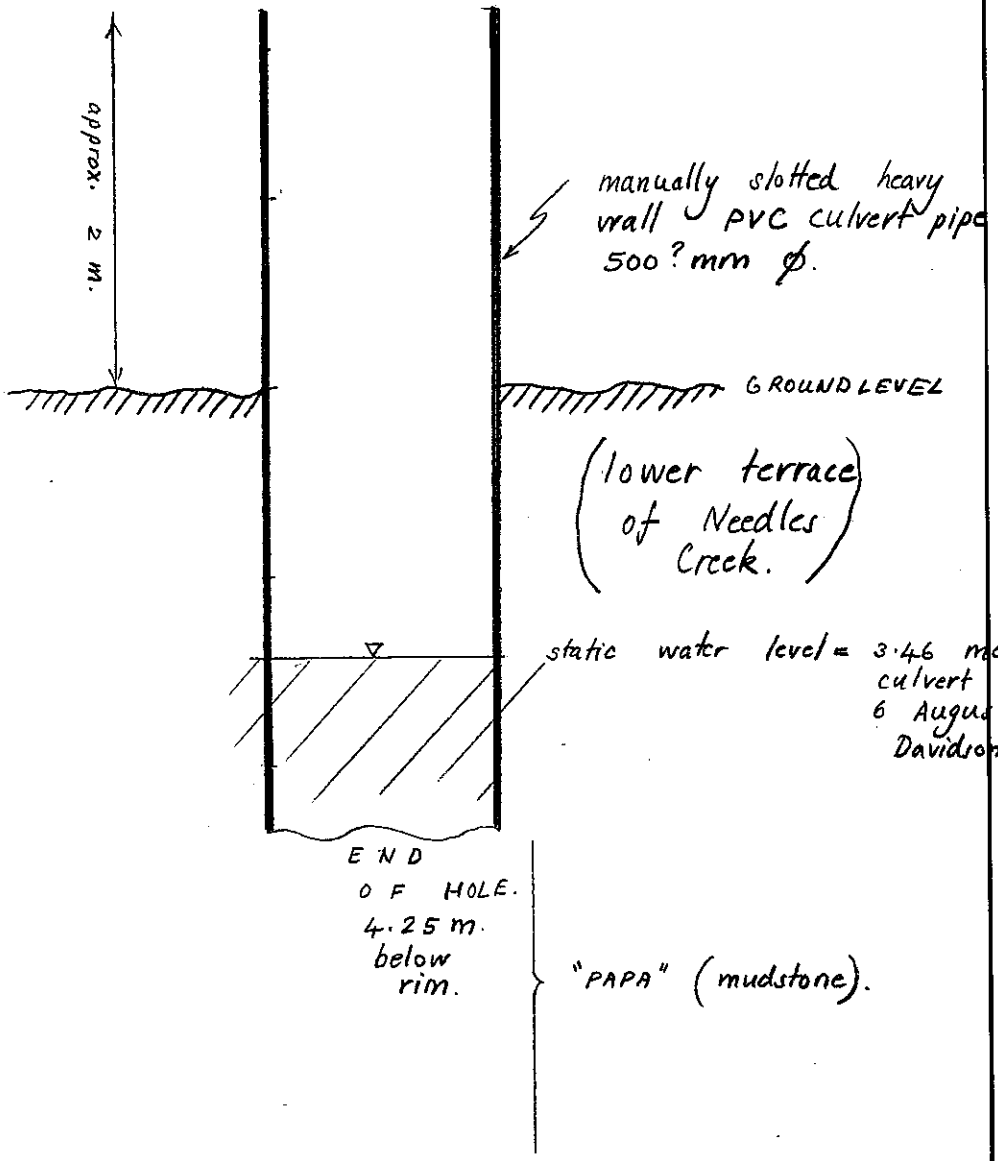
Date 7 August 2003

Owner : Bill Francis



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