AMBERLEY FLOODS – JULY AND AUGUST 2008

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ABSTRACT

On 31 July and again on 25 August 2008 the east coast of the South Island was hit by unusually severe rainfall events. The townships of Amberley and nearby Amberley Beach experienced widespread surface flooding in response to these. Amberley Beach was evacuated during the July event, and was placed on high alert for the subsequent August event. A number of houses were flooded in both Amberley and Amberley beach.

A series of aerial photographs flown soon after the July event were used in gaining a full understanding of the surface water network performance and of overland flow path locations. This was backed up by interviews with local residents and subsequent site visits, one of which was conducted during the August rainfall event.

This paper examines rainfall data collected over these two events. Statistically the July event was more severe than the August one, however similar levels of flooding for both occurred. Furthermore the drainage network for surface water in and around Amberley and Amberley Beach is examined and tested for level of service able to be provided. Where necessary mitigation works are discussed that would improve the flood response of this network, and meet desired levels of service.

KEYWORDS

Amberley, Floods, Stormwater

1. INTRODUCTION

Pattle Delamore Partners Limited (PDP) was commissioned by the Hurunui District Council (HDC) to investigate flooding issues in and around the Townships of Amberley and Amberley Beach in Canterbury. The need for such an investigation arose after a major rainfall event caused substantial flooding in and around Amberley on 31 July 2008. Subsequent to PDP's engagement, a second major event passed through Amberley and again caused a considerable amount of flooding. The August event resulted in the project scope being extended to include analysis and assessment relating to the August event.

The scope of the project was agreed to include the collection and investigation of rainfall records held from the two events. Meetings with relevant members of the community were also held in an attempt to gather opinions of the origin of any capacity constraints experienced. Aerial photographs taken during the July event (supplied by HDC) were examined and annotated in an attempt to compile an accurate record of the flooding event.

Using all of the above information, an assessment of the Average Recurrence Interval (ARI) of the July and August flood events for both Amberley and Amberley Beach were made. Statements were also prepared of how the primary and secondary drainage systems in both areas coped with these events. From the statements prepared regarding the existing systems, several opportunities for improvement became evident and were subsequently reported as recommendations to HDC.

2. RAINFALL ANALYSIS

2.1 RELEVANT RAIN GAUGES

A total of eight rain gauges were found within a ten kilometer radius of the Amberley Township that were deemed relevant to the assessment of the Amberley rainfall events. Four of these gauges are operated by the National Institute of Water and Atmospheric Research (NIWA), two by Environment Canterbury (ECan) and two are privately operated. Three of the rain gauges sourced for this investigation had rainfall depth readings taken at fifteen minute intervals while the remainder recorded daily total rainfall depths.

2.2 AVERAGE RECURRENCE INTERVAL

From the data obtained from the rain gauges it was possible to infer Average Recurrence Intervals (ARI) for each of the July and August rainfall events by reference to frequency analysis of historically recorded data. These ARI's were assessed by reference to version 2.0 of NIWA's High Intensity Rainfall Design System (HIRDS V2.0). For each gauge rainfall depths were totalled over varying durations and then compared against the HIRDS data. The duration that gave the highest estimate of ARI was selected for each location, with these ARI's being plotted in the form of contours.

According to analysis performed on data obtained from the NIWA weather station at Railway Terrace in Amberley and using HIRDS V2.0, a peak ARI of 48 years was determined for the July event based on a 24 hour duration. Using a similar analysis, an ARI of 17 years was determined for the August rainfall event based on a 72 hour duration. The difference in duration yielding the peak ARI suggests that the July event was much more intense and delivered more rainfall in a shorter time period. The August event resulted in a similar amount of total rainfall however the rain accumulation occurred over a much longer time period.

3. STORMWATER SYSTEM PERFORMANCE

Aerial photographs of Amberley and Amberley Beach were examined to gain a better understanding of existing stormwater system performance. The photographs were taken following the 31 July 2008 rainfall event, and were supplied by HDC. Discussions with local residents affected by the flooding event have also contributed greatly to the understanding of stormwater system performance during the two events in 2008. Figure 1 shows the four major waterways in the Amberley and Amberley Beach area.

3.1 DOCK CREEK

Dock Creek flows in a southerly direction through the Amberley Township east of State Highway 1 and eventually discharges into the near-by Kowai River (north branch). There was significant evidence that Dock Creek was unable to cope with the flow demands placed on it during the July and August 2008 rainfall events.

Inflow to Dock Creek is controlled by a structure at the upstream end, which is supposed to regulate not only low flows but also flood flows to the creek. During times of flood this control structure can be manually manipulated to divert excess runoff directly to the Kowai River. However, the creek is able to collect considerable runoff from catchments north of Amberley that are located downstream of this control structure, as well as from the township itself. Several reaches of Dock Creek, most notably within the Amberley Township, were observed to have exceeded the channel's capacity and as a result contributed to the Amberley flooding event. Figure 2 shows one instance of many where Dock Creek spilled its banks and resulted in the flooding of near-by houses.

Upon investigation it became clear that a control structure located upstream of Amberley along Dock Creek did not function properly during the 31 July event. The control structure consists of two separate devices: a gate which controls flow into the Kowai River, and a control weir which limits flow into Dock Creek. It has been reported that during the July flood event the gate was unable to be opened, diverting more flow into Dock Creek than would have been able to occur had the gate been lifted to allow free flow to the Kowai River. However, in the 25 August event with the gate raised above flood level (i.e. did not interfere with flow) there were still capacity issues in Dock Creek downstream. After further investigation, it became clear that stormwater flowing overland from Eastern Drain and other catchments had entered the Creek downstream of the control structure.

Figure 1: Stormwater Conveyance around Amberley and Amberley Beach

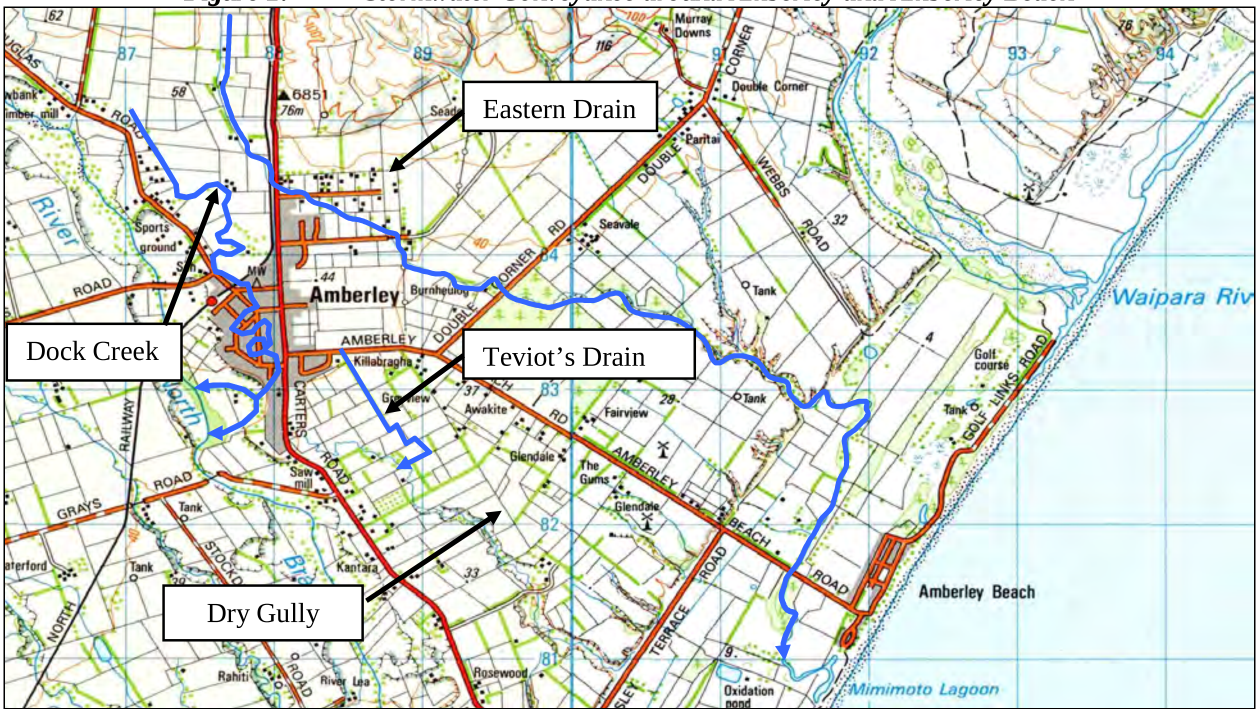
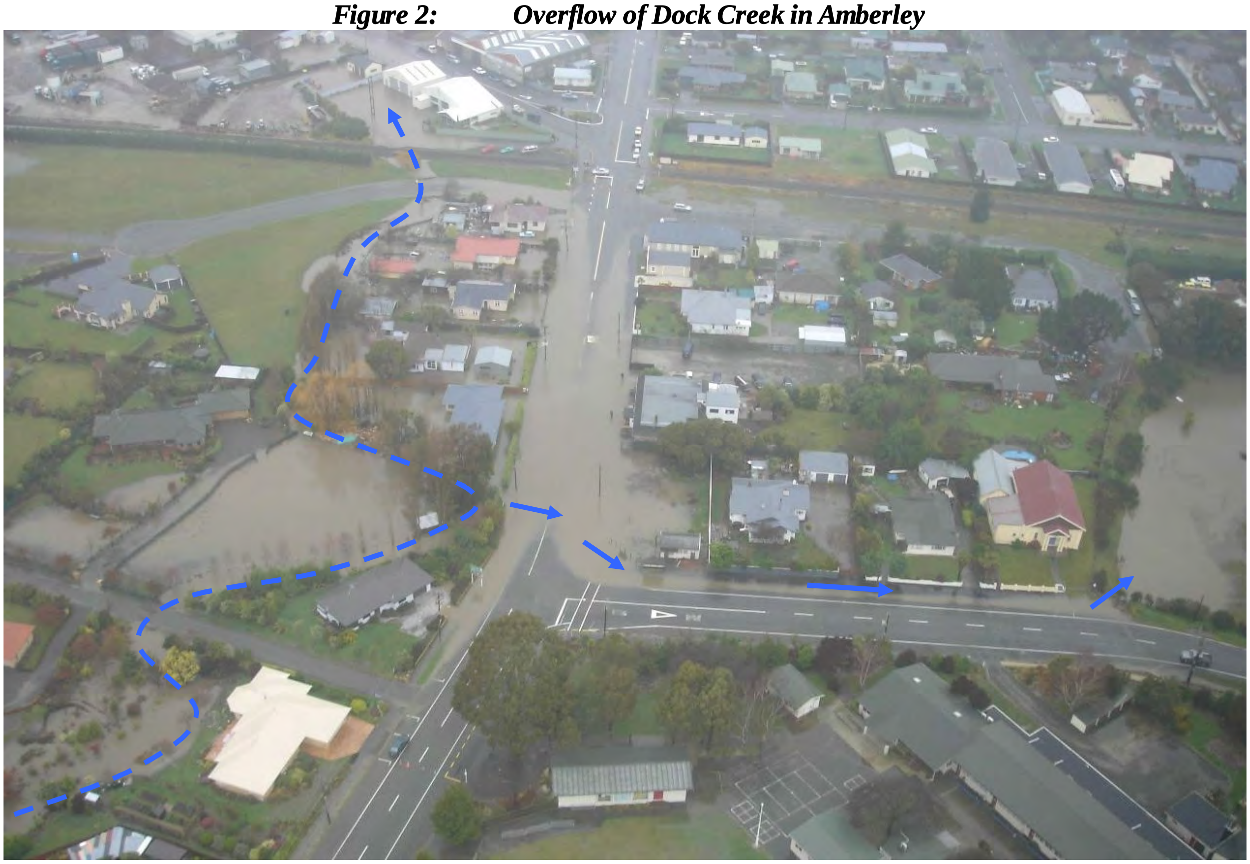


Figure 2: Overflow of Dock Creek in Amberley



3.2 EASTERN DRAIN

Eastern Drain receives runoff from a large catchment running parallel to State Highway 1 north of Amberley. To the east are a series of hills drained by gullies, with culverts under SH1 the catchment area of Eastern Drain becomes less well-defined, but comprises relatively flat areas in the vineyard and other largely agricultural land use. Unlike Dock Creek there is no flow control structure to limit the inflow to this waterway, and surface flows may be able to fluctuate with changing land use in the catchment. Spring flows also feed this waterway.

Eastern Drain runs in a south-easterly direction crossing both Osborne and Courage roads in Amberley before continuing to Amberley Beach and ultimately discharging into the Mimimoto Lagoon. Aerial photographs demonstrate that Eastern Drain did not have the necessary capacity to effectively carry discharge generated during the July and August 2008 events. Several reaches of Eastern Drain were completely overwhelmed by the storm and contributed to the flooding of Amberley and Amberley Beach.

Figure 3 shows Eastern Drain as it flows into Amberley from the north. This figure suggests that Eastern Drain was flowing well beyond its capacity and that excess flows spilled from Eastern Drain into Dock Creek to the west (right-hand-side in Figure 3), further exacerbating flooding issues in Dock Creek.

Evidence suggests that a large contributor of flow to Eastern Drain was runoff from the large vineyard operation located immediately north of Amberley. Once these vineyards became saturated, a significant amount of runoff was generated from the area and, having no other flow path available, this runoff flowed south and into Eastern Drain. Several culverts also exist along State Highway 1 north of the Amberley Township. These culverts convey runoff from the hills east of State Highway 1 via overland flow directly into the upper reaches of Eastern Drain. In conjunction with the flow from the vineyards, it is likely that these catchments north of Amberley caused Eastern Drain to exceed its capacity well before even entering the township. There have been suggestions to the effect that in conjunction with the change in rural land use that has occurred over recent years north of Amberley, some changes to contributing catchments were also made.

Figure 3: Flow of Eastern Drain North of Amberley

3.3 TEVIOT'S DRAIN & DRY GULLY

Flooding also occurred along Teviot's Drain, a tributary of Dry Gully, however the degree of flooding was to a lesser extent than that experienced along Eastern Drain and Dock Creek.

Whilst Teviot's Drain did exceed its capacity and spilled out beyond its banks, the flooding generally occurred in areas of minimal (current) development. It is evident that this waterway lacked capacity to convey the flow demand placed on it during the July and August events and that limited capacity for any increase in flow resulting from future development will not be able to be accommodated without additional works taking place.

During the 2008 rainfall events Dry Gully filled up substantially and was able to convey runoff towards Hursley Terrace (rural road east of Amberley Beach). A section of the so-called Dry Gully is shown in Figure 4. The upper end of this feature, immediately adjacent to State Highway 1, does not have a significant upstream contributing catchment area and appears to have excess capacity for the flows likely to be conveyed. It is possible that this is a result of construction of SH1 in that this road essentially beheads what may have been a larger catchment area prior to road construction.

Further downstream within Dry Gully there are known to be local constrictions to flood flows. The effects of these would be to cause the gully to fill to higher levels than would occur without such constrictions. It would be possible to remove such constrictions and allow for a greater conveyance capacity within this waterway. The major constraint with doing this comes at the downstream end, where runoff exits Dry Gully and runs across Hursley Terrace and enter the Amberley Beach area which has significant capacity constraints.

Figure 4: Dry Gully

3.4 AMBERLEY BEACH

Amberley Beach Township is located between a series of dunes along the beach and the floodplain of Eastern Drain. As some of the houses are low-lying, floodwater that has accumulated within the floodplain area of Eastern Drain is able to reach floor level in a few Amberley Beach houses after a significant rainfall event. Due to the large volume of ponding that generally occurs prior to flooding of the Amberley Beach township, the receiving system is likely to be sensitive to significant increases in total runoff volume entering the system via Eastern Drain, Dry Gully or other surface waterways, the system at Amberley Beach is unlikely to be sensitive to all but major increases in peak discharge rate from upstream waterways.

Runoff from Amberley flows south-east towards Amberley Beach via Eastern Drain and Dry Gully. The 2008 storm events had an extensive impact on the Amberley Beach area. Figure 5 shows an aerial photograph of the township taken during the July 2008 event. As can be seen in Figure 5, flooding was not confined to the township alone and that areas surrounding Amberley Beach also experienced widespread flooding.

Flow from Dry Gully and other surface waterways was able to flow over Hursley Terrace and continue overland to Amberley Beach Road. Figure 6 shows stormwater from northern reaches of Dry Gully flowing over Hursley Terrace and flowing overland towards Amberley Beach. Much of the water which passed over Hursley Terrace, as well as the runoff generated further north along Amberley Beach Road contributed to a large accumulation of water at the bottom of Amberley Beach Road which can be seen in Figure 5.

Flooding of a Readymix quarry also occurred in the vicinity of Amberley Beach. The bulk of this floodwater came from Eastern Drain, which flooded its banks in this area.

A schematic plan showing the progression of flood runoff and its convergence near to and within Amberley Beach is shown in Figure 7.

Figure 5: Flooding of Amberley Beach and Amberley Beach Road

Figure 6: Dry Gully Flowing Over Hursley Terrace

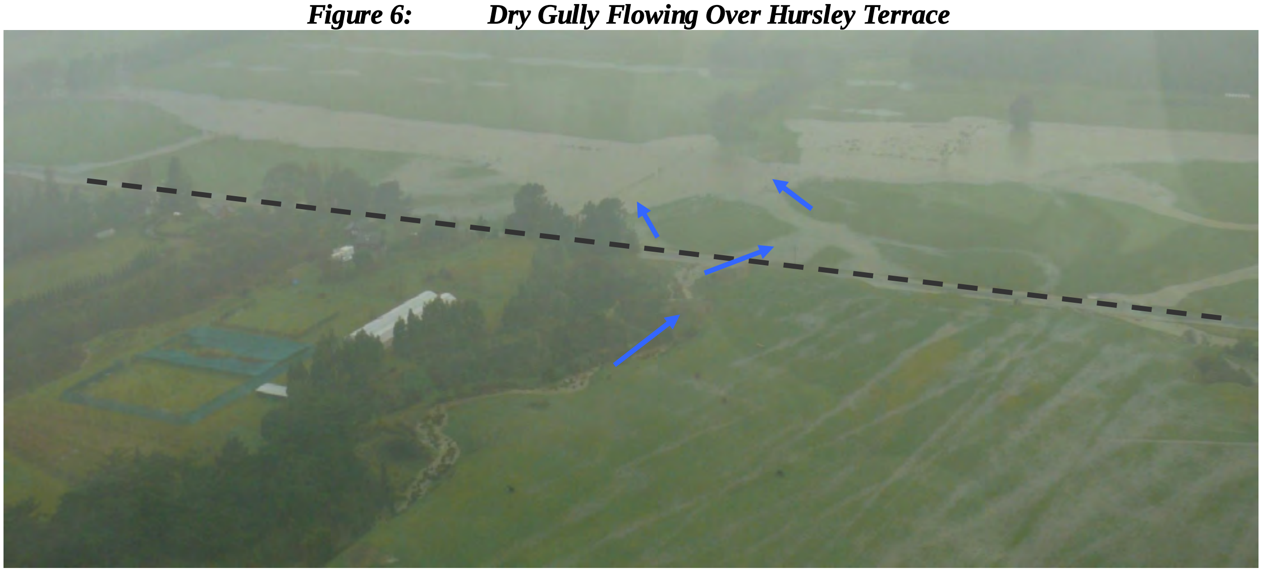


Figure 7: Schematic Flood Mechanism at Amberley Beach

4. FLOOD MITIGATION MEASURES

It is of the utmost importance that in consideration of any proposed flood mitigation measures the effects on the entire system be recognised and understood. This is particularly the case given that Amberley Beach is currently flood-prone, and is located towards the downstream end of the catchments currently under scrutiny. Mitigation works proposed upstream may have effects on the potential flooding in and around Amberley Beach. Similarly measures to protect Amberley could involve works being undertaken outside of the urban area of Amberley, highlighting the need for a catchment-wide view.

An ARI of approximately 50-years was determined for the Amberley Township during the July event, although it is more relevant to examine the severity of the event over the contributing catchment area as opposed to a single point at Amberley township. Most of the catchment area of Dock Creek and Eastern Drain experienced an event of 50 – 55 year ARI. It is usual that surface water systems are designed largely around the 50-year ARI level of severity, in other words an event that has an annual probability of occurrence of 1 in 50, or 2%. Clause E1.3.2 of the Building Code requires that:

"Surface water, resulting from an event having a 2 percent probability of occurring annually, shall not enter buildings."

It is therefore a reasonable expectation that for events of ARI less than 50 years, no floodwater should enter any buildings – that is, the drainage system must be of sufficient capacity to ensure this. Given that Amberley and Amberley Beach experienced flood events of about this level of severity, and also that these events did result in some floodwater entering buildings, it is likely that some remedial works will be required to return the system to meeting the design level of service of 50 years.

The rainfall event of 25 August 2008 had an ARI of between 15 and 30 years over most of the catchment area relevant to Amberley and Amberley Beach. Whilst this seems much less severe than the event of July 2008, a similar pattern of flooding was observed. This is largely because statistically the severity of the events does not take precedent rainfall into account, and in this case the precedent rainfall (causing the catchment to be in an almost saturated state at the start of the event) was particularly relevant.

Another factor not taken into account is the critical duration for the catchments concerned. It would be expected that areas higher up in the catchment, in steeper terrain, have shorter critical durations than those areas further downstream. The ARI's used in the investigation do not account for critical duration, and are therefore just rough approximations due to a lack of temporal resolution in the rainfall data.

4.1 EASTERN DRAIN

Flood mitigation works in and around Eastern Drain are required largely to reduce the likelihood of flooding in urban Amberley, particularly residences in the north-east areas of Amberley. Flood mitigation measures for Eastern Drain may also be used to prevent additional runoff from entering Dock Creek, and could also have knock-on beneficial effects on flooding at Amberley Beach.

Eastern Drain receives more runoff than it has capacity in the reaches flowing through urban Amberley. Examination of old aerial photographs suggests that the drainage system and connected catchment areas may have been modified over the years, resulting in this extended catchment. While there are several local drainage issues associated with Eastern Drain flooding, many of these could be remedied, at least in part, by diversion of some of the upper catchment runoff to the Kowai River. This would reduce the volume of runoff attempting to pass through Eastern Drain, thereby reducing the likelihood of overbank flooding. Figure 8 shows a schematic of a proposed flow diversion for Eastern Drain north of Amberley. This proposed diversion would seek to re-instate previous flow paths, and would not be intended for low flows, but would serve, rather, as a flood bypass. This would ensure maintenance of instream values through urban Amberley, but would provide flood relief to these areas without requiring upgrade to the existing channel geometry in the urban areas.

Allied to the upstream diversion of upper catchment runoff, there would be significant benefit in the diversion of lateral inflows to Eastern Drain where possible. An option was also discussed with local residents whereby some of the catchment area of this drain could be cut off, with runoff from this area being diverted around residential areas to ultimately end up in Eastern Drain, but via a slightly altered flow path.

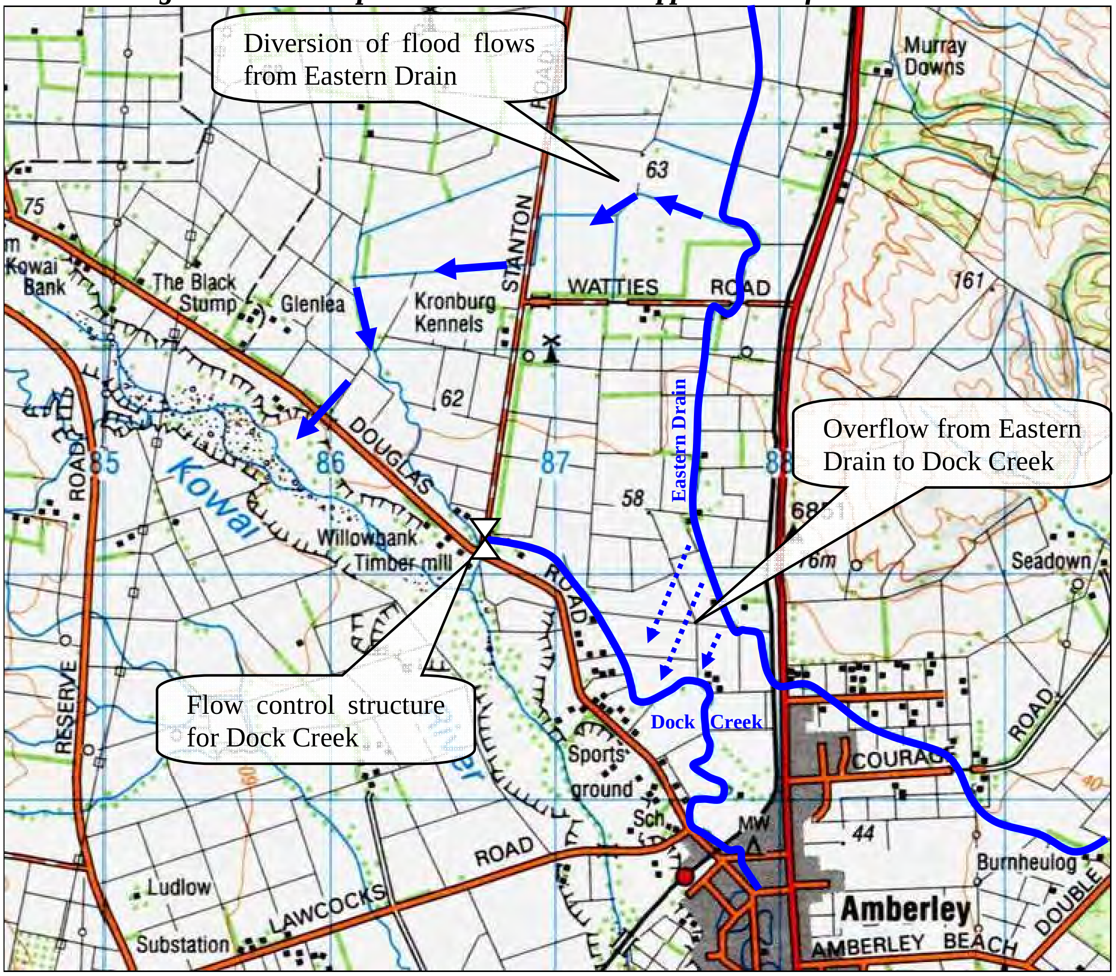
4.2 DOCK CREEK

As described in Section 3, the recent rainfall events in July and August 2008 caused some surface flooding in and around Dock Creek. Some of this flooding was a direct result of waterway constriction where floodwaters flowed out from the creek onto neighbouring areas, and other flooding was due to the lack of capacity of the creek to accept runoff from adjacent areas.

Following assessment of the recent flooding associated with Dock Creek it appears evident that a large part of the problem was that too much water is able to enter this system. This is due to a combination of factors, including Eastern Drain flooding causing overland flow and the control structure not working optimally. As Dock Creek has been designed as a controlled system (with inflow controlled by the control structure), removal of excess flows entering the system via paths other than this control structure is likely to return the creek to a manageable flow regime. This assumes that no degradation of the channel has occurred which is a maintenance issue.

During the 2008 events, Dock Creek received additional runoff via overland flow from Eastern Drain (as shown in Figure 3) that entered the main waterway downstream of the flow control structure. It has also been suggested that this structure was bypassed by other surface flows during these events, resulting in a greater inflow to the Creek than would have been allowed by the control structure design. In order to continue to limit the inflow to Dock Creek these other overland flows that contributed to the creek will need to be stopped, thereby ensuring that inflows to the creek are only controlled by the flow control structure and by locally generated runoff through Amberley. By undertaking inflow reduction works for Eastern Drain as outlined above, the likelihood of Eastern Drain causing overland flow to Dock Creek will be reduced. This is shown in Figure 8.

Figure 8: Proposed Flow Diversion at Upper Reach of Eastern Drain



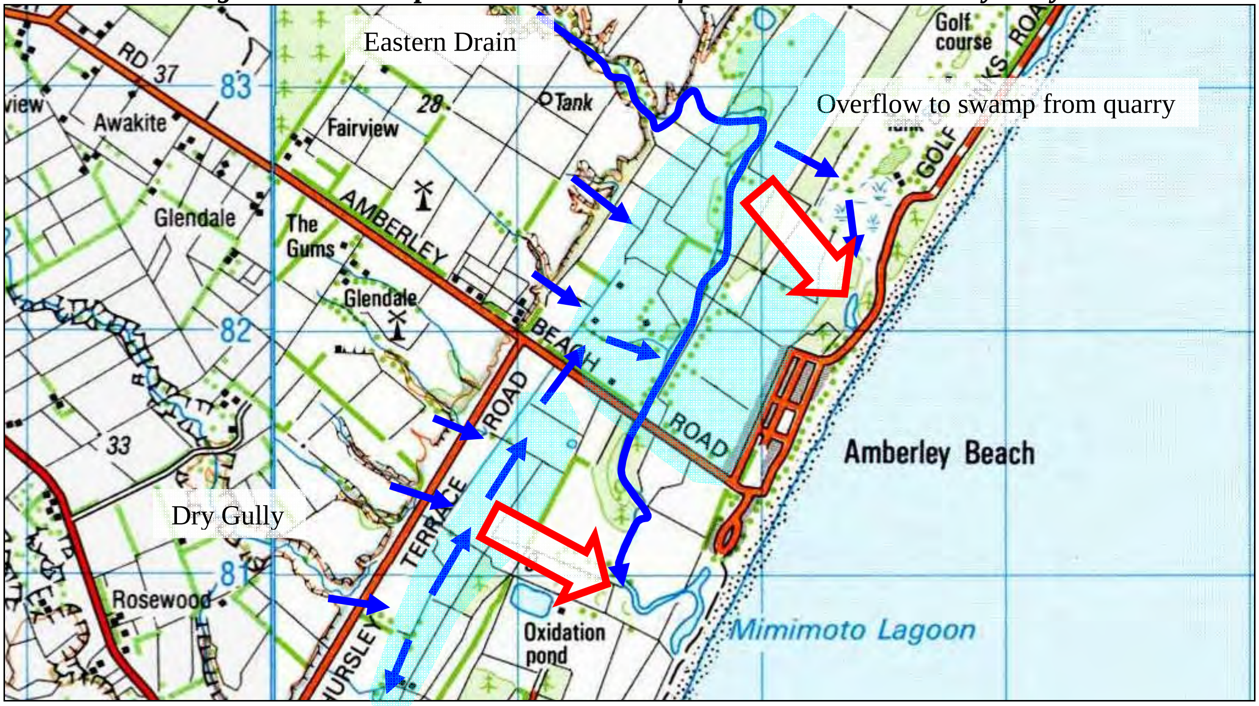
4.3 AMBERLEY BEACH

A cut-off for runoff that comes from Eastern Drain to the northern lagoon could be constructed by minimal excavation via a direct route. This could be a high-level cut-off that only flows during flood times, with the low flows in Eastern Drain continuing to follow the existing course to the Minimoto Lagoon. This option depends on landowner approval, and suggested routes for such a diversion are shown in Figure 9 below. This diversion which would result in the formation of an alternative outfall has hydraulic efficiencies over the existing Eastern Drain alignment.

Another improvement could be made by provision of a cut-off for runoff that comes from Dry Gully and other gullies, crossing Hursley Terrace south of Amberley Beach Road. This runoff currently flows in a northerly direction, crosses Amberley Beach Road (either via the culvert or by overtopping Amberley Beach Road) and is essentially mixed with flooding that comes from Eastern Drain. All of this (combined) runoff then attempts to exit via the twin culverts at Amberley Beach Road to the Minimoto Lagoon. If all or some of this runoff could be kept to the southern side of Amberley Beach Road and diverted more directly to the Minimoto Lagoon this would relieve the Eastern Drain system of some of the capacity demands that it currently faces. A schematic of this flow path is shown in Figure 9.

Having one or more free-flowing outlets is arguably the most important factor to flood mitigation in and around Amberley Beach. To achieve this, the lagoon mouths north and south of the township will need to be opened, either naturally or artificially. It may also prove necessary to increase conveyance capacity of the section of Eastern Drain between Amberley Beach Road and the Mimimoto lagoon.

Figure 9: Proposed Flow Diversions from Eastern Drain and Dry Gully



5. DISCUSSION

In assessing the 2008 flooding events in Amberley and Amberley Beach a catchment wide approach has been adopted. Instead of focusing on local drainage capacity issues, such as partially blocked culverts, the major issue facing the waterway systems in Amberley is that of too much water being able to enter at the top end. If this is remedied then many of the smaller drainage issues may also be remedied, up to the design level of service. This also avoids the possibility of transferring flooding problems downstream.

The major issues to do with the flood risk at Amberley Beach are those of too much runoff from upstream and of impeded outfall to safely dispose of it. Upstream diversion of Eastern Drain could partially relieve this, although future development could gradually claw back at any benefits achieved. However, if outfall capacity is increased then this should provide enduring protection to properties in and around Amberley Beach. Outfall capacity could be increased by waterway capacity enhancement (cleaning, widening, regarding) and by diversion of flood flows. It appears feasible at this stage to consider diversion of peak flows from Eastern Drain towards the lagoon to the north of Amberley Beach, and to also consider diversion of peak flows south of Amberley Beach Road towards the Mimimoto Lagoon via a more direct route.

Another point of interest is the effects of precedent rainfall during the August 2008 event. The rainfall event of the August 2008 event had an ARI of between 15 and 30 years over most of the catchment area relevant to Amberley and Amberley Beach. Although this seems much less severe than the July 2008 event, a similar level of flooding was observed. Given that the catchment area was in a saturated state when the August event began, significantly more runoff was generated and resulted in the flooding experienced in the area.

The final decision on which mitigation measures are most appropriate will require further assessment of community needs, financial cost, environmental effects, and degree of flood control effectiveness.

ACKNOWLEDGEMENTS

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REFERENCES

Pattle Delamore Partners (December 2008) ***Flood Management for Amberley and Amberley Beach***

GHD (February 2008) ***Stormwater Management Plan – Amberley Township***