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TECHNICAL REVIEW OF EFFECTS OF PROPOSED CHANGES TO THE MANAPOURI TAILRACE DISCHARGE



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1. INTRODUCTION

The Department of Conservation commissioned an evaluation of the Manapouri Tailrace Amended Discharge (MTAD) avifauna assessment (Boffa Miskell 2008) as it relates to birdlife in the Waiau River below the Manapouri Lake Control (MLC) structure, particularly for black-billed gulls (*Larus bulleri*). This review draws heavily on the PhD research project completed by the author from 2004-2008 (McClellan 2009).

2. HISTORY AND HYDROLOGICAL REGIME

The Waiau River is located in western Southland and flows from Lake Manapouri (24 km south-west of Te Anau) to Tuatapere (60 km east of Invercargill). Plans to build a hydro-electricity power station at Lake Manapouri were first developed in 1904. Work was finally started in 1964, and completed in 1972. The station remains the largest single hydro-electric power station in New Zealand. A low dam, the Manapouri Lake Control structure (MLC or Mararoa Weir), was constructed on the Waiau River immediately below its confluence with the Mararoa River. The MLC diverts most of the Waiau to the power station, via Lake Manapouri, to Deep Cove in Doubtful Sound down a 10 km underground tailrace that drops 183 m from the lake to sea level (Meridian Energy 2009a).

In 1972, the diversion of water resulted in the Waiau flow level being reduced to 0.3 m^3/s from the MLC (Innes 2003), compared to the mean flow of *c*.437 m^3/s prior to diversion (Table 3.2, Mabin 2009). At Tuatapere, the flow reduced from a median of 520 m^3/s (1964-1969) to 62 m^3/s (1973-1991). Magnitude and duration of flood events were also reduced. In 1996, the flow through the weir was increased to 12-16 m^3/s with flushing flows of 35 m^3/s to improve the biodiversity and recreational values of the river (Innes 2003).

The current maximum instantaneous discharge limit from the tailrace of the Manapouri Power Station into Deep Cove is 510 m^3/s. In order to avoid exceeding this limit, the station operates at a set point maximum discharge of 485 m^3/s. The theoretical maximum discharge is over 660 m^3/s. Meridian Energy Ltd is seeking resource consents to increase the present maximum allowable discharge from 510 m^3/s to 550 m^3/s. This will affect the flow of water from the MLC to the Waiau River. The amended discharge to Deep Cove will result in an average flow decrease of 10 m^3/s from the MLC. In 'wet' years, the decrease in flow will average 22 m^3/s, and in 'dry' years, the decrease in flow will average 3 m^3/s (terminology defined in Table 5-12, URS 2009). Increased discharge to Deep Cove will only be possible when natural conditions permit, particularly during high lake inflows. This means that flood peaks will be reduced and the return to normal flows will occur more quickly (Boffa Miskell 2008).

3. PROPOSED CHANGES TO MANAPOURI DISCHARGE

Existing discharge characteristics are given in Table 4-16 of Mabin (2009) and proposed changes in MLC discharge under the MTAD regime are set out in Table 5-12. This does not allow an easy assessment of overall changes. Table 1 below combines the two and adds a further column showing the percentage change for each category of flow for the three types of years ('typical', 'wet' and 'dry') to clarify the alterations to the existing regime. One error was found. Table 4-16 states that 'significant' floods occur on 0.6 days in a 'typical' year, while Table 5-12 states that these floods will occur on 0.3 days as part of the new regime, but that this represents no change. It is, in fact, a decrease in duration of 50%.

During 'typical' years (65.0% of years), the number of days of 'moderate' and 'significant' floods will be reduced by half, and 'small' floods by 20%. During 'dry' years, floods occur on an average of nine days only and, under the proposed regime, these will be reduced to six (a 33% decline). 'Large' floods (those greater than 1,000 m^3/s) only occur during 'wet' years. The duration of these floods will be reduced by almost 30%.

Table 1: Percentage changes in number of days/year of flow levels for the Manapouri Tailrace Amended Discharge regime (based on Tables 4-16 and 5-12 in Mabin 2009).

Flow from MLC	Number of days in existing regime	Change (days) due to MTAD	Percent change (%)
Typical Year (65.0% of years)*			
12-16 m^3/s (minimum flows)	246	+13	+5.3
16-49 m^3/s (minor flows)	35	-5	-14.3
50-149 m^3/s (freshes)	55	+3	+5.5
150-299 m^3/s (small floods)	15	-3	-20.0
300-599 m^3/s (moderate floods)	14	-7	-50.0
600-999 m^3/s (significant floods)	0.6	0.3	-50.0
>1,000 m^3/s (large floods)	0	0	0
Wet Year (16.7% of years)			
12-16 m^3/s (minimum flows)	179	+16	+8.9
16-49 m^3/s (minor flows)	37	1	-2.7
50-149 m^3/s (freshes)	68	+5	+7.4
150-299 m^3/s (small floods)	28	-5	-17.9
300-599 m^3/s (moderate floods)	43	-12	-27.9
600-999 m^3/s (significant floods)	7	-2	-28.6
>1,000 m^3/s (large floods)	2.4	-0.7	-29.2
Dry Year (18.3% of years)			
12-16 m^3/s (minimum flows)	291	+6	+2.1
16-49 m^3/s (minor flows)	27	-3	-11.1
50-149 m^3/s (freshes)	39	0	0
150-299 m^3/s (small floods)	6	-2	-33.3
300-599 m^3/s (moderate floods)	3	-1	-33.3
600-999 m^3/s (significant floods)	0	0	0
>1,000 m^3/s (large floods)	0	0	0

* Categorisation of years into 'typical', 'wet' and 'dry' is based on sixty years of data of annual mean inflows to the Manapouri Power Scheme.

4. THREATENED AVIFAUNA ON THE LOWER WAIAU RIVER

A number of threatened bird species breed on the lower Waiau River. Threat classifications differ from those in Boffa Miskell (2008) as a revised threat classification system has since been published (Townsend *et al.* 2008), and bird species have been reclassified accordingly (Miskelly *et al.* 2008).

Three threatened species nest on the bare to sparsely-vegetated gravel areas found along much of the lower Waiau main stem. Black-billed gulls (Threatened-Nationally Endangered) are usually the most numerous species on the lower Waiau. For example, in 2004, four colonies totalling almost 12,000 gulls (as counted from aerial photographs) were present during the breeding season (McClellan 2009). This represents more than 10% of the total New Zealand population, which is estimated to total approximately 90,000 birds (see McClellan 2009 for data on population estimates). Black-fronted terns ((*Sterna albostriata*; Threatened-Nationally Endangered) also regularly breed on the river, though their numbers are poorly known. Colonies tend to number less than 50 birds. The total population of black-fronted terns is generally said to be approximately 5,000 birds (Heather and Robertson 1996), although another estimate is 7,000-10,000 individuals (R. Keedwell in BirdLife International 2009). Likewise, small numbers of banded dotterels (*Charadrius bicinctus*; Threatened-Nationally Vulnerable) nest in pairs spread throughout the lower Waiau. The total population of this species is estimated to be *c.*50,000 (Heather and Robertson 1996). Given their regular usage of the lower Waiau main stem, these three species are most likely to be affected by changes in flooding regimes (and related changes in weed invasion)

A number of other threatened or 'At Risk' species breed on the lower Waiau, including red-billed gull (*L. novaehollandiae scopulinus*; Threatened-Nationally Vulnerable), pied shag (*Phalacrocorax varius varius*; Threatened-Nationally Vulnerable), black shag (*P. carbo novaehollandiae*; At risk-Naturally Uncommon), little shag (*P. melanoleucos brevirostris*; At risk-Naturally Uncommon), white-fronted tern (*Sterna striata striata*; At risk-Declining), pied oystercatcher (*Haematopus finschi*; At Risk-Declining), and pied stilt (*Himantopus himantopus leucocephalus*; At Risk-Declining). Of these, red-billed gulls, white-fronted terns, pied oystercatchers and pied stilts are occasionally known to breed upstream of the lagoon along the main stem, but their more usual breeding sites are around the lagoon (see Sagar 1994, Chisholm 1992, McClelland 1996, 1997, 2001, 2002).

5. REVIEW OF THE MTAD AVIFAUNA ASSESSMENT

The assessment of environmental effects on birds of the lower Waiau River lists four key areas of potential effects (Boffa Miskell 2008):

- Alteration of the amount of flow around islands that support nesting birds, subsequently affecting the accessibility of predators.

- A decline in the probability of nests being flooded.

- The amount and composition of the substrates used by nesting birds, and the extent of weed invasion of these substrates.

- The types and amounts of aquatic invertebrates and fish which form a significant part of the diet of many waterbirds.

These potential effects are reviewed in the following sections.

5.1 Increased accessibility of islands to mammalian predators

The conclusion in the Avifauna Assessment (Boffa Miskell 2008) that the MTAD will not have a significant effect on predator access to islands within the Waiau as there will be no reduction in minimum flows is a reasonable assessment. Research illustrates that productivity is affected significantly if predators are able to gain access to islands supporting nesting birds during low flows. For example, island colonies of black-billed gulls in Southland that became joined to the 'mainland' during periods of low flows ('partial islands') had significantly lower clutch sizes, nest success (percentage of nests hatching at least one egg), and hatching success (percentage of eggs hatching chicks) than permanent islands (refer to Table 2). These 'partial island' colonies had nest success rates akin to that of bank colonies, although consistently somewhat higher. Consequently, the six further days during which low flows are predicted to occur under the MTAD will not have a significant adverse affect on nesting birds as existing predation rates will simply continue for a slightly extended period of time.

Table 2: Black-billed gull clutch size, nest success and percentage of chicks hatching from eggs by colony site (island, partial island, or bank).

Colony Site	Colonies	Nests	Clutch Size (SE)	Nest Success (SE)	Hatching Success (SE)
Island	5	1,430	1.94 (0.02)	90.1% (2.1)	71.8% (1.4)
Partial island	4	1,080	1.90 (0.01)	73.1% (2.1)	54.9% (3.0)
Bank	11	2,758	1.87 (0.02)	66.8% (2.2)	49.7% (2.6)

5.2 Reduction in flooding of nests and colonies

As part of research investigating the vulnerability to flooding of different black-billed gull colony sites, a cross section was surveyed at the Motu Bush colony site on the Waiau River. Hydrological modelling indicated that a flood of 315 m^3/s was required to reach the boundary of the colony. MLC flow is classified as a moderate flood if it is between 300-599 m^3/s and a small flood if it is between 150-299 m^3/s. Under the MTAD, the number of days from September to December (the main breeding season) during which moderate floods or larger occur would be reduced significantly by 57.8% and small floods by 33.9% (based on data provided in Boffa Miskell 2008). Noting that the flow at the colony site is also affected by managed and unmanaged tributaries downstream of the MLC, namely the Monowai and Wairaki rivers, it is clear, nevertheless, that the risk of flooding of colonies is likely to be reduced to some extent.

Black-billed gulls and other bird species that breed on gravel-bedded rivers have presumably evolved to cope with flooding events. This is partly shown by the ability of black-billed gulls, black-fronted terns, and banded dotterels to re-nest after floods (or other factors such as predators) have destroyed nesting attempts. The overall impact of flooding on productivity of pairs or of colonies of the three species appears to have not been studied except for anecdotal observations by McClellan (2009). In this particular study, floods only affected black-billed gull colonies in one year (2006) of the three years of research. Seven colonies were subjected to floods that submerged part or all of the colony, mostly at the beginning of incubation or after the majority of nests had been deserted (i.e. chicks were mobile, and could move to higher ground). As such, most colonies appeared largely unaffected. Two colonies, however, were flooded on several occasions but remained at the colony location. One which numbered *c.*2,500 gulls produced *c.*200 fledglings, and another which numbered *c.*700 nests produced 20 fledglings. It is not known whether gulls that deserted the second colony after floods re-nested in other colonies, but it is unlikely (see McClellan 2009, Appendix J, for further details).

From these results, it is suggested that variation in the timing, frequency, and severity of floods influences the extent to which the overall productivity of colonies (i.e. the number of fledglings produced per nesting attempt) is affected. Additionally, the availability of food after a flooding event is likely to influence whether a pair chooses to re-nest. It is clear that, at least in the case of black-billed gulls, overall productivity can be reduced when nests are lost to flooding (McClellan 2009). A reduction in the probability of colony-destroying floods is likely to increase productivity of black-billed gulls to an unknown extent, and may have a similar effect on other gravel-nesting species.

5.3 Availability of nesting habitat and weed invasion

The avifauna assessment notes that invasion of gravel habitats by exotic weeds can force breeding birds to nest in habitats that may be more vulnerable to predation, flooding or disturbance, or that offer poor foraging opportunities, and that weed invasion can be exacerbated by water abstraction. The assessment does not suggest that the extent of weed invasion could be worsened by the significantly decreased number of small to large floods under the proposed MTAD regime. Instead it indicates that the existing weed management programme (funded primarily by Meridian Energy Ltd and Environment Southland), together with climate, grazing, plant competition, and the proximity of nearby weed sources, are key factors affecting habitat availability on the Waiau River.

5.3.1 Changes in vegetation in the Waiau River 1963-2002

GIS analysis of aerial photographs of the Waiau River was undertaken as part of a PhD investigation into the extent of vegetation change within the river between 1963 and 2002. The purpose of the study was to assess whether the availability of bare gravels required for nesting by black-billed gulls had decreased over time due to weed infestation and water abstraction. Five series of aerial photographs from each decade were scanned and aero-triangulation was used to co-register the series. Locational errors between registered aerial photographs were low (varying between 2.2-3.7 m). Two sections in the Waiau were chosen for analysis: an 8 km section between

Tuatapere and immediately north of Te Waewae Lagoon (lower Waiau), and a 13 km section between the confluence with the Wairaki River and the Clifden Bridge (mid-Waiau). In ArcMAP, a boundary line was drawn around the river encompassing all major morphological changes between 1968 and 2002. Also in ArcMAP, polygons were drawn manually around simple habitat types: gravel-dominated (>85% gravel), ≥15% vegetation and gravel, grass/herb-dominated, and tree/shrub-dominated.

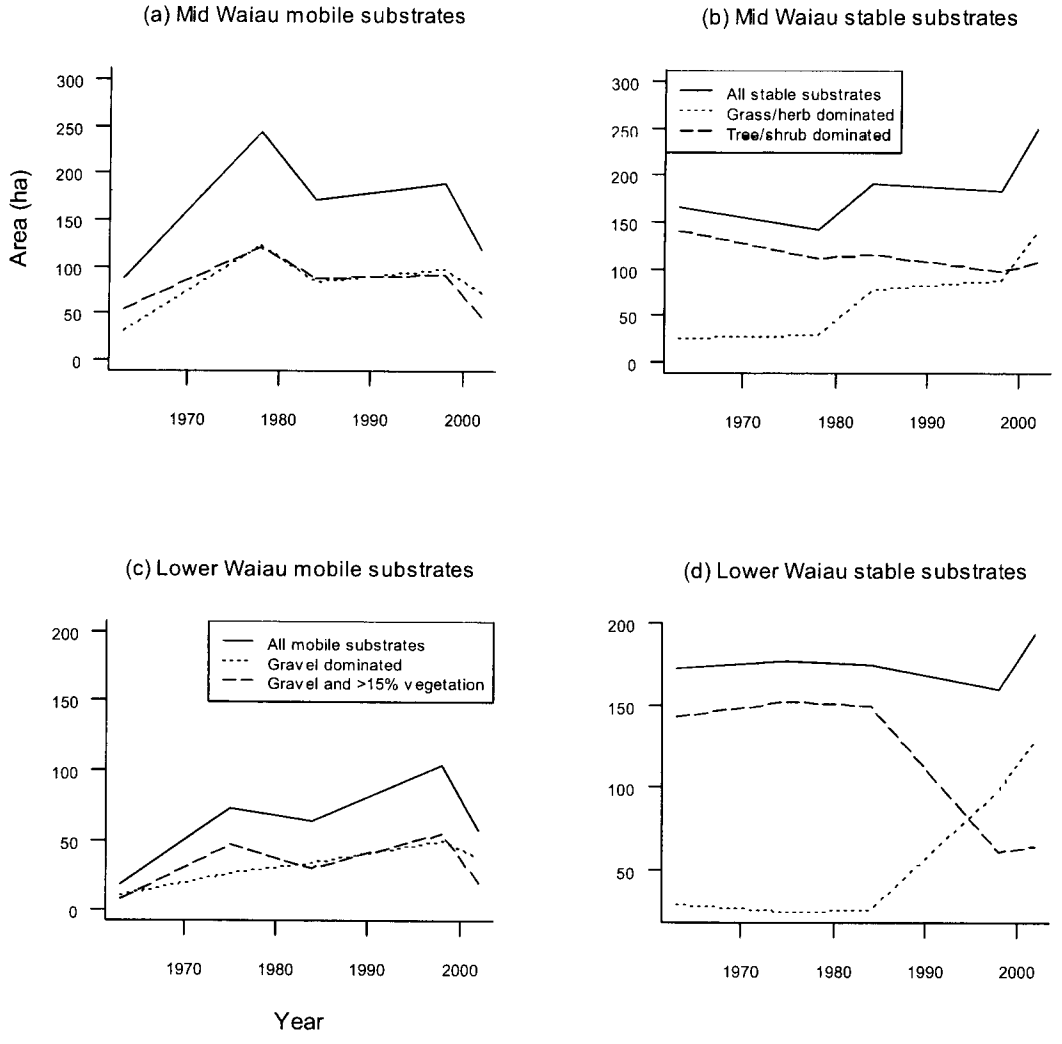


Figure 1: Vegetation changes in the bed of the Waiau River, 1963-2002.

In summary, changes in flow caused by the diversion of water in 1972 initially caused major increases in the availability of gravel habitat, particularly in the mid-Waiau (Figure 1). Since this initial increase, 'mobile' substrates (areas of moderate to high levels of gravel) have declined on the mid-Waiau. Initially, this is most likely to have been due to vegetation claiming much of the newly-exposed gravel habitats in response to the new flow regime. Associated increases in stable habitats also occurred. In the lower-Waiau section, mobile habitat types have fluctuated since 1975. However, in both sections, grass/herb-dominated areas increased and sparsely-vegetated gravel areas decreased between 1998 and 2002. According to the

MTAD Hydrology Report, four of these years were 'typical' and one was 'dry' (URS 2008).
The results of the GIS analysis were limited by three factors:

- Flows at the time of photography: flows were comparable for all years from the 1970s except for 1984 when the river was at a higher flow. Stable habitat types, however, are unlikely to have been affected.

- The five photographic series give only a snapshot of vegetation at that particular time, and do not illustrate the extent of 'natural' fluctuations in the areas of habitat types.

- At the time of writing, no similar study has been able to unravel the complex issue of assigning margins of error to area estimates (pers. obs.; P. Sirguey, Department of Surveying, Otago University, pers. comm.) and, as such, it is not possible to determine whether changes are statistically significant.

Nevertheless, this method is the only one available to investigate historical trends in weed infestation in the absence of a monitoring programme. Despite its limitations, the analysis demonstrates that changes in flow on the Waiau appear to have had major impacts on the extent of vegetation in the early years of operation of the power station. More recent changes (in the last 20 years) are more likely due to a combination of weed control operations (which included herbicide spraying of tree and shrub habitat in the lower Waiau section in the 1980s) and annual fluctuations in flows.

5.3.2 Weed control and the impacts of weeds on black-billed gulls

The present weed control programme targets willow species (*Salix* spp.), broom (*Cytisis scoparius*), and gorse (*Ulex europaeus*) on the Waiau River. The result of this is that these species have been reduced to extremely low levels within the Waiau and other managed Southland rivers. However, several hundred hectares of pasture grass-dominated habitat remain within the Waiau River.

Sixty-three percent of black-billed colony sites (of 46 assessed throughout Southland) supported exotic vegetation at the highest point, suggesting gulls were forced to nest closer to the water line and subsequently were at greater risk of being flooded (on a small number of occasions, however, gulls did not nest at the highest point when it was available). These weeds were primarily pasture grasses, lupins, and other herbaceous species. Only one colony was nesting below an area infested with target weed species (in this case, broom), and these plants were dead due to previous herbicide spraying (McClellan 2009). Colonies on islands at Clifden and Lill Burn (2004) in the Waiau were nesting below the highest points available, which were infested with lupins. Previously-used colony sites at Orauea Stream and Motu Bush appeared to be unusable due to weed infestation when last checked in 2005.

Research also determined that the colony size of black-billed gulls is related to the area of clear gravel in which the colony is located. The size of the gravel patch is likely to be partly related to the extent of weed spread; the more weeds present, the smaller the gravel patch. This is of some importance given that the size of

black-billed colonies is related to productivity; the larger the colony, the higher the nest success and breeding success (i.e. number of fledglings produced per nest). It follows that, as weed infestation worsens and patches become smaller, colony sizes are likely to decrease, and productivity will be negatively affected (McClellan 2009).

The weed control programme has almost certainly helped to maintain breeding habitat availability on the Waiau. Nevertheless, the majority of black-billed gull colonies are still breeding in sub-optimal conditions as a result of weed infestation.

5.3.3 Effect of the MTAD on weed infestations

The greatest impact of the MTAD is to significantly reduce the frequency/duration of small to large floods from the MLC. The Avifauna Assessment states that this effect is reduced with distance downstream as the flow is increased by tributaries. However, there is no documentation of the relative inputs of these waterways with which to evaluate the changes in flows at different points below the MLC. Nevertheless, the loss of a significant proportion of the 150-1,000+ m^3/s floods entering the Waiau is a highly significant effect. Such floods, particularly those over 600 m^3/s, are able to mobilise gravels, including those which are vegetated. Reducing their frequency is likely to lead to further stabilisation of gravels as a result of weed infestation, reducing the availability and quality of breeding habitat for black-billed gulls and other riverbed-breeding birds.

5.4 Impacts on aquatic invertebrates and fish

The Avifauna Assessment concludes that the MTAD will not have any adverse effects on aquatic food sources for birdlife in the Waiau River but does not mention the possible effects of reduced floods on the prevalence of the invasive aquatic weed didymo (*Didymosphenia geminata*) in the river, which is a major omission.

Didymo was first discovered in New Zealand in the Waiau River in 2004. The river regularly suffers from thick mats forming across much of the riverbed and major blooms. One of the most significant factors limiting the growth of didymo within rivers is 'bed mobilising flooding' (Biosecurity New Zealand 2009). As a consequence, the loss of a significant percentage of small to large floods from the MLC is likely to reduce the number of times per year that didymo will be cleared from the Waiau. Didymo has been found to increase the abundance and diversity of invertebrates in the Waiau and neighbouring Mararoa River, but the structure of the invertebrate community is altered and contains significantly less caddisflies, mayflies, and stoneflies; i.e. invertebrates of high quality aquatic communities (Kilroy *et al.* 2006). No effects on indigenous fish have been found (Biosecurity New Zealand 2009).

In Southland, black-billed gulls appear to feed largely on agricultural invertebrates (R.K. McClellan, unpublished data), and are unlikely to be significantly affected by any changes in the quality of freshwater invertebrate communities. However, it is not known how other bird species that feed from the river, such as black-fronted terns and banded dotterels, are affected by the introduction of didymo. It is possible that reduced scouring of the Waiau could negatively affect food sources for these species.

5.5 Importance of sites on the Lower Waiau River for black-billed gulls

Section 5.8.5 of the Assessment of Environmental Effects states that Te Waewae Lagoon "is the most important site on the Lower Waiau River in terms of numbers of nests for black-billed gulls" and gives examples of 2,329 nests counted in 2000 and 353 nests in 2001 (Meridian Energy 2009b). This review agrees that the Waiau Bar, which forms Te Waewae Lagoon, is an important breeding site for black-billed gulls and is used frequently (Sagar 1994; McClelland 1996, 1997, 2001, 2002; McClellan 2009). However, the main stem of the Waiau, particularly the section from the Tuatapere Bridge to the confluence with Wairaki River, is of similar, if not greater importance. During the 1977 ground survey of the Waiau, Aparima, Oreti, and Mataura Rivers, all seven colonies found on the Waiau (total *c.*8,700 nests) were located within this section, with no colonies present on the bar (R. Sutton, M. Barlow unpubl. data). Colonies of 3,319 birds (1993; Sagar 1994), two colonies totalling 2,200+ nests (1996; McClelland 1997), and two colonies exceeding 1,100 nests (2001; McClelland 2002) have been found in this section. In 2004, three colonies totalling almost 6000 nests were located on islands at Clifden, Lill Burn, and Motu Bush, with no colonies present at the bar (McClellan 2009).

The avifauna assessment concludes that Te Waewae Lagoon and its associated bird populations will not be affected by the MTAD (Boffa Miskell 2008). This review agrees with this conclusion, but is concerned that the assessment plays down the obvious importance for black-billed gulls of the main stem of the lower Waiau River, which the review considers will be negatively affected by the predicted decreases in duration of moderate, significant and large floods.

6. MITIGATION MEASURES

6.1 Weed monitoring

Weed monitoring should be initiated immediately in order to document the present state of weed infestation along the Waiau. If resource consents for the discharge amendment are granted, weed monitoring should then continue, to assess the impacts of reduced flooding frequencies and also to clarify 'natural' fluctuations in the extent and types of vegetation within the river.

6.2 Weed control for breeding habitat maintenance

Black-billed gull surveys undertaken from 1993-2006 have sometimes located colonies on the banks of the Waiau main stem. However, key island sites are present throughout the lower Waiau, particularly between Tuatapere and the Wairaki River confluence, and have been used irregularly since the earliest survey in 1977 (several are noted in the avifauna assessment). These sites include islands at Orauea Stream, below the Clifden Bridge, Lill Burn, and Motu Bush. Black-billed gulls are often considered to be a somewhat unpredictable species, showing little pattern in occupation and abandonment of colony sites. However, recent analysis of characteristics of black-billed gull colony sites that are re-used in the following season indicates that gulls are more likely to re-use sites that are morphologically stable and have a history of previous use (McClellan 2009). Many of these islands have been

present for at least 25 years although some occasionally change from island to bank sites (and back to islands).

Control of all weeds at these sites is recommended to preserve high quality habitat. This will maintain an adequate number of sites on the Waiau for black-billed gulls (and other species) should reduced flood frequencies act to increase weed infestation at these and other sites. Sites should be checked annually during autumn/winter to assess whether weed control is necessary in that year, and any control required should be carried out well before the breeding season commences in August. If shrubs are present (e.g. at Orauea and Motu Bush), these should be removed, rather than killed and left *in situ*. Recent trials carried out on the Oreti River targeted all vegetation including pasture grasses (primarily to mobilise gravels, but also to create high quality black-billed gull habitat). These trials have successfully cleared entire areas of exotic vegetation but the sites remain covered with silt (K. McGraw, Environment Southland Catchment Manager, pers. comm.). If weeds continue to be controlled annually at these and the proposed Waiau sites, it is likely that a 'moderate' (or larger) flood will eventually shift the silt to expose bare gravels, making the area suitable for nesting. It is not clear, however, to what extent silt will be a problem at the Waiau sites.

Under contract to Meridian Energy Ltd., Boffa Miskell Ltd. has successfully trialled the use of a digger on islands within the lower Waitaki River to remove the silt layer. Three species of threatened birds utilised the island in that season (Boffa Miskell Ltd. 2009).

The approximate area of the Waiau islands is 19 ha, based on GIS (remote sensing) analysis of the areas of the Motu Bush and Lill Burn 2004 colonies. The area requiring weed control will be substantially less than this, but will vary from season to season.

7. CONCLUSIONS

The proposed MTAD will significantly reduce the frequency of small (150-299 m^3/sec) to large (>1,000 m^3/sec) floods released from MLC. For example, in a 'typical' year (65% of years) there is expected to be a 20% decrease in the number of days with small floods and a 50% decrease in the number of days with moderate floods.

McClellan's (2009) research illustrates that changes in flow regimes significantly affected the availability of habitat when water was first diverted in 1972. Further changes in flow as a result of the MTAD, though of a much smaller nature, are also very likely to have an impact on vegetation patterns within the Waiau River below MLC. The loss of a significant proportion of bed-mobilising floods is likely to result in continuing stabilisation of high points within the river due to weed invasion, and an increase in the extent of weed cover as exotic vegetation spreads into lower areas. This will force a greater number of river-breeding birds to nest even closer to the water line and, as a consequence, increase their vulnerability to flooding. Additionally, the productivity of black-billed gull colonies is related to the colony size, and colony size is related to the size of the gravel patch. If the extent of weed

invasion increases causing gravel patches to decline, black-billed gull productivity is also likely to decline on the Waiau River (McClellan 2009).

Importantly, the present weed control programme within the Waiau River does not target weed species associated with black-billed gull colonies (such as pasture grasses) and, presumably, other species of river-breeding birds.

Another possible effect not addressed in the avifauna assessment is that the loss of a proportion of bed-mobilising floods will reduce the number of occasions on which didymo is flushed from the Waiau. Given that didymo has been shown to lower the quality of the freshwater invertebrate community in the Waiau (though it increases the overall abundance and diversity), it may affect the diets of bird species which feed on these organisms. Black-billed gulls appear to feed largely on agricultural invertebrates, and are unlikely to be significantly affected.

This review agrees with the findings of the assessment in regard to the MTAD having little effect on the rate of predation of birds nesting on islands, given that the MTAD will not reduce existing low flows. The review also concurs with the assessment's conclusions that the reduction in floods will result in a reduction in the frequency of nest/colony destruction caused by flooding. However, this positive effect of reduced flood frequency is offset by the likelihood that:

- Weed spread will further reduce available habitat (potentially reducing black-billed gull productivity);

- Weed spread will increase the risk of flooding by invasion of lower areas (forcing birds to nest even closer to the waterline); and

- Freshwater invertebrate sources will be modified due to greater proliferation of didymo which may reduce the quality of the diet of some avifauna species.

This review does not agree with the statement within the Assessment of Environmental Effects that Te Waewae Lagoon is the most important site for black-billed gulls on the lower Waiau River. Of at least equal importance is the main stem of the lower Waiau. Given the high threat status of this species, and the fact that the river is clearly of national importance for breeding black-billed gulls, further degradation of the river as a result of the proposed MTAD is of considerable concern.

The following actions are recommended:

- Weed monitoring should be instigated prior to any alteration to the flow regime and continued once changes have been instigated. The methods should be capable of identifying changes caused by the MTAD, as well as 'natural' fluctuations caused by differences in annual flows and flood sizes.

- Broad-scale, annual weed control should be commenced at a number of island sites within the Waiau, to maintain high quality breeding habitats for black-billed gulls and other river-breeding birds.

- Annual monitoring of black-billed gulls and black-fronted terns should be undertaken. Monitoring results should be examined in relation to water levels through the breeding season (e.g. low numbers of birds/colonies establishing may be related to high flows early in the season).

- Use of management islands should also be monitored. If black-billed gull colonies continue to regularly use unmanaged, poorer quality habitat (particularly on banks), the use of decoys to attract gulls and terns to nest on management islands should be trialled (see McClellan 2009).

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APPENDIX 1

AERIAL PHOTOGRAPHS
OF PROPOSED
MANAGEMENT ISLANDS



Figure A: Motu Bush sites. When last visited, the 2004 colony site had a major pasture grass infestation.

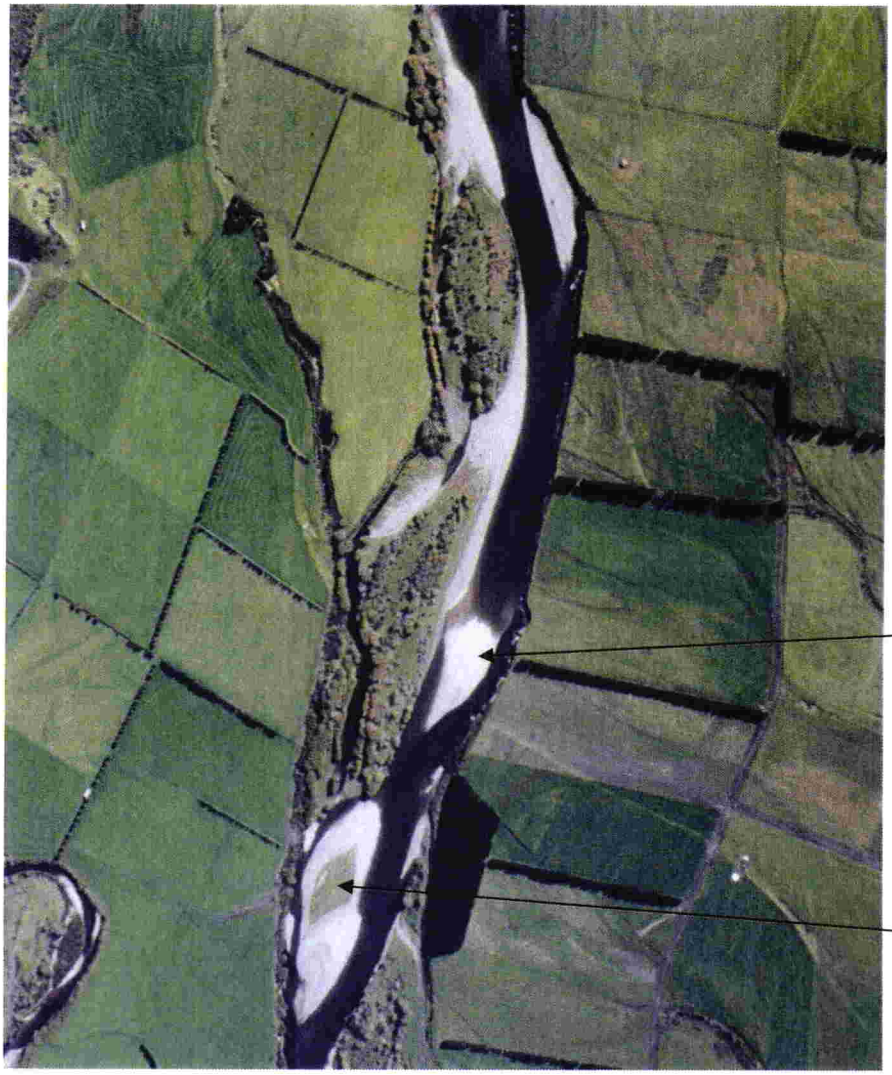


Figure B: Lill burn sites. When last visited, the 2004 colony site was infested with lupin at its highest point.



Figure C: Clifden sites (below the bridge).

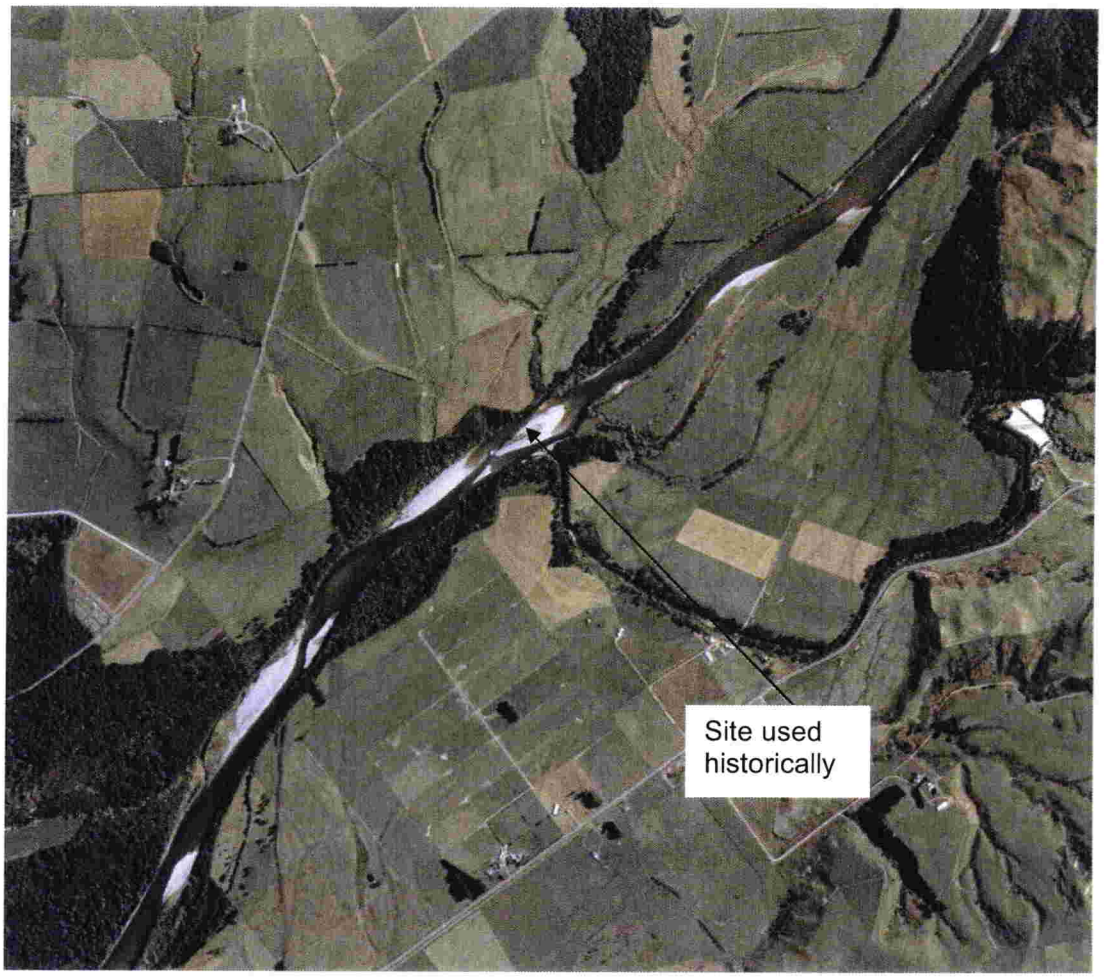


Figure D: Orauea Stream site.