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Ruataniwha Plains Water Augmentation Scheme

Aquatic ecological review – September 2010

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General background

This summary provides a review of the existing information on fisheries (indigenous and introduced) for the waterways potentially affected by the overall proposed Ruataniwha Plains Water Augmentation Scheme and assesses the relevance of this to assist an understanding of the potential effects of each individual storage scheme and the wider collection of schemes on aquatic ecology. It provides a high level review of constraints and issues. It provides guidance on further information needs and gives a broad scope and cost of this work required to address the issues and constraints. The summary has been broken down into a number of sections for each scheme. Each scheme has the same sections listed. Many of the schemes share common issues.

In considering the steps in assessing the impacts of individual or the wider collection of schemes it is evident that the first step in this process is to understand what both the wider catchment and then more localised values are in terms of fish species present. The New Zealand Freshwater database (FFDB) gives a very useful indication of this and the application of this information has been used by a range of researchers to model the likely distribution of key native species through New Zealand (Leathwick et al 2008, Joy et al 2000). The intent of this modelling was to remove the requirement for expensive and complex field based assessments. This is particularly so given the vast majority of our native fish species are diadromous and able to migrate some distance into the majority of our waterways. In our view the historical information available from the FFDB for the waterways of interest, and using the model by Leathwick (2008) provides a useful platform by which the next layer of understanding of fisheries in the Tukituki catchment can be developed.

With the availability of this distribution information the development of more detailed and site specific information can be derived for each scheme. In our view this is an important first step that will guide the further 'drill downs' in assessing the effects of developing these schemes.

It should be noted that this review has at this stage focused on the streams and rivers directly impacted by the proposed schemes. No consideration has been given to the wider cumulative effects of multiple scheme operations on the wider Tukituki catchment. This will require consideration once the final mix of schemes is known at some stage in the future.

Current fishery – make up/values

The Tukituki River currently has recorded 17 species of freshwater fish of relevance to these schemes, 2 species of marine fish, 14 native fish species and 3 species of sports fish this information coming from 420 individual records in the FFDB[i]. Some species exhibit diadromy (migration to and from the sea at well defined seasons and development stages) through various strategies (McDowall 1993). As recorded in McDowall (1997) some are amphidromous (larvae go to sea on hatching, and return to freshwater as well grown juveniles), some are anadromous (mature adults migrate into freshwater to spawn, the larvae returning to sea for most growth and maturation), finally some are catadromous (mature adults migrate to sea to spawn with progeny returning to freshwater as juveniles to grow and mature). Others are described as laucustrine or non-migratory whereby their full life history occurs within freshwater. Some species such as common smelt or brown trout can exhibit both non-migratory and anadromous behavior.

All species currently known in the catchment include:

Yellow eyed mullet (*Aldrichette forsteri*) M	Grey mullet (*Mugil cephalus*) C
Longfinned eel (*Anguilla dieffenbachii*) C	Shortfinned eel (*Anguilla australis*) C
Torrent fish (*Cheimarrichthys fosteri*) AP	Koaro (*Galaxias brevipinnis*) AP
Dwarf galaxias (*Galaxias divergens*) L	Inanga (*Galaxias maculatus*) AP
Lamprey (*Geotria australis*) A	Crans bully (*Gobiomorphus basalis*) L
Upland bully (*Gobiomorphus breviceps*) L	Common bully (*Gobiomorphus cotidianus*) AP
Giant bully (*Gobiomorphus gobiodes*) AP	Bluegill bully (*Gobiomorphus hubbsi*) AP
Redfin bully (*Gobiomorphus huttoni*) AP	Common smelt (*Retropinna retropinna*) A/L[1]
Rainbow trout (*Oncorhynchus mykiss*) L	Brown trout (*Salmo trutta*) A/L
Perch (*Perca fluvitalis*) L	Goldfish (*Carassius auratus*) L

Key: C- catadromous, AP – amphidromous, A – anadromous, L - laucustrine

From this list it is evident that the majority are migratory species of some description. For this reason it is my view that intensive, field based, investigations into the distribution of fish is not warranted at this point. On the basis that many are migratory it would be safe to make an assumption (backed up by distribution modelling as explained later) that the species are likely to be present and manage as such.

The age of the data within the FFDB records for the Tukituki is variable, some going back to the 1960's with most from the mid 1980's to around 2005. At this point I consider the age of

[1] Smelt can be either anadromous or laucustrine. They are highly likely to be anadromous in the Tukituki River.

the data is immaterial given the proposal to model distributions. The work completed by Leathwick et al (2008) deals with the historical nature of some records and provides the generic distribution model. If additional site specific data is deemed necessary after reviewing the modelled data then this can be gathered as required.

Within the fish species present there are several species that require specific mention and possibly slightly different approaches depending on the scheme and potential affects.

- Rainbow trout – The Tukituki has historically been one of the top ten most fished catchments in the country (Unwin 2003), but more recently angler use has declined (Unwin 2009) most likely as a result of angler perceptions on the status of the fishery with among other things a perceived decline in water quality (Jellyman et al 2003). The schemes present potential to prevent spawning migrations through weirs and dams. It is unlikely that this could be effectively mitigated for given the size of many of the dams and weirs proposed in affected catchments. The wider Tukituki fishery is limited by the availability of adult habitat (Maxwell & Pitkethley 2006) with the adult habitat is driven by water quality and quantity. In the context of these schemes we could potentially manage both to mitigate for the loss of spawning and juvenile rearing habitat through the provision of environmental flows therefore retaining or enhancing the remaining adult trout habitat.
- Longfin eel – A strong migrant that is listed in the New Zealand Threat Classification System (Hitchmough 2008) as being in gradual decline. Barriers to elver migrations and adult downstream spawning migrations are the key issues here. For many of the weirs the provision of a residual flow through a fish passage system would be sufficient mitigation and the larger dams may require a combination of fish passage and possibly a trap and transfer system. Both are feasible for all of the schemes. The most significant hurdle would be presented in the downstream migration of adults, particularly in schemes that have a hydro power add on. There are issues in preventing the downstream entrainment of adults into turbines that would require the development of careful screening. At this stage this is also considered possible and should be able to be provided in the scheme designs. The loss of adult habitat could also be modelled for those schemes that upstream elver migrations were considered problematic so that off site mitigation could be considered for those populations deemed to be significantly impacted. From the information available it would appear that the schemes most likely to have significant issues around eel migrations and loss of habitat are those on Dutch Creek and the Makaroro.
- Dwarf galaxias – A non migratory species that has a particular stronghold in the Hawke's Bay. It is listed in the New Zealand Threat Classification System as being in gradual decline (Hitchmough 2008). The most significant issue here is the inundation of adult habitat through the 'footprint' of the impoundment. There is no direct mitigation that is sensible for this other than the wider possibility of offsite mitigation through the development or protection of habitat through riparian management.

Common issues

That said there are some key common issues identified that are listed below that the reader will find recurs in most of the proposed schemes. The schemes and associated systems and impacts are summarized in table one.

- Conduct a desktop review of the modelled distribution of fish in all catchments identified as being directly affected by damming, weirs, intakes or affected by wider alteration of catchment flows using the models developed by Leathwick et al (2008). If the available information is not of a fine enough resolution to model this will direct and focus efforts to areas where site specific investigations are required. Within the consideration of distribution it would be sensible to consider reviewing the available information around any potential new barriers to fish migration such as culverts or water intake weirs. It is anticipated that this information could be gathered in a desktop process using for example Hawke's Bay Regional Council consent information. This new information could be used to further fine tune the model

- If site specific investigations are required these should follow the protocols outlined in David et al 2010
- Populations of dwarf galaxias may need site specific investigations to determine the extent of their distribution relative to the proposed footprint of the impoundment. This will guide our understanding on the proportion of the populations lost through habitat loss
- Longfin eel populations have been modelled recently through consent processes relevant to the Mokihinui River hydroelectric proposal. The models predict the distribution of eels and would allow informed assessments of the proportion of populations that are likely to be lost as a result of migration barriers
- The flow statistics used for the majority of the smaller catchments are best guess estimates. It is essential to have accurate flow data for these catchments in order that sensible flow regimes are developed for residual flows. Generalised additive models could be developed to guide our understanding of the width by flow relationship for smaller systems that we have no flow records for and the cost and practicality of obtaining these flows for is limited. This will allow informed assessments of the scale of proposed abstractions on smaller systems
- All schemes, except D2a and D2b, have the significant potential to alter the flow regime (in particular the range of variability of flows and/or a reduction of median flows) of either the catchment they are in or the catchment they are taking from. Given the known complexities of the basins hydrogeology and the fact that they all ultimately contribute to the flows in the Tukituki River, it is impossible to try and manage them or consider them in isolation from one another
- All schemes have the potential for adverse water quality developing within the impoundment and then being subsequently released to meet residual flows. This prediction of water quality change and required management response is subject to a parallel work-stream and is dealt with separately to this report
- The absence of guidance in the Regional Resource Management Plan (RRMP) for Hawke's Bay in terms of allocation of flows for harvesting makes an assessment of their effects difficult. We effectively do not have an agreed benchmark by which we can judge the impacts of the schemes against community expectations for these resources. What we do know is that other regions (Horizons, Environment Waikato and Southland) have set guidelines that if we assess the proposed takes against, by in large are significantly higher than is likely to be accepted by the wider community and would represent an undesirable alteration to the flow regime
- The consideration of flow related issues and options in the context of the wider development of the schemes is complicated by the unknown mix of the final schemes and the fact that they are all taking water for storage within the same wider catchment. The catchment is complex from a hydrogeological perspective making the next steps uncertain in some aspects of this work. The wider flow related issues that will probably develop through consultation with stakeholders will be;

- Overall reduction in the median flows for both directly impacted streams and wider catchment. This is probably able to be mitigated through environmental flows and residual flows
- Range of variability of flows altered. May require some flow management in conjunction with flushing flows
- Managed flows result in nuisance periphyton growth. Can be managed through flushing flows

Scheme specific comment

- The detailed information for each scheme is outlined in appendix two to this report. Each scheme is considered against the same questions/issues and a summary is provided including likelihood to consentability based on fish ecology issues
- I have been asked to specifically comment on the relative impact of scheme A1 (Dutch Creek) versus A7 (Makaroro). The suggestion is that A7 while will impact a larger catchment area it will potentially have less impact than A1 due to the smaller 'footprint' of the area to be inundated under the impoundment.
    - The suggestion is true and is potentially correct if we consider dwarf galaxias in isolation. This to some degree depends on the extent of habitat use in both areas by dwarf galaxias and will become evident through site specific investigations.
    - A7 will potentially exclude both rainbow trout and longfin eel from a larger catchment area than A1. This probably presents the largest issue for mitigation for both schemes. As expanded on in the fishery section the movement of longfin eel elvers upstream and then spawning adults downstream, particularly if there is a hydro power add on, will require specific investigation and design

Further investigative work (all prices are GST exclusive)

- All figures quoted below are cost estimates based on the available information to date. They should not be construed as a final indication of the total cost
- As indicated the next critical step is to confirm the distribution of fish within the relevant catchment using the models developed by Leathwick et al (2008) and from the Mokihinui. The costs of this exercise will vary considerably as the resolution of the model is refined. The finer the level of detail, the greater the cost. The cost to develop a general understanding of distributions of fish in the wider catchment (for all schemes) is estimated to be in the vicinity of $15,000-$25,000
- If, from the proposed modelling exercise, dwarf galaxias are confirmed to potentially exist in any area proposed to be inundated by an impoundment then we would need to know the site specific scale of the population that was likely to be lost through flooding habitat. This would involve field investigations using the protocols in David et al (2010). This is estimated to cost $10,000 to $20,000 per site
- If species have been recorded from the FFDB and yet the predictive models suggest that they should not exist within the catchment, this will require a more detailed field investigation of fish distribution along the lines suggested by David et al (2010). This is difficult to cost accurately as it largely depends on the size and length of the area required to investigate. Using suggestions from David et al (2010) we would estimate that each investigation could cost $10,000 to $20,000 per scheme

- Once the values and distributions of fish species are confirmed this would allow a further level of investigation to occur dealing with flows and allocations. As noted earlier this would need to be considered in the wider catchment sense and so should occur when the range of schemes to go forward is known. To provide cost estimates for this work is impossible given the high degree of uncertainty around which schemes are going to operate and what the final flow regimes are

Table one: Summary table of schemes, values, potential impacts, mitigation options, likelihood of consenting. Details on the abbreviations are included as footnotes

Scheme	Fishery values	Potential scheme effects[2]	Potential mitigation options[3]	Is the scheme likely to be consentable?
A1 – Dutch Creek	High salmonid High Native	B, I, L, E, W, F, P, LF	FP (for strongest migrants only), S, EF, FF, MW	Has some issues that will require significant mitigation but yes
A2 – Gwavas	Low to moderate salmonid Moderate native	B, possible I, possible L, E, W, F, possible P, LF	FP (for natives only), S, EF, possible FF, MW	Yes
A4 – Glenalvon	Low salmonid Low to moderate native	B, possible I, possible L, E, W, F, possible P, LF	FP (for natives only), S, EF, possible FF, MW	Yes
A7 – Makaroro	High salmonid High native	B, I, L, E, W, F, P, LF	FP (for strongest migrants only), S, EF, FF, MW	Possible, but with significant investment required in mitigation
B1 – Upper Ngaruru	Low to moderate salmonid Moderate to high native	B, possible I, possible L, E, W, F, possible P, LF	FP (for natives only), S, EF, possible FF, MW	Yes
B2 – Lower Ngaruru	Low to moderate salmonid Moderate to high native	B, possible I, possible L, E, W, F, possible P, LF	FP (for natives only), S, EF, possible FF, MW	Yes
C2 – Sherwood	Low salmonid Low to moderate native	B, possible I, possible L, E, W, F, possible P, LF	FP (for natives only), S, EF, possible FF, MW	Yes
C3 – Ashley Clinton	Moderate salmonid Moderate native	B, possible I, possible L, E, W, F possible P, LF	FP (possibly both salmonid and native), S, EF, possible FF, MW	Yes
D2a – Rangitoto	Low salmonid Low to moderate native	B, possible I, possible L, E, W, F, possible P, LF	FP (for natives only), S, EF, possible FF, MW	Yes
D2b – Rangitoto	Low salmonid Low to moderate native	B, possible I, possible L, E, W, F, possible P, LF	FP (for natives only), S, EF, possible FF, MW	Yes
D3 - Hinerangi	Moderate to high salmonid Moderate to high native	B, possible I, L, E, W, F, P, LF	FP (may not be required), S, EF, FF, MW	Has some issues that will require significant mitigation but yes
D5 – Makaretu	Moderate salmonid Moderate to high native	B, possible I, L, W, F, P, LF	FP(for strongest migrants only), S, EF, FF, MW	Has some issues that will require mitigation but yes

[2] Key – B = migration barrier for diadromous species, I = inundation of dwarf galaxias habitat, L = creation of salmonid lake fishery, E = intakes may entrain downstream migrants, W = water quality of released water lowered (temperature and chemical issues), F = flow variability of impacted streams altered, median flows lowered, P = nuisance periphyton growths downstream of residual flows, LF = low flows improved.
[3] FP = fish passage, S = screening intakes, EF = environmental or residual flows, FF = flushing flows, MW = model water quality for best release options

Appendix two: Site specific reviews

Site A1 – Dutch Creek

Scheme Description:

- On-river dam – Dutch Creek
- NTWL 516 mRL (full supply level)
- Dam height 63 m
- Crest elevation 518.5 mRL
- Storage volume 20.5 million m^3
- Reservoir area 131 ha
- Potential infill (pumped) from Makaroro River, if needed.

Potentially impacted streams:

- Dutch Creek and tributaries
- Makaroro River flows

Scale of abstraction relative to flow:

- Potential to take up to 70 L s^{-1} from the Makaroro River during winter months. Some years no take is required with Dutch Creek contribution sufficient. This rate of take relative to the Makaroro winter median flow at the intake of 2500 L s^{-1} is small (2.8% of winter median) and unlikely to be an issue. The take is likely to occur on the shoulder of the critical flow periods and is possible to be mitigated for by environmental releases during critical low flow periods

FFDB info availability and relevance:

- 9 records from Dutch Creek, from 1983 to 2004
- 19 records from Makaroro River, from 1984 to 2004
- Indicates diadromous fish were present so it is still relevant and useful for modelling using fish distribution models such as Leathwick et al (2008)

Fish species of significance and/or relevance to scheme design:

- Dwarf galaxias
- Rainbow trout
- Longfin eel

Data gaps:

- Confirmation of species distribution using Leathwick et al model. Model may not give fine enough resolution to give accurate indications of distribution relative to impoundment. May require site specific investigation.
- If the database indicates the historical presence of a species but modelling suggests it is not possible this needs site specific investigation

- As dwarf galaxias are present from FFDB records or it is indicated that they should be from models, we need to understand what proportion of the population is lost/impacted through the footprint of the impoundment through site specific investigations to guide the necessity for mitigation
- As longfin eel are present from FFDB records or if it is indicated that they should be from models, then we need to understand what proportion of the population within the catchment is potentially removed or isolated through the barrier to guide the necessity for mitigation. This can be developed through work with models on eel distribution

Potential scheme effects:

- Dam a migration barrier for all diadromous fish species, particularly longfin eel and rainbow trout. Size of the dam wall likely to be an issue for providing fish passage – loss of habitat, interruption to lifecycle migrations, reduced population fitness
- Loss of spawning and subsequent juvenile rearing habitat for rainbow and possibly brown trout
- Loss of adult habitat through inundation for non migratory species (dwarf galaxias)
- Increased risk of predation to non migratory species through impoundment stocking of sports fish
- Impoundment creates new salmonid fisheries through the development of lake type habitat
- Intake in Makaroro Stream may entrain downstream migrating species
- Water quality through impoundment and subsequent stratification may be altered. Release of water below the dam may result in cooling or warming of the receiving waters impacting fish with narrow thermal tolerances.
- Flow variability in the section of Dutch Creek downstream of the dam, the Makaroro Stream and Waipawa River reduced, flows more 'peaky' as a result of both flow harvesting and abstractive releases.
- Median flows of Dutch Stream, Makaroro Stream and Waipawa River reduced. May result in nuisance periphyton growths downstream of dam
- Low flows may be improved (increased) at critical times

Possible mitigation:

- Development of fish passage provision for key species. Given the height of the proposed dam wall only fish passage for the strongest of migrants such as elvers is likely to be possible. Eel trap and transfer techniques now well developed so it may also be possible to use this technology
- Review and model lake water quality. This will provide direction on the best possible release depths within the lake. This work will come through later investigations
- Screening intakes to prevent entrainment
- Significant potential to provide environmental flows to mitigate impacts of lost habitat for diadromous species (particularly trout). Flow sharing regimes (1:1 flow sharing or similar) to allow for higher low flows at critical times in the Makaroro and Waipawa (usually summer)

- Development of a flushing flow regime for periods of sustained low flow

Scheme summary:

- Dutch Creek is a high value tributary of the Makaroro River. The Makaroro River is a high value tributary of the Waipawa River. Both have extensive salmonid spawning/rearing habitat. Both are likely to be high value habitat for diadromous and non migratory native species. The Makaroro River is a recreational fishery for salmonids
- This scheme has a range of potential impacts that are likely to be successfully mitigated for. Primarily through the provision of fish passage, fish screening, environmental flows (this may require a range of variability approach as discussed in the main body of this report) and management of where and when the water is released from the reservoir.
- The scheme is likely to be consentable from a fish ecology perspective

A2 Gwavas Forest (Matheson Road)

Scheme Description:

- Middle Upokororo Stream
- NTWL 387 mRL (full supply level)
- Dam height 45 m
- Crest elevation 389 mRL
- Storage volume 8.1 million m^3
- Reservoir area 60 ha
- Infill (gravity feed and supplementary intake) from 2 tributaries of the Upokororo River.

Potentially impacted streams:

- Upokororo Stream (flows and fish passage) – ephemeral, likely to have isolated populations of non migratory species
- Taumahapu Stream (flows and fish passage) – unknown values
- Middle Upokororo stream – ephemeral, likely to have isolated populations of non migratory species
- Potentially also Mangamauku flow regime – ephemeral, likely to have isolated populations of non migratory species

Scale of abstraction relative to flow:

- Winter median of Upokororo 170 L s^{-1}. Proposed winter average abstraction 40 L s^{-1} or 24% of median flow. This represents a high degree of alteration
- Potential exists to abstract up to 290 L s^{-1} which is higher than mean flow. This again represents a significant degree of alteration with potential to create a very 'peaky' hydrograph with flows ranging from the residual 7day MALF to large flood events in a short space of time.

FFDB info availability and relevance:

- 4 records from Upokororo all 1988
- 6 records from Mangamauku, from 2001 to 2004
- Indicates diadromous fish were present so it is still relevant and useful for modelling using fish distribution models such as Leathwick et al (2008)

Fish species of significance and/or relevance to scheme design:

- Dwarf galaxias
- Rainbow trout
- Longfin eel

Data gaps:

- Confirmation of species distribution using Leathwick et al model. Model may not give fine enough resolution to give accurate indications of distribution relative to impoundment. May require site specific investigation.
- If the database indicates the historical presence of a species but modelling suggests it is not possible this needs site specific investigation
- As dwarf galaxias are present from FFDB records or it is indicated that they should be from models, we need to understand what proportion of the population is lost/impacted through the footprint of the impoundment through site specific investigations to guide the necessity for mitigation
- As longfin eel are present from FFDB records or if it is indicated that they should be from models, then we need to understand what proportion of the population within the catchment is potentially removed or isolated through the barrier to guide the necessity for mitigation. This can be developed through work with models on eel distribution

Potential scheme effects:

- Intake weirs on Upokororo and Taumahapu a migration barrier for all diadromous fish species – loss of habitat, interruption to lifecycle migrations, reduced population fitness. This effect is dependent on the area and time of year that the stream is ephemeral for. This effect is likely to be minor and able to be easily mitigated for through the weir design and location of the residual flow outlet
- Dam on Middle Upokororo a migration barrier for all diadromous fish species – loss of habitat, interruption to lifecycle migrations, reduced population fitness. This effect is dependent on the area and time of year that the stream is ephemeral for. This effect is likely to be minor and able to be easily mitigated for through the provision of the residual flow
- Loss of adult habitat through inundation for non migratory species (dwarf galaxias)
- Increased risk of predation to non migratory species through impoundment stocking of sports fish. Access to previously inaccessible areas of the stream due to its ephemeral nature may expose non-migratory dwarf galaxias to predation by salmonids
- Water quality through impoundment and subsequent stratification may be altered. Release of water below the dam may result in cooling or warming of the receiving waters impacting fish with narrow thermal tolerances.
- Impoundment creates new salmonid fisheries through the development of lake type habitat
- Intake in Upokororo and Taumahapu streams may entrain downstream migrating species
- Abstraction and damming potentially significantly reduces flow in Upokororo, Middle Upokororo and Taumahapu streams. This in turn reduces the contributing flow to the Mangaonuku Stream
- Flow variability in Upokororo and and Taumahapu streams reduced, flows more ‘peaky’

- Winter median flows of Upokororo, Middle Upokororo and Taumahapu streams reduced. May result in nuisance periphyton growths downstream of dam

Possible mitigation:

- Development of fish passage provision for key species. Given the height of the proposed dam wall only fish passage for the strongest of migrants such as elvers is likely to be possible. Eel trap and transfer techniques now well developed so it may also be possible to use this technology. Weirs to have residual flows through fish passage channels for migrant native species
- Retention of a residual flow for all affected streams. Significant potential to reduce periods of extreme low flow
- Review and model lake water quality. This will provide direction on the best possible release depths within the lake. This work will come through later investigations
- Screening intakes to prevent entrainment
- Link abstractive takes to flow and allocation limits for the catchment. Set abstractive takes as lower category takes and restrict dam fill periods from intakes for shoulder and/or winter periods. Limit rates of take to a proportion of instantaneous winter median flow
- Development of a flushing flow regime for periods of sustained low flow

Scheme summary:

- The Upokororo, Taumahapu, Middle Upokororo and Mangmauku streams are moderate value tributaries of the Mangaonuku Stream. The Mangaonuku Stream is a high value tributary of the Waipawa River. The directly impacted streams are unlikely to be significant from a salmonid habitat perspective. They are likely to offer moderate value habitat for diadromous and non migratory native species.
- This scheme has a range of potential impacts that are likely to be successfully mitigated for. Primarily through the provision of fish passage, fish screening, environmental and flushing flows (this may require a range of variability approach as discussed in the main body of this report) and management of where and when the water is released from the reservoir.
- The scheme is very likely to be consentable from a fish ecology perspective

Site A4 – Glenalvon Road

Scheme Description:

- On small (unnamed) tributary of Mangaonuku Stream
- NTWL 277 mRL (full supply level)
- Dam height 32.5 m
- Crest elevation 278.5 mRL
- Storage volume 10.0 million m^3
- Reservoir area 82 ha
- Infill:
  - gravity feed from Mangamauku Stream
  - 2 supplementary intakes from 2 branches of Mangaoho Stream

Potentially impacted streams:

- Unnamed tributary of Mangaonuku – unknown values
- Mangamauku stream flows and passage – ephemeral, likely to have isolated populations of non migratory species
- Mangaoho stream flows – unknown values

Scale of abstraction relative to flow:

- Proposed average winter take of 390 L s^{-1} from Mangamauku which has a winter median flow of 1200 L s^{-1}. At 32.5% of the winter median this represents a high degree of hydraulic alteration.
- Transfer capacity of 620 L s^{-1} has the potential to significantly alter flood flow regimes with potential to create a very 'peaky' hydrograph with flows ranging from the residual 7 day MALF to large flood events
- No flow data is available for the Mangaoho Stream

FFDB info availability and relevance:

- 13 records for the Mangaoho Stream, from 1988 to 2005
- 6 records for the Mangamauku Stream, from 2001 to 2004
- Indicates diadromous fish were present so it is still relevant and useful for modelling using fish distribution models such as Leathwick et al(2008)

Fish species of significance and/or relevance to scheme design:

- Dwarf galaxias
- Rainbow trout
- Longfin eel
- Koaro (observed not caught)

Data gaps:

- Confirmation of species distribution using Leathwick et al model. Model may not give fine enough resolution to give accurate indications of distribution relative to impoundment. May require site specific investigation.
- If the FF database indicates the historical presence of a species (such as koaro) but modelling suggests it is not possible this needs site specific investigation
- As dwarf galaxias are present from FFDB records or it is indicated that they should be from models, we need to understand what proportion of the population is lost/impacted through the footprint of the impoundment through site specific investigations to guide the necessity for mitigation
- As longfin eel are present from FFDB records or if it is indicated that they should be from models, then we need to understand what proportion of the population within the catchment is potentially removed or isolated through the barrier to guide the necessity for mitigation. This can be developed through work with models on eel distribution

Potential scheme effects:

- Intake weirs on Mangamauku and Mangaoho potential migration barriers for all diadromous fish species, particularly longfin eel and rainbow trout – loss of habitat, interruption to lifecycle migrations, reduced population fitness. This effect is likely to be minor and able to be easily mitigated for through the weir design and location of the residual flow outlet
- Dam on tributary of the Mangaonuku a migration barrier for all diadromous fish species – loss of habitat, interruption to lifecycle migrations, reduced population fitness. This effect is likely to be minor and able to be mitigated for through the provision of the residual flow
- Abstraction from Mangamauku and Mangaoho potentially significantly reduces contributing flow in Mangaonuku, may result in Mangaonuku dewatering in larger areas for longer periods – loss of habitat, interruption to lifecycle migrations, reduced population fitness. This effect able to be mitigated for to some extent through the provision of residual flows at all intakes
- Loss of adult habitat through inundation for non migratory species (dwarf galaxias)
- Water quality through impoundment and subsequent stratification may be altered. Release of water below the dam may result in cooling or warming of the receiving waters impacting fish with narrow thermal tolerances.
- Increased risk of predation to non migratory species through impoundment stocking of sports fish
- Impoundment creates new salmonid fisheries through the development of lake type habitat
- Intake on Mangamauku and Mangaoho streams may entrain downstream migrating species
- Flow variability in Mangaonuku Stream reduced, flows more ‘peaky’
- Winter median flows of Mangamauku and Mangaoho streams reduced. May result in nuisance periphyton growths downstream of dam

Possible mitigation:

- Development of fish passage at the weirs and dams for key species – longfin eel and possibly Koaro, could be developed in conjunction with residual flow bypass
- Review and model lake water quality. This will provide direction on the best possible release depths within the lake. This work will come through later investigations
- Screening intakes to prevent entrainment
- Retention of a residual flow for all affected streams. Significant potential to reduce periods of extreme low flow in abstracted tributaries and wider catchment
- Development of a flushing flow regime for periods of sustained low flow
- Link abstractive takes to flow and allocation limits for the catchment. Set abstractive takes as lower category takes and restrict dam fill periods from intakes for shoulder and/or winter periods. Limit rates of take to a proportion of instantaneous winter median flow

Scheme summary:

- The Mangaoho and Mangamauku streams are low value tributaries of the Mangaonuku Stream. The Mangaonuku Stream is a high value tributary of the Waipawa River. The directly impacted streams are unlikely to be significant from a salmonid habitat perspective. They are likely to offer moderate value habitat for diadromous and non migratory native species.
- This scheme has a range of potential impacts that are likely to be successfully mitigated for. Primarily through the provision of fish passage, fish screening, environmental flows (this may require a range of variability approach as discussed in the main body of this report) and management of where and when the water is released from the reservoir.
- The scheme is very likely to be consentable from a fish ecology perspective

Site A7 – Makaroro River

Scheme Description:

- In-river dam – Makaroro River
- NTWL 450 mRL (full supply level)
- Dam height 68 m
- Crest elevation 453 mRL
- Storage volume 48.4 million m^3
- Reservoir area 277 ha

Impacted streams:

- Makaroro and mainstem tributaries (Gold Creek and Dutch Creek of significance) - High value tributary of the Waipawa. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species. Recreational fishery for salmonids

Scale of abstraction relative to flow:

- Potentially significant with proposal to dam mainstem. Unable to provide clear direction until the development of the residual flow or abstractive release regime is confirmed
- Potential to significantly alter the range of variability of flows

FFDB info availability and relevance:

- 19 records from Makaroro, from 1984 to 2004
- 39 records from Waipawa, from 1965 to 2005
- 9 records from Dutch Creek, from 1983 to 2004
- 7 records from Gold Creek, from 1988 to 2004
- Indicates diadromous fish were present so it is still relevant and useful for modelling using fish distribution models such as Leathwick et al (2008)
- The distribution of non-migratory fish needs updating to consider the impact of the impoundment footprint on these species

Fish species of significance and/or relevance to scheme design:

- Dwarf galaxias
- Rainbow trout
- Longfin eel
- Smelt, seems unlikely that they have migrated as far as the proposed dam site

Data gaps:

- Confirmation of species distribution using Leathwick et al model. Model may not give fine enough resolution to give accurate indications of distribution relative to impoundment. May require site specific investigation.

- If the FF database indicates the historical presence of a species (such as smelt) but modelling suggests it is not possible this needs site specific investigation
- As dwarf galaxias are present from FFDB records or it is indicated that they should be from models, we need to understand what proportion of the population is lost/impacted through the footprint of the impoundment through site specific investigations to guide the necessity for mitigation
- As longfin eel are present from FFDB records or if it is indicated that they should be from models, then we need to understand what proportion of the population within the catchment is potentially removed or isolated through the barrier to guide the necessity for mitigation. This can be developed through work with models on eel distribution
- Model the relative proportion of the populations of non migratory dwarf galaxias isolated by the dam. This may give an indication on the scale of the impact in isolating the population
- Contribution that production and recruitment of rainbow trout from the Makaroro makes to the adult fishery in the Waipawa and Tukituki.

Potential scheme effects:

- Dam a migration barrier for all diadromous fish species, particularly longfin eel and rainbow trout. Size of the dam wall likely to be an issue for providing fish passage – loss of habitat, interruption to lifecycle migrations, reduced population fitness
- Loss of spawning and subsequent juvenile rearing habitat for rainbow and possibly brown trout
- Loss of adult habitat through inundation (dwarf galaxias)
- Increased risk of predation to non migratory species through impoundment stocking of sports fish
- Impoundment develops new salmonid fisheries through the creation of lake type habitat
- Median flow in Makaroro reduced. May result in nuisance periphyton growths downstream of dam
- Water quality through impoundment and subsequent stratification may be altered. Release of water below the dam may result in cooling or warming of the receiving waters impacting fish with narrow thermal tolerances.
- Significant potential to improve minimum flows in the Makaroro and Waipawa through environmental flow releases in much the same way could occur out of Dutch Creek. As noted in the opening summary this presents significant potential to mitigate the impacts of the loss of spawning and rearing habitat for salmonids
- Bed transport processes altered with potential to impact habitat below dam through changing pool/run/riffle characteristics and sequences

Possible mitigation:

- Development of fish passage provision for key species. This may be difficult given the height of the proposed dam wall. Given the height of the proposed dam wall only fish passage for the strongest of migrants such as elvers and Koaro (if present) is likely to be possible. Eel trap and transfer techniques now well developed so it may be possible to use this technology

- Review and model lake water quality. This will provide direction on the best possible release depths within the lake. This work will come through later investigations
- Development of a flushing flow regime for periods of sustained low flow
- Significant potential to provide environmental flows to mitigate impacts of lost habitat for diadromous species (particularly trout). Flow sharing regimes (1:1 flow sharing or similar) to allow for higher low flows at critical times in the Makaroro and Waipawa (usually summer)

Scheme summary:

- The Makaroro River is a high value tributary of the Waipawa River. It has extensive salmonid spawning/rearing habitat. It is high value habitat for diadromous and non migratory native species. The Makaroro River is a recreational fishery for salmonids
- This scheme has a range of potential impacts that are probably able to be successfully mitigated for, but will require a significant investment in resource understanding and mitigation option development. Primarily through the provision of fish passage, fish screening, environmental flows (this may require a range of variability approach as discussed in the main body of this report) and management of where and when the water is released from the reservoir.
- The scheme is probably able to be consentable from a fish ecology perspective, but will require a more significant understanding than this summary can provide. Stakeholder involvement at an early stage is probably vital to understanding all of the real and perceived impacts

Site B1 Upper Ngaruru

Scheme Description:

- On Ongaonga Stream
- NTWL 322 mRL (full supply level)
- Dam height 57 m
- Crest elevation 324 mRL
- Storage volume 21.3 million m^3
- Reservoir area 144 ha
- Infill:
    - gravity feed from Waipawa River (near Lookout Road or Pendle Hill Station)
    - 3 supplementary intakes from 3 tributaries of Kahahakuri Stream

Impacted streams:

- Waipawa mainstem flows - High value tributary of the Tukituki. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species. Recreational fishery for salmonids
- Kahahakuri Stream and upper tributaries - High value tributary of the Tukituki. Salmonid spawning/rearing habitat in lower river. Likely high value habitat for diadromous and non-migratory native species. Recreational fishery for salmonids. Likely that upper catchment is rainfall driven while lower catchment is dominated by groundwater inputs
- Ongaonga Stream - Moderate value tributary of the Tukituki. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species. Ephemeral nature means that non migratory native species are protected by the drying sections from trout predation. The extent and duration of the ephemeral reach will better inform the information gaps and need for mitigation

Scale of abstraction relative to flow:

- Proposed intake to average 1200 L s^{-1} out of the Waipawa River. Waipawa winter median flow 2000 L s^{-1}. Proposed take 60% of winter median flow in Waipawa River. This represents a very significant degree of hydrological alteration of the Waipawa River
- Nominal transfer capacity of 2800 L s^{-1} has the potential to significantly alter flow regimes in the Waipawa River creating a very 'peaky' hydrograph with flows ranging from 7day MALF to full flood events
- No data available for the proposed takes from the upper Kahahakuri tributaries

FFDB info availability and relevance:

- 12 records from Kahahakuri, from 1983 to 2005.
- 39 records from Waipawa, from 1965 to 2005.
- 5 records from Ongaonga, from 1988 to 2001 (Ephemeral stream).

- Indicates diadromous fish were present so it is still relevant and useful for modelling using fish distribution models such as Leathwick et al (2008)
- The distribution of non-migratory fish needs updating to consider the impact of the impoundment footprint on these species

Fish species of significance and/or relevance to scheme design:

- Dwarf galaxias
- Rainbow trout
- Longfin eel

Data gaps:

- Confirmation of species distribution using Leathwick et al model. Model may not give fine enough resolution to give accurate indications of distribution relative to impoundment. May require site specific investigation.
- If the FF database indicates the historical presence of a species but modelling suggests it is not possible this needs site specific investigation
- As dwarf galaxias are present from FFDB records or it is indicated that they should be from models, we need to understand what proportion of the population is lost/impacted through the footprint of the impoundment through site specific investigations to guide the necessity for mitigation to guide the necessity for mitigation
- As longfin eel are present from FFDB records or if it is indicated that they should be from models, then we need to understand what proportion of the population within the catchment is potentially removed or isolated through the barrier to guide the necessity for mitigation. This can be developed through work with models on eel distribution
- Model the relative proportion of the populations of non migratory dwarf galaxias isolated by the dam. This may give an indication on the scale of the impact in isolating the population
- Lack of flow data for Kahahakuri River
- Confirmation of the extent of the ephemeral areas of the Ongaonga Stream

Potential scheme effects:

- Intake weirs on Kahahakuri tributaries a potential migration barrier for all diadromous fish species, particularly longfin eel and rainbow trout – loss of habitat, interruption to lifecycle migrations, reduced population fitness. This effect is likely to be minor and able to be easily mitigated for through the weir design and location of the residual flow outlet
- Abstraction from Kahahakuri tributaries potentially significantly reduces contributing flow in the Kahahakuri mainstem – loss of habitat, interruption to lifecycle migrations, reduced population fitness
- Significant reduction in winter median flows in Waipawa River, significant change to flow variability. May result in nuisance periphyton growths downstream of dam/weirs

- Loss of adult habitat through inundation for non migratory species (dwarf galaxias)
- Increased risk of predation to non migratory species through impoundment stocking of sports fish
- Impoundment creates new salmonid fisheries through the development of lake type habitat
- Intake on Waipawa River may entrain downstream migrating species

Possible mitigation:

- Development of fish passage at the weirs and dams for key species – longfin eel, could be developed in conjunction with residual flow bypass
- Screening intakes to prevent entrainment
- Retention of a residual flow for all affected streams. Significant potential to reduce periods of extreme low flow
- Development of a flushing flow regime for periods of sustained low flow
- Link abstractive takes to flow and allocation limits for the catchment. Set abstractive takes as lower category takes and restrict dam fill periods from intakes for shoulder and/or winter periods. Limit rates of take to a proportion of instantaneous winter median flow

Scheme summary:

- The Kahahakuri Stream is a high value tributary of the Tukituki River, it has significant salmonid habitat. The Ongaonga Stream is a moderate value tributary of the Waiapwa River with limited salmonid habitat. The Waipawa River has significant salmonid habitat. All streams are likely to offer high value habitat for diadromous and non migratory native species.
- This scheme has a range of potential impacts that are likely to be successfully mitigated for. Primarily through the provision of fish passage, fish screening, environmental flows (this may require a range of variability approach as discussed in the main body of this report) and management of where and when the water is released from the reservoir.
- The scheme is likely to be consentable from a fish ecology perspective

Site B2 Lower Ngaruru

Note that may of the issues overlap with the previous scheme due to their proximity and related nature

Scheme Description:

- On Ongaonga Stream
- NTWL 254 mRL (full supply level)
- Dam height 25 m
- Crest elevation 256 mRL
- Storage volume 8.3 million m^3
- Reservoir area 82 ha
- Infill (same as Upper Ngaruru):
  - gravity feed from Waipawa River (near Lookout Road or Pendle Hill Station)
  - 3 supplementary intakes from 3 tributaries of Kahahakuri Stream

Impacted streams:

- Waipawa mainstem flows - High value tributary of the Tukituki. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species. Recreational fishery for salmonids
- Ongaonga Stream - Moderate value tributary of the Tukituki. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species. Ephemeral nature means that non migratory native species are protected by the drying sections from trout predation
- Kahahakuri Stream - High value tributary of the Tukituki. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species. Recreational fishery for salmonids

Scale of abstraction relative to flow:

- This matter is covered in the previous section on the upper Ngaruru. As the dam fill for this scheme comes from the upper dam it has no direct impact on flow regimes (this is assuming that both schemes will be developed at the same time). If only this scheme is constructed then the Upper Ngaruru scale of abstraction issues are applicable here.

FFDB info availability and relevance:

- 12 records from Kahahakuri, from 1983 to 2005.
- 39 records from Waipawa, from 1965 to 2005.
- 5 records from Ongaonga, from 1988 to 2001 (Ephemeral stream).
- Indicates diadromous fish were present so it is still relevant and useful for modelling using fish distribution models such as Leathwick et al(2008)
- The distribution of non-migratory fish needs updating to consider the impact of the impoundment footprint on these species

Fish species of significance and/or relevance to scheme design:

- Dwarf galaxias
- Longfin eel
- Rainbow trout – the significance of this species is dependant to some extent on the length of the ephemeral area of the Ongaonga, otherwise is relevant to only flow related issues in the Waipawa and Kahahakuri

Data gaps:

- Confirmation of species distribution using Leathwick et al model. Model may not give fine enough resolution to give accurate indications of distribution relative to impoundment. May require site specific investigation.
- If the FF database indicates the historical presence of a species but modelling suggests it is not possible this needs site specific investigation
- As dwarf galaxias are present from FFDB records or if it is indicated that they should be from models, we need to understand what proportion of the population is lost/impacted through the footprint of the impoundment through site specific investigations to guide the necessity for mitigation
- As longfin eel are present from FFDB records or if it is indicated that they should be from models, then we need to understand what proportion of the population within the catchment is potentially removed or isolated through the barrier to guide the necessity for mitigation. This can be developed through work with models on eel distribution
- Model the relative proportion of the populations of non migratory dwarf galaxias isolated by the dam. This may give an indication on the scale of the impact in isolating the population
- Lack of flow data for Kahahakuri River
- Confirmation of the extent of the ephemeral areas of the Ongaonga Stream

Potential scheme effects:

- Intake weirs on Kahahakuri tributaries a potential migration barrier for all diadromous fish species, particularly longfin eel and rainbow trout – loss of habitat, interruption to lifecycle migrations, reduced population fitness. This effect is likely to be minor and able to be easily mitigated for through the weir design and location of the residual flow outlet
- Abstraction from Kahahakuri tributaries potentially significantly reduces contributing flow in the Kahahakuri mainstem – loss of habitat, interruption to lifecycle migrations, reduced population fitness
- Significant reduction in winter median flows in Waipawa River, significant change to flow variability. May result in nuisance periphyton growths downstream
- Loss of adult habitat through inundation for non migratory species (dwarf galaxias)
- Increased risk of predation to non migratory species through impoundment stocking of sports fish

- Impoundment creates new salmonid fisheries through the development of lake type habitat
- Intake on Waipawa River may entrain downstream migrating species

Possible mitigation:

- Development of fish passage at the weirs and dams for key species – longfin eel, could be developed in conjunction with residual flow bypass
- Screening intakes to prevent entrainment
- Retention of a residual flow for all affected streams. Significant potential to reduce periods of extreme low flow
- Development of a flushing flow regime for periods of sustained low flow
- Link abstractive takes to flow and allocation limits for the catchment. Set abstractive takes as lower category takes and restrict dam fill periods from intakes for shoulder and/or winter periods. Limit rates of take to a proportion of instantaneous winter median flow

Scheme summary:

- The Kahahakuri Stream is a high value tributary of the Tukituki River. The Ongaonga Stream is a moderate value tributary of the Waiapwa River. All the directly impacted streams are significant from a salmonid habitat perspective. All streams are likely to offer high value habitat for diadromous and non migratory native species.
- This scheme has a range of potential impacts that are likely to be successfully mitigated for. Primarily through the provision of fish passage, fish screening, environmental flows (this may require a range of variability approach as discussed in the main body of this report) and management of where and when the water is released from the reservoir.
- The scheme is likely to be consentable from a fish ecology perspective

Site C2 Sherwood

Scheme Description:

- On Parikaka Stream
- NTWL 310 mRL (full supply level)
- Dam height 40 m
- Crest elevation 312 mRL
- Storage volume 14.0 million m^3
- Reservoir area 138 ha
- Infill: gravity feed from Tukipo River (near Sentry Hill)

Impacted streams:

- Parikaka stream – unknown values
- Tukipo flows and passage - High value tributary of the Tukituki. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species. Recreational fishery for salmonids

Scale of abstraction relative to flow:

- The proposed average winter take is 390 L s^{-1} from the Tukipo River. The Tukipo winter median flow is 520 L s^{-1} and the 7 Day MALF is 67 L s^{-1}. The take is 75% of the Tukipo winter median. This represents a high degree of hydrological alteration
- The nominal transfer capacity of 1250 L s^{-1} has the potential to significantly alter flow regimes with creating a very 'peaky' hydrograph with flows ranging from zero to full flood events

FFDB info availability and relevance:

- 24 records from Tukipo, from 1984 to 2005
- No records for Parikaka
- Indicates diadromous fish were present so it is still relevant and useful for modelling using fish distribution models such as Leathwick et al (2008)
- The distribution of non-migratory fish needs updating to consider the impact of the impoundment footprint on these species

Fish species of significance and/or relevance to scheme design:

- Dwarf galaxias
- Rainbow trout
- Longfin eel

Data gaps:

- Confirmation of species distribution using Leathwick et al model. Model may not give fine enough resolution to give accurate indications of distribution relative to impoundment. May require site specific investigation.

- If the FF database indicates the historical presence of a species but modelling suggests it is not possible this needs site specific investigation
- As dwarf galaxias are present from FFDB records or if it is indicated that they should be from models, we need to understand what proportion of the population is lost/impacted through the footprint of the impoundment through site specific investigation to guide the necessity for mitigation
- As longfin eel are present from FFDB records or if it is indicated that they should be from models, then we need to understand what proportion of the population within the catchment is potentially removed or isolated through the barrier to guide the necessity for mitigation. This can be developed through work with models on eel distribution
- If the FF database indicates the historical presence of a species but modelling suggests it is not possible this needs site specific investigation

Potential scheme effects:

- Intake weir on Tukipo River a potential migration barrier for all diadromous fish species, particularly longfin eel and rainbow trout – loss of habitat, interruption to lifecycle migrations, reduced population fitness
- Abstraction from Tukipo River potentially significantly reduces contributing flow to the balance of the Tukipo catchment – loss of habitat, interruption to lifecycle migrations, reduced population fitness
- Significant reduction in median flows in Tukipo River, significant change to flow variability. May result in nuisance periphyton growths downstream
- Loss of adult habitat through inundation for non migratory species (dwarf galaxias)
- Increased risk of predation to non migratory species through impoundment stocking of sports fish
- Impoundment creates new salmonids fisheries through the development of lake type habitat
- Dam a migration barrier for all diadromous fish species, particularly longfin eel. Size of the dam wall likely to be an issue for providing fish passage
- Loss of adult habitat through inundation (dwarf galaxias)
- Increased risk of predation to non migratory species through impoundment stocking of sports fish
- Impoundment develops new salmonids fisheries through the creation of lake type habitat

Possible mitigation:

- Development of fish passage at the weirs and dams for key species – longfin eel, could be developed in conjunction with residual flow bypass
- Retention of a residual flow for all affected streams. Significant potential to reduce periods of extreme low flow
- Development of a flushing flow regime for periods of sustained low flow
- Link abstractive takes to flow and allocation limits for the catchment. Set abstractive takes as lower category takes and restrict dam fill periods from intakes for shoulder

and/or winter periods. Limit rates of take to a proportion of instantaneous winter median flow

Scheme summary:

- The Parikaka Stream is a low value tributary of the Tukipo River. The Tukipo Stream is a high value tributary of the Tukituki River. Both the Tukipo and Tukituki rivers have significant salmonid habitat. They offer high value habitat for diadromous and non migratory native species.
- This scheme has a range of potential impacts that are likely to be successfully mitigated for. Primarily through the provision of fish passage, fish screening, environmental flows (this may require a range of variability approach as discussed in the main body of this report) and management of where and when the water is released from the reservoir.
- The scheme is very likely to be consentable from a fish ecology perspective

Site C3 – Ashley Clinton Road

Scheme Description:

- On Rakautihiau Stream (two branches)
- NTWL 302 mRL (full supply level)
- Dam height 21.5m
- Crest elevation 303.5 mRL
- Storage volume 7.6 million m^3
- Reservoir area 111 ha
- Infill:
  - ➢ pumped from Mangatewai River or
  - ➢ pumped from Tangarewai Stream

Impacted streams:

- Mangatewai River flows, or; - Moderate value tributary of the Tukituki. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species
- Tangarewai Stream flows, and; - Moderate value tributary of the Tukituki. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species
- Rakautihiau Stream – unknown values
- Tukipo River flows - Moderate value tributary of the Tukituki. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species

Scale of abstraction relative to flow:

- Proposed average winter take is 300 L s^{-1} (or 310 L s^{-1}) from the Mangatewai (or Tangarewai) Stream. Mangatewai Stream winter median flow is 720 L s^{-1} (unknown for Tangarewai). The proposed take is 42% of the winter median. This represents a high degree of hydrological alteration to the flow of the Mangatewai Stream.
- The nominal transfer capacity is 500 L s^{-1}. It is possible that at times all of the flow from the Mangatewai could be abstracted. No data is available for the Tangarewai.

FFDB info availability and relevance:

- 8 records from Mangatewai River, from 1987 to 2004
- 12 records from Tangarewai Stream, from 1987 to 1998
- 24 records from Tukipo River, from 1984 to 2005
- No records for Rakautihiau Stream
- Indicates diadromous fish were present so it is still relevant and useful for modelling using fish distribution models such as Leathwick et al (2008)
- The distribution of non-migratory fish needs updating to consider the impact of the impoundment footprint on these species

Fish species of significance and/or relevance to scheme design:

- Dwarf galaxias
- Rainbow trout
- Longfin eel

Data gaps:

- Confirmation of species distribution using Leathwick et al model. Model may not give fine enough resolution to give accurate indications of distribution relative to impoundment. May require site specific investigation.
- If the FF database indicates the historical presence of a species but modelling suggests it is not possible this needs site specific investigation
- As dwarf galaxias are present from FFDB records or if it is indicated that they should be from models, we need to understand what proportion of the population is lost/impacted through the footprint of the impoundment through site specific investigations to guide the necessity for mitigation
- As longfin eel are present from FFDB records or if it is indicated that they should be from models, then we need to understand what proportion of the population within the catchment is potentially removed or isolated through the barrier to guide the necessity for mitigation. This can be developed through work with models on eel distribution

Potential scheme effects:

- Abstraction from Mangatewai (or Tangarewai) Stream potentially significantly reduces contributing flow to the balance of the Tukipo catchment – loss of habitat, interruption to lifecycle migrations, reduced population fitness. This effect likely to be mitigated for through provision of a residual flow
- Significant reduction in median flows in Tukipo River, significant change to flow variability. May result in nuisance periphyton growths downstream
- Loss of adult habitat through inundation for non migratory species (dwarf galaxias)
- Increased risk of predation to non migratory species through impoundment stocking of sports fish
- Impoundment creates new salmonids fisheries through the development of lake type habitat
- Dam a migration barrier for all diadromous fish species, particularly longfin eel. Size of the dam wall likely to be an issue for providing fish passage
- Entrainment of downstream migrants at weirs

Possible mitigation:

- Development of fish passage at the weirs and dams for key species – longfin eel, could be developed in conjunction with residual flow bypass
- Screening intakes to prevent entrainment

- Retention of a residual flow for all affected streams. Significant potential to reduce periods of extreme low flow. Residual flows for contribution to wider Tukipo River flows
- Development of a flushing flow regime for periods of sustained low flow
- Link abstractive takes to flow and allocation limits for the catchment. Set abstractive takes as lower category takes and restrict dam fill periods from intakes for shoulder and/or winter periods. Limit rates of take to a proportion of instantaneous winter median flow.

Scheme summary:

- Rakautihiau Stream has unknown values but is unlikely to be of significance. The Mangatewai and Tangarewai streams are a high value tributaries of the Tukipo River. Both the Tukipo and Tukituki rivers have significant salmonid habitat. They offer high value habitat for diadromous and non migratory native species.
- This scheme has a range of potential impacts that are likely to be successfully mitigated for. Primarily through the provision of fish passage, fish screening, environmental flows (this may require a range of variability approach as discussed in the main body of this report) and management of where and when the water is released from the reservoir.
- The scheme is very likely to be consentable from a fish ecology perspective

Site D2a Rangitoto Road

Scheme Description:

- On tributaries of the Otutatahi Stream (Porangahau catchment)
- NTWL 292 mRL (full supply level)
- Dam height 21.5 m
- Crest elevation 293.5 mRL
- Storage volume 2.4 million m^3
- Reservoir area 41 ha
- Infill:
  - Gravity feed from Makaretu River
  - Refill pipe between D2a and D2b

Impacted streams:

- Otutatahi Stream – unknown values
- Porangahau Stream – low value tributary of Tukipo River
- Makaretu River flows - High value tributary of the Tukituki. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species

Scale of abstraction relative to flow:

- Proposed average winter take is 70 L s^{-1} from the Makaretu River. Makaretu River winter median flow is 1500 L s^{-1} and the 7 Day MALF is 200 L s^{-1}. The proposed average take is 5% of the winter median. This represents a low degree of hydrological alteration to the flow of the Makaretu River
- The nominal transfer capacity is 400 L s^{-1} and if implemented has the potential to flatten flows and reduce the overall winter median flow of the Makaretu significantly

FFDB info availability and relevance:

- 15 records from Makaretu River, from 1987 to 2005
- No record for Otutatahi Stream
- 8 records for Porangahau Stream, from 1988 to 2004
- Indicates diadromous fish were present so it is still relevant and useful for modelling using fish distribution models such as Leathwick et al (2008)
- The distribution of non-migratory fish needs updating to consider the impact of the impoundment footprint on these species

Fish species of significance and/or relevance to scheme design:

- Dwarf galaxias, gradual decline under the New Zealand Threat Classification Status
- Rainbow trout, sports fish, wider fishery of national significance
- Longfin eel, gradual decline under the New Zealand Threat Classification Status

Data gaps:

- Confirmation of species distribution using Leathwick et al model. Model may not give fine enough resolution to give accurate indications of distribution relative to impoundment. May require site specific investigation.
- As longfin eel are present from FFDB records or if it is indicated that they should be from models, then we need to understand what proportion of the population within the catchment is potentially removed or isolated through the barrier to guide the necessity for mitigation. This can be developed through work with models on eel distribution
- If the FF database indicates the historical presence of a species but modelling suggests it is not possible this needs site specific investigation

Potential scheme effects:

- Dam a migration barrier for all diadromous fish species, particularly longfin eel.
- Loss of adult habitat through inundation (dwarf galaxias), unlikely to be significant
- Increased risk of predation to non migratory species through impoundment stocking of sports fish
- Entrainment of downstream migrants through Makaretu intake
- Impoundment develops new salmonid fisheries through the creation of lake type habitat
- Abstraction reduces median flow in Makaretu River. May result in nuisance periphyton growths downstream
- Impoundment reduces total catchment flows into Tukipo River

Possible mitigation:

- Development of fish passage at the weirs and dams for key species – longfin eel, could be developed in conjunction with residual flow bypass
- Screening intakes to prevent entrainment
- Retention of a residual flow for all affected streams if values require it. Significant potential to reduce periods of extreme low flow
- Development of a flushing flow regime for periods of sustained low flow
- Link abstractive takes to flow and allocation limits for the catchment. Set abstractive takes as lower category takes and restrict dam fill periods from intakes for shoulder and/or winter periods. Limit rates of take to a proportion of instantaneous winter median flow

Scheme summary:

- The Otutatahi Stream has unknown values but is unlikely to be of significance. The Porangahau Stream is a low value tributary of the Tukipo River. Both the Makaretu and Tukipo rivers have significant salmonid habitat. Both the Makaretu and Tukipo rivers offer high value habitat for diadromous and non migratory native species
- This scheme has a range of potential impacts that are likely to be successfully mitigated for. Primarily through the provision of fish passage, fish screening, environmental flows (this may require a range of variability approach as discussed in

the main body of this report) and management of where and when the water is released from the reservoir.

- The scheme is very likely to be consentable from a fish ecology perspective

Site D2b Rangitoto Road

Scheme Description:

- On tributaries of the Otutatahi Stream (Porangahau catchment)
- NTWL 293.5 mRL (full supply level)
- Dam height 29.5 m
- Crest elevation 292 mRL
- Storage volume 4.1 million m^3
- Reservoir area 39 ha
- Infill:
  - Gravity feed from Makaretu River
  - Refill pipe between D2a and D2b

Impacted streams:

- Makaretu River flows - High value tributary of the Tukituki. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species

Scale of abstraction relative to flow:

- This matter is covered in the previous section on the D2a Rangitoto Road. As the dam fill for this scheme comes from the upper dam it has no direct impact on flow regimes (this is assuming that both schemes will be developed at the same time). If only this scheme is constructed then the D2a scale of abstraction issues are applicable here.

FFDB info availability and relevance:

- 8 records from Mangatewai River, from 1987 to 2004.
- Indicates diadromous fish were present so it is still relevant and useful for modelling using fish distribution models such as Leathwick et al (2008)
- The distribution of non-migratory fish needs updating to consider the impact of the impoundment footprint on these species

Fish species of significance and/or relevance to scheme design:

- Dwarf galaxias, gradual decline under the New Zealand Threat Classification Status
- Rainbow trout, sports fish, wider fishery of national significance
- Longfin eel, gradual decline under the New Zealand Threat Classification Status

Data gaps:

- Confirmation of species distribution using Leathwick et al model. Model may not give fine enough resolution to give accurate indications of distribution relative to impoundment. May require site specific investigation.

- As longfin eel are present from FFDB records or if it is indicated that they should be from models, then we need to understand what proportion of the population within the catchment is potentially removed or isolated through the barrier to guide the necessity for mitigation. This can be developed through work with models on eel distribution
- If the FF database indicates the historical presence of a species but modelling suggests it is not possible this needs site specific investigation

Potential scheme effects:

- Dam a migration barrier for all diadromous fish species, particularly longfin eel.
- Loss of adult habitat through inundation (dwarf galaxias), unlikely to be significant
- Increased risk of predation to non migratory species through impoundment stocking of sports fish
- Entrainment of downstream migrants through Makaretu intake
- Impoundment develops new salmonid fisheries through the creation of lake type habitat
- Abstraction reduces median flow in Makaretu River. May result in nuisance periphyton growths downstream
- Impoundment reduces total catchment flows into Tukipo River

Possible mitigation:

- Development of fish passage at the weirs and dams for key species – longfin eel, could be developed in conjunction with residual flow bypass
- Screening intakes to prevent entrainment
- Retention of a residual flow for all affected streams if values require it. Significant potential to reduce periods of extreme low flow
- Development of a flushing flow regime for periods of sustained low flow
- Link abstractive takes to flow and allocation limits for the catchment. Set abstractive takes as lower category takes and restrict dam fill periods from intakes for shoulder and/or winter periods. Limit rates of take to a proportion of instantaneous winter median flow

Scheme summary:

- The Otutatahi Stream has unknown values but is unlikely to be of significance. The Porangahau Stream is a low value tributary of the Tukipo River. Both the Makaretu and Tukipo rivers have significant salmonid habitat. Both the Makaretu and Tukipo rivers offer high value habitat for diadromous and non migratory native species
- This scheme has a range of potential impacts that are likely to be successfully mitigated for. Primarily through the provision of fish passage, fish screening, environmental flows (this may require a range of variability approach as discussed in the main body of this report) and management of where and when the water is released from the reservoir.
- The scheme is very likely to be consentable from a fish ecology perspective

Site D3 Hinerangi Road

Scheme Description:

- On tributaries of the Maharakeke Stream
- NTWL 210 mRL (full supply level)
- Dam height 19 m
- Crest elevation 212 mRL
- Storage volume 11.1 million m^3
- Reservoir area 226 ha
- Infill:
    - Gravity feed from Porangahau Stream (if required)
    - Supplementary intake from tributary of Awanui Stream

Impacted streams:

- Maharakeke Stream dam - High value tributary of the Tukituki, specifically a high value Brown trout fishery. Salmonid spawning/rearing habitat. Likely high value habitat for diadromous and non-migratory native species
- Porangahau Stream flows – low value tributary of Tukituki. Some limited habitat for native species
- Awanui Stream – unknown values

Scale of abstraction relative to flow:

- Proposed average winter take is 70 L s^{-1} from the Porangahau Stream. Porangahau Stream winter median flow 380 L s^{-1}. Proposed take is 18% of winter median flow. This is a moderate degree of hydraulic alteration to the Porangahau Stream.
- The nominal transfer capacity is 130 L s^{-1} and if implemented has the potential to flatten flows and reduce the overall winter median flows significantly
- Large area of the upper Maharakeke Stream catchment sits behind the impoundment and will be taken out of the wider catchment flows. This represents a potentially significant degree of hydrological alteration of the catchment.

FFDB info availability and relevance:

- 15 records from Maharakeke Stream, from 1988 to 2005
- 8 records from Porangahau Stream, from 1988 to 2004
- Indicates diadromous fish were present so it is still relevant and useful for modelling using fish distribution models such as Leathwick et al(2008)
- The distribution of non-migratory fish needs updating to consider the impact of the impoundment footprint on these species

Fish species of significance and/or relevance to scheme design:

- Dwarf galaxias, gradual decline under the New Zealand Threat Classification Status
- Rainbow trout, sports fish, wider fishery of national significance

- Brown trout, recognised brown trout tributary of Tukipo, sports fish, wider fishery of national significance
- Longfin eel, gradual decline under the New Zealand Threat Classification Status
- Smelt

Data gaps:

- Confirmation of species distribution using Leathwick et al model
- If the database indicates the historical presence of a species but modelling suggests it is not possible this needs site specific investigation
- As dwarf galaxias are present from FFDB records or if it is indicated that they should be from models, we need to understand what proportion of the population is lost/impacted through the footprint of the impoundment through site specific investigations
- As longfin eel are present from FFDB records or if it is indicated that they should be from models, then we need to understand what proportion of the population within the catchment is potentially removed or isolated through the barrier to guide the necessity for mitigation. This can be developed through work with models on eel distribution
- If the FF database indicates the historical presence of a species (such as smelt) but modelling suggests it is not possible this needs site specific investigation
- Model the relative proportion of the populations of non migratory dwarf galaxias isolated by the dam. This may give an indication on the scale of the impact in isolating the population
- Extent of spawning and juvenile rearing habitat for brown and rainbow trout excluded through the creation of a dam. May indicate extent of production lost to adult fishery.

Potential scheme effects:

- Dam a migration barrier for all diadromous fish species, particularly longfin eel and rainbow trout. Size of the dam wall likely to be an issue for providing fish passage
- Loss of spawning and subsequent juvenile rearing habitat for rainbow and brown trout
- Loss of adult habitat through inundation (dwarf galaxias)
- Increased risk of predation to non migratory species through impoundment stocking of sports fish
- Impoundment develops new salmonid fisheries through the creation of lake type habitat
- Abstraction reduces median flow in Porangahau Stream. May result in nuisance periphyton growths downstream
- Dam significantly reduced median flow in Maharakeke. May result in nuisance periphyton growths downstream

Possible mitigation:

- Development of fish passage at the weirs and dams for key species – longfin eel, could be developed in conjunction with residual flow bypass

- Retention of a residual flow for all affected streams. Significant potential to reduce periods of extreme low flow
- Development of a flushing flow regime for periods of sustained low flow
- Link abstractive takes to flow and allocation limits for the catchment. Set abstractive takes as lower category takes and restrict dam fill periods from intakes for shoulder and/or winter periods. Limit rates of take to a proportion of instantaneous winter median flow

Scheme summary:

- The Awanui Stream has unknown values but is unlikely to be of significance. The Porangahau Stream is a low value tributary of the Tukipo River. The Maharakeke has significant salmonid habitat, particularly as a brown trout resource. The Maharakeke River offers high value habitat for diadromous and non migratory native species
- This scheme has a range of potential impacts that are likely to be successfully mitigated for. Primarily through the provision of fish passage, fish screening, environmental flows (this may require a range of variability approach as discussed in the main body of this report) and management of where and when the water is released from the reservoir.
- The scheme is likely to be consentable from a fish ecology perspective

Site D5 Makaretu

Scheme Description:

- On Makaretu River mainstem
- NTWL 346 mRL (full supply level)
- Dam height 41 m
- Crest elevation 349 mRL
- Storage volume 25 million m^3
- Reservoir area 155 ha
- Infill:
    - Other than mainstem no infill proposed

Impacted streams:

- Makaretu River flows - Moderate value tributary of the Tukituki. Has some salmonid spawning/rearing habitat, though the scale and extent of spawning is believed to be light in this catchment. Likely high value habitat for diadromous and non-migratory native species. Mid reaches of Makaretu ephemeral in summer.

Scale of abstraction relative to flow:

- Potentially significant with proposal to dam mainstem. Unable to provide clear direction until the development of the residual flow or abstractive release regime is confirmed
- Potential to significantly alter the range of variability of flows

FFDB info availability and relevance:

- 15 records from Makaretu River, from 1987 to 2005
- Indicates diadromous fish were present so it is still relevant and useful for modelling using fish distribution models such as Leathwick et al(2008)
- The distribution of non-migratory fish needs updating to consider the impact of the impoundment footprint on these species

Fish species of significance and/or relevance to scheme design:

- Dwarf galaxias, gradual decline under the New Zealand Threat Classification Status
- Rainbow trout, sports fish, wider fishery of national significance
- Longfin eel, gradual decline under the New Zealand Threat Classification Status

Data gaps:

- Confirmation of species distribution using Leathwick et al model
- If the database indicates the historical presence of a species but modelling suggests it is not possible this needs site specific investigation
- As dwarf galaxias are present from FFDB records or if it is indicated that they should be from models, we need to understand what proportion of the population is

lost/impacted through the footprint of the impoundment through site specific investigations
- As longfin eel are present from FFDB records or if it is indicated that they should be from models, then we need to understand what proportion of the population within the catchment is potentially removed or isolated through the barrier to guide the necessity for mitigation. This can be developed through work with models on eel distribution
- If the FF database indicates the historical presence of a species (such as smelt) but modelling suggests it is not possible this needs site specific investigation
- Model the relative proportion of the populations of non migratory dwarf galaxias isolated by the dam. This may give an indication on the scale of the impact in isolating the population
- Extent of spawning and juvenile rearing habitat for rainbow trout excluded through the creation of a dam. May indicate extent of production lost to adult fishery.

Potential scheme effects:
- Dam a migration barrier for all diadromous fish species, particularly longfin eel and rainbow trout. Size of the dam wall likely to be an issue for providing fish passage
- Loss of spawning and subsequent juvenile rearing habitat for rainbow trout
- Loss of adult habitat through inundation (dwarf galaxias)
- Increased risk of predation to non migratory species through impoundment stocking of sports fish
- Impoundment develops new salmonid fisheries through the creation of lake type habitat
- Water quality through impoundment and subsequent stratification may be altered. Release of water below the dam may result in cooling or warming of the receiving waters impacting fish with narrow thermal tolerances.
- Flow variability in the section of Makaretu River downstream of the dam reduced.
- Flows more ‘peaky’ as a result of both flow harvesting and abstractive releases.
- Median flows of Makaretu River reduced. May result in nuisance periphyton growths downstream of dam
- Low flows may be improved (increased) at critical times

Possible mitigation:
- Development of fish passage provision for key species. Given the height of the proposed dam wall only fish passage for the strongest of migrants such as elvers is likely to be possible. Eel trap and transfer techniques now well developed so it may also be possible to use this technology
- Review and model lake water quality. This will provide direction on the best possible release depths within the lake. This work will come through later investigations
- Significant potential to provide environmental flows to mitigate impacts of lost habitat for diadromous species (particularly trout). Flow sharing regimes (1:1 flow sharing or similar) to allow for higher low flows at critical times in the Makaretu and Tukituki (usually summer)

- Development of a flushing flow regime for periods of sustained low flow

Scheme summary:

- Makaretu River a valued tributary of the Tukituki River. Makaretu likely to have some salmonid spawning/rearing habitat, although the extent and range of this and subsequent contribution to the Tukituki fishery is as yet uncertain. Makaretu likely to be high value habitat for diadromous and non migratory native species. The Makaretu River has a small amount of recreational fishing for salmonids (Unwin 2009)
- This scheme has a range of potential impacts that are likely to be successfully mitigated for. Primarily through the provision of fish passage, fish screening, environmental flows (this may require a range of variability approach as discussed in the main body of this report) and management of where and when the water is released from the reservoir.
- The scheme is likely to be consentable from a fish ecology perspective

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i New Zealand Freshwater Fish Database (http://fwdb.niwa.co.nz/), provided by Hawke's Bay Regional Council Staff on 1 September 2010.