Water

A VITAL LIFEFORCE

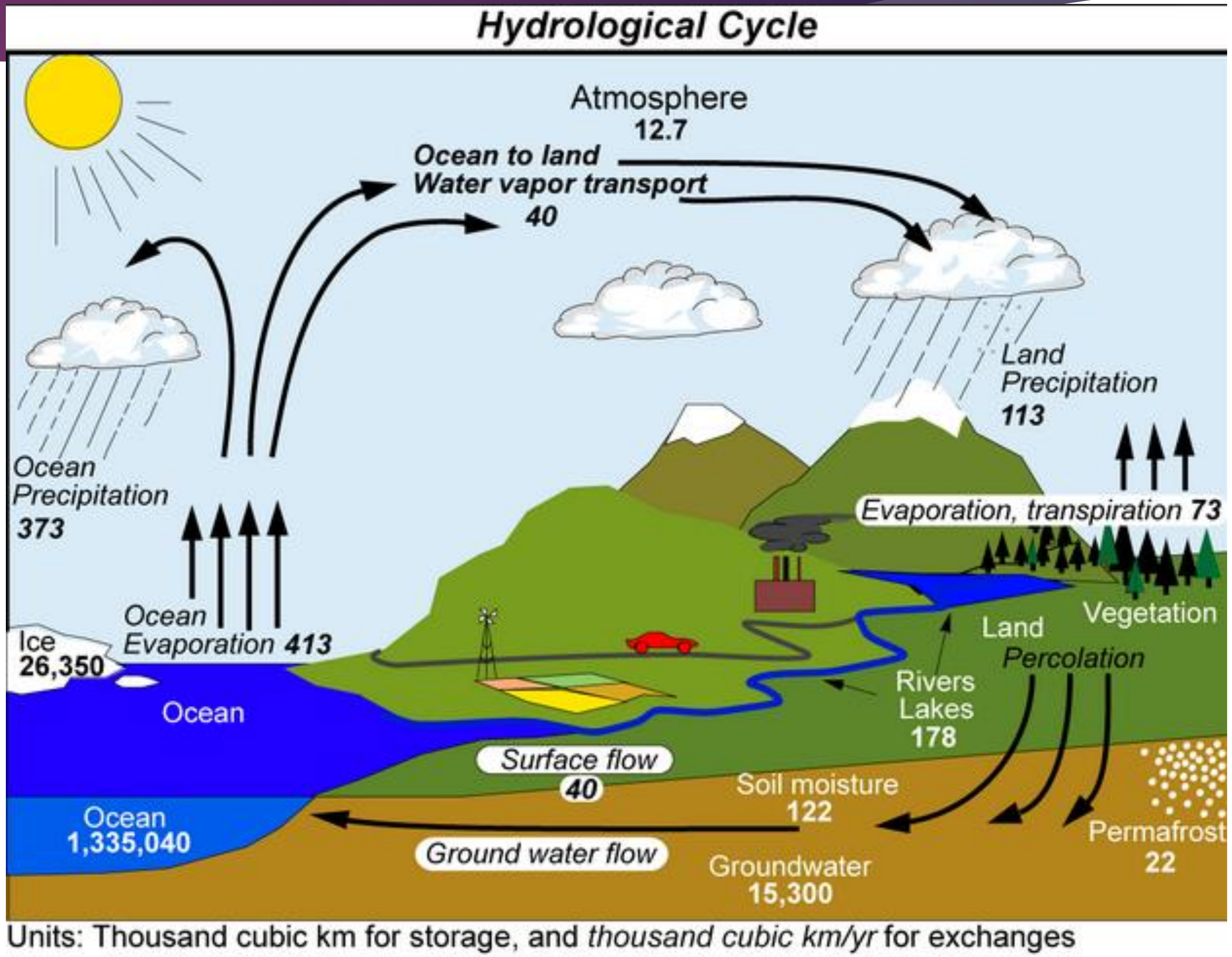
180 000km of rivers

- Longest river ?

= Waikato River (425 km)

- Largest river (by volume)?

= Clutha River (mean discharge of 533 $m^3 s^{-1}$)



Lotic Systems

Lotic systems such as rivers are diverse ranging from glacial rivers and huge braided river systems to small urban streams.

These natural systems are vital for water resources, especially for agriculture as well as for recreational purposes

Lentic Systems

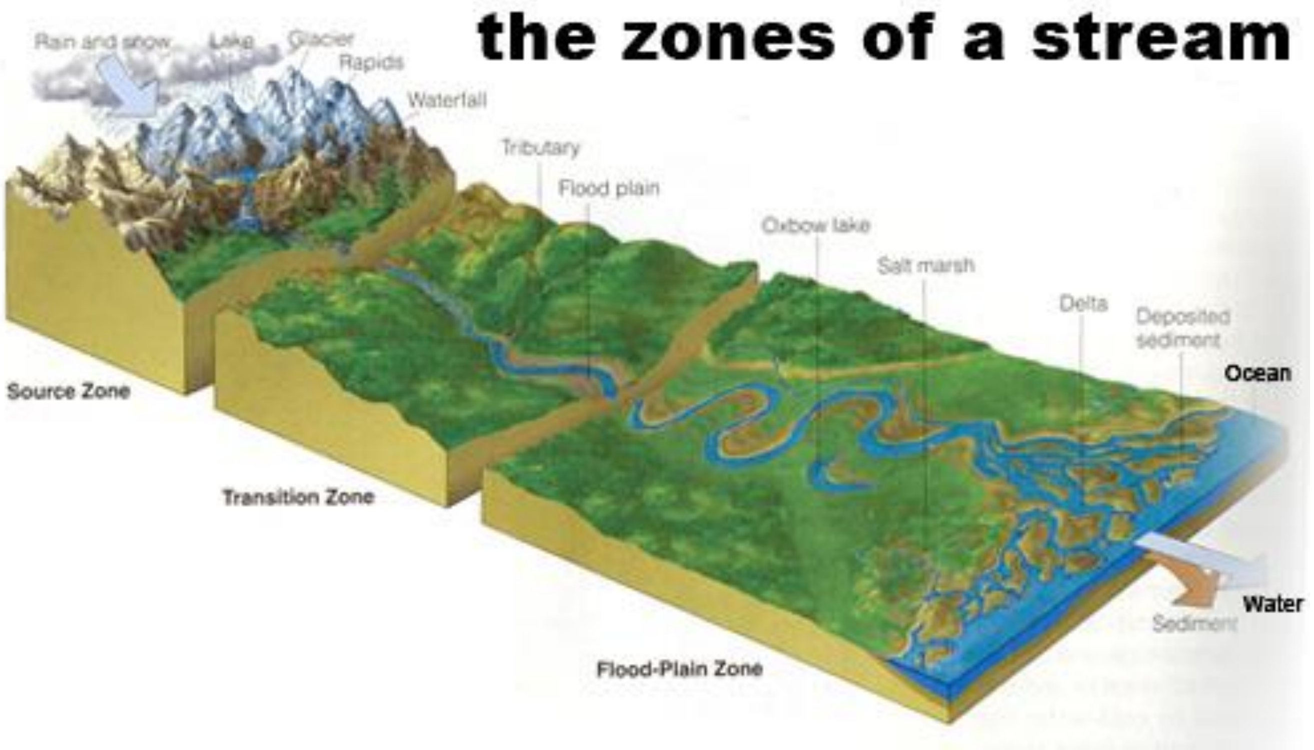
Closed environments, e.g. ponds and lakes are susceptible to anthropogenic influences, for example, discharges of stormwater, wastewater or agricultural runoff.

In New Zealand, there are:

- 41 lakes (surface area > 10 km^2)
- 229 lakes greater > 0.5 km^2
- 3820 lakes greater > 0.01 km^2
- Largest lake: Lake Taupo – 616 km2
- Deepest lake: Lake Hauroko – 462 m

Estuaries

An estuary is a partly enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a free connection to the open sea.



Transition Zone

Estuaries form a transition zone between river environments and maritime environments

They are influenced by **marine systems**, such as tides, waves, and the influx of saline water; and **riverine systems**, such as flows of fresh water and sediment.

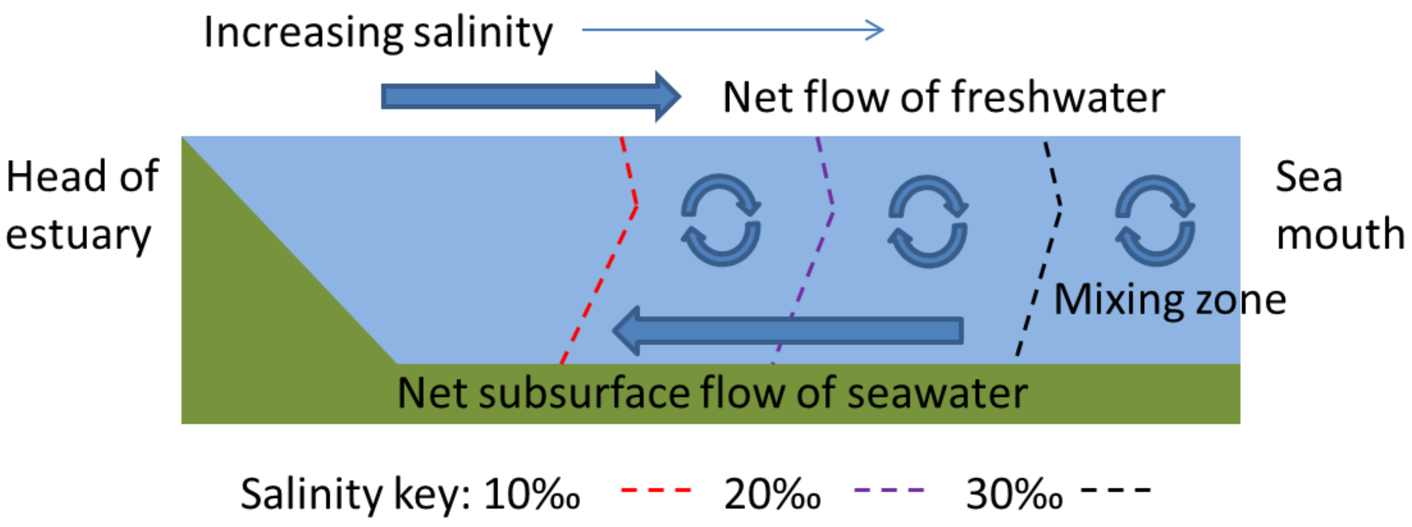


Diagram adapted from Trujillo & Thurman, 2014

Contamination

Estuaries can provide areas for the settling of particulate discharges so accumulation of contaminants may be significant in these regions.

Mining pollution at the Wheal Jane Estuary, Cornwall, UK

Estuarine Characteristics

Estuaries are varied across New Zealand and their characteristics may depend on many factors including:

- size
- depth
- type
- extent of seawater mixing.

In the North Island of New Zealand, estuarine systems may contain mangroves (plants which have adapted to living in seawater).

Estuary Types

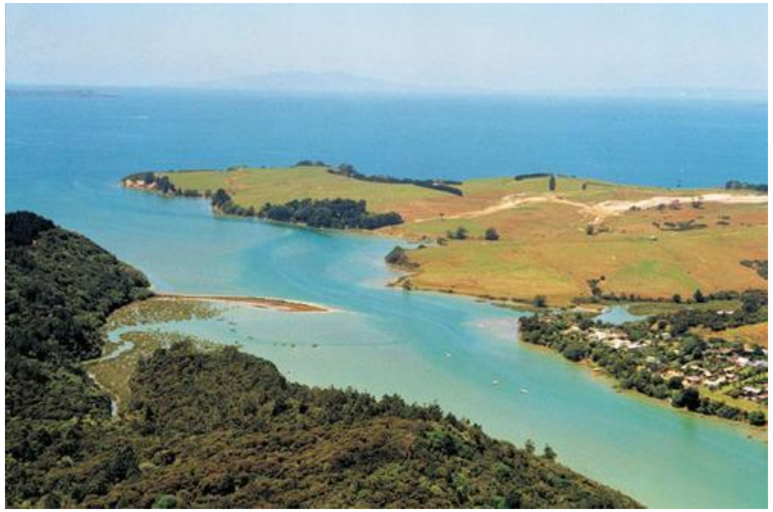
Rising sea level since the Ice Age (when major continental glaciers began melting) created four types of estuary:

1. Coastal Plain Estuary
2. Fjord
3. Bar-built Estuary
4. Tectonic Estuary

Coastal Plain Estuary

Formed by sea level rises and the flooding of existing river valleys.

E.g, Okura Estuary, North Auckland.



Okura Estuary

Fjord

High sided "U" shaped valley which forms as sea level rises and floods a glaciated valley. The glacier leaves a deep channel with a shallow barrier or narrow sill near the ocean.

This sill restricts the amount of seawater entering the Fjord and lack of deep water mixing can cause anoxia at the lower levels

Doubtful Sound

Bar-built Estuary

Occur when sandbars or barrier islands are built up by ocean waves and currents along coastal areas fed by one or more rivers or streams.

The streams or rivers flowing into bar-built estuaries typically have a very low water volume

Tauranga

Tectonic Estuary

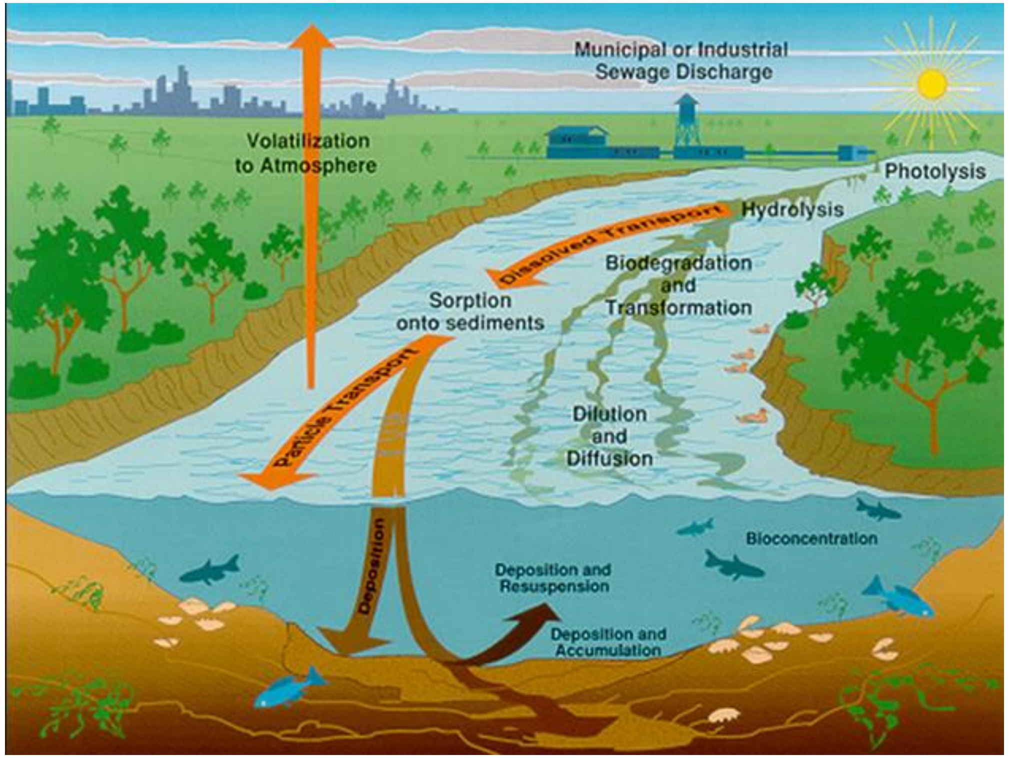
Faulting/folding of rocks creates a restricted downdropped area into which sea floods

More information

(including animations) → link.

Activities affecting water include:

- Roads / Transport (Pollution)
- Developments (Hydrology)
- Coastal infrastructure (Harbours)
- Water infrastructure (Abstraction)
- Agriculture / Farming (Nutrients)
- Power infrastructure (Damming)
- Mining (Tailings- Acid)
- Discharges (from all sources e.g. spills).



Rainfall Effects

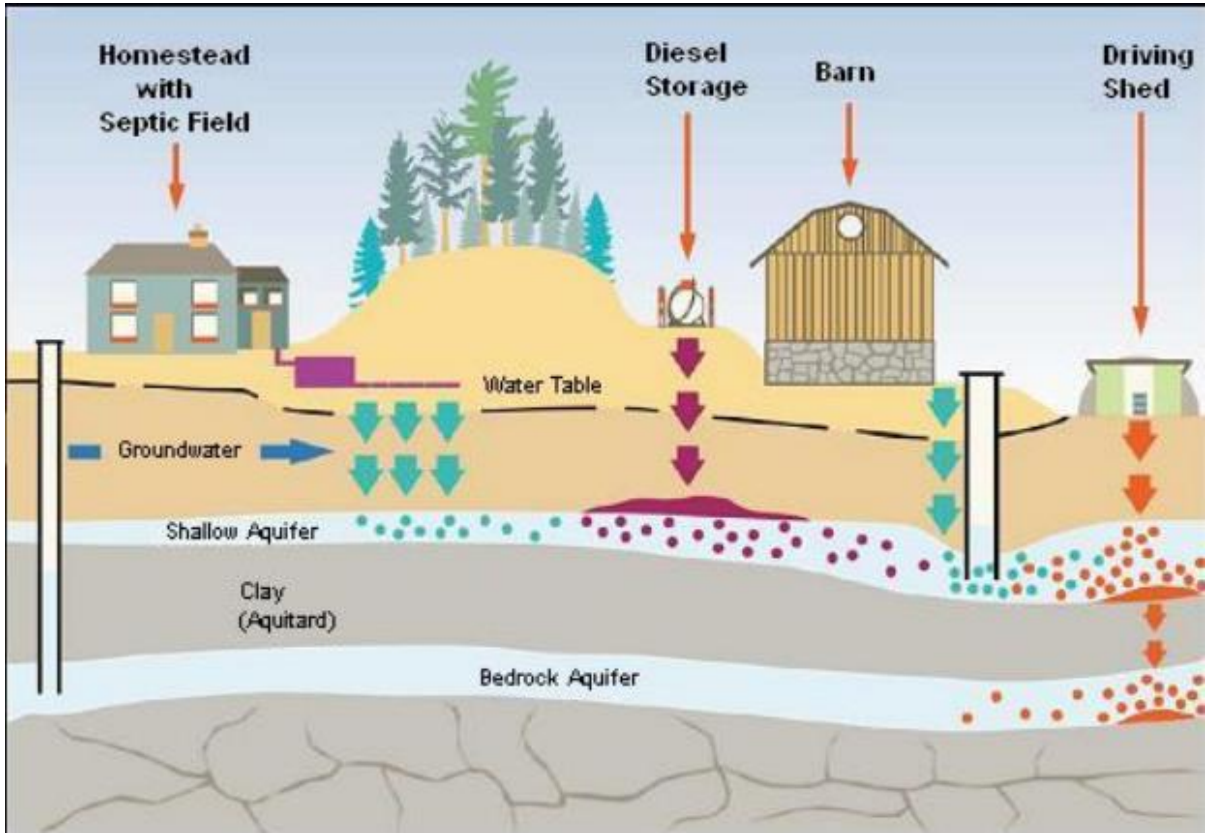
Rainfall patterns and intensity can affect the water quality of our rivers and lakes.

Often very dry periods, which are succeeded by heavy rainfall, result in the deposition of contaminants such as hydrocarbons and heavy metals into these systems.

Groundwater

Activities on land which may affect groundwater are shown in the diagram below. These may include:

- Accidental spills
- Intentional leaks
- Industrial processes



Thermal Pollution

"The degradation of water quality by any process that changes ambient water temperature"

Sources of elevated water temperatures can arise from urban road runoff and the use of water as coolants by power plants.

Most organisms will tolerant only a fairly narrow range of ambient temperatures.

Sources of Thermal Pollution

Natural variation include:

- Diurnal variations
- Seasonal fluctuations

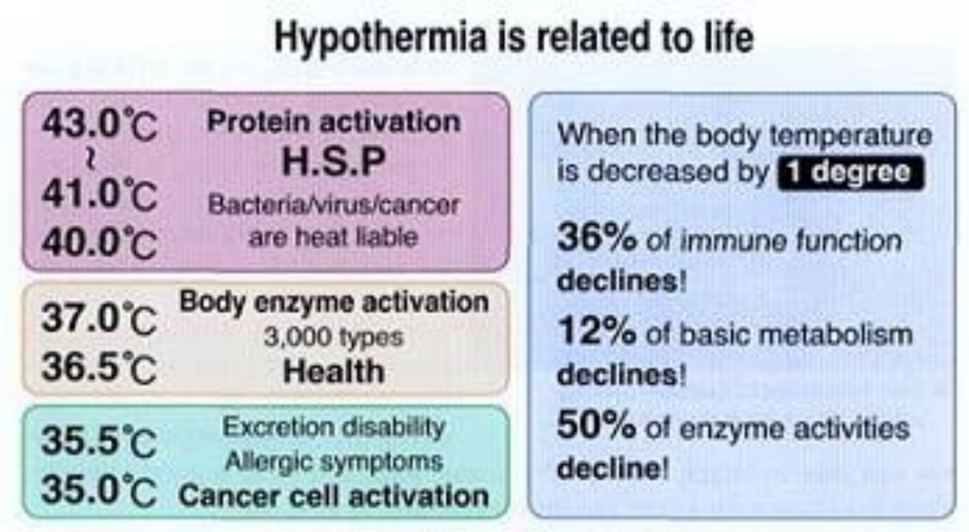
Anthropogenic sources include:

- Discharges from industry
- Riparian vegetation removal
- Drainage network alteration
- Increased imperviousness

Thermal Stress

- The human body has a tolerance range of just 3°C, with 37°C an average "normal" temperature and hypothermia observed at <35°C and hyperthermia at 38°C.

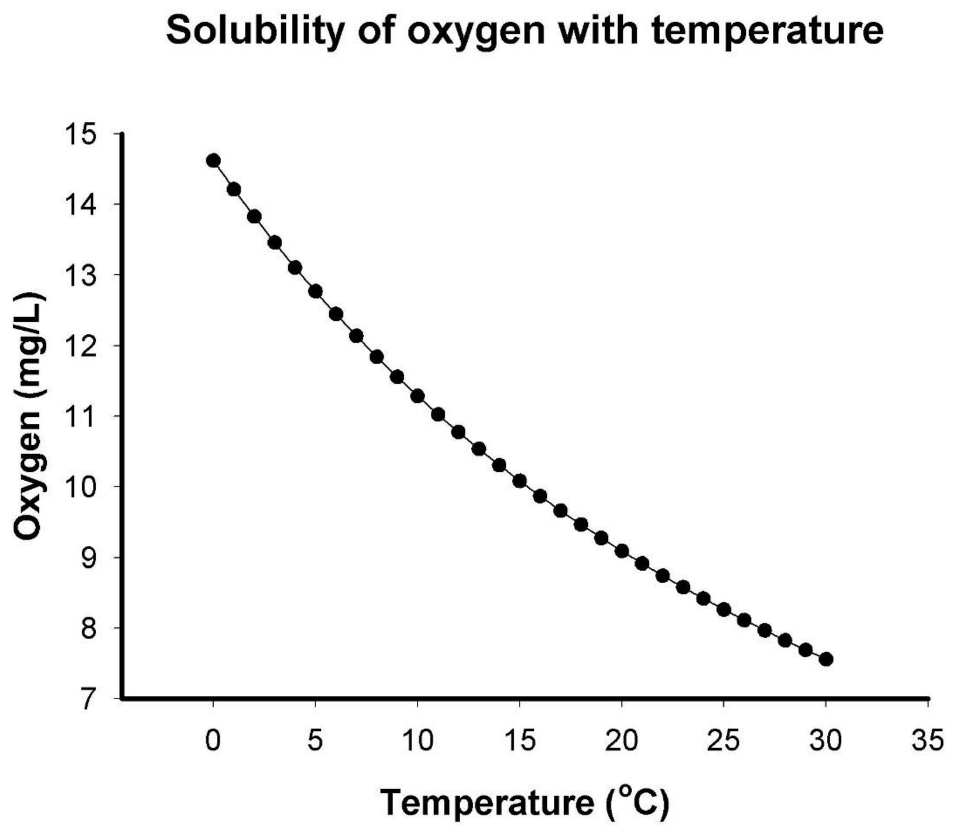
- Visible signs of stress may be observed outside the range of 35-38°C but there are also internal changes which may occur which are not observed.



Oxygen Solubility

In aquatic systems, fluctuations in temperature are made worse by the change in oxygen solubility.

Remember that oxygen solubility increases with decreasing temperature.



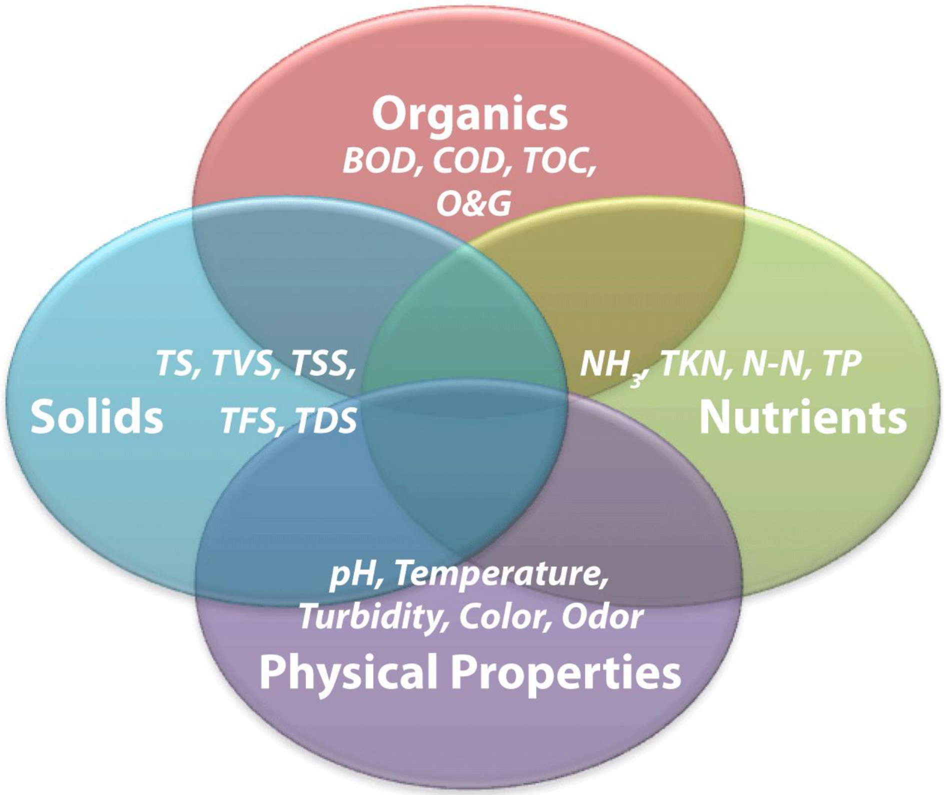
Impact on Biodiversity?

- Some organisms are more sensitive to fluctuations in oxygen concentrations than others and may either move to a more suitable environment or perish.
- Adverse affects on cellular biology due to elevated temperatures is specific to each organism (larger organisms are generally more sensitive).
- Anaerobic conditions encourage bacterial growth which may out-compete other species.

Other Types of Discharge

Including:

- Easily-degraded carbon-based waste
- Persistent carbon-based chemicals
- Heavy metals



Easily degraded carbon-based wastes

Wastes which are rich in organic carbon are commonly discharged into waterways in various forms including:

- Sewage
- Food processing wastes
- Agricultural fertilisers

Organic wastes stimulate microorganisms respiration, consuming **oxygen** and reducing the dissolved oxygen levels.

In addition, the release of nitrogen and phosphorus can lead to further problems; namely **nutrient enrichment** and **eutrophication**.

Oxygen Solubility

Oxygen has limited solubility in water (6-14 mg l^{-1}).

Substantial reductions in dissolved oxygen can have significant implications for aquatic organisms.

Measured as BOD and/or COD

Aerobic resp: $6(CH_2O) + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Nitrification: $NH_4^+ + 2O_2 \rightarrow NO_3^- + 2H^+ + H_2O$

Water Type	BOD mg/l
Clean Water	<1
Polluted water	>10
Wastewater	>100

BOD_5 versus COD

The **Biochemical Oxygen Demand** test (**BOD_5**) measures the loss of dissolved oxygen in water samples incubated over a period of 5 days.

The **Chemical Oxygen Demand** test (**COD**) is commonly used to indirectly measure the amount of organic compounds in water.

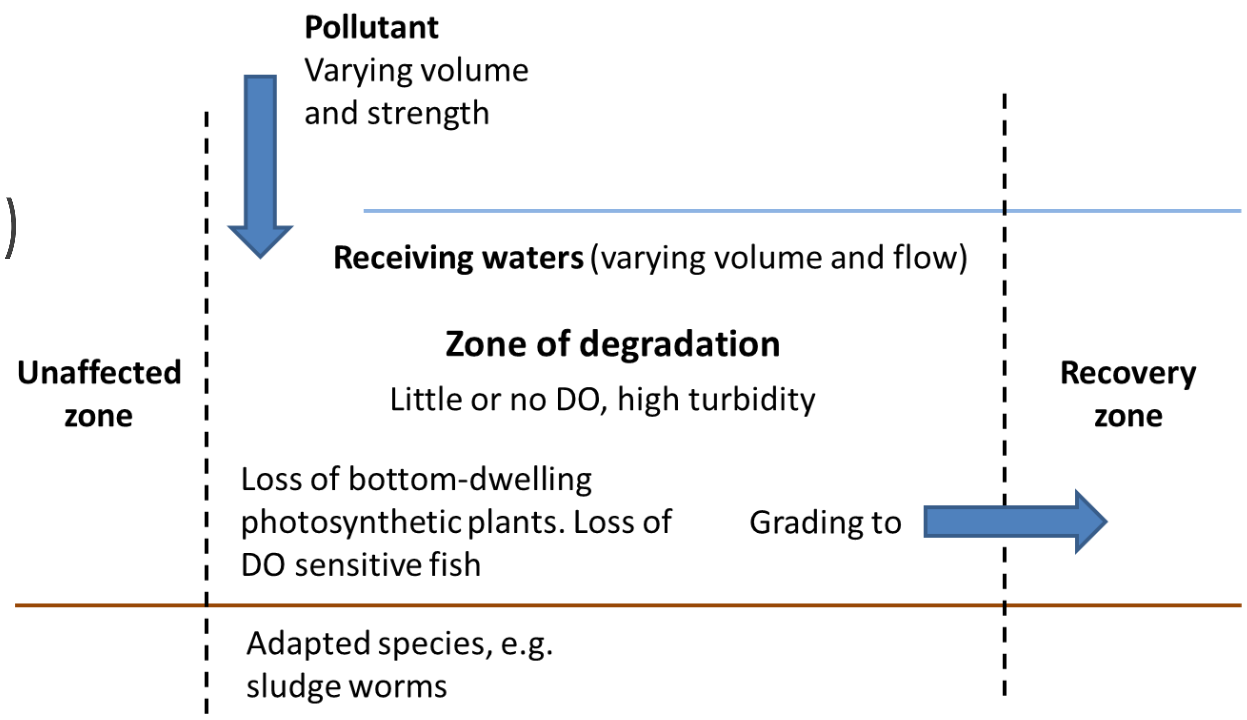
Both useful measures for identifying chemical water quality

Note: COD > BOD

Discharge impact

Depends on at least some of the following factors:

- Magnitude (maximum & range)
- Duration of exposure
- Frequency of exposure
- Spatial extent of effects



Longer term impacts

- The release of substances which are bound within an organic matrix (e.g the release of nutrients) from wastewater can cause long term effects such as Eutrophication.
- This can lead to issues such as algal blooms, loss of water clarity, a reduction In biodiversity when can impact use for recreational or drinking purposes.

Eutrophication is natural process in which lakes "age" and with time the nutrient content increases Human interactions can accelerate this process.

Recent report into the condition of NZ's freshwater systems is concerning

Types of Consent/Permit

Three types - **land-use**, **water** or **discharge**, may be applicable for any activity affecting freshwater water systems.

Land-Use Consents

- Different land uses which can affect water quality, land stability and the incidence of flooding.
- Land use consents which identify, control and minimise the impacts of activities on people and the environment.

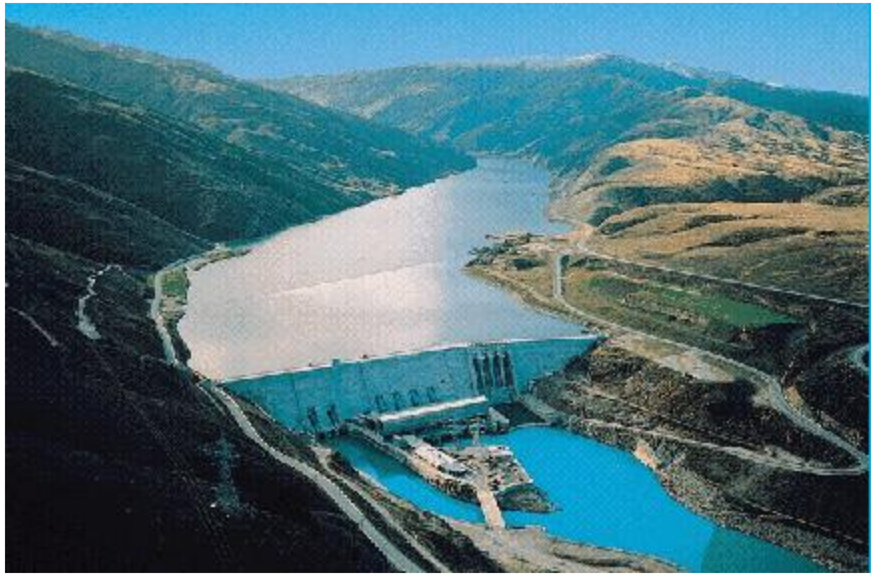
Why might you need a Land-use consent ?

- Construct/alter a bridge, well, culvert or ford.
- Drain a wetland area
- Drill, tunnel, excavate or otherwise disturb the bed of a river/lake
- Carry out soil disturbance (earthworks), vegetation clearance, roading or tracking
- Place cleanfill onto land
- Erect an erosion control structure
- Remove sand/gravel from watercourse bed
- Carry out soil cultivation near a watercourse

Water Permits

Damming, diverting and taking water can affect people's ability to use the water, as well as affecting a stream's plant and animal life.

Water consents identify, control and minimise the impacts of an activity on people and the environment.



Clyde Dam, South Island, NZ

Why might you need a Water Permit ?

- Take or use water from a river, stream, dam, lake or spring.
- Take or use water from an underground source (groundwater)
- Take or use geothermal water, heat or energy.
- Construct or alter a dam or stopbank and impound water behind the structure.
- Divert a watercourse.

Red Bluff Diversion Dam – Sacramento USA

Discharge Permits

Discharge permits cover activities which discharge contaminants into water into or onto land to air.

Why might you need a Discharge Permit ?

- Discharge potentially contaminated water, water containing sediment or animal farm effluent into water or land
- Discharge treated human sewage onto land or water
- Discharge treated/untreated wastes into water or land involve dumping or landfills
- Create offending odours
- Involve intensive indoor farming of pigs, broiler chick or mushrooms
- Discharge dust, steam or other matter into the air

Assessment Tools

Aside from chemical water quality markers, there are a number of other assessment tools and treatment guidelines including:

- Stream Ecological Valuation (SEV)
- Macroinvertebrate Community Index (MCI)
- Trophic level index (TPI)
- LakeSPI
- ANSECC Guidelines Sediment Quality
- Auckland Council Design Guides GD01, GD04, GD05
- Modelling Tools (flow/nutrients) e.g Hec hms

SEV – using Ecological Function Markers

Assessment parameters allow a quantitative and/or qualitative comparison between streams and in addition a number of ecological function markers can be used.

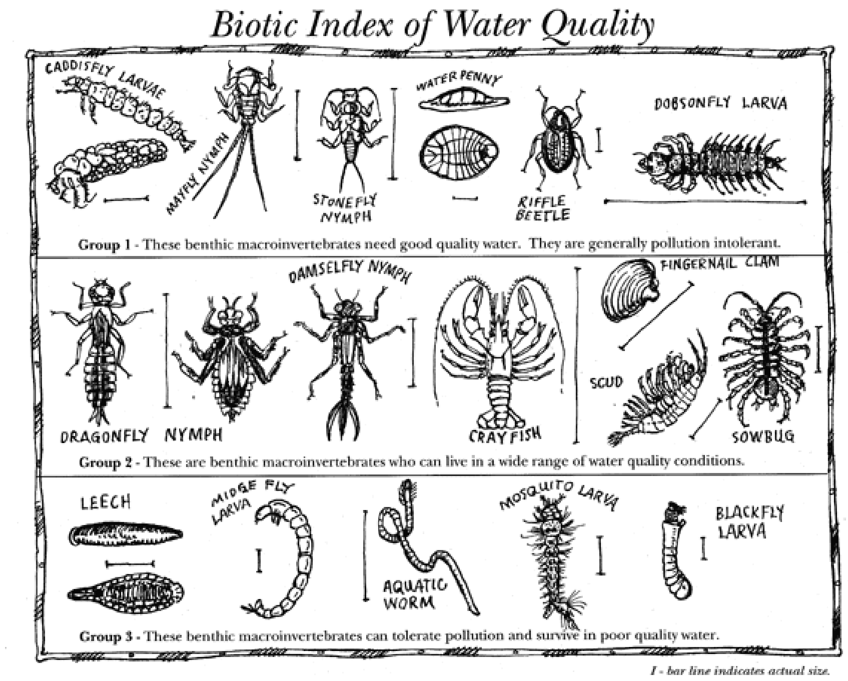
Ecological Categories	Ecological Functions
Hydraulic functions	- Natural flow regime - Floodplain effectiveness - Connectivity for natural species migrations - Natural connectivity to groundwater
Biogeochemical functions	- Water temperature control - Dissolved oxygen levels - Organic matter input - In-stream particle retention - Decontamination of pollutants
Habitat Provision functions	- Fish spawning habitat - Habitat for aquatic fauna
Biotic Provision functions	- Fish fauna intact - Invertebrate fauna intact - Riparian vegetation intact

Basis of SEV methodology from Auckland Council

MCI Test and Sensitive species

The MCI test requires the identification of a number of different species which may be biological quality markers.

Species may be deemed "**sensitive**" (their presence indicating a high level of water quality), **moderately sensitive** or **tolerant** (whose presence would be expected in most streams).



Sensitive Species

Include:

- Caddisflies – free-living
- Caddisflies - cased
- Stoneflies (see image)
- Freshwater mussels
- Freshwater crayfish

These species are only found in highly oxygenated water, mainly due to their poorly developed gills.

Moderately Sensitive species

Include:

- Damselflies
- Dragonflies (see image)
- Beetles
- Crustaceans

Tolerant Species

Species which are tolerant to most conditions include:

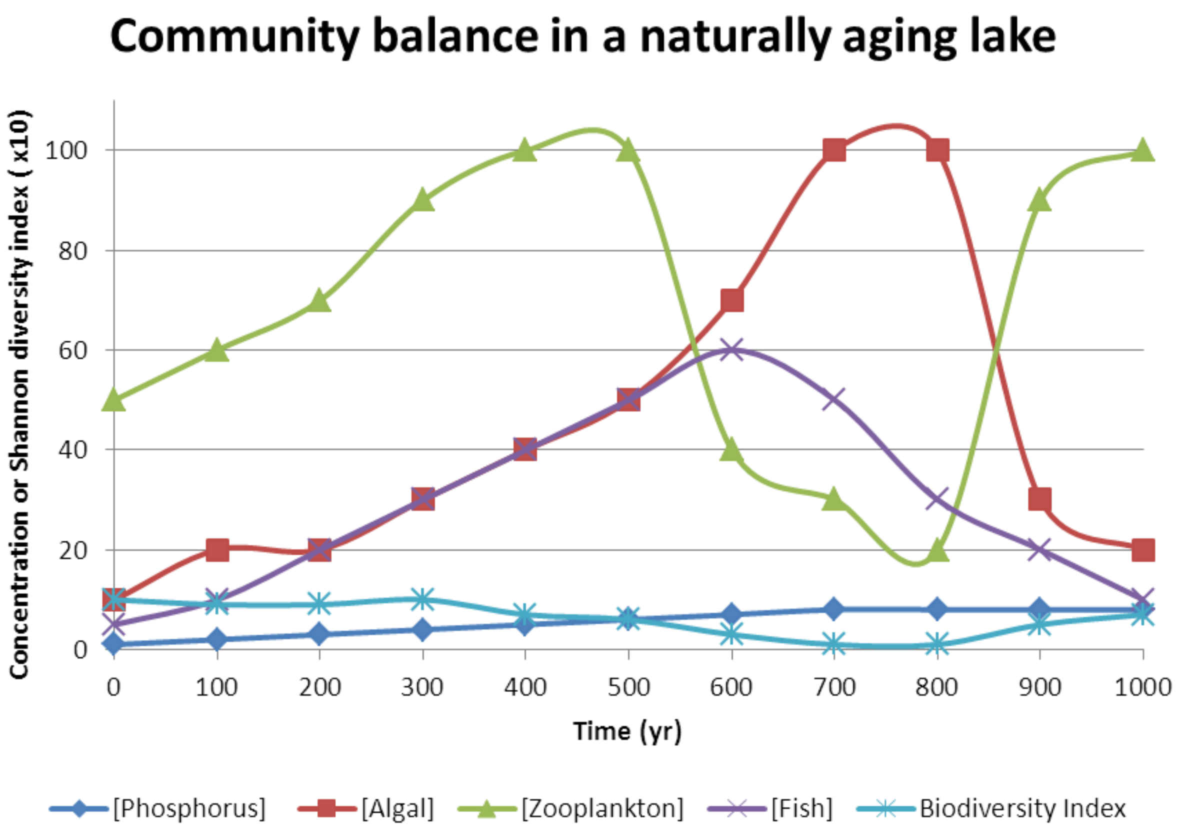
- Snails
- Maggotflies
- Mosquito larvae
- Leeches

Most of these species take their oxygen from the air rather than from the water which means that they are more tolerant to poorly oxygenated waters.

Trophic Level Index

TPI - measures the nutrient status of lakes via four indicators.

Uses four separate water quality measurements – total nitrogen, total phosphorous, water clarity, and chlorophyll-*a*.



Lake SPI

Lake SPI uses submerged plants as indicators of the effects of water quality, the impact of catchment management and aquatic weed invasion

- **Native Condition Index** — diversity and quality of native plant communities.
- **Invasive Impact Index** — the invasive character of vegetation in a lake based on the degree of impact by invasive weed species.
- **LakeSPI Index** — Uses indices described to provide an overall measure of the lake's ecological condition.

ANSECC Guidelines Sediment Quality

These guidelines provide water managers with tools and guidance to assess, manage and monitor the water quality. Complimenting the Freshwater National Policy Statement

- Available from the ANZECC website

Australian & New Zealand
GUIDELINES FOR FRESH & MARINE WATER QUALITY

Auckland Council Design Guides

Available from Auckland Council Website (and there will be similar guides for other Regional or Unitary Councils nationwide.

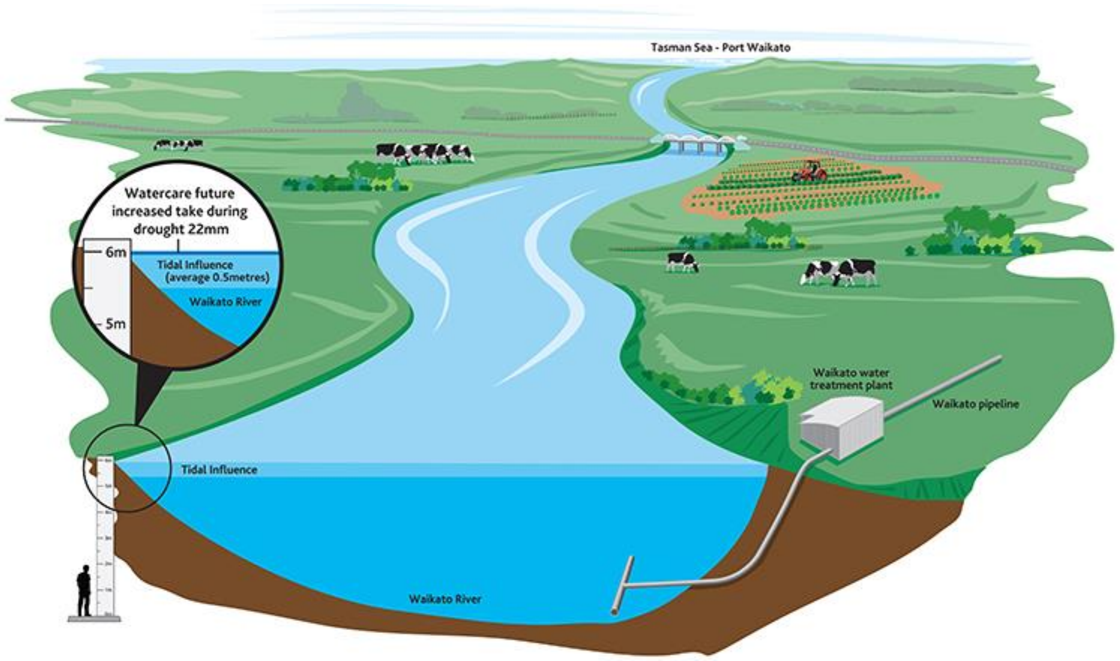
The most relevant for water-based projects are:

- GD01- Stormwater management Devices Guide
- GD04-Water Sensitive Design Guide
- GD05 – Erosion and Sediment Design Guide

Case Study – Waikato River

Watercare is seeking resource consent for:

- Additional abstraction of 200,000 m^3/day (net) of water from the Waikato River for municipal supply
- The discharge of process and off-spec water to the Waikato River in the vicinity of the Waikato WTP
- The construction and operation of a new intake and discharge structure and pipes in the bed of the Waikato River.



AEE

The AEE was split into the following subsections:

- Positive effects;
- Cultural effects;
- Construction effects;
- Abstraction and intake effects;
- Discharge effects;
- Effects on recreation and navigation.

Abstraction and intake effects

Actual and potential effects on the environment within the following six areas:

- The hydrological effects of reduced of flow in the Waikato River;
- Changes in sediment movement within the river due to the presence of the intake structure and reduced flow in the river;
- Effects on river temperature & dissolved oxygen due to reduced flow in the river;
- Effects on instream freshwater ecology;
- Effects on the location of the salt wedge as a result of the changed flow;
- Effects on other users of the Waikato River.

Findings

- By monitoring data (obtained through the operation of the existing intake structure), identification of potential effects associated with the new intake structure and the water take as a whole could be estimated.
- The existing water take and discharge operation has a less than minor effect on the environment
- No reason has been identified why this situation would change if the operation is expanded to include the proposed additional take of water.

Hydrological Effects – Water level

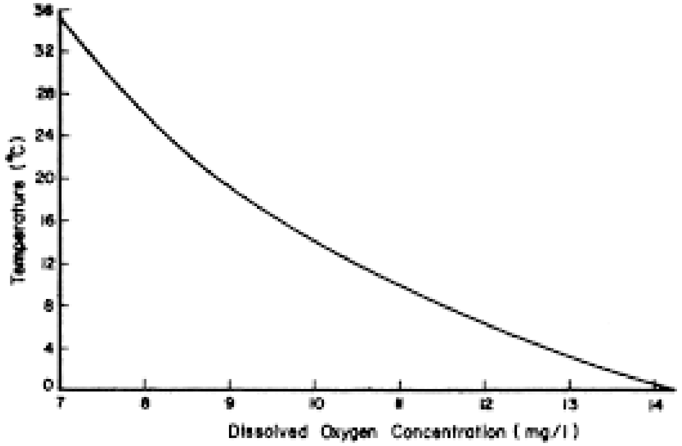
Summary of the effects of the proposed abstraction on the river:

A water level change of approx. 15 mm (low tide) and 22 mm (high tide) (compared with a typical water depth for these scenarios of approximately 6 m and a daily tidal variation of approximately 0.5 m).

Hydrological Effects – Water Velocities

A change in mean velocity of 0.004 m/s (low tide) and 0.002 m/s (high tide) (compared with a mean velocity in these conditions of ~ 0.5 m/s).

Low summertime flows need to be calculated as during this time, the flow and energy will be reduced which changes sediment motion, can increase temperatures, change oxygen concentration and increase the intrusion of a saltwater wedge from the estuary.



Effects on Sediments

Principal effect = reduced flow velocity (reduced sediment carrying capacity)

However, reduction in velocity = reduction of less than 0.5 % (at low flows).

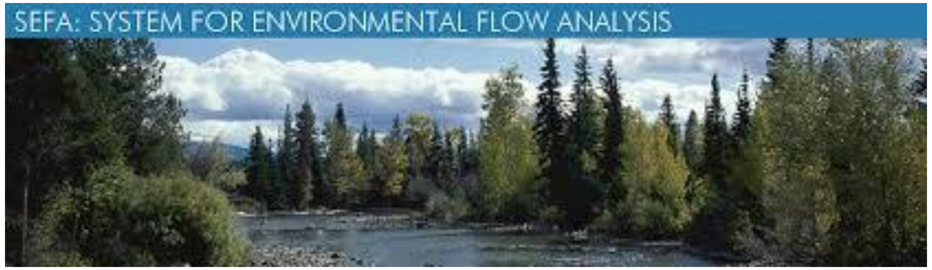
This effect will be less at higher flows, when greater sediment loads are likely in the river.

Effects on Water Quality

Computer software (SEFA) used Instream Flow Incremental Methodology (IFIM) to allow the effects of flow alteration on various physical parameters to be assessed.

Abstraction of an additional 200,000 m^3/day (net) will, at a distance of 10 km or 20 km downstream of the intake, create:

- Maximum temp change of < 0.01 °C.
- Reduction in DO conc of < 0.002 mg/L.



Conclusions

Compared to the existing conditions on the river, and the effects due to everyday tidal variation, the effects on the hydrology and hydraulic regime of the river due to the proposed abstraction will be no more than minor.

Case Study – Pūhoi to Wellsford Upgrade

- Construction water management
- Operational water management

Plus "changes to ecology" to be discussed under flora and fauna

Construction

Key issues are changes to water quality from:

- discharge of sediments from earthworks
- discharge of contaminants
- sediment from in-stream works

Construction Water - Solutions

- Key erosion control areas identified and a range of control measures implemented.
- Stream work restricted to summer months to avoid wet periods
- Water quality monitoring implemented
- Management of hazardous substances
- Effects on drinking water supply – Mahurangi River: slight increase in nutrients but will not exceed drinking water standards for nitrate/nitrite
- Increase in TSS but river water already treated by Watercare as exceeds NZDWS

Effects = Minor

Operational Water

Key issues are:

- Stormwater quantity and quality
- Human impacts

Effects include:

- Changes to runoff and drainage patterns
- Changes in flows of tributaries
- Increased risk of in-stream disturbance
- Stream bed and channel disturbance
- Human effects - drinking water users

Plus “ecological effects” and “Flooding” to be discussed under flora and fauna

Operational Water - Solutions

Effects = Minor

- Runoff from all new impervious surfaces will be treated by conveyance by drains or swales to constructed wetlands for treatment prior to discharge
- Use of bridges, culverts and stream diversions to prevent effects on water flow.
- Potential moderate effect on flooding reduced to minor