Checklists for Artificial Lakes: Guiding Principles

Appendix A from:

Gibbs, M.M.; Hickey, C.W. (2012). Guidelines for Artificial Lakes: Before construction, maintenance of new lakes and rehabilitation of degraded lakes. NIWA report prepared for Ministry of Building, Innovation and Employment, October. 178 pp.

The following check lists contain a summary of key points that need to be considered during the development of an artificial lake. Their primary purpose is to assist the approval process. They cover:

Pre-development considerations under the Regional Plan or RMA: Is the artificial lake a permitted, controlled, restricted discretionary, discretionary, non-complying or prohibited activity in the region covered by the active plan.

Setting Consent Conditions including getting the appropriate paperwork in order. Check list 2 covers the site development and construction with a clear focus on safety. Check list 3 covers water quality considerations.

Design Guidance summarises the many factors that influence a lake and need to be considered when designing an artificial lake. The design guidance covers the three main types of lake: Shallow, Deep, and Quarries.

Details relative to these check lists will be found in the Guidelines text and prescribed in the local Regional Plan. Where there is no active Regional Plan for a region, the consent considerations default to the appropriate section of the RMA.

Note: Check list Part 1, Question 4 refers to the Building (Dam Safety) Act 2008 proposed amendments which are scheduled to come into effect in July 2014. Until they become law, the definition of a large dam is as defined in Question 3.

The inclusion of the new definitions of what constitutes a large dam in the proposed amendment to the Act is to inform developers and consenting authorities of the impending changes and to highlight critical changes to the wording of the legal definition.

The present definition uses the word "**depth**" and is referring to the maximum depth of water retained by the dam, not the depth of water at the dam wall.

The proposed definitions use the word "**height**" and are referring to the height of the dam structure from the toe to the crest.

For example, under the present definition, an off stream reservoir which has a volume of more than 20,000 m^3 with a dam wall less than 3 m high must be classified as a large dam if the maximum water depth in any part of the reservoir is greater than 3 m. Under the proposed amendments this would not be a large dam.

Artificial Lakes Check List: Part 1 (To assist the approval process)

Applies to all artificial lakes with an area of 1 ha or more

PRE-DEVELOPMENT	Requirements

1 **What is the purpose of the artificial lake?**

- ☐ Water supply reservoir
- ☐ Irrigation reservoir
- ☐ Hydro power
- ☐ Water feature
- ☐ Other

2 **Is the artificial lake to be on stream or off stream**

☐ On stream	Defined as:	Dam across a permanently flowing stream
☐ Off stream	Defined as:	Dam across an intermittent stream

3 **Is the artificial lake to be a large dam as defined by the Building Act 2004**

(Dam retains 3 or more metres depth and holds 20,000 or more cubic metres volume of water)

☐ Yes	A building consent
☐ No	Go to question No. 5

4 **Is the artificial lake a large lake as defined under the Building (Dam Safety) Act 2008, July 2014 amendment**

(Proposed 2014 amendment: Dam is 3 m or more high and holds a reservoir of at least 100,000 m^3 of water or 8 m or more high and holds a reservoir of at least 50,000 m^3 of water)

☐ Yes - Dam Safety Scheme applies	Audited Dam Classification Certificate (DCC) Potential Impact Classification (PIC)

5 **Are artificial lakes addressed in the active Regional Plan?**

☐ No - The RMA rules apply	Continue below - tick one box
☐ Yes - The Regional Plan rules apply	Continue below - tick one box
☐ Is this a permitted activity?	No consent required
☐ Is this a controlled activity?	Consent always approved
☐ Is this a restricted discretionary activity?	Consent required
☐ Is this a discretionary activity?	Consent required
☐ Is this a non-complying activity?	Consent required
☐ Is this a prohibited activity?	No consent will be issued

6 **Have neighbours, Iwi and other potentially affected parties been consulted?**

☐ Yes	Signed letter(s) of approval

7 **Has a registered certified civil engineer approved the plan for the dam structure?**

☐ Yes	Certified copy of plans

8 **Has the proposed site been checked against the register of land-fills and toxic waste dumps?**

☐ Yes	Site plan showing nearest relevant dump site

9 **Has a Geotechnical report been provided for the site showing suitability of soils for dam construction and the location of any and all known local earthquake fault lines?**

☐ Yes	Certified copy of report

10 **Is there sufficient legal and physical access to the site of the artificial lake?**

☐ Yes	Site plan showing access and legal title

11 **Will the public have access to the artificial lake?**

☐ Yes	Health & Safety Act 1992 applies.

12 **Will the use of the artificial lake for the stated purpose generate increased road traffic activity?**

☐ Yes	Land Transport New Zealand approval

Artificial Lakes Check List: Part 2 (To assist the approval process)

Applies to all artificial lakes with an area of 1 ha or more

SETTING CONSENT CONDITIONS	Consent conditions to consider:

PLANNING APPROVAL

13 **Does the project have planning approval for a resource consent?**

☐ Yes — Approved plans to be certified

14 **Has the design and appearance of the the structure been given Planning approval?**

☐ Yes — Approved plans to be certified

15 **Is there a site development plan for rehabilitation of the environment once the dam is complete?**

☐ Yes — Approved plans to be certified

16 **Does the project have approval from Land Transport New Zealand for access from public roads?**

☐ Yes — Written confirmation required

SITE DEVELOPMENT AND CONSTRUCTION

17 **Safety**

- ☐ Provide construction site safety instructions and hazard warnings to all site workers
- ☐ Maintain a hazards register for the duration of the site development and dam construction
- ☐ All hazards found on the site shall be recorded and appropriately notified
- ☐ No access for visitors to the construction site without approval and a site guide
- ☐ High visibility clothing and hard hats mandatory for all site workers and visitors
- ☐ All site workers to comply with safe work practice for their occupation and for the site

18 **Construction of access roads required to get to the site to build the dam**

- ☐ Where possible use existing roading - minimize new road cuts
- ☐ Provide sediment retension system for all surface runoff from roads

19 **Site clearance**

- ☐ Safety shall be paramount during all site clearance work
- ☐ No soil or vegetative debris shall be allowed to enter any natural water course from:
  - ☐ the site of the dam construction work
  - ☐ the footprint of the artificial lake

20 **Earthworks**

- ☐ Safety shall be paramount during all earthworks
- ☐ No soil or vegetative debris shall be allowed to enter any natural water course from the site

21 **Diversion of water courses**

- ☐ Safety shall be paramount during work on diverson of water courses
- ☐ Diversion of water courses shall comply with the approved site plan and schedule work

22 **Dam construction**

- ☐ Safety shall be paramount during all work on the dam construction
- ☐ The movement of heavy materials to be scheduled with Transport New Zealand
- ☐ Truck movements for debris removal, fill and concrete may need to be scheduled to avoid interruption of peak traffic flows on public roads
- ☐ Hours of construction may need to be restricted where noise will affect neighbours
- ☐ Hazards noted during dam construction will be mitigated by completion of the dam
- ☐ Hazards associated with sluice gates and hydraulic jumps will be fitted with appropriate signs and, where appropriate, security / safety screens are to be fitted

23 **Site rehabilitation**

- ☐ Safety shall meet the Health & Safety Act 1992 as they relate to open bodies of water
- ☐ The site shall be left free of waste material and debris, holes, pits, sumps and sudden drop-offs that are not readily visible

Artificial Lakes Check List: Part 3 (To assist the approval process)

Applies to all artificial lakes with an area of 1 ha or more

SETTING CONSENT CONDITIONS	Consent conditions to consider:

24 What is the life expectancy of the dam in normal use?

☐ Less than 20 years	Decommissioning plan required
☐ 20 years to 100 years	Maintenance schedule required
☐ Greater than 100 years	Engineering reports and maintenance schedule

WATER QUALITY

This assessment will require detailed information from the developer which may include an Assessment of Environmental Effects (AEE) report

25 **Is an AEE required?**

☐ Yes	Large deep lakes on rivers require an AEE Would also benefit from use of predictive modelling

26 **How will the proposed artificial lake be constructed and filled? (With reference to Q 1 and Q 2)**

☐ Dam across a permanently flowing stream	Minimum flow downstream Periodic high flows to simulate storm events Water quality in lake Water quality of discharge water from lake Provision of a fish pass
☐ Dam across an intermittent stream	Dam affects on local groundwater flow
☐ Raised bund on flat land	Water take limits to fill off-stream lake Diversion structure in river Safety around all control valves and gates
☐ Excavated site in sub-division	Either exclusion of stormwater or for water quality management and litter control if stormwater included
☐ Flooding a quarry	Pre-clean up of quarry to remove metal and rubbish
☐ Other	As appropriate

27 **Where will the water come from to fill an off-stream artificial lake?**

☐ Rainwater	
☐ Groundwater	Groundwater take allocation
☐ Permanently flowing stream/ river (Name)	Water take allocation
	Peak flow take for storage of flood flows

28 **Will the artificial lake discharge water into a permanently flowing stream?**

☐ Yes	Discharge water quality including temperature, dissolved oxygen, nutrients (N & P), sediment Algal species in discharge water Fish species in discharge water Macrophyte species in discharge water

29 **Adverse effects on downstream environment**

Receiving water quality changes in a defined mixing zone below the discharge

☐ Elevated temperatures in discharge water	Limit temperature increase and maximum (e.g. $< 3^{o}C$ increase, up to a maximum temperature of $26^{o}C$)
☐ Depleted oxygen concentrations	Limit oxygen depletion to minimum of (e.g., 5 g/m^3)
☐ Water clarity	Limit water clarity change to maximum of (e.g., 40 NTU)
☐ Water quality	Limits as set out in the Regional Plan

MONITORING

The water quality in the artificial lake and receiving water will require some level of compliance monitoring to ensure that the conditions of the consent are met.

Artificial Lakes Check List: Part 4 (To assist the design process)

Applies to all artificial lakes with an area of 1 ha or more

DESIGN GUIDANCE

Factors affecting water quality in an artificial lake include	Parmeters to consider
Size of the lake	(surface area, depth, volume)
Solar heating	(temperature and thermal stratification)
Morphometry	(shape of the lake basin)
Position in landscape	(shelter from or exposure to prevailing wind)
Position in the country	(altitude and latitude)
Rainfall	(longitude - East coast drier than West coast)
Residence time	(how often the artificial lake is flushed each year)
Catchment size	(nutrient and sediment runoff)
Nutrient input	(nitrogen, phosphorus and organic carbon loads)
Lake bed geology	(rock or sand or clay or silt or mud)
Plant community (native and invasive)	(macrophytes promote clearer water, no macrophytes low clarity and phytoplankton growth)
Fish species (exotic pest)	(rudd, tench destroy macrophyte beds; perch predate zooplankton allowing phytoplankton to grow; catfish and koi carp destabilise the sediments and macrophyte beds)

Catchment land-use will affect nutrient and sediment runoff into the artificial lake

	Land-use	Expected nutrient and sediment production
☐	Native forest	Low nutrient and sediment runoff
☐	Exotic production forest mature	Low nutrient low sediment runoff
☐	Exotic production forest clear-fell	Low nutrient but high sediment runoff
☐	Pasture (sheep)	Medium nutrients and medium sediment runoff
☐	Pasture (beef)	Medium nutrients, high sediment runoff on hills
☐	Pasture (Dairy)	High nutrients, medium-high sediment runoff
☐	Cropping (potatoes, corn/maize, cerials)	Medium nutrients, high sediment runoff
☐	Market gardening	High nutrients, very high sediment runoff
☐	Lifestyle blocks	Variable
☐	Parks, Golf courses	High nutrients, low sediment runoff
☐	Zoo enclosures	Very high nutirents, very high sediment runoff
☐	Urban (Street stormwater disposal)	High nutrients (P), high sediment if it enters lake
☐	Urban (Reticulated stormwater disposal)	Low to medium nutrients and sediment if not into lake
☐	Other	

Water quality will change over the year and between rainfall events

Detailed information for primary source water will help predictions of expected water quality in the lake

Seasonal flows (m^3/s)	Max:	Min:
Seasonal temperatures (°C)	Max:	Min:
Summer temperatures (°C)	Daytime Max:	Daytime mean:
Suspended solids (g/m^3) or	Max:	Min:
Turbidity (NTU)	Max:	Min:
Nitrate-N (mg/m^3)	Max:	Annual mean:
Ammonium-N (mg/m^3)	Max:	Annual mean:
Total N (mg/m^3)	Max:	Annual mean:
Phosphate-P (mg/m^3)	Max:	Annual mean:
Total-P (mg/m^3)	Max:	Annual mean:
Chlorophyll *a* (mg/m^3)	Max:	Annual mean:
Dissolved oxygen (g/m^3)	Daytime Max:	Night time Min:

Most of these parameters should be monitored in the lake too

Need to establish beaches, planted riparian buffer zones and, where required, public access (refer to Q11)

Artificial Lakes Check List: Part 5 (To assist the design process)

Applies to all artificial lakes with an area of 1 ha or more

DESIGN GUIDANCE

Artificial lakes are either shallow or deep with the water depth having a large effect on in-lake processes

SHALLOW LAKES — See text details

Natural valleys

Do not form stable thermal stratification	Sediment frequently disturbed by wind waves
Become very hot in summer	Discharge of hot water mitigated with shading along northern banks and around outflow
	Need deeper cooler refugia for fish
Highly turbid without macrophytes	Resuspended sediment releases nutrients in pore water
	Nutrients support phytoplankton growth

Water quality will depend on the amount of organic matter left in the lake at the time of filling
Need appropriate fish passes
Exclude stormwater runoff or road runoff where-ever possible

Off-stream irrigation reservoirs

Formed by raising a bund to retain the water
Exclude stormwater runoff or road runoff where-ever possible
Design should allow for paired lakes where the water level in one can be manipulated to control filamentous algae or macrophytes while the other is still in use
Water supplied from a diversion system in a nearby river
Health & Safety issues around the diversion weir, sluice gates, and water transfer canals

DEEP LAKES — See text for details

Water quality in first 5 years will depend on the amount of vegetation and organic matter left in the lake footprint at the tme of filling. Decomposition processes will cause oxygen depletion / anoxia.

Form stable thermal stratification	Bottom water may become oxygen depleted and enriched with nutrients
Aeration can destratify the lake	Aerator bar across the lake bed near the dam wall
Bottom water aeration can reduce nutrients	Aerators below thermocline in mid-lake position
Near bottom outtake valves	Induced draw depth currents keep lake aerated at depth provided there is sufficient flow through the system
Temperature induced density currents	Carry sediment to bottom of dam wall
Low or variable through flow	Use multiple outtakes valve depths for good water quality
	Outtake water can be blended from several valves

Need to be designed to cope with 1-in-100 year floods
Need spillways and special fish passes
Design scenarios can be tested using predictive modelling

QUARRIES

Steep sided deep lakes	May have little vegetation to decompose
Will thermally stratify	Unlikely to mix each year
Coal mines will have unusual issues	Decomposition of residual coal will release sulphide which may cause fish kills when the lake mixes

Aeration / destratification should be considered to maintain acceptable water quality.
Will have long residence times giving nutrients time to accumulate and recycle.
Prevent nutrients and sediments jetting out into the lake from inflows using planted buffer zones.