Taupo-nui-a-Tia 2020

An Action Plan to Protect the Health of Lake Taupo and its Surrounding Area

Human Health Risk Assessment

April 2003

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Manatu Mō Te Taiao
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Introduction

2020 Taupo-nui-a-Tia is a three-year multi-agency project initiated in July 2001 to develop a long-term vision and action plan for the sustainable development of Lake Taupo and its catchment. It is based on the values and aspirations of the local Ngati Tuwharetoa and the wider community. Funding support has been provided by Central and Local Government and input from local community groups.

The project is built around three strands (iwi, community, and science). The task of the science group is to provide the information and knowledge support for the project. This report is from the human health component of that group.

Extensive community consultation and a science review[1] have resulted in a list of perceived threats (i.e., hazards) associated with the lake and its catchment as given in the appendices to this report, where 111 such threats are listed.

Following completion of the science review and compilation of the list of threats the science groups have conducted Comparative Risk Assessments (CRAs) for two science topics: *Ecological/ecosystem* (completed), and *Human Health* (this report).[2] Findings from a workshop on the first topic have been reported.[3] Accordingly this comparative human health risk assessment follows the process laid down in that report, as far as is appropriate. However some changes in that process are necessary because the focus of our task is safe drinking water and safe recreational water (for swimmers, skiers, boaties and fishers).

Comparative Risk Assessment

In essence this is a process whereby informed experts attempt to reach consensus on risks that may be posed by a range of potential hazards (i.e., threats), using a simple scoring system. It is a comprehensive approach for identifying and prioritising risks so that effective and timely actions can be taken. The fundamental paradigm of risk assessment used herein is:[4]

Risk = Likelihood x *Consequences*

By scoring both likelihood and consequences an overall risk score is obtained. These scores can then be compared to obtain a list of *relative* risks—the end product of this report.

The definitions of these terms adopted by the Human Health Working Party are given below.

[1] Chapters of that report are available on the web (www.taupoinfo.org.nz).
[2] Four other CRAs are also underway: *Quality of Life*, *Economic*, *Institutional* and *Cultural/Iwi*.
[3] Huser, B.; Donaldson, C.; Thomson, J. 2002. Taupo-nui-a-Tia 2020 Risk Assessment Report. Ministry for the Environment. November. 73 p. This report includes an extensive discussion on the application of CRA methodology in New Zealand.
[4] For example, AS/NZS (2000). *Environmental Risk Management—Principles and Processes*. Standards Australia and Standards New Zealand, document HB 203.

Process

A team of informed professionals was assembled to conduct the assessment, comprising:

Convenor

Graham McBride	Scientist, NIWA, Hamilton

Members

Andrew Ball	Microbiologist, ESR, Christchurch
Greg Curtis	Health Protection Officer, Toi Te Ora Public Health, Rotorua
Max Gibbs	Scientist, NIWA, Hamilton
John Hadfield	Scientist, Environment Waikato
Colin Light	Engineering manager, Taupo District Council
Les Porter	Harbourmaster, Taupo
Bill Vant	Scientist, Environment Waikato
Paul White	Scientist, IGNS, Wairakei

Observer

Beat Huser	2020 Taupo-nui-a-Tia project co-ordinator for the science strand (Scientist, Environment Waikato, Hamilton)

This team met in Taupo on 4 April 2003. Prior to the meeting the convenor circulated notes for discussion to facilitate an efficient start to the meeting. At the meeting the team first resolved definitions, as follows (key terms are italicised on first usage).

Definitions

A *hazard* (or *threat*) is a situation, action, event or substance that can cause harm or damage to humans (e.g., for drinking water supply, swimming).

Likelihood is the chance of the threat occurring in a year.[5] The time scale for this is taken to be one generation (i.e., until about 2020). This is assessed on the same five levels as were used by the ecological workshop,[6] as follows:

SCORE	ANNUAL LIKELIHOOD OF HUMAN HEALTH THREAT (%)	
2	Very unlikely	<5
4	Unlikely	5–39
6	Even	40–59
8	Likely	60–95
10	Very Likely	>95

[5] That is, not in *any* year, but in *a* year. This is important because an event (e.g., a sewer overflow) may have only a 50% chance of happening in a given year, but therefore nearly a 100% chance of that occurring over *any* year in the 20 year horizon (assuming independence of hazard events, that chance is actually $1 - 0.5^{20} = 99.9999\%$).

[6] The ecological working party considered the effects of threats persisting over a much longer time period. This is because ecological processes and ecosystem recovery generally take longer to ameliorate than do human health effects.

Note that this likelihood is independent of whether the public are actually exposed to the threat.

Consequences are assessed on three criteria (*Scale*, *Severity*, and *Duration*), each also with five levels, i.e.,

HUMAN HEALTH CONSEQUENCES		
Scale (of people affected)[¶]	**Severity (of health effect)**	**Duration (of health effect)**
1 = Person	**1** = No symptoms	**1** = Day
2 = Family	**2** = Discomfort	**2** = Week
3 = Neighbourhood	**3** = Visit doctor	**3** = Month
4 = Village/town	**4** = Hospitalisation	**4** = Year
5 = Whole community	**5** = Death	**5** = Permanent

[¶] In terms of numbers of persons: "Person" = 1; "Family" ≈ 10; "Neighbourhood" ≈ 100, "Village/town" ≈ 1,000; "Whole community" > 10,000.

The *score* is obtained by multiplying the four individual scores. Its maximum is therefore 10x5x5x5 = 1,250, corresponding to a highly likely event causing the death of most people in the region. The minimum score is 2 (i.e., 2x1x1x1).

Note that exposure of humans to the hazard is incorporated into the Scale criterion—not into the Likelihood. So, for example, the occurrence of a contaminated site (a hazard) may be very likely so it would score a 10 on the Likelihood scale, but few if any people may be exposed and the Scale score would be low (1).

Note also that Severity and Duration refer to the health effect (i.e., the consequence), not to the persistence of the hazard. So giardiasis illness will probably result in a visit to a doctor (Severity = 3) and symptoms will typically persist for a month (and so Duration = 3).

The ecological workshop also used three criteria for assessing consequences, each with five levels, giving the same maximum possible score. However the nature of ecological problems versus human health issues meant that their three criteria were Intensity, Geographic Scale and Reversibility (as given in Appendix 1). Note that these differences mean that ecological scores are not directly comparable with human health scores.

Grouping the threats

The set of 111 threats identified in the *Lake Taupo Accord* (and associated discussions, Huser *et al.* 2002)[7] is listed in Appendix 2.

Fortunately for the Human Health Working Party the task of grouping these threats into common (ecological) themes has already been completed by the Ecology Working Party (Huser *et al*. 2002). The 12 groups so identified were found to be generally satisfactory for the Human Health Workshop, except that seven additional threats were identified. Table 1 groups the threats to human health that the Working Group considered (Group numbers are everywhere italicised in this report, to facilitate their distinction from Threat numbers). Note that only 32 out of the total of 111 threats were considered to be relevant to Human Health issues.

[7] Huser, B.; Donaldson, C.; Thomson, J. 2002. Taupo-nui-a-Tia 2020 Risk Assessment Report. Ministry for the Environment. November. 73 p.

In some cases the descriptions of these threats has been changed a little to better reflect the Working Party's interest (e.g., Group 1 contains threat 34a that refers to increasing Black Swan populations, whereas the Working Party takes the view that the concern is to do with wildfowl in general).

Scoring results

The final scorings by the Working Party are given on Table 2, for Likelihood, Scale, Severity, Duration, and Total Score. The highest score was 240 (pathogens in roof tank water deposited by birds); the lowest was 2 (low lake levels causing a decline in water quality[8]).

These results are further compacted and summarised on Table 3, the main outcome of the Working Party's deliberations. That Table includes a *relative* ranking, obtained by splitting the scores into terciles, with breakpoints at 80 and 160 (the highest score being 240). Accordingly any score between 160 and 240 has a relative rank of "High". However, this must not be taken to mean that the Working Party views human health risks associated with the Lake and its catchment to be high—on a national (or international) scale we say that they are not, as is suggested by comparison with the maximum and median scores obtained (240 and 60 respectively) with the maximum possible score (1,250). However, there is never room for complacency in such matters: were even a few people to become infected with cysts of *Giardia* or the Hepatitis A virus from the Lake water, many more people could be subsequently infected through secondary transmission (at children's play groups for example), and Hepatitis A may cause lifetime illness.

It is notable that the maximum and median scores obtained by the Ecology CRA Working Party (i.e., 800 and 262) are higher—roughly fourfold—than those obtained herein. The comparison in the table below shows that this difference arises particularly because of higher scoring by the Ecology Working Party for the last two components in the Consequences scale, as is appropriate when considering the long time scale of ecological effects. (The Table is included to demonstrate the origin of the different scores between the two Working Parties, but we wish to emphasize that the scores assigned by the two Working Parties are not comparable.)

Comparing average scores for the Ecology and Human Health Working Parties

Ecology	**Likelihood**	**Intensity**	**Geographic Scale**	**Reversibility**
	7.0	2.8	3.6	3.6
Human Health	Likelihood	Scale	Severity	Duration
	8.0	2.3	2.3	2.0

[8] Low Lake level may be associated with a lowering of water quality, but it is not the cause.

Summary

From the list of over one hundred potential threats that have been identified in the 2020 Taupo-nui-a-Tia project (see Appendix 2), 32 were identified as threats to human health. Seven additional threats were added by this working party. All these threats relate to drinking water and recreational water use, and can be grouped into five types (with 17 sub-categories):

1. Pathogens in water
2. Beach litter
3. Toxic algal blooms
4. Chemicals
5. Lake levels

The relative ranking of these risks was established using comparative risk analysis methodology (see Appendix 1). The majority of the threats pose only a low (8) or medium (3) risk. The risks with the highest relative ranks were:

- Faecal micro-organisms in roof tank water (from birds).
- Faecal micro-organisms in lake water (from septic tanks, pipe failure, stormwater, wildfowl).
- Faecal micro-organisms in groundwater (from surface leakage).
- Beach litter (nails, glass shards) causing wound infection.
- Toxic algal blooms in lake water (impairing drinking water quality at source).
- Chemicals in groundwater (As, B, Mn), for susceptible persons.

This risk assessment complements the work of other expert groups assessing the relative risks from an ecological, cultural/iwi, economic, human safety and quality of life perspectives.

The next step will look at solutions to avoid, remedy and/or mitigate the identified risks and to identify the priorities for an Action Plan to protect the community values.

Table 1: Grouping the human health threats (hazards)

Group	Summary description	Threats (Appendix 2)[^]
Identified in the Lake Taupo Accord and in the 2020 Science Review (see Huser et al. 2002, Taupo-nui-a-Tia 2020 Risk Assessment Report, MfE, Part 4)[%]		
1	Increased wildfowl populations pollute the foreshore[*]	34a*
2a	Sewage leaching and emergency disposal causing contamination of Lake water with harmful micro-organisms	25, 39b, 50a,[#] 63b
2b	Septic tank effluent or pipe failure causing contamination of Lake water with harmful micro-organisms	25, 39b, 43, 63b
2c	Stormwater contamination of Lake water	39a, 57b, 63a
3	Discharges of human effluent from boats contaminating Lake water (including rogue activity)	10, 31b, 42, 52
4	Discharges of fuel and boat hull scrapings contaminating Lake water (latter is an occupational safety issue)	11, 13, 31a
5	Unnatural lead inputs (lead shot, fishing lines and sinkers) contaminating Lake water	14, 30, 59
6	Volcanic eruption effects on Lake water quality	58, 74a
7	Runoff and input of herbicide sand pesticides contaminating Lake water (includes consideration of 1080)	65
8	Stormwater chemistry, roadside spraying causing illness (especially dermatitis and skin infections)	1a, 9, 26a, 57a
11	Lahar effects on water quality (assuming no intercepting trench is constructed)	74b
12	Sewage nutrient inflow causing growth of harmful micro-organisms in Lake water (e.g., growth of *Aeromonas* spp.)[%]	50b[@]
21a	Leaching of farm chemicals causing groundwater contamination	55
21b	Spray-drift of farm chemicals contaminating roof drinking-water	55
22a	Beach litter (nails, glass shards) causing wound and infection	29b
22b	Beach litter (discarded syringes) causing wound and infection	29b
22c	Low lake levels causing declining drinking water quality	51
22d	Toxic algal blooms in Lake waters impacting on drinking water quality[@]	56
New threats identified at the Human Health Comparative Risk Assessment Workshop, 4 April 2003		
26	Pathogens being deposited in roof tank water by birds	–
27	Recreational water users contacting algal blooms	–
28	Contaminated sites (e.g., Lakeshore service station)	–
29	Nitrate in groundwater (causing methemoglobinemia—blue babies)	–
30	Chemical contamination of groundwater, especially by Arsenic, Boron and Manganese[$]	–
31	Pathogen contamination of groundwater, e.g., by surface runoff over insecure wellheads or in by-pass situation	–
32	Nutrients in runoff causing growth of harmful micro-organisms in Lake water (i.e., growth of *Klebsiella* spp.)	–

[%] There are 12 groups here. ^ There are 32 threats in total. * Replacing "Black Swan" by "Wildfowl". [#] Replacing "bacteria" with harmful micro-organisms. [%] E.g., in Acacia Bay. [@]The Lake has had relatively low algal counts thus far (cf. Rotorua lakes), but recent bloom results are surprising. [$] Not always a "contaminant", as defined in the Resource Management Act, as it may be of geothermal origin.

Table 2: Workshop Scores and Ranking (from highest to lowest)

Rank	Hazard Group	Group number	Likelihood	Scale	Severity	Duration	Score
1	Pathogens deposited in roof tank water	*26*	10	4	3	2	240
2=	Wildfowl contamination of foreshore	*1*	10	3	3	2	180
2=	Septic tank effluent or pipe failure[%]	*2b*	10	3	3	2	180
2=	Beach litter (nails, glass shards) causing wound infection	*22a*	10	2	3	3	180
2=	Toxic algal blooms impairing drinking-water quality	*22d*	6	5	3	2	180
2=	Groundwater pathogen contamination	*31*	10	3	2	3	180
7	Stormwater contamination of Lake	*2c*	10	4	2	2	160
8	Discharge of sewage to Lake from boats	*3*	10	2	3	2	120
9	Contamination of Lake by reticulated sewage	*2a*	6	2	4	3	144
10	Spray-drift contaminating roof drinking-water*	*21b*	10(2)[$]	2(1)	2(4)	2(5)	80(40)
11	Recreational water users contact with toxic blooms	*27*	6	2	3	2	72
12	Stormwater chemistry, roadside spraying	8	10	3	2	1	60
12=	Sewage nutrients causing growth of harmful micro-organisms	12	10	1	3	2	60
14	Groundwater chemical contamination (As, B, Mn)[#]	*30*	10	4(1)	1(4)	1(5)	40(200[^])
15	Beach litter (discarded syringes) causing wound infection	*22b*	2	1	4	4	32
16	Nitrate in groundwater[@]	*29*	10	3(1)	1(4)	1(2)	30(80[^])
17=	Lahar effects on water quality	*11*	4	4	1	1	16
17=	Nutrients in runoff causing growth of harmful micro-organisms	*32*	4	1	2	2	16
19=	Fuel discharges and boat scrapings contaminating Lake	*4*	10	1	1	1	10
19=	Unnatural lead inputs to Lake	*5*	10	1	1	1	10
19=	Volcanic eruption effects on water quality	*6*	2	5	1	1	10
19=	Herbicide/pesticide inflows to Lake	*7*	10	1	1	1	10
19=	Leaching of farm chemicals to groundwater	*21a*	10	1	1	1	10
19=	Contaminated sites	*28*	10	1	1	1	10
25	Low Lake levels causing decline in source drinking water	*22c*	2	1	1	1	2

Dashed lines separate three sets of hazards (threats) according to their *relative* risks: high (160–240), medium (80–159), low (2–79).

[%] Water hammer causes breakages in rising mains once every 2 or 3 years. Motor soft starters may be fitted to all lakeside pump stations, lessening risk from pipe failures. On the other hand land subsidence (from geothermal extraction) or earthquake could cause sewer pipe fracture, and some pipes run along the Lake foreshore.

* Scores in brackets consider only the population with that may suffer a birth defect from exposure to teratogen compounds, causing genetic alteration.

[$] Likelihood lessens when considering teratogens only, as few spray-drift preparations contain these compounds.

[#] Scores in brackets consider only the population that have inherent sensitivity to chemicals, e.g., arsenic leading to cancer issues.

[^] Medium risk

[@] Scores in brackets consider only the population that are babies (and therefore susceptible to methemoglobinemia).

Table 3: Workshop Scores and Relative Ranking

Type of threat	Relative Rank*
Pathogens in water	
In roof tank water, deposited by birds, possums, etc.	Highest
In Lake water from wildfowl, septic tanks, pipe failure, stormwater.	High
In groundwater from surface leakage (inadequate wellhead protection)	High
In Lake water from discharge of boat sewage	Medium
In Lake water caused by nutrients in sewage and runoff, causing pathogen bloom	Low
Beach litter	
Nails, glass shards causing wound infection	High
Discarded syringes causing wound infection	Low
Toxic Algal blooms	
In Lake water, impairing drinking-water quality at source	High
In Lake water for recreational water users in contact with blooms	Low
Chemicals	
In groundwater: chemical contamination (As, B, Mn) for susceptible persons	High
In roof drinking-water: spray-drift contamination for general population	Medium
In groundwater: elevated nitrates impairing health of the very young	Medium
In roof drinking-water: spray-drift contamination causing birth defects	Low
In groundwater: elevated nitrates and other chemicals affecting whole population	Low
In Lake: from lahar, farm chemicals, contaminated sites, boat fuel and hull scrapings, volcanic eruption and unnatural lead inputs	Low
In catchment: from stormwater and roadside spraying	Low
Lake levels	
Low levels causing decline in source drinking water	Lowest

* Relative Ranking is determined by dividing the highest score (240) into three: Low = 2–79; Medium = 80–159; High = 160–240.

Note: the ranking reflects the relative importance of the identified threats, i.e., 'high' risks are high relative to those ranked as 'medium' or 'low' risks.

Appendix 1: Ecological and Human Health Scoring Definitions

Likelihood

***Ecological*:** Probability of event happening within the next 20 years

***Human Health*:** Probability of event happening in a year (cf. *any* year) over the next 20 years

Both the Ecological and Human Health Working Groups used the same scoring vector, i.e.,

2	= very unlikely	(<5%);
4	= unlikely	(5–39%);
6	= even	(40–59%);
8	= likely	(60–95%);
10	= very likely	(>95%).

Consequences

ECOLOGICAL CONSEQUENCES		
Intensity	**Geographic Scale**	**Reversibility**
1 = Negligible	**1** = 10 m² or less (any point)	**1** = Totally reversible – in weeks
2 = Low stress	**2** = Paddock or beach or 100 m river reach	**2** = Totally reversible – in months/years
3 = Medium stress	**3** = Farm scale or bay	**3** = Partially – months/years
4 = High stress	**4** = Sub-catchment or 1/3 → 2/3 of Lake	**4** = Partially or total – decade
5 = Extreme (e.g., death)	**5** = Whole catchment and/or Lake	**5** = Irreversible

HUMAN HEALTH CONSEQUENCES		
Scale (of people affected)[¶]	**Severity (of health effect)**	**Duration (of health effect)**
1 = Person	**1** = Asymptomatic	**1** = Day
2 = Family	**2** = Discomfort	**2** = Week
3 = Neighbourhood	**3** = Visit doctor	**3** = Month
4 = Village/town	**4** = Hospitalisation	**4** = Year
5 = Whole community	**5** = Death	**5** = Permanent

[¶] In terms of numbers of persons: "Person" = 1; "Family" ≈ 10; "Neighbourhood" ≈ 100, "Village/town" ≈ 1,000; "Whole community" > 10,000.

Appendix 2: List of Threats (Hazards) to Community Values

From: Huser, B.; Donaldson, C.; Thomson, J. 2002. Taupo-nui-a-Tia 2020 Risk Assessment Report. Ministry for the Environment. November. 73 p.

Note: Some of the threat statements contain more than one consequence or source and these have been divided into (a), (b), (c) etc. and the relevant wording underlined. This means that one threat statement may appear three times on the list, each under a different grouping.

Number	Threat	Source Document
1	Stormwater carrying pollutants	**Stewart et al. 2000, Table 5 "Most Important Perceived Issues /Concerns"**[9]
2	Proliferation of nuisance weeds around lake edges	"
3	Increasing nitrogen levels in the Lake	"
4	Jetskiing and water skiing near shore	"
5	Lakeshore subdivision	"
6	Fluctuations in the Lake level	"
7	Conflicts between water users (e.g. boats/swimmers)	"
8	Increasing number of tourists and visitors	"
9	Pouring used engine oil/paint down gutters or drains.	**Stewart *et al.* 2000, Table 6 "List of Perceived Harms"**[9]
10	Dumping raw sewage from boats into lake	"
11	Scraping and painting boat hulls without proper containment	"
12	Littering	"
13	Fuel spills from boats	"
14	Using lead sinkers for fishing or lead shot for duckshooting	"
15	Uncertainty about who is responsible for different management aspects can cause duplication or gaps in management action.	**Lake Taupo Accord (Draft April 1999; pages 10/11)** - Lake Taupo Accord – Administration and Resourcing Issues
16	Limited funding and difficulty in identifying who should pay can restrict or deny management solutions or options.	Lake Taupo Accord – Administration and Resourcing Issues
17	Lakeshore subdivision can restrict public access unless adequate roading and lakeshore reserves are maintained and developed.	Lake Taupo Accord – Recreation Issues
18	Insufficient boat ramps and parking can restrict access to the lake.	Lake Taupo Accord – Recreation Issues
19	Boat ramp users can cause problems with weed introduction unless adequately supervised.	Lake Taupo Accord – Recreation Issues
20	Activities with persistent or offensive noise	Lake Taupo Accord – Recreation Issues
21a	Small high speed water craft are dangerous and offensive in near shore areas eg Jetskis	Lake Taupo Accord – Recreation Issues
21b	Small high speed water craft are dangerous and offensive in near shore areas eg Jetskis	Lake Taupo Accord – Recreation Issues
22	Inappropriate land use can have the potential to degrade lake water quality	Lake Taupo Accord – Environmental Issues
23	Competing activities on the lake can exclude other activities (surface of lake)	Lake Taupo Accord – Environmental Issues
24a	The range of lake levels particularly the extremes can cause flooding on high levels and access problems at low levels.	Lake Taupo Accord – Environmental Issues
24b	The range of lake levels particularly the extremes can cause flooding on high levels and access problems at low levels.	Lake Taupo Accord – Environmental Issues
25	Sewage (seepage water from sewage treatment facilities to groundwater)	Lake Taupo Accord – Environmental Issues

[9] Stewart, C., Johnston, D., Rosen, M., Boyce, W. 2000. Public involvement in environmental management of Lake Taupo: preliminary results of the 1999 surveys. GNS Science Report 2000/7. 16 p.

Number	Threat	Source Document
26a	Stormwater runoff from roads and urban areas contain contaminants reducing lake water quality	Lake Taupo Accord – Environmental Issues
26b	Stormwater runoff from roads and urban areas contain contaminants reducing lake water quality	Lake Taupo Accord – Environmental Issues
27	Agricultural run-off can increase nutrient levels in lake water	Lake Taupo Accord – Environmental Issues
28	Forestry run-off can affect catchment waterways and the lake	Lake Taupo Accord – Environmental Issues
29a	Rubbish and litter is unsightly, dangerous and pollutes the lake	Lake Taupo Accord – Environmental Issues
29b	Rubbish and litter is unsightly, dangerous and pollutes the lake	Lake Taupo Accord – Environmental Issues
29c	Rubbish and litter is unsightly, dangerous and pollutes the lake	Lake Taupo Accord – Environmental Issues
30	Unnatural lead input into the lake (fishing lines and shooting) can increase lead levels in the water.	Lake Taupo Accord – Environmental Issues
31a	Pollution from boating (fuel and human effluent) can contaminate lake water.	Lake Taupo Accord – Environmental Issues
31b	Pollution from boating (fuel and human effluent) can contaminate lake water.	Lake Taupo Accord – Environmental Issues
32	The increase in temperature of water diverted from the Tongariro River may result in water staying on the surface of the lake, resulting in reduced O2 levels in the bottom of the lake.	Lake Taupo Accord – Environmental Issues
33	Weed growth in shallow or recreational areas is unsightly and conflicts with recreation use and adversely effects lake ecology	Lake Taupo Accord - Animal and Plant Pests
34a	Increased Black Swan populations pollute the foreshore and spread weed	Lake Taupo Accord - Animal and Plant Pests
34b	Increased Black Swan populations pollute the foreshore and spread weed	Lake Taupo Accord - Animal and Plant Pests
35	Uncontrolled growth of willows adversely affect trout spawning habitat	Lake Taupo Accord - Animal and Plant Pests
36	Further introduction of exotic fish (eg catfish) species could affect trout fishing	Lake Taupo Accord - Animal and Plant Pests
37a	Erosion of riverbanks and foreshore can result in loss of land or damage to structure and risk to public safety (eg walkways).	Lake Taupo Accord - Other Issues
37b	Erosion of riverbanks and foreshore can result in loss of land or damage to structure and risk to public safety (eg walkways).	Lake Taupo Accord - Other Issues
38	Increased nutrient input into the lake from farming and other land uses that result in large increases in nutrient loads.	**2020 Science Review (Huser 2002, A Review of Current Information on Taupo Community Values[10]) – Clear Water**
39a	Nearshore human development and disposal of wastewater and stormwater (faecal contamination).	**2020 Science Review (Huser, 2002[10]) – Safe Swimming**
39b	Nearshore human development and disposal of wastewater and stormwater (faecal contamination).	2020 Science Review - Safe Swimming
40	Increased nutrient input leading to reduced water clarity, toxic algal blooms, algal growth and slime on rocks and lake bottom	2020 Science Review - Safe Swimming
41	Increasing use of high speed pleasure craft, including windsurfers, jet skis, personal water craft)	2020 Science Review - Safe Swimming
42	Sewage discharges from boats	2020 Science Review - Safe Swimming
43	Poor maintenance and operation of nearshore septic tanks.	
44	Boats spreading existing and introducing new weeds leading to the establishment of dense weedbeds.	2020 Science Review - Safe Swimming

[10] Huser, B. 2002. A review of current information on Taupo community values. SMF Project #2193 Taupo-nui-a-Tia report, February 2002. 150p.

Number	Threat	Source Document
45	Spread of existing weeds leads to displacement of native water plants and results in depletion of native seed banks and biodiversity.	**2020 Science Review (Huser, 2002[10]) – Weed Free Lake**
46	Introduction of new weeds by lake users with boats, fishing gear and other equipment	2020 Science Review - Weed Free Lake
47	Nutrient enrichment increasing algal slimes and other algal nuisance growths	2020 Science Review - Weed Free Lake
48	Climate change resulting in warmer water can be expected to affect water plant types and distribution, and lead to algal growth	2020 Science Review - Weed Free Lake
49a	Introduction of new fish species affecting ecological processes and distribution of water plants.	2020 Science Review - Weed Free Lake
49b	Introduction of new fish species affecting ecological processes and distribution of water plants.	2020 Science Review - Weed Free Lake
50a	Sewage disposal causes nutrient levels to increase in groundwater and surface waters and can cause bacteria to grow	**2020 Science Review (Huser, 2002[10]) - Safe Drinking Water**
50b	Sewage disposal causes nutrient levels to increase in groundwater and surface waters and can cause bacteria to grow	2020 Science Review - Safe Drinking Water
51	Low lake levels can result in declining drinking water quality (algal growth affects taste)	2020 Science Review - Safe Drinking Water
52	Disposal of wastewaters from boats could spread illness-causing micro-organisms into the Lake	2020 Science Review - Safe Drinking Water
53	Increased nutrients from farmland causes an increase in algal growth	2020 Science Review - Safe Drinking Water
54	Increased development and population growth may cause increased nutrient flows to the lake even with sewage treatment	2020 Science Review - Safe Drinking Water
55	Inappropriate use of farm chemicals can pose a threat to drinking water quality (e.g. through spraydrift or leaching into groundwater).	2020 Science Review - Safe Drinking Water
56	Toxic algal blooms could impact on drinking water quality if concentrations of cells exceed the limit	2020 Science Review - Safe Drinking Water
57a	Stormwater has the potential to transmit pollutants such as heavy metals and illness-causing micro-organisms	2020 Science Review - Safe Drinking Water
57b	Stormwater has the potential to transmit pollutants such as heavy metals and illness-causing micro-organisms	2020 Science Review - Safe Drinking Water
58	Volcanic eruptions have the potential to impact on water quality (e.g. through the deposition of toxic elements such as arsenic and fluorine).	2020 Science Review - Safe Drinking Water
59	Lead shot may contribute to the detectable lead levels in the lake (these are within acceptable thresholds)	2020 Science Review - Safe Drinking Water
60	Increased stocking rates on farms increase the nitrogen load to the lake	**2020 Science Review (Huser, 2002[10]) - High Quality Inflowing Water**
61	Historical land use changes have resulted in increased nitrogen concentrations in some streams	2020 Science Review - High Quality Inflowing Water
62	Sewage disposal to land in some cases increases localised algal growth in nearshore areas.	2020 Science Review - High Quality Inflowing Water
63a	Stormwater and sewage leaching pose a potential threat to the bacterial quality of the lake water in some localised areas	2020 Science Review - High Quality Inflowing Water
63b	Stormwater and sewage leaching pose a potential threat to the bacterial quality of the lake water in some localised areas	2020 Science Review - High Quality Inflowing Water
64	Forestry harvesting operations can increase nitrogen leaching if herbicides used after felling, less if weeds grow.	2020 Science Review - High Quality Inflowing Water
65	Use of herbicides and pesticides on farms may affect water quality.	2020 Science Review - High Quality Inflowing Water
66	Forestry fertiliser applications may increase nitrogen loads to the lake.	2020 Science Review - High Quality Inflowing Water
67	Cropping may lead to increased nitrogen leaching.	2020 Science Review - High Quality Inflowing Water

Number	Threat	Source Document
68	Forestry harvesting operations and road construction may cause soil erosion and affect stream water quality.	2020 Science Review - High Quality Inflowing Water
69a	Introduction and spread of exotic fish could impact on invertebrates and native fish (e.g. smelt in L. Taupo or koaro in L. Rotoaira).	**2020 Science Review (Huser, 2002[10]) - Diverse Plants and Animals**
69b	Introduction and spread of exotic fish could impact on invertebrates and native fish (e.g. smelt in L. Taupo or koaro in L. Rotoaira).	2020 Science Review - Diverse Plants and Animals
70a	Widespread introduction of eel could impact on freshwater crayfish and water plant populations	2020 Science Review - Diverse Plants and Animals
70b	Widespread introduction of eel could impact on freshwater crayfish and water plant populations	2020 Science Review - Diverse Plants and Animals
71	Nutrient enrichment increases algal growth which influences invertebrate communities in the lower Tongariro and may be expected to have similar impacts on other streams	2020 Science Review - Diverse Plants and Animals
72	Nutrient enrichment would pose a threat to smelt abundance	2020 Science Review - Diverse Plants and Animals
73	Introduction of alien invasive macrophytes would be expected to alter habitat conditions for benthic invertebrates.	2020 Science Review - Diverse Plants and Animals
74a	Volcanic eruptions and secondary lahar flows pose a threat to invertebrates through inputs of acidic water with high sediment loads.	2020 Science Review - Diverse Plants and Animals
74b	Volcanic eruptions and secondary lahar flows pose a threat to invertebrates through inputs of acidic water with high sediment loads.	2020 Science Review - Diverse Plants and Animals
74c	Volcanic eruptions and secondary lahar flows pose a threat to invertebrates through inputs of acidic water with high sediment loads. (Smothering by sediments)	2020 Science Review - Diverse Plants and Animals
75	Reduction in quality or extent of spawning and rearing habitat as a result of floods, climate change, water abstraction/damming, poor land management (erosion/siltation), volcanic activity threatens fishery.	**2020 Science Review (Huser, 2002[10]) - Good Trout Fishing**
76	Increased nutrients cause a reduction in trout growth and/or numbers.	2020 Science Review - Good Trout Fishing
77	Introduction of new species may cause negative impact on the fishery.	2020 Science Review - Good Trout Fishing
78	Overharvesting in Lake Taupo could have a significant impact on the fishery	2020 Science Review - Good Trout Fishing
79	Poaching, if left unchecked, could have a significant impact on the fishery	2020 Science Review - Good Trout Fishing
80	Imported fish products, unwashed angling equipment etc. pose a risk to the introduction of trout disease and parasitic infections.	2020 Science Review - Good Trout Fishing
81	Unauthorised access to the lake, rivers and streams (e.g. people using private land without permission from landowner)	**2020 Science Review (Huser, 2002[10]) - Recreational Opportunities**
82	In Taupo township, busy main road along waterfront lacks adequate pedestrian crossings	2020 Science Review - Recreational Opportunities
83	Low lake levels cause some boat ramps to be unusable	2020 Science Review - Recreational Opportunities
84	Severe congestion occurs at popular boat ramps during holiday season	2020 Science Review - Recreational Opportunities
85	Nuisance weed growths can hinder boating, limit swimming access, cause unpleasant odours and reduces aesthetic appearance.	2020 Science Review - Recreational Opportunities
86	Population pressures (both residents and visitors) and use of recreational resources (e.g. boating and angling) are steadily growing and causes general environmental impacts (littering, destruction of native forests, pollution of waterways and the lakeshore by human wastes).	2020 Science Review - Recreational Opportunities

Number	Threat	Source Document
87	Overcrowding affects some angler's enjoyment of the Tongariro River.	2020 Science Review - Recreational Opportunities
88	Recreational carrying capacity not known	2020 Science Review - Recreational Opportunities
89	Increasing pressures and disregarding regulations lead to increased conflict.	2020 Science Review - Recreational Opportunities
90	Thefts from parked cars	2020 Science Review - Recreational Opportunities
91	Noise intrusion from skeet shooting, powerboats and jet skis conflicts with passive uses that enjoy the intrinsic qualities of the area - its peace and tranquility.	2020 Science Review - Recreational Opportunities
92	High boat speed near the shore can threaten swimmers and anglers.	2020 Science Review - Recreational Opportunities
93a	Boats may spread weeds from Lake Taupo to nearby lakes Otamangakau and Kuratau threatening the fishery and ecosystems in these lakes.	2020 Science Review - Recreational Opportunities
93b	Boats may spread weeds from Lake Taupo to nearby lakes Otamangakau and Kuratau threatening the fishery and ecosystems in these lakes.	2020 Science Review - Recreational Opportunities
94	Easy access to the foreshore facilitates increased recreational use and places stresses on conservation values.	**2020 Science Review (Huser, 2002[10]) - Foreshore Reserves**
95	Some shoreline structures have had an impact on natural processes along the shoreline (e.g. groynes obstructing sediment paths).	2020 Science Review - Foreshore Reserves
96a	Fluctuations in lake levels cause erosion which in turn diminishes access, diminishes aesthetic appeal, affects discharge of lakeside hot springs, creates safety hazards and may damage infrastructural assets.	2020 Science Review - Foreshore Reserves
96b	Fluctuations in lake levels cause erosion which in turn diminishes access, diminishes aesthetic appeal, affects discharge of lakeside hot springs, creates safety hazards and may damage infrastructural assets.	2020 Science Review - Foreshore Reserves
96c	Fluctuations in lake levels cause erosion which in turn diminishes access, diminishes aesthetic appeal, affects discharge of lakeside hot springs, creates safety hazards and may damage infrastructural assets.	2020 Science Review - Foreshore Reserves
96d	Fluctuations in lake levels cause erosion which in turn diminishes access, diminishes aesthetic appeal, affects discharge of lakeside hot springs, creates safety hazards and may damage infrastructural assets.	2020 Science Review - Foreshore Reserves
96e	Fluctuations in lake levels cause erosion which in turn diminishes access, diminishes aesthetic appeal, affects discharge of lakeside hot springs, creates safety hazards and may damage infrastructural assets.	2020 Science Review - Foreshore Reserves
97	Development (subdivision) threatens the 'wilderness' element and natural character of Lake Taupo, particularly on the western side.	2020 Science Review - Foreshore Reserves
98a	Animal and plant pests have become naturalised and are a threat to natural vegetation and native wildlife.	**2020 Science Review (Huser, 2002[10]) - Wilderness Areas**
98b	Animal and plant pests have become naturalised and are a threat to natural vegetation and native wildlife.	2020 Science Review - Wilderness Areas
99	Fire is a major threat to second-growth shrublands around the margins of Lake Taupo, and to the South Taupo wetland, where fire facilitates the spreading of grey willow.	2020 Science Review - Wilderness Areas
100	Changes in lake levels are likely to favour the spread of grey willow in the South Taupo wetland.	2020 Science Review - Wilderness Areas
101	Lack of legal protection threatens the South Taupo wetland (only 20% protected) and areas of native vegetation in the Western Bay areas through development of privately-owned land.	2020 Science Review - Wilderness Areas

Number	Threat	Source Document
102	Visible presence of built structures and infrastructure reduces natural character of the area.	**2020 Science Review (Huser, 2002[10]) - Outstanding Scenery**
103a	Deterioration in water clarity due to increased sediment or algae reduces the lake's aesthetic appeal.	2020 Science Review - Outstanding Scenery
103b	Deterioration in water clarity due to increased sediment or algae reduces the lake's aesthetic appeal.	2020 Science Review - Outstanding Scenery
104	Excessive weed growth reduces aesthetic appeal, worse in remote, unspoiled areas	2020 Science Review - Outstanding Scenery
105	Changing land use such as incremental subdivision and plantation forestry add up to substantial change over time which fundamentally alters the character, vistas and views of the catchment.	2020 Science Review - Outstanding Scenery
106	Utilities (e.g. hydrodams and associated transmission lines) are a particular factor affecting scenic values.	2020 Science Review - Outstanding Scenery
107	Rubbish and litter whether in the water or on lakeshores detracts from the scenic enjoyment and spoils the natural character of the area.	2020 Science Review - Outstanding Scenery
108	Degradation of many of the important exposure and integrity sites has resulted due to human activity (e.g. road construction).	**2020 Science Review (Huser, 2002[10]) - Geological Features**
109	Lack of protection of sites in the Proposed Taupo District Plan.	2020 Science Review - Geological Features
110	Vulnerability of geothermal sites e.g. disturbance from lakeside tracks, storm water drains or roading, and constraint on natural discharge due to commercial exploitation	2020 Science Review - Geological Features
111	Lake level changes can impact on geothermal springs.	2020 Science Review - Geological Features