Aotearoa/New Zealand Policy Proposals on healthy waterways:

Are they fit for purpose?

Soil & Health Association of New Zealand
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PSGR
Physicians & Scientists for Global Responsibility

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New Zealand
Policy Proposals on healthy waterways: Are they fit for Purpose? (2019)

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How can you have an opinion if you are not informed? H.Arendt

Executive Summary

Excellent water quality is of paramount importance for our Treaty obligations, agriculture, tourism industry, health and sense of national identity. In September 2019 the Ministry for the Environment released its proposals for dealing with the crisis in our waterways: '*Action for healthy waterways – A discussion document on national direction for our essential freshwater*'. While the document outlines possible ways of 'reducing soil loss, reducing nutrient run-off, and/or investing in upgrading wastewater and stormwater infrastructure', there is one glaring omission – it does not address the need to monitor synthetic chemicals in our waterways. Diffuse emissions must be urgently addressed.

Chemical production is predicted to increase exponentially, constituting a present and growing threat to human and environmental health, and risking the wellbeing of future generations. Chemical contaminants include pesticides, household products, resins, plastics, petroleum products, pharmaceuticals and personal care products. Currently, *routine* national monitoring for chemical contaminants in New Zealand freshwater that is publicly accessible, is confined to groundwater. While laudable, this is not sufficiently protective of public or environmental health.

Polluting synthetic chemical contaminants create intersecting social, cultural and economic harms. Without a mandate to monitor chemical contaminants in waterways as well as aquifers, territorial and national authorities will not have the capacity to safeguard:

- The quality of our drinking water;
- Māori customary fishing and traditional riverside food gathering;
- Favourite Kiwi swimming areas;
- Key tourist destinations as safe and ecologically healthy;
- Food production and processing, and organic systems from contamination.

Excluding diffuse chemical contaminants from monitoring and regulation additionally leaves Māori without appropriate scientific resourcing to assert rangatiratanga and kaitiakitanga. We will be unable to protect biodiversity and our food chains, reverse declining fish populations and ensure that our agricultural exports are not inadvertently contaminated. And the possibility of endocrine disruption puts at risk our most vulnerable citizens – our babies.

The solution is not to stick our heads in the sand, because it is not politically comfortable, nor convenient. Nor is it acceptable to wait for certainty - until scientific endpoints are established. It is evident, for many endocrine disruptors, that it may not be possible to establish endpoints because of the miniscule levels at which these chemicals cause harm, and because of the varying vulnerability at different life stages.

In such an environment, there remain many opportunities to ensure policy and regulation concerning freshwater are fit for purpose and can reasonably meet the foreseeable needs of future generations.

1. Where degraded areas are identified, scientists can utilise a suite of nationally regulated testing screens for diffuse chemical contaminants and publish this information for public debate.
2. New Zealand can resource scientist experts in chemical toxicology, endocrinology and environmental chemistry and build on international research to innovatively evaluate the risk to both aquatic food chains and human health – at arms-length from industry.

3. Our chemical risk assessment can adopt best practice alongside Europe, sending a firm message to trading partners and tourist operators that freshwater and food in Aotearoa is clean and safe.
4. We can update regulations to recognise additional risk from chemical mixtures; and the risk from exposures at low levels that impacts the hormone system and can set the stage for disease and dysfunction.
5. New Zealand can appropriately engage the precautionary principle as the key policy instrument that over-arches risk evaluation, rather than retaining it where it currently sits in legislation and policy, alongside social, cultural and economic considerations where it is rarely called upon, and frequently ignored.

We recommend that the monitoring of diffuse chemical pollutants in our fresh water is required as a national environment standard and that the recommendations for reform in this paper are included in any policy on protecting the quality of our fresh water.

Soil & Health Association of New Zealand — Established 1941

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The following public sector organisations have expressed their wish to support this document:

PAN ANZ

Safe Food Campaign

for the love of bees

WEGC
WAITAHA EXECUTIVE GRANDMOTHERS COUNCIL

Whitewater NZ
Mo te aroha o nga awa

MANU WAIATA RESTORATION & PROTECTION SOCIETY

CERTIFIED ORGANICFARMNZ

NZ FEDERATION OF FRESHWATER ANGLERS

ODPG ORGANIC DAIRY & PASTORAL GROUP INC

KATIKATI TAIAO

The following private sector organisations have expressed their wish to support this document:

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1. Introduction

Robust and fit for purpose policy, designed to protect human and environmental health, safeguard and steward freshwater quality for future generations, ought to address known scientific risks at the time of policy development. In degraded freshwater regions, *monitoring* to assess and estimate risk from synthetic organic chemicals should guide policy, risk assessment and control, and form the foundation of evidence-based policy, as *diffuse* emissions are major drivers of pollution. To manage we must measure.

Different industrial and agricultural regions produce different chemical signatures – different mixtures typical to the regions that result from industrial, agricultural and urban land use. Diffuse pollution is an international problem. It is especially important that scientists have national funding and direction to transparently identify *diffuse* synthetic organic chemical pollutants so that the politics of regions can be tempered, in the public interest.

The September release of proposed national freshwater standards contained no reference to synthetic chemical contaminants, indeed, the only mention of pesticides referred to stormwater runoff from cities (MfE, 2019a). Diffuse pollution is underreported and poorly regulated. Discussion of chemicals and trace metals have remained outside consultation for several years.

In Europe, where more progressive legislation is in place, the 'main anthropomorphic pressures on surface bodies are from diffuse sources, particularly from agriculture' (EEA, 2018). Continued ignorance of environmental chemicals mixtures has no scientific basis, in fact, 'understanding environmental consequences of chemical mixtures remains one of the most challenging issues in achieving sustainable environmental quality' (Gaw, et al., 2019). The OECD has noted 'Lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation' (OECD, 2017b, p. 107)

New Zealand can start monitoring for diffuse chemicals in a risk-based approach to monitoring *now*.

Cultural, political, legal and economic drivers create and shape the priorities that impact decision-making. The decision to monitor or not monitor synthetic chemicals in Aotearoa do not arise via a simple process, they are likely fundamentally political, rather than scientific. The processes by which science is harnessed, or left outside consideration are complex and difficult to untangle. This paper seeks to explore the issues that distort the process of understanding, assessing and controlling risk relating to chemical contaminants. It encompasses our weak application of the precautionary principle in chemical regulation; the requirement for a coordinated approach across agencies; our reluctant approach to banning toxic chemicals and the necessity to resource science around risk and chemical pollution if we are to appropriately inform and engage civil society. These issues are necessarily complex and interdisciplinary. Yet they are of the essence if Aotearoa is to ensure effective, accountable and transparent policies and regulations are in place that protect and restore freshwater environments in the public interest.

1.1 Global chemical acceleration

We are witnessing often irreversible tipping points in our freshwater environments, and civil society has asked their government to protect freshwater. Ecological systems are complex and non-linear, there are time lags between when a stressor first impacts the system and harm that is later observed. Small sub-lethal impacts such as alterations in fertility, development rate and predator evasion may resonate through ecosystems in unexpected and difficult to predict ways.

Biodiversity in Aotearoa, as with much of the world, is in dramatic decline. Indigenous fish, whitebait (īnanga), eels (tuna) and crayfish (kōura) are in decline or under threat (Allibone & et al, 2010; Dunn, et al., 2018; Goodman, et al., 2013). New Zealand has some of the highest levels of threatened freshwater species in the world. Almost three-quarters of New Zealand's thirty-nine native fish species are threatened with extinction (OECD, 2017a; Weeks, et al., 2015).

Chemical production is predicted to continue to increase exponentially, constituting a present and growing threat to human and environmental health, and risking the wellbeing of future generations. Diffuse pollution from agricultural chemicals and urban sources contaminate freshwater environments.

Six thousand chemicals constitute 99% of the total volume of chemicals. It is considered that 62% of these chemicals are hazardous to health (UNEP, 2019). Pollution from agricultural chemicals drives biodiversity loss, contributing to declining rates of insect species (DiBartolomeis, Kegley, Radford, & Klein, 2019). Continued declines are predicted to lead to widespread extinction (Sánchez-Bayo & Wyckhuys, 2019).

In order to transparently evaluate the drivers of ecosystem collapse, comprehensive chemical testing of freshwater and sediment is required. International science is very clear – it is not only nutrients, sediments and pathogens that stress our freshwater systems and damage our drinking water – it is environmental chemicals. However, in order to scientifically understand the toxicity revealed by testing, New Zealand's outdated hazardous substances regulations require a significant overhaul.

1.2 Diffuse Pollution

The OECD has stated that New Zealand's growth model is based largely on exploiting natural resources. New Zealand derives three-quarters of its export earnings (OECD, 2017a, p. 156) from high agricultural input occupations - agriculture, horticulture, viticulture, forestry, fishing as well as mining, an industry frequently associated with pollution and habitat loss.

A recent UN report advised 'Urgent action is needed to tackle chemical pollution as global production is set to double by 2030' (UNEP, 2019). Further the OECD is very clear that polluting externalities should not be ignored:

> 'Without effective policy instruments to reduce pollution, the cost of pollution typically falls on drinking water utilities (and subsequently households) and downstream water users, such as downstream industry and agricultural users, eco-tourism operators, recreational users, and waterfront property owners' (OECD, 2017b, p. 61).

Routine national monitoring for diffuse chemical contaminants in New Zealand freshwater that is publicly accessible, is confined to groundwater. While laudable, this is not sufficiently protective of public or environmental health.

The OECD has pointed to the problem of diffuse pollution remarking that:

> 'management of point-source pollution to freshwater bodies is commendable' … Diffuse sources of water pollution from agricultural and urban runoff, and their impacts on human and ecosystem health, remain underreported and under-regulated throughout OECD member countries' (OECD, 2017a, p. 158).

1.3 Eight years of the NPS-FW – chemicals outside consultation?

The draft National Policy Statement contains important objectives (MfE, 2019b). However, without national guidelines to step into monitoring a wide range of pollutants in degraded areas and imposing state or region level controls, in regards to achieving the objectives, National Environment Standards remain relatively toothless. After eight years, only three pollutants- 'the 'big three' pollutants characteristic of the dominant land use in New Zealand, pastoral agriculture' (Davies-Colley, 2013) have *bottom lines* - E. coli, nitrogen, phosphorous. Every other attribute (in the National Policy Statement Appendix 2A) is an indicator of ecosystem health that reflects pollution or degrading activities. There is no national policy process requiring that regions step into a suite of monitoring screens once indicators show harm is occurring.

A previous Parliamentary Commissioner for the Environment affirmed 'There are other pollutants in water, of course, including trace metals, toxic chemicals and pesticides. Much, but not all, is a legacy of past industry. But from a national perspective, the big three are pathogens, sediment, and nutrients' (PCE, 2012). The question is, where is the science, the paper trail of consultation, reviewing the data on freshwater and sediment that ensures that chemicals and trace metals can be 'left off the table' over an 8 year period?

Polluting synthetic chemical contaminants create intersecting social, cultural and economic harms. Ignorance around chemical contaminants - particularly from diffuse emissions - effectively ties one hand behind the back of civil society. New Zealand's chemical challenge is complex, and new chemicals continue to create unanticipated risks - 'too often, the chemicals substituted for problematic substances display unacceptable toxicity profiles' (Gaw, et al., 2019). Appropriate policy and legislative instrumentation are essential in order to guide implementation of effective and actionable controls to prohibit toxic exposures. Excluding chemical contaminants leaves Māori without appropriate scientific resourcing to assert rangitiratanga and kaitiakitanga.

Without such measures New Zealand will remain without the capacity to safeguard key tourist destinations and favourite Kiwi swimming areas; whitebaiting; drinking-water source quality; biodiversity and food chains; Māori customary fishing and traditional riverside food gathering; safeguard clean water for agriculture, food processing and organic systems; protect declining fish population; stock health; and to ensure export product is not inadvertently contaminated.

1.4 Monitoring, Control and Innovation

Nationally led, routine, comprehensive chemical monitoring to understand the chemical profiles (signatures) of river and lake water and sediments that serve as the nursery for the aquatic food chain can be initiated immediately. It is well known scientifically that chemicals and their toxic breakdown metabolites bind to sediments, - and that the dark environment slows down the breakdown process, facilitating more chemical accumulation.

New Zealand laboratories have tests, (or screens) available for separate chemical classes – so in most cases it is not necessary to test chemical contaminants one by one. New Zealand already has guidelines and 'bottom lines' for polluting chemicals such as ANZECC guidelines; Environmental Exposure Limits (EELs) and Tolerable Exposure Limits for humans (TELs). Chemicals will be captured in many established screens. These contain significant knowledge gaps as they are derived using predominantly industry data and the supporting data can be 20 or 30 years old, and they don't capture all chemicals - however they would be a practical starting point and could identify primary stressors.

Routine monitoring, to ensure regulation and control of EELs and TELs in freshwater and sediment, can be put in place in 2020. However, this does not scientifically address mixture effect and hormone level toxicity that contributes to health and environmental harm. The Resource Management Act requires that regional councils protect water quality, and the Health Act requires they protect drinking water.

What is instead required, is transparency; science harnessed across disciplines, and the latest analytics software engaged in pursuit of problem solving *for the public purpose*. The classic ideal of innovation is not going to solve the problems as effectively as it has done in the past, and the productivity of innovation is decreasing (Tainter J. , 2000; Tainter & Taylor, 2014).

A long term, international cross-disciplinary effort is required to monitor, undertake analytics to parse out system complexities, and integrate the latest in biological and hormonal science, to understand the nature of risk - whether to protect fish, frogs or eels - or source water for drinking supplies. With the data, the experts in chemical toxicology, endocrinology, epigenetics and immunotoxicity and the latest algorithmic and problem-solving software, New Zealand can step into deep knowledge in order to inform policy – in the public interest and serve future generations.

Suggestions for reform can be found in Part 10.

2. Pollution is Political: Informed governance

The OECD have acknowledged 'governments have struggled to implement policies that successfully reduces pollution from diffuse sources' noting there is 'no silver bullet or one-stop shop for effective diffuse water pollution management' (OECD, 2017b, p. 104).

A paper by Catherine Knight recently discussed two themes that thread through New Zealand freshwater management. The first is the 'ever-present tension between the need for environmental protection on the one hand, and the desire to protect the interests of industry on the other' and the second is the 'tendency for government to intervene only when serious damage has been done'. The author noted that the growing magnitude of diffuse discharges (non-source point) was unforeseen at time of introduction of the Resource Management Act – but that diffuse pollution represents a 'growing menace'. (Knight, 2019)

In discussing the potential for improvement of parliamentary scrutiny and long-term governance, authors Jonathan Boston, David Bagnall and Anna Barry counselled 'Safeguarding long-term interests, however, is not easy. There are strong political incentives in democratic systems for policy-makers to prioritise short-term interests over those of future generations. Powerful vested interests often hinder prudent economic or environmental stewardship. Governments must also grapple with deep uncertainty, policy complexity and multiple intra-generational and intergenerational trade-offs' (Boston, Bagnall, & Barry, 2019, p. 34).

Boston and colleagues have pointed to the disconnect between obligations in law to protect future generations. This includes disconnects within the Resource Management Act, HSNO Act and Local Government Act – and the lack of mechanisms to value existing assets to understand this.

Absence of data on chemical contamination also distorts the capacity to fulfil obligations to Māori. The concept of stewardship was introduced into New Zealand legislation via kaitiakitanga defined in the RMA as 'the exercise of guardianship by the tangata whenua of an area in accordance with tikanga Māori in relation to natural and physical resources; and includes the ethic of stewardship' (Boston, Bagnall, & Barry, 2019, p. 221). The State Sector Act appears to contain the only definition of 'stewardship' in New Zealand statute law as 'stewardship means active planning and management of medium- and long-term interests, along with associated advice' (p. 220).

The RMA makes it clear that decision-makers exercising statutory powers under the RMA are required to have 'particular regard' to kaitiakitanga and to the ethic of stewardship. In addition, the State Sector Act requires the head of a departments and agencies to exercise long term sustainability and appropriate stewardship of its assets. (pp. 220-222).

2.1 Economics for the environment

While economic growth dominates media in New Zealand, an increasing cohort of economists are drawing attention that the economy is situated inside world ecological systems (Raworth, 2017) and conventional closed loop economic systems 'based on undervalued exhaustible resources and unvalued pollution' (Martinez Alier, 2009). It is becoming increasingly evident that 'environmental and social sustainability and the equity dimension can no longer be separated' (Olsson & Gooch, 2019) (UN, 1987).

Chemical pollution exacerbates inequality (poorer people often live in more polluted environments); damages health and wellbeing; impacts food production and food safety; reduces community sustainability; reduces the supply of clean water available for agriculture and industry and this will be exacerbated in times of drought. The OECD has recognised that 'aquifers, lakes and reservoirs, especially those with low recharge rates and high residence times that limit their ability to absorb pollutants, are particularly vulnerable to pollution' (OECD, 2017a, p. 158).

The damage associated with soil erosion, salinization, pollution of water, loss of biodiversity has traditionally been undervalued and externalised (Weis, 2010). Mainstream economic approaches to valuing ecosystems are inadequate (Costanza, et al., 2017) and do not effectively address the combined social, cultural, ecological and economic benefits of the life-supporting capacity of freshwater systems. Costanza and colleagues have noted that decision-makers are obligated to take a 'pluralistic and precautionary approach to assessing these connections and to valuation of the benefits. There is not one right way to assess and value ecosystem services. There is however a wrong way, that is, not to do it at all' (Costanza, et al., 2017, p. 3).The cost of protecting natural resources is dwarfed by the greater costs of cleaning up environmental pollution and restoring degraded habitats and ecosystem services (Costanza, et al., 1997).

Conventional economic analyses tend to externalise pollution, making it difficult for civil society and policy-makers to appropriately value existing resources and the system level benefits of controls in place to sustain systems and prevent ecological collapse. Cost-benefit analyses used by regulators are misleading when long term pollution is excluded. New Zealand is disadvantaged as there is no legislation requiring maintenance of a national balance sheet to understand the value of clean freshwater, and the costs to future generations if systems as 'capital stocks' degrade further.

This further complicated by other political barriers, for example the combination of outdated pesticides legislation that cannot appropriately assess risk (Iorns, 2018) and the absence of an impartial external body outside the regulatory environment that might prompt revision. Similarly, the Resource Management Amendment Bill is in process, but, like the RMA, is silent on the issue of control of diffuse chemical pollution.

Redesign to respond to pollution creep might be better steered by other participants. The absence of 'provisions in legislation that require periodic reviews or independent evaluations of policy and regulatory frameworks' has been noted (Boston, Bagnall, & Barry, 2019, p. 142). This makes it difficult to negotiate for disruptive system level change, and easy for regulators and allied stakeholders to set the terms of reference when change is mooted, or suggest tacked on amendments rather than stronger revision.

New Zealand wetlands have been estimated to provide more than $5 billion in value per year. Agriculture's total value is $11.3 billion while recreational and commercial fishing is worth $4.2 billion (MfE & Stats NZ, 2019).

Forestry and logging have been valued at $5 billion per year and employs 20,000 people. In comparison, in 2018 tourism's value was $39.1 billion – international visitors spend $16.2 billion and domestic tourists spent $23 billion and over 210,000 people employed (Tourism New Zealand, 2019). Tourism increased 7.7%. Analysing the benefit from water based tourism activities is difficult, but valued at over $320 million, and this may be underestimated (Gluckman P. , 2017). The total size of the organic sector has increased by 30% between 2015 and 2017. Of this, exports increased by 42%. (OANZ, 2018) The 2018 Organic Market Report report drew attention to the hidden costs of food production, and the use of True Cost Accounting (TCA) to incorporate both costs and benefits to natural and social capital. TCA involves:

> 'identifying, categorising, quantifying, and putting a price on the range of costs and benefits arising from different production systems and developing various mechanisms through which we can ensure that in the future, polluters will pay and those that are producing healthy and

> sustainable food will be better rewarded financially than those whose food production systems are damaging the planet and undermining public health' (OANZ, 2018, pp. 71-72).

A TCA analysis could be usefully engaged to guide cost-benefit analyses of current forestry practices which use a conventional approach to herbicides. The profit (and job creation) from local forestry could be contrasted with the value of freshwater systems and groundwater to local citizens, tourism, local iwi, local anglers local school groups and future generations, that inhabit forestry regions. This might help shape future economic development.

As Sir Peter Gluckman has recommended, 'New ways of utilizing our land for economic gain that also have lower environmental footprints need to be found and adopted if we are to meet the vision New Zealanders have for their fresh waters' (Gluckman P. , 2017).

The New Zealand Biodiversity Strategy contains no controls to protect the freshwater food-chain from diffuse pollution and has been hampered by lack of mechanisms with which to measure progress. In 2015 New Zealand signed the 2030 Agenda for Sustainable Development. Unfortunately, the agenda is goal heavy and not control heavy – failure to protect freshwater and life below water can have adverse downstream impacts that distort the capacity to achieve the majority of goals.

The cost to future generations cannot be said to be impartially explored. When 'cost-benefit' analyses are undertaken, the industry stakeholders are resourced and motivated to supply details of the economic benefit, however the environment is not similarly equipped. Volunteers cannot compete. It has been a values-based decision to elect to privatise laboratories, but the barriers to testing implicitly benefit polluting industries.

Industry is a 'major source of negotiating power in the modern state' (Cozzens & Woodhouse, 2001). Industry will act to shape political priorities to prevent regulation and restriction of polluting activities (Ross, 2010) and influence risk assessment (Muilerman & Houkema, 2014). Adam Smith, writing in the 1700's, was concerned that the 'State would be captured by the merchant class and thus be subservient only to its interest' (Basu, 2016, pp. 10-11).

3. Freshwater: Chemical contaminants outside terms of reference.

New Zealand policy highlights management of consented discharges while avoiding reference to diffuse chemical emissions, presenting a distinct gap in New Zealand water governance. In contrast the European Environmental Agency (EEA) acknowledges diffuse pollution is a problem and that chemical mixtures form scientifically worrying pollution 'cocktails'. Of course, it is only through scientific monitoring that the chemical signatures may be parsed out:

> 'Nutrients from urban point sources, agricultural diffuse pollution, metals from stormwaters and atmospheric deposition, as well as many potentially harmful organic chemicals from urban waste-water and agriculture, have been shown to be present in freshwater systems simultaneously. Indeed, scientific monitoring approaches highlighted the co-occurrence of hundreds of chemicals in different freshwater bodies' (EEA, 2018, p. 17).

The EEA report went on to consider:

> 'Both point source (from a known discharge) and diffuse source (from multiple sources in an area) should be covered by emissions reporting' noting that 'as point sources become better controlled, the significance of diffuse sources is getting higher' (EEA, 2018, p. 28)

European science policy briefs note the 'cocktail' effect and that:

> 'Combined exposure to multiple chemicals can lead to unacceptable effects, even if single substances in the mixtures are below their individual safety thresholds' (JRC, 2018).

Terms such as 'chemical' or 'pesticide', and risk from chemical mixtures have lain outside the scope of consideration throughout the development of New Zealand freshwater policy.

The present freshwater consultation process is over 7 years old. A July 2014 Report and Recommendations (MfE, 2014) excluded any reference to chemical contaminants, as did the Section 32 Evaluation Report discussing the proposed amendments to the National Policy Statement for Freshwater Management 2014. (MfE, 2017a) This was an initiative set in place after heavy criticism from groups fronting the now disbanded Freshwater Rescue Plan. The 2017 response to criticism once more excluded any reference to chemical contaminants. Neither the February 2017 Clean Water paper (MfE, 2017b) setting out targets to 2040; nor a suite of August 2017 releases including the update to the National Policy Statement for Freshwater Management; (MfE, 2017c; MfE, 2017d; MfE, 2017e) nor the final public paper, dated September 2017 (MfE, 2017f) – considered chemical contaminants. Thus, as of September 2017, there was no existing terms of reference nor policy scope incorporating consideration of chemical contamination of New Zealand lakes and rivers in the National led government policy.

It may appear that the terms of reference – the decision to nominate the pollutants that would be considered - were established in 2012 or before. Over this time five Cabinet papers were drafted for review, covering governance, objective and limit setting and managing water quality and quantity limits. Briefs supplied to Cabinet included the papers Water Reform Paper Two: Objectives and Limit Setting (MfE, 2012a); and Water Reform Paper Three: Managing within Water Quality Limits (MfE, 2012b). However the papers, by an unknown principal author have not been released to the public.

On commencement of the sixth Labour government October 2017, consistent with the prior government, chemical contaminants remained outside any terms of reference. The major policy document *Essential Freshwater: Healthy Water, Fairly Allocated* establishing the work programme, the 'freshwater agenda for the next two years' did not discuss chemical contaminants. This includes associated documents in the Further Reading section in the Essential Freshwater paper (MPI and MfE, 2018) and an associated regional paper for setting swimmability targets. (MfE, 2018)

3.1 Ecologists advised by MfE officials to leave chemicals *outside the framework*

In personal communications with a Science and Technical Advisory Group (STAG) scientist, when probed the scientist mentioned that research on stormwater contaminants was recommended for future work, but in the current consultation on freshwater chemicals would be left out due to 'uncertainty' stating:

> 'EOCs were not considered in this round of reforms mainly because of uncertainties in the links (i.e., the dose-response relationships) between EOCs and ecosystem health attributes. These relationships have not yet been developed to the point where EOC thresholds can be accurately estimated at a national scale, covering waters of highly differing physico-chemistries and with differing biological communities. Personally, I hope that eventually there will be strong relationships established that would allow EOCs to be brought into an effects-based freshwater management framework.'

When further pressed the scientist explained that it was Ministry for Environment officials who steered the STAG working group that provided this advice, and as such the STAG group

> 'were comfortable with their recommendation on ECs, with the proviso that work should be done on them (in terms of stormwater discharges) urgently'….. This was based on our understanding of the current state of knowledge with respect to ecosystem health impacts. The STAG was not competent to discuss the issue from a human health perspective. There was agreement that emerging contaminants in general (EDCs amongst others) were important matters that need attention (as confirmed in recommendation 15). We were not "directed" by officials in this discussion, but accepted advice that these contaminants were best left out of the framework at this time.'

Chemical contaminants are variously referred to by different sectors and regions as 'contaminants of emerging concern' (CECs), emerging organic contaminants (EOCs), or 'emerging contaminants' (ECs) – the definition is a 'moving target' as new chemicals are identified. Meeting minutes of the STAG group reveal that they repeatedly drew attention to the data gaps for CECs in the New Zealand environment (MfE, 2019c). CECs include naturally occurring, manufactured or manmade chemicals or materials. They can include legacy chemicals, such as DDT; and historical pollutants such as arsenic and lead (which continue to pollute systems as components of industrial chemicals and fertilisers). 'True or really new' can include 'pesticides, pharmaceuticals and personal care products, fragrances, plasticizers, hormones, flame retardants, nanoparticles, perfluoroalkyl compounds, chlorinated paraffins, siloxanes, algal toxins, various trace elements including rare earths and radionuclides'. The definition can include chemicals previously considered innocuous, but for whom new evidence reveals the substance to represent a risk to human or environmental health (Sauvé & Desrosiers, 2014).

The advice proposed to the consulting ecologists is scientifically problematic:

a. It fails to address the scientific understanding that emerging contaminants when acting as endocrine disruptors will likely have no achievable endpoints or thresholds. This means no bands with readily definable thresholds within bands can be established (See Part 4). Tumor promoting carcinogens have similar issues (Neumann, 2009).
b. Many CECs already have guidelines. The ANZECC guidelines (ANZECC, 2000) are well known (Stewart, Northcott, Gaw, & Tremblay, 2016). New Zealand law requires that environmental exposure limits (EELs) for class 9 substances and tolerable exposure limits (TELs) for class 6 substances are in place to protect human and environmental health (ERMA, 2004; NZEPA, 2019a; PCO, 2001). EELs and TELs are set by the NZEPA which the Ministry for Environment administers.

c. It suggests that the MfE officials were advised in some way so that they could guide the ecologists, yet expert toxicologists and environmental chemists appear left outside the consultation process.
d. Screening for diffuse pollutants is a critical in order to accurately identify contaminant chemicals (EEA, 2018; OECD, 2017b). (See Part 10.5)

3.2 Chemical toxicology left outside the consultation process

Restricting consideration to a selected number of pollutant attributes is inadequate to build a profile of system stressors, this may be a legacy of historic political decision-making. It is no doubt that controls on nutrients, bacteria and sediment will *improve* freshwater quality, but scientifically, there can be no claim that the life-supporting capacity of freshwater can be safeguarded. The knowledge gap may reflect political decisions in the 1980's to adopt privatised models of operation for publicly owned laboratories. The downstream effect has inevitably discouraged freshwater testing for chemical contaminants. The consequent costs to regional organisations become a barrier to testing, as chemical screens are financially onerous for already strained budgets.

The groups advising the current Freshwater Taskforce do not appear to include experts on chemical contaminants, such as chemical toxicologists, endocrinologists or environmental chemists (MfE, 2019c). Experts in chemical toxicology and related disciplines that might draw attention to this issue have not been invited to participate. The officials advised the ecologists engaged in the process, yet the officials do not appear to have engaged with authoritative sources, there appears to be no 'paper trail' that underpins this advice (see section 8.1 Mandatory Relevant Considerations).

An Official Information Act (OIA) request (19-D-01891) was undertaken to clarify the name of the person/people who provided the scientific advice to the STAG group: that it would not be necessary to include chemical contaminants in the NES Freshwater consultation process. The OIA request then asked for the internal documents to support this advice. This was unsuccessful and details of official staff, and possible documents, have not been supplied.

(An OIA request to understand if the earlier unnamed author who drafted the 2012 papers for Cabinet, conducted a comprehensive scientific analysis of chemical contaminants (CECs, pesticides, trace metals) in order appropriately advise Cabinet has been undertaken.)

Innovative work to understand risk from diffuse chemical pollution in New Zealand is happening outside the political and regulatory arena. There is a cohort of scientists who seek to draw attention to the toxicity of increasing chemical pressures, and the urgency of overhauling the single chemical risk assessment approach (Gaw, et al., 2019). The study of CECs in the New Zealand environment is limited, perhaps reflecting funding opportunities. Cawthron Institute are currently undertaking a five-year study, but the locations for screening are limited to the Whau River (Auckland) and the Mataura River (Southland). Previous research has been undertaken in Hawkes Bay the Waikato and Rotorua (Stewart, Northcott, Gaw, & Tremblay, 2016).

Louis Tremblay, who is presently overseeing the Cawthron Institute study, was not invited to provide expertise regarding synthetic organic chemicals in the freshwater consultation process. Neither was Chris Nokes' team at ESR who have considerable experience screening for pesticides in the New Zealand environment. Other scientists not invited to provide expertise relating to chemical contaminants include environmental chemist Nick Kim who has substantial experience in trace metals; ecotoxicologist Chris Hickey; toxicologist Ian Shaw, environmental chemist Sally Gaw and Christoph Matthaei. New Zealand has very few scientists with comparable expertise to this cohort.

(OIA Act requests to the Ministry for Environment to understand the origin of the advice supplied to the STAG group by the senior MfR officials involved in the process, has been extended to October 17, 2019).

3.3 Uncertainty and Doubt

The response to exclude CEC/EOCs due to 'lack of certainty' mimics many familiar case studies relating to protection of human and environmental health, such as action on climate change, tobacco and sugar where uncertainty has been actively manufactured in order to delay policy and regulation (Dunlap & McCright, 2011). The approach recommended by MfE officials disregards chemical contaminants that already have guidelines and that could be integrated in established monitoring operations such as those undertaken by NIWA. The NZEPA reports to the MfE and the MfE has power to direct the NZEPA on policy. Absent of data, continued non-knowledge will more effectively privilege polluting industries.

Further, there is the problem that 'ecological risk assessment seldom performs any chronic exposure test at all' (Buonsante, Muilerman, Santos, Robinson, & Tweedale, 2014). This is due to historic convention. This paper draws attention to the problem of endocrine disruption, particularly as it relates to the thyroid. Humans, frogs, eels and fish – all vertebrates - are vulnerable to chemicals that can damage thyroid function at parts per billion and parts per trillion – the thyroid hormone for all these species has exactly the same chemical structure. Thyroid researcher Jacques Legrand is reported to have said

> 'Without a minimum of thyroid hormone at the right time, a tadpole fails to become a frog and a human baby becomes a cretin' (Demeneix, 2017, p. 30).

Ignorance can emerge as a result of rules, procedures and protocols that limit scrutiny of a given environment, or permit cherry-picking of data by key actors. Ignorance can be driven by an absence of funding, or funding that privileges certain types of research (for example to identify a pathway suitable for medication) while restricting other types of research (for example, interdisciplinary work to identify multiple modes of action resulting from exposure to a chemical mixture). Social scientists have noted that political and economic priorities can actively work to produce non-knowledge. Specific actors can then 'use differing paradigms of non-knowledge in strategic and flexible ways toward advancing their own interests' (Kleinmann & Suryanarayanan, 2012).

3.4 Sediment

While there is no doubt that nutrients and pathogenic bacterial loads represent significant public and environmental health issues, the political dialogue around sediment deserves scrutiny. Chemicals, their breakdown metabolites and toxic trace metals lodge, or bind to sediment.

Historically, sediment was simply dirt– an inorganic particle resulting from the breakdown of rocks. The Resource Management Act was historically minimally concerned with sedimentation, perhaps, due to the fact that when the RMA was established, chemical agriculture was not intensive as it is now. A long-recognised problem with sediment, is that chemicals, their metabolites and trace metals bind to sediment, and in the darker environment, degrade more slowly and can remain for long periods and accumulate (Boyd, 2010; Burton, 2002). The guidelines for Drinking-water Quality Management in New Zealand clearly illustrate that many chemicals degrade more slowly when in sediment or soil (MoH, 2018).

Chemical and trace metal contamination of sediment may constitute a fundamental factor rendering habitats inhospitable for ecological communities, and a limiting driver in habitat restoration, yet this remains out of the scope of consideration (Varanasi & Stein, 1991; Veljanoska-Sarafiloska, Jordanoski, & Stafilov, 2013).

If 'sediment' as an inorganic particle resulting from the breakdown of rocks is retained at front of mind, the inclination of stakeholders to highlight sediment rather than contamination issues (LAWF, 2018) may reflect industry-related stakeholder priorities rather than address risk from pollution arising from intensive chemical use in the forestry, horticulture, pastural and the arable sectors, and the chemical contaminants accumulating in New Zealand sediments. Fine sediment represents a distinct threat to the integrity of aquatic environments, but there is evidence this threat is reduced in organic or low-input agricultural systems (Magbanua, Townsend, Hageman, & Matthaei, 2013).

New Zealand's degraded and dysbiotic lakes have not been tested to understand if chemicals trapped in lake sediment render ecosystems inhabitable.

The challenge of course, is providing resourcing for scientists and analysts to undertake the monitoring and evaluation of results to inform policy, and to publish the data for public consultation. NIWA scientists have confirmed that water quality downstream from agricultural and urban sources tends to be poorer, and that these effects result from legacy effects (from long term agricultural input use), continued agricultural intensification and urban growth. New Zealand testing has been restricted to the variables most frequently used in river monitoring programmes: water clarity, ammoniacal-nitrogen, nitrate-nitrogen, total nitrogen, dissolved reactive phosphorous, Escherichia coli (E. coli), and the macroinvertebrate index (Larned, Snelder, Unwin, & McBride, 2016).

At a recent Environmental Defence Society conference, a Watercare manager lamented that the public didn't understand the toxic nature of urban waste. At a September 2019 regional freshwater hui in Tauranga, when asked why trace metals weren't included as attributes a Ministry for the Environment official explained to the attendees that so many trace metals came from road use and tyres and this could not be stopped, therefore there was no point creating attributes to require monitoring for trace metals in freshwater. Another staffer insisted that 'you can't monitor everything'. No, - but existing chemical screens and European guidelines can guide science so this can then inform policy.

Transparency can guide scientific knowledge, but also improve accountability. Improvements in land use management, or greater responsibility and caution to limit what is poured down urban sinks and toilets may have little long-term effect if the polluting chemical contaminants aren't monitored, identified and communicated back to the upstream polluter, and, if necessary, regulatory controls put in place to limit future pollution.

In Europe it is recognised that it is:

> ‘widely accepted that there is a need for an early warning system able to play the role of the “watchdog”. Such a system should anticipate the risks associated with the dynamic change in the use of chemicals so as to prevent the environmental impact of chemical substances before they become “contaminants of emerging concern”. In other words, our ultimate objective should be to advance our knowledge and environmental monitoring abilities to the point, where the need for the term “emerging” disappears altogether’ (Dulio, et al., 2018).

4. What’s with Endocrine Disruption?

Synthetic organic chemicals can interfere with the hormone system. This can lead to disease and damage biological and neurological function. These chemicals are known as hormone hackers or endocrine disruptors (EDCs). Some contaminants in the environment may not be necessarily captured by the ‘CEC’ term. Trace metals can act as EDCs and impair hormone function and damage ecological function (Boyd, 2010; Rana, 2014).

Chemicals can interfere with hormone system functioning at staggeringly lower concentrations - at parts per billion and parts per trillion. Science knowledge regarding EDCs has undergone ‘a remarkable evolution’ and nearly 1000 chemicals have been reported to have endocrine effects. Studies undertaken to determine the EDC loads have detected ‘EDCs in every individual tested and in ecosystems at the far corners of the Earth’ (Schug, et al., 2016). Endocrinologist Leo Trasande has claimed that ‘Endocrine-disrupting substances are the second greatest environmental challenge of our time’ (Trasande, 2019, p. 163).

Scientific consensus on EDCs was arrived at in 2016 at a scientific meeting, and the expert scientific group that arrived at the consensus included epidemiologists, endocrinologists and toxicologists (Solecki , et al., 2017). Science cautions that the human foetus is particularly vulnerable to harm from endocrine disruption, and harm occurring in infancy and childhood may not be evident until years later – this is recognised as the developmental origins of disease. Endocrine disruptors can impact IQ, fertility, and set the stage for chronic disease risk including cancer (Demeneix, 2017; Gore, et al., 2015). New Zealand and Australia have the worst incidence of cancer in the world (Bray, et al., 2018). New Zealand has particularly high levels of prostate, breast and bowel cancer; and chemicals that imitate and disrupt hormones and/or alter gene function can drive cancer.

The human health cost of endocrine disruptors to contribute to disease and neurodevelopmental impairment is significant (Attina, et al., 2016) and responses to chemical can be sex dependent, further complicating matters (Lozano, et al., 2018).

Trace metals are endocrine disruptors and can impact foetal development (Bonmarito, Martin, & Fry, 2017) (Hill, 2019). Cadmium is a common contaminant ingredient in fertiliser and pesticides. Scientific research is demonstrating that the trace metal cadmium can lower methylation and it can be sex specific (Kippler, Engström, Jurković Mlakar, & Bottai, 2013). Of concern to policymakers and human health specialists is that women are more vulnerable to cadmium exposure as they have higher absorption, particularly throughout pregnancy (Dharmadasa, Kim, & Thunders, 2017).

4.1 Risky at hormone hacking levels: Non-linear dose response

A key characteristic of natural hormone responses and endocrine disrupting action is that responses display non-monotonic dose response curves (Demeneix & Slama, 2019).

Studies testing the dose-response EDC exposures frequently describe a biological response that does not resemble the Paracelsian standard dose-response curve. At slightly higher concentrations, no harm may occur, however at much lower, delicate levels (not tested for in regulatory toxicology) harm can occur. The chemical is more potent at a lower dose. Rigorous scientific studies demonstrate that the dose does not necessarily make the poison, and scientists consider non-linearity should be incorporated in chemical risk assessment and regulation.

Drugs such as tamoxifen are developed to work at the hormone level and the potential for a non-linear response is accepted scientifically in medicine (Hass, Christiansen, Andersson, Holbech, & Bjerregaard; Vandenberg, et al., 2013). In many cases drugs are carefully designed and monitored to ensure adverse endocrine disrupting effects do not arise or that they arise beneficially for the patient.

4.2 Intergenerational risk: Epigenetic function and disease risk

The potential for risk aggregates as the potential for a chemical contaminant to promote intergenerational toxicology via future generations via epigenetic processes is recognised. The gene is not damaged, rather the epigenetic 'molecular factors and processes around DNA that regulate genome activity (e.g. gene expression)' (Nilsson, Sadler-Riggleman, & Skinner, 2018) may be altered from direct exposure in a parent generation. While negligible risk may be observed from direct exposure to the parent, disease or pathologies may arise in children, grandchildren or great grandchildren or via epigenetic transgenerational inheritance via germline epimutations (for example via sperm). The diseases are frequently associated with the hormone system, for example increased risk has been observed for prostate disease, obesity, kidney disease, ovarian disease, and parturition (birth) abnormalities (Kubsad, et al., 2019). The ethical issues that arise from intergenerational exposures are substantial (Lamoureaux, 2016).

4.3 The example of thyroid hormone action – from humans to fish and eels

In order to illustrate how this may apply to human and ecological health, the vulnerability of the thyroid hormone provides a useful starting point. Thyroid hormone is required by the developing foetus, baby and child for the 'harmonious development of all organs, bone, muscle, intestine, and skin, but above all, the brain' (Demeneix, 2017, p. 34).

Scientists consider 'thyroid hormone action to be the target of more chemicals than any other endocrine system' (p. 7) - many common synthetic chemicals interfere with the ability of thyroid glands to capture iodine and produce the thyroid hormone. The chemical structure of the thyroid hormone is composed of phenyl rings. Endocrinologist Barbara Demeneix has pointed to the fact that 'chemists have always found the phenyl ring to be an extremely versatile base for synthesising new substances, particularly with other halogens such as bromine, fluorine, and chlorine, instead of iodine. Many halogenated substances look like thyroid hormone' (p. 50).

As a final complication, the scientific evidence is pointing to the potential for replacement chemicals in the same class or grouping, to be similarly harmful, a phenomenon referred to as 'regrettable substitution' (Demeneix & Slama, 2019, p. 89). As the endocrine disrupting potential of bisphenol A has become apparent, organisations have responded and produced 'BPA free' products. However, the chemical substitutes were chemically similar, and the replacements have frequently exerted similar hormone damaging potential. (Howard, 2018)

Research on EDCs is not dominated by a single field of expertise, rather it is an interdisciplinary approach. A recent review (Schug, et al., 2016) noted that collaborative multidisciplinary environments continue to drive knowledge.

5. Weak regulatory landscape – at regional and state level

5.1 Knowledge Gaps

Knowledge gaps exist across the chemical regulation sphere. Many normative protocols and procedures that create a safer and more transparent environment in Europe, for example: (E.C., 2019a) are not in place in New Zealand.

Requirement for public registry of tonnages of chemicals sold has been disbanded; there is no national screening program for chemicals in freshwater nor for source water for drinking water; ubiquitous chemicals such as glyphosate are not routinely monitored; many chemicals banned in Europe remain authorised for use. There is no capacity to assess the cumulative toxicity of mixtures; environmental limits set by the NZEPA are not incorporated into national standards requirements; and regional council monitoring is inconsistent and mediated by political and economic will.

New Zealand ceased requiring public disclosure of tonnes of pesticides sold despite increasing sales volumes which enhance environmental pressures. From 2010 to 2014 (when data was last supplied) the value of pesticide sales in New Zealand increased from USD161,427,300 to USD204,812,900, a jump of 27%. The most recent entry in the Food and Agriculture Organization FAOSTAT pesticides database advised that in 2008, of the 5,857 tonnes of active ingredients of pesticides sold New Zealand, well over half, 3,761 of these tonnes, were sold as herbicides. There is no data after 2008. (FAO, 2019)

Pesticides are present in the New Zealand freshwater environment but council testing to evaluate pressures on a national scale is hampered by lack of political will and funding. Public funding for screening freshwater for environmental chemicals is sporadic and tends be restricted to target areas, for example a stream outlet or a marine bay. Part of the problem may stem from the fact that regional councils must pay for testing through our publicly owned laboratories which operate as a privatised business-model. Industry stakeholders are active participants of the regional council policy process, and there is much evidence to support the political unpalatability of testing for industrial chemicals.

However, an important paper by University of Otago researchers Kimberly Hageman and Christoph Matthaei and colleagues was recently released. The authors collated pesticides data from 36 streams, the largest study undertaken to date in New Zealand (Hageman, et al., 2019). The chemical chlorpyrifos, which will be banned in Europe from 2020 was the most commonly detected pesticide. Toxic insecticidal neonicotinoids clothianidin and thiamethoxam which are banned in Europe were detected.

The paper also noted that nutrient data does not correlate with a streams' chemical load - 'nutrient concentrations cannot be used as a proxy for expected pesticide concentrations in the sampled streams' (Hageman, et al., 2019) – emerging organic contaminants and especially pesticides, require their own suite of tests.

Most of the sites sampled contained two or more pesticides, while at 40% of the sites, four or more pesticides were detected, reflecting the growing international concern that toxic chemical cocktails may be more dangerous than the linear approach of regulatory risk assessment (Hageman, et al., 2019).

Figure 1 NZEPA Symposium 2019

The same researchers had earlier undertaken research to assess the interplay of fine sediment exposure and pesticide stress. The research indicated that glyphosate, while harmful, was less adversely impactful to invertebrates than fine sediment. (Magbanua, Townsend, Hageman, & Matthaei, 2013) However this study was short term, and may not have addressed long-term chronic sub-lethal exposures from the mixture effects, as the study, though illuminating, restricted consideration to a single chemical stressor. In light of their 2019 finding, more resourcing to support data collection and analytics to address the chemical complexity may be appropriate.

The section above outlined the risk from endocrine disruption. Data regarding EDC may be supplied by applicants but is not a requirement in authorisation. The NZEPA has not published documents outlining the risks of EDC, indeed a recent tweet from a Symposium to NZEPA and government staff suggested that knowledge is limited. The EPA does not have a mandate to explore non-linear dose response. There has been little public consultation regarding the endocrine disrupting properties of many toxic chemicals and environmental health risk from sub-lethal exposures, which may weaken intergenerational aquatic populations. At this stage neither legislation nor policy includes requires toxicity from mixture effects or endocrine-related non-linear dose response effects to be assessed. (PCO, 2001)

5.2 Ubiquitous Chemicals – No data – but what is the ecosystem impact?

New Zealand lacks sufficient regulatory triggers to flag risk from chemical mixtures (and additive adjuvants such as organosilicons) in freshwater and sediment. This makes it difficult to assess baseline exposures to aquatic ecological communities and claim whether current exposures are safe, or not safe.

The New Zealand forestry industry also uses glyphosate to prepare regions before planting, and terbuthylazine and hexazinone for post plant control, and these three 'herbicides comprise 90% of the estimated 447 tonnes of *active ingredient* that is annually used' by the forestry sector (Rolando, 2013). The Department of Conservation use herbicides mixtures to control invasive weeds in national parks. OIA requests confirm the Auckland region of the New Zealand Transit Agency purchased 4000 litres of glyphosate in the last financial year. However, the active ingredient is frequently less than half of the total chemical formulation. Glyphosate 360 is a formulation made up of 36% glyphosate (Mesnage, Defarge, de Vendômois, & Séralini, 2014).

The dominant brand Roundup contains adjuvants which include trace metals and petroleum distillates (Defarge, de Vendômois, & Séralini, 2018), and only 41-42% constitutes the glyphosate salt (Monsanto, 2015). Organosilicon surfactants such as Boost Penetrant are commonly tank-mixed with herbicides to increase efficacy and are released into the New Zealand environment in significant quantities. Organosilicon surfactants are acutely toxic (Chen, Fine, & Mullin, 2018) but are neither assessed for toxicity nor screened in New Zealand aquatic environments. Scientists consider the current safety standards for glyphosate-based herbicides are outdated. (Vandenberg, et al., 2017)

Globally, glyphosate use has increased 15-fold since genetically engineered crops were introduced, and two-thirds of the total volume in the U.S. has been applied in the last 10 years (Benbrook C. , 2016).

The forestry chemical hexazinone is a local groundwater pollutant that has been banned in Europe. Hexazinone and terbuthylazine are increasingly detected in New Zealand groundwaters (Close & Humphries, 2014; Close & Humphries, 2019). Terbuthylazine is an endocrine disruptor and toxic to aquatic organisms, it may be a common sediment contaminant in freshwater areas near forestry regions due to its propensity for binding, and may pose a challenge to drinking water suppliers as conventional treatments do not strip out the chemicals (Tasca, Puccini, & Fletcher, 2018).

Similarly, there are no public records of annual tonnages applied to the New Zealand landscape of the controversial substance sodium fluorocitrate, and testing screens are not formally published. The 2018 Guidelines for Drinking Water notes that five hundred samples have been taken in the target area over the last five years (MoH, 2018). An NZEPA report advised that post-operational monitoring was carried out for 19 operations in 2017 and no samples exceeded the tolerable exposure limit of 0.0035mg (NZEPA, 2017). The degradation rate for sodium fluorocitrate is dependent on water temperature and soil biological activity. In dry cold conditions the DT50 value can be 43 days (Northcott, Jensen, Ying, & Fisher, 2014).

The cost of screening in soil (sediment) and water constitutes a high barrier for the public sector (Hills Laboratories, 2019). In order to enhance public trust in the operations where hazardous substances are emitted into the environment and in order to provide more scientific transparency, tonnages of these chemicals should be recorded, and diffuse monitoring undertaken throughout the New Zealand landscape and transparently recorded as public information, as is done in Europe.

There appears to be no national approach to monitoring nor enforcement of environmental exposure limits (EELs). Yet the NZS 8409: 2004 Management of Agrichemicals Code of Practice (ERMA, 2004) (Edict of Government) is very clear that environmental exposure limits must not be exceeded (sections G1, G6, N3, S2, S3) and that it is an offence to exceed these limits. The code of practice states:

> 'Once a TEL has been set, then by law, no person or place where a person may be, shall be exposed to a level of the substance that exceeds the TEL….. Similarly a person must not use a Class 9 (ecotoxic) substance in a manner that allows the EEL set for that substance to be exceeded in the environmental medium concerned (water soil or sediment). Exceeding a TEL or

an EEL is illegal, regardless of whether any adverse effect actually arises. TELs and EELs apply to any area that is not defined as the target.'

Further, there are omissions. For example, chlorpyrifos, atrazine, diazinon, and 2-4-D were commonly detected in the first wide-ranging study of pesticides in New Zealand streams. Yet none of these commonly used and applied pesticides are included in the New Zealand Environmental Protection Authority excel datasheet. It's not as if these chemicals are not toxic. Atrazine and diazinon are not approved in Europe (E.C., 2019b) and the chlorpyrifos approval will not be renewed as chlorpyrifos produces possible genotoxic effects and is a neurodevelopmental toxicant (EFSA, 2019). The International Agency for Cancer has determined that 2,4-D is possibly carcinogenic to humans (IARC, 2015).

A wide range of chemicals banned in Europe remain available locally. New Zealand has a 'Priority Chemicals List' that the NZEPA 'believe are most of in need of review' (NZEPA, 2019b). We lag in decision-making, nineteen out of thirty-five are not approved for use in the European Union. Ubiquity in the environment and evidence of risk published in the international scientific literature are not guiding parameters for a chemical being added to the list.

The ability of European regulators to proactively ban toxic chemicals may stem from the European precautionary understanding that there can be no safe level of exposure to for example, a cancer-causing agent. Therefore:

> 'EU pesticide regulation is hazard-based (and not risk-based) for carcinogenicity, reproductive/developmental toxicity, neurotoxicity and endocrine effects' (Székács & Darvas, 2018).

5.3 Regulatory Capture?

> 'Under the RMA, central government can direct regional councils through: i) National Policy Statements; (ii) National Environment Standards; (iii) regulations; and Water Conservation Orders' (OECD, 2017a, p. 165). The Environmental Protection Authority reports to the Ministry for the Environment (MfE), and the MfE 'may direct the EPA to give effect to a government policy that relates to the entity's functions and objectives' (PCO, 2004).

The MfE monitors the NZ EPA and:

> 'is the Government's principal advisor on environmental policy and legislation' (NZEPA, 2019c).

Despite interlocking mechanisms in law there is poor oversight of New Zealand's regulatory environment; and an apparent cultural and political reluctance to address new knowledge around risk. The gaps have the result, despite New Zealand being signatories to various international conventions, in there being no effectively coordinated regulatory mechanisms to prevent chemical contamination, nor address mixture risk to control and prevent the harm exerted by permitted chemical/s on local biological systems including fish, frogs, eels and humans, at hormonally relevant levels.

MfE is well aware of the NZEPA's statutory obligations. A science-based approach might include monitoring for contaminants that already have established environmental exposure limits (EELs) and tolerable exposure limits (TELs) for human health. The NZEPA prima facie appears outside the consultation process despite its functions including a requirement 'to provide technical advice to the Minister on the development of a national environmental standard' (PCO, 1991, p. Sn. 42C(da)). The MfE does not appear to have considered the opportunity to embed monitoring of already established guidelines or limits into a national standards approach as the OECD recommends.

The NZEPA oversees an outdated risk assessment process, which includes not just the HSNO Act but the protocols and guidelines utilised by decision-makers. Three dominant factors may perpetuate this – (1) the fact that industry selects and supplies the data and regulatory conventions keep the data secret from civil society; (2) the understanding that New Zealand has adopted a weak version of the precautionary principle; and the (3) fact that regulators do not conduct impartial literature reviews of the published science to keep abreast of new scientific knowledge.

5.3.1 Chemical industry control of data

Firstly, the data is predominantly selected and supplied by the chemical companies that seek authorisation and reassessment (NZEPA, 2018). This is a function of international regulatory convention (Clausing, Robinson, & Burtscher-Schaden, 2018). Because industry is in the position of selecting the toxicological studies, studies showing the formulation is potentially harmful are unlikely to be supplied (Mesnage & Antoniou, 2018). Regulators select preferentially GLP studies over published and publicly available data despite the inadequacies of GLP. Published non-GLP studies receive less weighting (Portier, et al., 2016).

A commentary by 94 scientists stated:

> 'we strongly disagree that data from studies published in the peer-reviewed literature should automatically receive less weight than guideline studies. Compliance with guidelines and Good Laboratory Practice does not guarantee validity and relevance of the study design, statistical rigour and attention to sources of bias' (Buonsante, Muilerman, Santos, Robinson, & Tweedale, 2014; Myers, et al., 2009; Portier, et al., 2016).

Good laboratory Practice is increasingly understood by endocrinologists as inadequate for detecting endocrine disrupting substances – it is merely a laboratory documentation process designed to prevent fraud– it will not necessarily assure sensitive results are reported (Trasande, et al., 2016).

As GLP studies are privileged due to regulatory weighting there has been no pressure for industry studies to be published in the scientific literature where they might be scrutinised. Commercial confidentiality agreements with regulators have create further barriers to scrutiny outside the regulatory environment. Industry and regulatory reliance on the insensitive Good Laboratory Practice (GLP) criterion is a shortcut to consideration as an authoritative study suitable for consideration. The foundation of science validity is that it must be able to be reproduced and replicable.

5.3.2 Keeping abreast of new knowledge

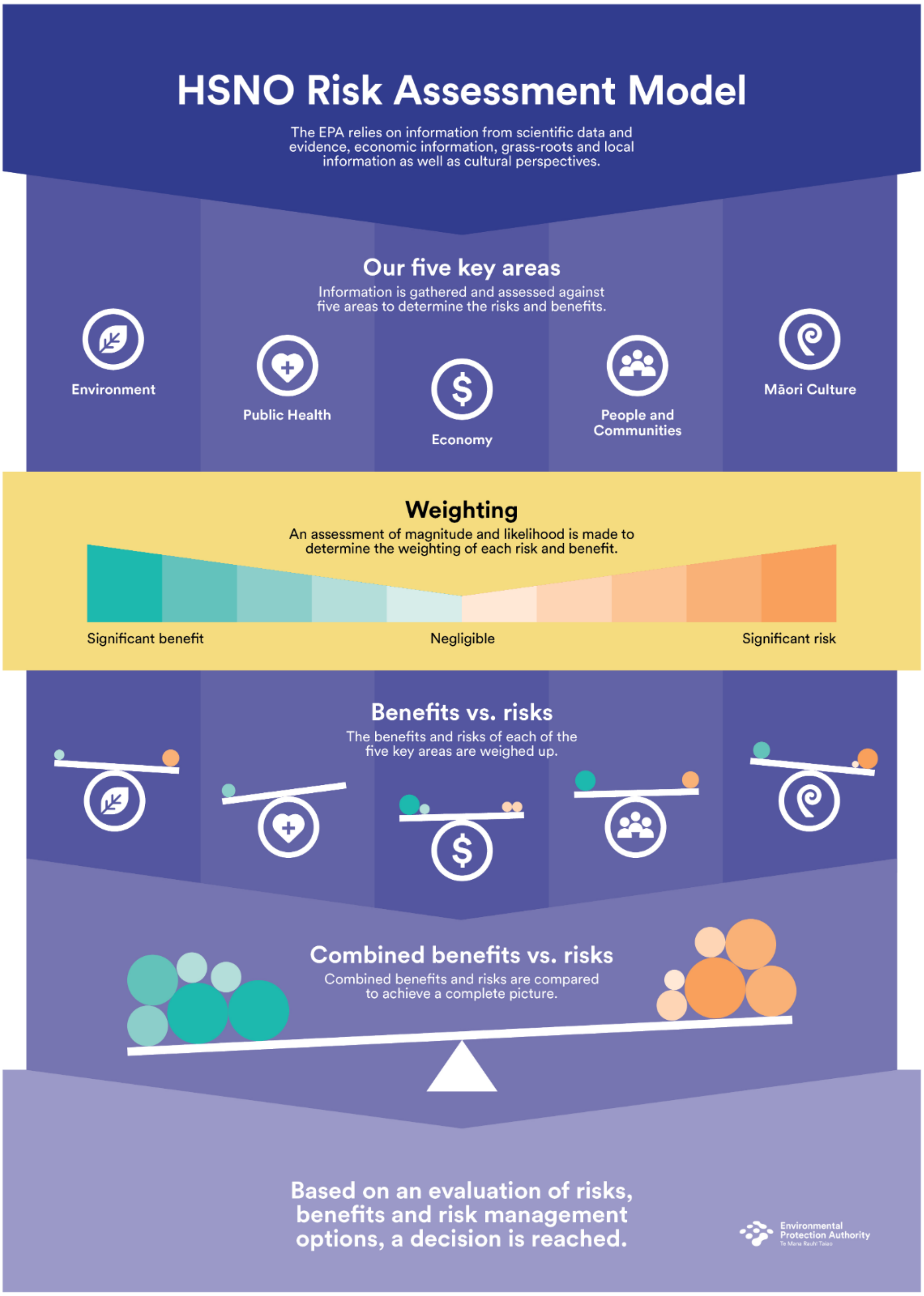
Science is very clear that harm can result from exposure to toxic synergies of combinatory mixtures (Singh, Gupta, Kumar, & Sharma, 2017); delicate low dose (hormone-level) toxicity (discussed previously); and the fact that long-term chronic emissions 'back-up' and accumulate beyond the capacity of surrounding environments to assimilate and degrade the chemicals. (Kubiszewski, Constanza, Anderson, & Sutton, 2017; Steffen, et al., 2015; UNEP, 2019).

In addition to the key issues, the emerging challenge posed from evidence that chemical exposures in the parent generation can adversely change gene function in subsequent generations, referred to as transgenerational epigenetic inheritance, should be considered a new constituent of risk. (Nilsson, Sadler-Riggleman, & Skinner, 2018) Epigenetic alterations frequently occur via endocrine pathways. (Zhang & Ho, 2011). Epigenetic inheritance is a game changer, a moral quandary, as the dose of a toxic chemical in the parent generation creates the environment for increased disease and dysfunction in future generations, without exposing those future generations to the toxin (Lamoureaux, 2016). If government policy is to protect the health of future generations, the implications of epigenetics must be considered in policy-making.

Opportunities for there for the NZEPA to undertake policy work to address formulation toxicity chemical mixtures (Kortenkamp & Faust, 2018); endocrine disruption (Lee, 2018; Trasande, et al., 2016); dose-response (Zoeller & Vandenberg, 2015). Policy revision may take into account the fact that common herbicides accelerate antibiotic resistance (Kurenbach, et al., 2017) and that problematic conventions privilege industry data. These issues have been left off the table in recent consultations. This includes consultation for 'Risk Assessment Methodology for Hazardous Substances' draft released for public consultation (NZEPA, 2018) and October 2019 consultation 'to improve decision-making'.

In New Zealand, exciting and innovative work in chemical toxicology is happening outside the regulatory sphere. A recent paper noted the exponential rise in chemical discovery and synthesis exceeds the capacity to determine the toxicity of compounds via conventional methods. This has resulted in chemicals entering 'global circulation without a thorough understanding of their potential toxic impacts'. Innovative risk assessment approaches are necessary and a 'higher throughput approach' is required in order to adequately identify and examine the multiple and stressors and mixtures. This is because:

> 'Unfortunately, conventional toxicity testing provides too narrow a funnel (in terms of time, cost, and ultimately, throughput) to assess the risk of the vast number of new compounds designed daily by chemical, pharmaceutical, and agricultural industries' (Gaw, et al., 2019).



This new NZ EPA chart is attractive – but quality of studies supplied in risk assessment, the state of science regarding low-dose and mixture risk, and who selected and supplied the studies – are not discussed.

The knowledge gaps underlie a growing body of scientific evidence demonstrating that many chemicals and their more toxic formulations are toxic at much lower levels than is determined via conventional regulatory risk assessment. (Kortenkamp A., 2014; Želježić, et al., 2018; Lee, 2018).

Regulatory inaction, or more appropriately, local action to retain regulatory approvals of glyphosate-based herbicides serve as a case study. After the IARC released a monograph demonstrating that glyphosate and its formulations probably caused cancer (IARC, 2015), the NZEPA engaged a single toxicologist to refute the findings of the IARC (the international gold standard in cancer and NZEPA's own authority on cancer), by way of a carcinogenicity review (Temple, 2016). This review was criticised by New Zealand public health scientists. The group included a scientist who had contributed to the original IARC monograph (Douwes, et al., 2018). The authors questioned the fact that the NZEPA depended on data and analysis obtained from the flawed European risk assessment process (Clausing, Robinson, & Burtscher-Schaden, 2018; Portier, et al., 2016). This resulted in both NZEPA and EFSA relying 'heavily on non-peer reviewed industry-funded studies that are not publicly available' (Douwes, et al., 2018, p. 85). Similar criticisms have been levied on the USA process (Benbrook C. , 2019).

While many people believe glyphosate has been risk assessed in New Zealand, it has never undergone formal assessment or reassessment. Limited assessment has been by way of the Temple cancer review which excluded formulation toxicity data. Important health parameters including neurotoxicity, reproductive and developmental toxicity and microbiome and endocrinological toxicity have never been explored in formal risk assessment in New Zealand. Lack of formal assessment may be due to the expense of engaging staff in the process, or entail political pragmatism, but it leaves civil society vulnerable to weak regulatory oversight.

It is noteworthy that where authoritative sources are used to inform the NZEPA, they by convention are retained to other regulatory environments which also base toxicological assessments around unpublished industry supplied data. This includes the Food and Agricultural Organisation - World Health Organisation (FAO-WHO) Joint Meeting on Pesticides Residues (JMPR), the European Food Safety Authority (EFSA), and the United States Environmental Protection Agency.

Inaction in multiple regulatory environments sits in stark contrast to the busy international litigation environment as court cases mount up following sequential decisions affirming that exposure to glyphosate and its formulations contribute to non-Hodgkin lymphoma. The court discovery process is drawing light on the degree to which chemical corporations strategically guard their chemical assets. The IARC's decision that glyphosate probably caused cancer resulted in tactical and ongoing assault from organisations connected to Monsanto. Litigators who have represented plaintiffs in the Roundup cancer lawsuits have drawn attention to the 'cozy relationships' in the:

> '2015 Monsanto PR plan that identified Genetic Literacy Project as one of its "industry partners. "Monsanto planned to engage GLP and numerous other similarly-affiliated "independent" third parties to "protect the reputation" of Roundup and "orchestrate outcry" about the International Agency for Research on Cancer's (IARC) conclusions about glyphosate.'

'As of today, GLP has posted over 280 articles about IARC'.

Some of these articles include personal attacks concerning the scientists who served on the IARC Working Group tasked with evaluating glyphosate, calling them "frauds,""liars" and "greed-driven" (Baum Hedlund, 2019).

5.3.4 Glyphosate & companion herbicides: the all or nothing log-jam

The controversial herbicide glyphosate is mixed with co-formulants, other herbicides and organosilicon surfactants to control weeds. Herbicides can provide a public benefit, protecting national parks from noxious weeds while newer technology (such as electrothermal) is developed. The New Zealand environment absorbs hundreds of tonnes of herbicide mixtures. Herbicide mixtures are applied along roadsides; in forestry regions; prior to planting, post planting. Herbicides can be applied as a desiccant on human crops (cereals and lupin) and animal feed crops and pasture.

Controlled spot-spraying for a weed or stump-spraying to kill an invasive plant is more likely to result localised exposures that do not impact the public nor volatise into streams. An informed adult spot-spraying noxious weeds may be morally acceptable as the adult may elect to risk the consequences of exposure (assuming the adult is informed on the increased risk of cancer, EDC linked illness, Parkinsons etc). This is an entirely different moral issue to risk arising from broadcast spraying along roadsides where pets and children run; where groundwater can be polluted; on pasture; and on human and animal feed crops, resulting in positive tests in human biomonitoring. This is entirely another question. Such debate is difficult in New Zealand.

Groups have attempted to engage in such a debate on this issue, yet the media has been disinterested in complex discussion. The NZEPA have not responded to critiques (Douwes, et al., 2018). These groups are left outside the mainstream (See section (9.1 Media and 'shadow publics') or permitted limited media exposure. There is certainly no complex panel engagement. This is divisive and cannot parse the public interest – the ethics of the potential risk of exposure to pregnant mothers, infants, and children as well as our drinking water - to troubling chemical mixtures.

In this climate the status quo is privileged, with the 'all or nothing' approach in the public sphere, moral outrage can be expressed at the removal of an important weed control tool essential for agriculture or habitat restoration. The effect is that that vulnerable populations have no greater rights than the right of a farmer or local council to spray food crops or roadsides, because the discussion does not untangle more subtle issues that impact human rights, precaution and protection.

There are additional barriers to change as groups seeking to develop non-chemical technologies for weed control and pasture management struggle to obtain funding. Dominant organisations and government sectors are uninterested in supporting development of non-chemical means as, over the short-term alternative technologies appear more expensive.

These issues overlay a regulatory system stymied by lack of transparency, regulatory convention and the sheer volume of chemicals to be managed. The knowledge gaps outlined in the previous sections reveal a risk assessment infrastructure that grows more antiquated by the day. The freshwater process has been lengthy, and the choice not to, by all appearances, consult with experts in toxicology, not to grasp the implications of endocrinological science, not to consider the peer reviewed literature, reflects the values embedded in government. The position forms a moral line in the sand, a declaration of the ethics of our current age.

Without reform the exasperated individual spot-weeding is cast as the bad guy; while extensive cropping, industrial forestry and roadside spray regimes go unchallenged and the pregnant mother, the infant and the child – and the aquatic landscape - must merely, as they say, suck it up.

5.4 Regional Politics – Case Study: BOPRC Air Plan

The RMA requires that regional councils 'control of the use of land for the purpose of the maintenance and enhancement of the quality of water in water bodies and coastal water' and the 'maintenance and enhancement of ecosystems in water bodies and coastal water'. (PCO, 1991, p. Sn30(c))

However, local politics can impede effective monitoring. Without monitoring for diffuse emissions, risk cannot be assessed, targets arrived at, and controls implemented. Submissions to the Bay of Plenty air plan in 2017-2018 can serve as a case-study to demonstrate the different stakeholders and powerful players that closely monitor and guard the policy process.

Air emissions can pollute the surrounding environment, and 'air quality is intrinsically linked with water quality' (OECD, 2017b). Agrichemicals emitted into air can accumulate in freshwater systems (EEA, 2018). In the Bay of Plenty's case, diffuse emissions as agrichemical applications to air that are sprayed on pasture, horticultural, arable or roadside areas are not routinely tested in freshwater and sediments to establish if EELs or TELs are breached. This reflects Sir Geoffrey Palmer's lament that 'Pollution laws are ad hoc and do not recognise the physical connections between land, air and water' (Palmer, 2015).

The BOPRC air plan restricts itself to air testing and does not link air emissions to freshwater pollution, and the water plans do not test for chemical contaminants that may arise via diffuse sources.

Submission (021) (BOPRC, 2019) to the Regional Natural Resources Plan (RNRP) Plan Change 13 (air quality), recommended that the scope of the air plan be strengthened to require freshwater monitoring of sediment to test for bioaccumulation, ensure that agrichemical sprays are not volatising into water or onto sensitive sites and that sensitive sites are monitored and environmental exposure limits (EELs) are not breached in sensitive areas. The submitter advised the council of the obligations in law that EELs and TELs are not breached in sensitive areas, and that costs of instrumentation and testing were reducing which would make the process less financially onerous for council.

The submission was counter submitted by Fonterra, Balance Agri-Nutrients, New Zealand Agrichemical Trust, Mercury NZ, Oji Fibre Solutions, HortNZ, Federated Farmers, AgCarm, Fonterra, Port of Tauranga, and Lawter NZ (BOPRC, 2019).

Counter submissions from industry claimed that the requirement that EELs not be breached in sensitive areas, remain excluded as the controls were theoretically already in place. Industry was insistent the air plan should exclusively relate to air monitoring. Industry particularly considered a clause that considered industry should 'avoid' a discharge of contaminants beyond a boundary, and that limits should not be exceeded in sensitive areas overly unreasonable. Industry considered that EELs were established, and this was sufficient. (BOPRC, 2019) The fact that regular monitoring was not in place to ensure EELs were not breached - and that consequently controls would remain unenforced as had been the historical pattern, was of no concern to the submitters. One supportive counter-submission, by Toi te Ora expressed concern that Bay of Plenty Regional Council would permit exceedances of EELs. There was no other representation speaking to diffuse chemical emissions outside of industry counter-submitters.

Staff concurred with industry and none of the (021) recommendations were adopted (BOPRC, 2018). No resourcing for the submitter (021) was available to appeal. The counter-submission process is permitted through RMA and it privileges entities with the greatest resourcing capabilities and an acute interest in the policy outcome.

The aim of (021) was pull together the disparate legislation that guides chemicals regulation. It is difficult for the public and council staff to understand the full extent of obligations in law. Opaque monitoring guidelines, political pressure and the cost of monitoring and technology produce formidable political barriers to monitoring that might inform policy. This is why the submission drew attention to the shrinking cost of laboratory instrumentation. Regional councils have not invested in scientific instrumentation and testing capabilities, and the privatised nature of our public laboratories mean that fees for testing have historically stressed council budgets.

Marie Brown has written 'Key constraints on the adoption of new technology include a resistance to the capital funding costs and political drivers against the transparency they bring about' (Brown, 2017, p. 16).

The BOPRC example, with its brand-new Air policy and years of consultation, is an example of how powerful organisations sway the policy process and prevent monitoring.

While regional councils do test for agrichemicals, testing is infrequent. Not all chemicals will be screened for and the most degraded areas rarely undergo testing. Even though lakes receive funding for restoration, chemical contaminant testing in sediment to scientifically assess the extent of pollution is rare, Rotorua's lake sediments have never been screened, while the groundwaters of the same region are polluted with forestry chemicals (Close & Humphries, 2014; Close & Humphries, 2019).

Bringing disparate legislation together, linking air plans to ensure airborne pollutants do not degrade aquatic systems, should be a common-sense component of effective governance. The cascade of effects from legislation in one area being ignored, and public non-knowledge about the various policy instruments, the privatised expense of testing, combined with a lack of political will at regional and national levels to address diffuse pollution - has resulted in the ad hoc governance regime in place today.

5.5 The Treaty of Waitangi

The Treaty of Waitangi is embedded in the RMA (PCO, 1991, p. Sn8). The NZEPA is required to 'take appropriate account of the Treaty of Waitangi' (PCO, 2011b). The HSNO legislation requires that 'All persons exercising powers and functions under this Act shall take into account the principles of the Treaty of Waitangi' (PCO, 1996, p. Sn8). The NZEPA claims to incorporate for key Māori principles in decision-making: partnership, protection, participation and potential. He Whetū Mārama is the 'framework that guides the Environmental Protection Authority in the undertaking of its statutory and other obligations to Māori' (NZEPA, 2019d).

Does absence of monitoring of diffuse chemicals in freshwater, at regional and national level, constitute a breach of the Treaty? Surely, if chemicals are permitted in the environment, and serve an economic benefit, appropriate governance is required in the form of monitoring and appropriate resourcing to ensure 'cost-benefit' analyses incorporate the best scientific evidence around risk and harm – including for mixture effects and low dose endocrine effects that might impact, for example, indigenous fish and eel, in order to ensure appropriate stewardship or guardianship and protect future generations.

A recently released interdisciplinary paper by Sally Gaw and colleagues sought to identify priority research questions to identify, prioritize, and advance environmental quality research on anthropogenic stressors, particularly concerning chemical substances, from an Australia/New Zealand perspective. The paper acknowledged that:

> 'Applying an indigenous knowledge lens considers the whole of environmental change in determining the impact of contaminants. In addition to considering the impact of contaminants to indigenous people's environments, biodiversity, and culture, the impact of practices that disrupt ecological patterns and services are also critical to consider, particularly for those communities that are reliant on natural resources for their physical and cultural existence' (Gaw, et al., 2019, p. 3).

The authors also pointed out that recently revised water quality guidelines continue to depend on values defining toxicity thresholds that are drawn from studies of USA and European species (with a few exceptions).

> 'This approach makes the considerable assumption that native Oceania species are of a similar sensitivity to that of non-native species. This assumption has not been comprehensively tested because there have been no broad-scale systematic comparisons on toxicity data from native Oceania species and non-native species' (p. 10).

While most of the research questions identified in the paper appear relevant to Māori (p. 4), two of the identified questions, in particular appeared highly relevant:

- Are there differences in toxicological thresholds among native and non-native organisms, and how can species sensitivity information from non-resident species be used to predict adverse outcomes and protect our unique biota and ecosystems?
- How do we incorporate and protect cultural and social values (relating to humans, biota, and ecosystems) to empower citizen, societal, and indigenous engagement in the research, management, and legislation of priority environmental contaminants?

The paper recognised that indigenous peoples and knowledge systems can play a key role in environmental management, and that:

> 'the environmental science and engineering communities can assist in co-creating protocols in close consultation with the relevant indigenous peoples that are specific to regions, are equitable, empower mutual benefit, and are enduring' (p. 11).

Presenting a policy that excludes a robust approach to chemical contaminant monitoring may inadvertently render future freshwater policy unfit for purpose as it will not be able to fulfill statutory obligations under the Resource Management Act. It also raises questions about the capacity for Treaty of Waitangi principles, and for human rights, particularly of infants and children, to be respected. It may be difficult to achieve rangatiratanga, guaranteed by Article Two of the Treaty if the state of science is ignored that recognises the systemic risk from mixtures and hormone level chemical exposures, and if monitoring is not undertaken to understand the pressures that effectively render freshwater lifeless.

5.6 Weak application of the Precautionary Principle

> 'Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation' (UNCED, 1992).

The Precautionary Principle has enabled jurisdictions to move more swiftly to protect the environment from the adverse effects of hazardous substances. The Precautionary Principle (PP) is embedded in European legislation. While the PP has been criticised for being ill-defined and undermining legal certainty it remains that the 'clearest benefits of the principle is its overt recognition of uncertainties and the negotiated nature of decision-making' (EC, 2017, p. 20). In risk assessment particularly, uncertainty is commonplace.

Despite the Precautionary Principle or precautionary approach being incorporated in environmental legislation in New Zealand for over twenty years, decision-makers in the public sector have been slow to formally adopt the principle and court decisions have been inconsistent.

Iorns submits that despite the word 'precaution' being included in the legislation, there is no requirement that a precautionary approach is followed. Instead 'instructions' guiding decision-makers in the accompanying methodology order implies a traditional risk assessment, rather than precautionary approach.

Catherine Iorns has drawn attention the tiered decision-making processes that result in a weak interpretation of precaution. Stringent requirements guiding decision-making under the HSNO Act are contained in Part 2 - principles relevant to the purpose of the Act where decision-makers must 'recognise and provide for'. The following sections 6 and 7, concern lower order matters which must be 'taken into account' (See Appendix III). The specific section for determining pesticide applications is contained in s 29. Iorns notes that the factors in s 29 'are not explicitly made subject to the purpose and principles of the Act' (Iorns, 2018, pp. 28-29). The result is that second tier principles shift to become defining factors.

In addition, consideration is hampered by the accompanying methodology which sets out the 'risks, costs and benefits of the substance the subject of an application', guiding decision-makers through scientific and technical uncertainty, such as beginning with 'consideration of the scientific evidence'.

Unfortunately, standard toxicological processes are guided by protocols and processes. These contain scientific knowledge gaps that mean that regulatory interpretations of 'all effects of the substance' differ greatly from scientific publications in the peer reviewed journals, and these protocols which limit consideration of the scientific evidence may end up thwarting the purposes of the Act. Another issue is the failure to consider the effects pesticides have on *taonga* species and the general environment, as Iorns has remarked 'applicants appear to equally consistently fail to comply with this request' (p. 30). Similarly, the NZEPA has been criticised for public submissions not being given sufficient consideration, and for inadequate engagement with Māori.

As Iorns notes 'Section 7 and the accompanying Methodology Order have been criticised for implementing a very weak form of precaution'. This is because, 'caution is but one factor that a decision-maker must merely take into account, and there is no requirement to actually favour caution'

(p. 47) By becoming just another variable, precaution is unable to be effectively utilised in the decision-making process:

> A precautionary approach is more than just part of risk assessment. Precaution is meant to guard against the unknowns and unanticipated consequences; precaution "does not simply mandate that one conduct a risk assessment, but rather mandates a specific response to uncertainty: err on the side of precaution" (pp. 47-48).

Therefore, Iorns considers that the Methodology Order implements a traditional risk assessment approach. The PP guards against unknowns and unanticipated effects, it - mandates a specific response to uncertainty: err on the side of precaution' – whereas traditional risk assessment approach only recognises known uncertainties and thereby necessarily discounts if not excludes unknown uncertainties' (p. 48).

The problem, as Iorns outlines, is that caution can be taken into account, but then rejected, if, for example, the probabilities of uncertain effects cannot be calculated. This may lead the decision-maker to 'not just prioritise science, but scientism, with a seemingly blind adherence to the faith that the risks can be assessed well enough to judge the role that caution needs to play within that assessment' (p. 48) (Watts, 2000).

6. Drinking Water Sources

If drinking water is to be protected, and regional councils are to protect drinking water sources, appropriate monitoring of chemical contaminants that include chemicals recognised as potential endocrine disruptors should be scientifically incorporated in a national regulatory program. Chemical contaminants in food remains a global food safety issue (Thompson & Darwish, 2019), best practice oversight of contaminants in freshwater and drinking water, provides intersecting benefits to trade.

6.1 National reporting standards – not for pesticides

Drinking water infrastructure in New Zealand is severely degraded (EDS, 2019) and a national revision of drinking water management is in process (DIA, 2019). There is sufficient evidence that regional councils will not lead in monitoring of diffuse emissions (Bruning, 2018). Current filtration technologies for drinking-water and wastewater may be ineffective in treating particular classes of chemicals and nano-scale contaminants. While Auckland drinking-water treatment utilises ultrafiltration, most other drinking-water suppliers in New Zealand have older technology (and it remains uncertain whether ultrafiltration is the best technology for removing CECs).

Drinking-water management of synthetic organic chemicals appears historically related to the competency and resourcing of local operators; and the degree to which regional chemicals may taint water; and the capacity of drinking-water-suppliers to practically address the problem. Updates of drinking-water guidelines and inter-governmental co-ordination and oversight appear ad hoc.

A recent ESR report on changes in water quality since 2005 drew attention to the absence of national standards to ensure regional councils appropriately monitor source water for drinking water suppliers (Mattingley & Nokes, 2019a). The National Environment Standards for human drinking water requires that drinking water sources do not exceed health quality criteria for determinands (see below). The standards do not consider toxicity from mixtures of other contaminants, nor require testing for diffuse emissions (PCO, 2007). The technical guidelines do not include testing requirements (MfE, 2018b). The report noted there was no clear evidence that the drinking water national environment standards had influenced the quality of source waters, rather, the paper suggested that the legal requirements of section 69V of the 1956 Health Act, that drinking water suppliers comply with the Drinking Water Standards more directly affected improvement in compliance (Mattingley & Nokes, 2019a).

Regional councils may not grant consents for new activities that degrade source water quality 'beyond the limits allowed for in any regulation'. While the report acknowledges that exceedance of maximum acceptable values will depend on levels of contamination from existing consented activities, pollution from diffuse (non-point source) sources to exceed limits are not addressed.

6.2 Keeping up with the science – MAVs and metabolites

New Zealand drinking-water guidelines claim 'pesticides should only be found rarely in NZ waters, and for short periods' (MoH, 2018, p. 3). No national scientific resource exists to publicly support this claim.

6.2.1 Determinands

The ESR report and appendices noted that *national* reporting for water quality is restricted to reporting on a narrow range of contaminants, referred to as 'determinands' (see Appendix I). While maximum acceptable values (MAV) are established for pesticides (MoH, 2018) pesticides are not included in national drinking-water reporting standards. Determinand reporting includes some trace metals, chlorination by-products and fluoride (Mattingley & Nokes, 2019b). It is unclear why the determinands exclude the toxic trace metal cadmium.

As the ESR report notes 'Most Priority 2 determinands were identified in a Ministry of Health programme active during the late 1990s. Identification of Priority 2 determinands since this programme has been the responsibility of water suppliers' (Mattingley & Nokes, 2019a, p. 10). In the years following, ESR's role has been to draft advice to assist water suppliers to identify P2 determinands, and review for district health boards, monitoring data collected by DHBs to assess whether the criteria of determinands has been met. Councils may post the screens publicly (TCC, 2019). Once a chemical listed in the DWSNZ is found to exceed half the MAV, standard protocol is to regularly monitor for compliance. (Populations of over 500 are monitored for chemical determinand maximum acceptable values (MAVs).

While maximum acceptable values for chemical contaminants are established, the science informing levels of exposure that will be considered toxic is historically derived from industry data, which in many cases is decades old and unpublished. The guidelines draw attention to increasing groundwater contamination from herbicides (particularly the triazine group), insecticides and herbicides (MoH, 2018).

6.2.2 Drinking water knowledge and data gaps: mixtures and metabolites

If there is no maximum acceptable value (MAV) established for a chemical, there appears no regulatory requirement that drinking-water suppliers test for it. While the guidelines were updated June 2018, there are still no maximum acceptable values MAV for glyphosate and metsulfuron-methyl, two of the most commonly sprayed herbicides in the New Zealand environment (MoH, 2018). Metsulfuron-methyl and glyphosate require separate test methods (screen) that are not included in standard chemical screens. It remains the choice of drinking water suppliers to use their own moral compass to test for these chemicals. The screen for glyphosate is also more expensive.

Further, there are no national standards to guide decision-making if mixtures of chemicals (such as the triazine group) are present *below* MAV but might cumulatively represent a health threat. Studies have drawn attention to the health risk from mixture toxicity (Kortenkamp & Faust, 2018). Twenty-year old European standards require that the sum total of pesticides and their metabolites residues in drinking water do not exceed 0.5μg/L (E.C., 1998). It is unclear what metabolites New Zealand laboratories screen for. As discussed, Europe has the most rigorous risk assessment processes and these processes identify relevant toxic metabolites.

It is also unclear to what degree metabolites or degradation productions are tested for as laboratory reports may not define specific metabolites (TCC, 2019). Metabolites may have similar toxicity to the parent compound. For example, the MAV for groundwater pollutant terbuthylazine is 0.008 mg/L. This is based on an average daily intake of 0.003mg/kg drawn from data from 1995 drinking water standards (MoH, 2018). It is unclear if New Zealand testing incorporates testing screens for the parent chemical *and* the metabolites LM2, LM3, LM4, LM5, LM6, MT1, MT13 and MT14 – and particularly MT1 - to derive a total of concentrations that includes all components. The EFSA assessment expressed concern that drinking-water sourced from groundwater in alpine (forestry) regions, may exceed safe exposure levels for infants (EFSA, 2017).

Even if a MAV is selected, if a chemical is not on the standard aqueous screen for drinking water it may evade testing. This appears the case for sodium fluorocitrate, a toxic compound banned in the European Union (IUPAC, 2019).

Urban wastewater in New Zealand contains similar chemical profiles as other international regions, and the efficacy of treatment depends on filtration technologies (Kumar, Sarmah, & Padhye, 2019) (Kumar, et al., 2019). More wastewater is discharged into streams than on land (Cass & Lowe, 2016). Diffuse pesticide emissions stressors from forestry, horticulture, roadside and council spraying, pastoral farming and arable cropping are significant, alongside urban pressures, constitute the bulk of pressures. Without monitoring to draw attention to the diffuse pollutants that arise via urban waste treatments and urban-runoff, regional and local councils cannot provide feedback to civil society that may over the long term, protect drinking water.

However, it is a little bemusing to note that the only mention of pesticides in the September policy document, Action for Healthy Waterways, noted 'Stormwater run-off from towns and cities carries contaminants such as pesticides, trace metals, and litter into the waterways' (MfE, 2019a, p. 25). Most pressure from pesticides use arises from rural agricultural use and NZTA and territorial authority roadside use.

New evidence on low dose endocrine disrupting effects; cumulative risk from the pesticide classes (including metabolites) and chemical mixtures are not considered in the HSNO Act nor by the Ministry of Health in setting drinking water standards.

Science researching low dose, hormonal level effects remain under-resourced, and so the toxicity from exposure to parent chemicals, breakdown metabolites and trace metals in the environment that may contribute to human and environmental health damage is largely unexplored – at least in the public sphere. This applies to groundwater, freshwater (including source water for drinking-water supplies) and drinking water. New Zealand groundwater contains a significant cocktail of CECs (Close & Humphries, 2019). The political reluctance to allocate science funding to develop this knowledge means that continued assumptions that the population, and particularly pregnant mothers and infants are safe – cannot be scientifically confirmed. It also means that statutory authorities cannot claim to be practising appropriate stewardship in order to guard drinking water safety five, ten or thirty years from now.

7. Forty years of European scientific monitoring of chemical contaminants

The European community define good chemical status as limits in concentration of certain pollutants found across Europe, referred to as priority substances. Priority metals, including cadmium and pesticides are included in a suite of chemical pollutant regulations designed to monitor and evaluate risk to surface water quality. The European Commission recognises that

> 'the main anthropomorphic pressures on surface bodies are from diffuse sources, particularly from agriculture and from atmospheric deposition'. (Point source and water abstraction stressed surface water systems considerably less). (EEA, 2018)

In 1976, Europe commenced regulating and monitoring chemical pollutants in water and currently chemical monitoring programs are conducted in river basin districts, monitoring both surface and groundwater (E.C., 2019c) (E.C., 2013). In 2018 Europe commenced additional monitoring of substances – as an updated Watch List including pharmaceutical (antibiotics), neonicotinoid insecticides (2018/840) (E.C., 2018).

The European Environment Agency has drawn attention to the 'cocktail effect' where chemicals at lower concentrations which might not pose an individual toxic risk, when combined as a chemical mixture may increase risk to human and environmental health (EEA, 2018; EEA, 2019).

As discussed earlier, New Zealand lacks national databases to understand the altered risk profile of additional risk from high volume chemicals. New Zealand ceased such monitoring around 2008. Unlike New Zealand, European REACH legislation maintains chemical tonnage data (E.C., 2018d; ECHA, 2019).

8. Issues of public law: The Public Interest - a yardstick of indeterminate length.

Relevant principles of administrative law should guide regulatory decision-making – and an earlier paper (Bruning & Browning, 2017) drew attention to principles of law that civil society and public servants may be unfamiliar with. The content of which was drawn from Professor Philip Joseph's book *Constitutional and Administrative Law* (Joseph, 2014).

The statutory authorities assigned to protect freshwater have duties to safeguard the life-supporting water and ecosystems; and avoid adverse effects of polluting activities on the environment. These duties are derived from the relevant purposes and functions of the Acts of parliament that give them the powers to make (enact) policies and regulations. The caveat, is that these policies and regulations must at all times be consistent with the purpose (or function) of the relevant Act. Government employees and elected representatives cannot avoid this obligation as 'statutory powers are never at 'large'' (Joseph, 2014, p. 942). Courts have found that 'decision makers abuse their powers when they exercise their power in a way that 'which cannot rationally be regarded as coming within the statutory purpose' (p. 939). This may include situations where the policy is deficient or is incompatible with the legislative purpose and intentions of the Act enacted by Parliament.

'The courts have interpreted statutes robustly, sometimes 'filling gaps' within the statutory framework, 'to make the Act work as Parliament would have intended'. Judicial review considers the relevant context, asking 'Has something gone wrong' which can 'throw light on the 'controlled' subjectivity that characterises the application of administrative law principles (p. 940).

Decisions can be challenged through judicial review, as:

> 'Judicial review ensures that public authorities act within the law by defining the principles of law that govern administration, and by safeguarding individual interests against illegal or unreasonable administrative action, or administrative action taken without following proper procedures' (CLO, 2005).

A challenge may arise because of (a) illegality; (b) unfairness and/or (b) unreasonableness, and grounds may overlap. Review on the grounds of illegality refers to three situations: (1) Abusing a discretionary power under the Wednesbury principle (for example, exercising a power for an improper purpose or disregarding relevant considerations) (2) Abdicating a discretionary power (for example, adopting a rigid rule or policy); and (3) Committing a reviewable error in making findings of law or fact' (Joseph, 2014, p. 939).

8.1 Mandatory Relevant Considerations

Courts have found that

> 'The exercise of discretionary power, even for a proper purpose, may be invalid if the decision-maker fails to take into account relevant considerations, or is influenced by conditions that are legally irrelevant... It is only when a decision maker fails to have regard to a mandatory consideration that the decision-maker makes a reviewable error of law' (p. 948).

Decision-makers must consider information material to the decision:

> 'Prudent decision-makers will be transparent in their deliberative processes and leave a 'paper trail' specifically discounting irrelevant matters and emphasising relevant matters on which they rely. Decision-makers may be under duty to take positive steps to inform themselves. They must have 'sufficient information to allow a reasonably informed decision', and they must genuinely weigh matters which must be taken into account. Ministerial decisions may be especially susceptible to challenge where ministers rely on officials' fact-findings and report. A failure by officials to place before the minister information relevant to a mandatory consideration will contaminate the decision-making. Decision-makers cannot give genuine

> consideration to relevant considerations and accord appropriate weight without being in full receipt of the facts' (p. 949).

Transparency is essential, and 'failure to display transparency in the decision-making may invite an adverse inference' (p. 950) particularly if it cannot be demonstrated that a mandatory relevant consideration has not been genuinely considered.

It would be up to the courts to judge whether the relevant Ministries sought sufficient consultation on the matter of chemical contamination from relevant scientists expert in the field of chemical toxicology. As would be the decision to exclude chemicals in the current consultation because of the contention that sufficient endpoints have not been derived. The extended consultation process which has been in play prior to 2012, might have offered adequate opportunity for Ministry staff to consult on chemical pollution, diffuse chemicals and risk. Further, the courts may consider it may have been appropriate for decision-makers to take into account the practices of other jurisdictions, such as the EU, or the recommendations of known authorities, such as the OECD.

Experts in administrative law are familiar with the phrase 'the public interest' is 'a yardstick of indeterminate length' from Attorney General v Car Haulaways. Thus, the issues that must be considered should not be restricted, and as Joseph has outlined:

> 'The more comprehensive and detailed the criteria, the more likely they will be construed as exhaustive. If a listed criterion is open-ended, a court may hold that the criteria are not exhaustive and concede the decision-maker greater latitude' (p. 950).

Nor should guidelines be rigid – 'elevated 'into something inflexible' (p. 951) - and in addition, it is noted that 'it is a reviewable error for a decision-maker to misinterpret or fail to apply guidelines which it has voluntarily adopted' (p. 952).

There are other questions that might be of interest, for example, questioning why EELs and TELs have not been regularly tested for at a national level, and why regional councils have rejected submissions to require monitoring to scientifically understand environmental levels that constitute legitimate guidelines in New Zealand legislation.

Joseph also draws the attention to the context of decision-making must be taken into account. For example, principles of the Treaty of Waitangi might be considered a relevant mandatory consideration; and weighting of mandatory considerations – such considerations must not be

> 'rebuffed… by a closed mind so as to make the statutory process some idle exercise'. Such matters must receive genuine consideration in the cognitive processes of decision-making: 'They must be taken into account, considered and given due weight, as a guide in the decision-making process' (p. 953).

However there is a close interplay of where issues of weighting – which may be based on a decision-makers value judgement – may instead be considered an error of law if the mandatory relevant consideration is excluded and as such 'Decision-makers must not disable themselves from considering information relevant to their statutory function' (p. 954).

Openness is critical to good governance as:

> 'decision-makers bear an obligation to show candour in their reasoning processes. In recent decisions, courts have emphasised the disciplines on decision-makers to demonstrate that they have properly applied their decision-making power. They must weigh mandatory considerations 'on a fine-grained basis', 'openly and transparently', or risk a finding of 'no weight'. Ordinarily, the decision-maker must specifically refer to the mandatory consideration and evaluate each consideration in turn. Failure to do so is a 'strong indication' of a failure in genuine evaluation. But nor is mere recitation sufficient. Reciting facts does not equate to weighing their significance: 'One cannot assume from the mere reference to a fact that the fact has been adequately considered' (pp. 954-5).

8.2 Abdication of discretionary power

A further principle of administrative law is the requirement 'that a public authority must not disable itself from exercising its discretion in individual cases…. Each case must be decided on its merits and decided as the statute and public interest may require.' Grounds for challenge of abdication of discretionary power includes if an authority (1) adopts a fixed rule of policy; (2) acts under the dictation of another; (3) fetters its discretion by contract or representation; or (4) sub-delegates its powers.

Personal judgement must not be displaced by a fixed rule of policy, and as Joseph quotes, those exercising statutory discretion must not 'shut his ears to an application' – each case requiring an 'individual response' rather than ''slavish adherence' to a rule. Abdication of discretion under fixed rules of policy is a common ground for administrative law challenge' (p. 964).

It is also important to note guidelines are not set in stone. Each case:

> 'should be decided on its own merits, even where decision-makers have adopted guidelines or policies to facilitate the decision-making. Decision-makers must reserve a power to depart from an adopted policy and indicate a genuine willingness to exercise the power' (p. 965).

Policies or rules which limits the scope of discretion can be challenged. As Joseph remarks 'Limiting the scope of discretion may make administrative good sense, provided policy guidelines do not lapse into rules of binding application. The decision-maker must not 'shut his ears to an application' or refuse to hear an argument urging a change of policy' (p. 966). One wonders at a term of reference, inherited from previous governments, that excludes chemical contaminants.

The process of 'rubber stamping' comes under the principle of surrendering the exercise of a discretion. However, this principle need not necessarily apply to a minister but may apply, as a function of administrative expedience to the actions of departmental officials who 'are the alter ego of their minister and stand in the shoes thereof for exercising the minister's powers of decision.' It is noteworthy that

> 'Designated non-ministerial decision-makers who delegate those functions risk a finding of rubber stamp decision-making' (p. 970).

If an authority refuses or fails to exercise a discretionary power, this will also constitute an abdication of discretionary power. 'A public body must not renounce its decision-making responsibility nor preclude itself from inquiring into matters relevant to its inquiry'. Cases have found that 'a blanket refusal to exercise the power was unlawful'. Whether a decision-maker fails to act because the inaction is deliberate, or whether the decision-maker believes it lacks jurisdiction to proceed can still produce a finding of abdication of discretionary power. Similarly, an undue delay may also constitute a breach of the duty to decide. However, as Joseph notes, inaction will not constitute abdication of discretion where the decision-maker is authorised to initiate the decision-making' (p. 972).

A gap in the chain of reasoning may result in decisions being set aside resulting from misinformation or misrepresentation. As Philips notes:

> 'Such decisions may be unsound, although neither outrageous nor absurd. Judicial review is of varying intensity also when a decision-maker must consider and weigh mandatory relevant considerations. The courts insist on higher standards of probative evidence to support decisions that directly adversely affect rights' (p. 1007).

The barrier of course, to such review, to 'policing' obligations of administrative law, is resourcing. Organisations in New Zealand that would be interested in pursuing such actions lack the financial resources, and the financial risk for individuals constitutes a formidable barrier. This may explain why decisions made under administrative law are frequently the result of industry sectors claiming rights, rather than public organisations or civil society acting to enforce or shape administrative law in support of the maintenance and protection of environmental or human health.

8.3 Human Rights: 'The best interests of the child'

The United Nations Special Rapporteur on Human Rights and Toxics, Bascut Tuncak has drawn attention to the unique vulnerability of children to adverse health impacts from hazardous substances. Pollution contributes to the global burden of disease and early life exposures to toxic chemicals contribute to this burden. In September 2016 the Special Rapporteur drew attention to the scientific evidence that chemical pollutants are increasingly commonplace, and that exposures from conception, are contributing to a 'silent pandemic' of disease and disability. The Special Rapporteur noted that 'States have a human rights obligation and businesses a corresponding responsibility to prevent childhood exposure to toxic chemicals and pollution' (UN Human Rights Council, 2016). The document included specific recommendations for nation states (Appendix II).

The most widely ratified human rights covenant states that children are entitled 'to the enjoyment of the highest attainable standard of health and to facilities for the treatment of illness and rehabilitation of health' (United Nations, 1989). In 2010 the United Nations General Assembly explicitly recognized the human right to water and sanitation and acknowledged that clean drinking water and sanitation are essential to the realisation of all human rights (2010).

A 2017 UN human rights report discussed further the risk to women and children from lifetime exposures of pesticides, noting that weak regulatory standards result in higher exposures to children (UN Human Rights Council, 2017)

The unborn foetus, infants and young children are much more vulnerable to synthetic organic chemicals than adults. They ingest more relative to their bodyweight and they 'have a greater ability to absorb pesticides than do adults' – for example infants breathe more and their skin surface relative to bodyweight is greater (Watts, 2013, p. 34). Children have critical windows where they are particularly vulnerable to exposures. The blood brain barrier is not fully developed until six months of age, and metabolic pathways are similarly immature. Liver and kidneys are still developing and children are 'less able to eliminate pesticides through the urinary tract' (p. 35). Enzymes used for detoxifying pesticides might not be produced until mid-childhood. Because of this, newborn children can be 65 to 164 times more vulnerable to the organophosphate class. Genetic variations can result in sensitivity between mothers and newborns.

Pesticides can cause developmental immunotoxicity, damaging the immune system so that the child is more vulnerable to infection, tumours and disease later in life. Exposure during critical windows can impair the respiratory system, damaging lung function. Foetal exposures can result in birth defects, early onset of puberty and establish conditions for endometriosis, fibroids and infertility in adulthood. (Watts, 2013)

In addition to children being more vulnerable to toxic chemicals than adults, the Special Rapporteur has noted that this confers a fiduciary responsibility on governments to protect the developing child:

> 'Children are defenseless to protect themselves from hazardous substances. From the time of conception, children are exposed to toxic chemicals in their mother's womb. Long before children are able to identify risks and make informed choices for themselves, children continue to be exposed to toxic chemicals in their mothers breast milk and other sources of food, the air they breathe, and water they drink. While the responsibility to protect children rests primarily with governments and secondarily with parents, significant information gaps regarding the risks of hazardous substances to children obstructs efforts to ensure necessary protective measures are in place' (Tuncat, 2016).

9. The Political and Media Landscape in Aotearoa

9.1 Media and 'shadow publics'

A survey of published documentation, media releases and discussion, finds chemical contaminants sit outside of contemporary political, social and economic consideration in the national freshwater policy process. This is not unexpected. Media plays a powerful role in shaping the narrative around science and technology controversy (Nisbet, Brossard, & Kroepsch, 2003). Further, technical and scientific arenas can have higher barriers, reducing input from those that might suspect something is awry, but lack the technical expertise to comment. New Zealand academics have described the activities of influential 'shadow publics' that are not easily identified, having a 'fluid existence, manifesting at particular points in the media discourse and subsequently dissolving back into an amorphous community as media attention shifts elsewhere' (Munshi, Kurian, Fraser, & Rupar).

This has the effect of framing debate and effectively legitimising the key issues selected as terms of reference in ongoing 'consultation' that forms public policy. Newspaper and media sources 'create news frames, thereby serving as mechanisms in the creation of public perceptions and opinions (Klein, Byerley, & McEachern, 2009). Munshi and colleagues suggest that journalists can sometimes privilege a middle point – at times 'simply constructing a desired middle point in these debates' (p. 92) and that this process creates the shadow publics. The paper noted that scientific experts who might be knowledgeable about the issue in question 'presented only infrequently in opinion columns. They remained on the periphery of the debate and seemingly unable to influence policy' (p. 104). To understand the nature of the influence, requires examination of surrounding ideologies, or cultural, political and social narratives that inform and frame the New Zealand media environment which has been described as 'historically weak' (Kelsey, 1997, p. 276).

In New Zealand, intervention to remediate pollution appears more likely to have political will when pollution threatens tourism or recreational fishing, in contrast to if a place is highly valued by Māori communities or simply valued for scenic beauty (Knight, 2019).

Sally Gaw, Louis Tremblay and colleagues are driving innovative work to progress risk assessment policy outside the regulatory sphere and largely outside the media sphere. With such a relatively small cohort of expert scientists, and without a stakeholder body in the freshwater consultation process to express chemical contamination of New Zealand freshwater as an issue, at this stage there appears no political 'force' to balance entrenched representative groups. Nor are the scientist's efforts likely to transform obdurate regulatory environments at the speed that is required in order to prevent continued degradation, with innovative methodologies that reflect the current state of scientific knowledge.

Pollution will always be political. When scientists have historically expressed dismay regarding an issue that may have economic ramifications to industry, the social, political and media environment has historically been reluctant to impartially parse out the complex issues raised in the public interest. Rather, the media has sought to balance the interests of stakeholders, pragmatically shaping that 'middle point', rather than representing the 'public good', the interests of public and environmental health. This plays out as technical and scientific issues in media are frequently 'balanced' by a talking heads industry expert, versus a public actor and relevant political representative.

What is rarely observed, are interdisciplinary panels of impartial, publicly paid experts and citizens who can engage in complex discussion in the public interest, and – particularly - contemplate moral and ethical issues. Such debate could help Aotearoa more appropriately value future generations and address risk or promises of success from new technology. Such debate is unknown to young people in Aotearoa. The economic cost and the drain on the taxpayer from expert groups is emphasised by media. The critical role played by the impartial expert, or rather, the actor who has a vested interest in long term public or environmental health is not emphasised enough in civil society. Those that have courage to speak are few, risking contestation from vested interests. In the science realm, there are few specialists who have broad interdisciplinary knowledge and who are not dependent on commercial funding for research.

A further barrier to public knowledge is media concentration and the problem that much mainstream media is offshore owned, platforms and 'dangerously dependent on Facebook traffic'. Predatory actions by social media engines further damage the capacity to engender public debate in the national interest (Myllylahti , 2018). Scoop is an extensive repository of civil society protestation, as most press releases by non-government organisations are printed on this site.

9.2 Undone Science

The claim that science is value free is increasingly viewed with scepticism as social scientists demonstrate that the 'risk frame' is a social and political concept - mediated by power networks, access to knowledge and social inequality (Auyero & Swistun, 2008; Braun & Kropp, 2010). The choices around which science to pursue, and to the benefit of whom, are eminently subjective and can be driven by political aspirations and connections.

Governments are pressured to under invest in risk management and mitigation because of the short-term costs, but at the expense of higher future costs. Jonathan Boston and colleagues have noted 'Governments are pressured to allow renewable resources, such as forests, fisheries and fresh water supplies, to be overexploited in the interests of short-term commercial gains, thereby putting at risk their sustainability and long-term societal returns. For prudent long-term governance, such pressures could be recognised, and processes enacted to help minimise the risk that renewable resources will be poorly managed' (Boston, Bagnall, & Barry, 2019, p. 42).

Sociologist David Hess has described the phenomenon of knowledge gaps as 'undone science' (Hess, 2015). Absence to address a politically undesirable scientific problem (as chemical pollution which might affect a broad swathe of industry) can also act to systematically reduce the power any available data might provide to reinforce and drive reform. Thus, as Hess explains, 'the idea of undone science draws attention to a kind of non-knowledge that is systematically produced through the unequal distribution of power in society' Hess goes on to note: 'A corollary of the concept of undone science is that it involves the systematic underfunding of a specific research agenda, and the underfunding occurs through a continuum of mechanisms. At one end, there is a well-documented literature on the active suppression of scientists who produce evidence that demonstrates risk and dangers associated with new technologies or technologies for which there is a broad public dispute' (Hess, 2015, p. 3).

The absence of science may create the opportunity to step into a precautionary policy environment. Hess points out that the barriers of 'undoable' science may be partly technical and financial, but are potentially surmountable in the long run, noting that there are 'policy implications for the deployment of precautionary rationales in the regulatory field, because it transforms a precautionary policy from a temporary status (a moratorium until more research is done) into a permanent status' (p. 4).

Hess has described the potential for 'industrial or political elites' to shape research agendas and select what will be considered the problem/s to be addressed and consequently funded. Hess notes that 'Where there is an absence of a social movement mobilization, regulatory policy will tend to follow the directions established by industry, even if civil society organizations have institutionalized access to the policy process' (p. 11).

The decision to make the switch to a science-based approach that prioritises environmental health is intrinsically connected to the culture, values and ethics of decision-makers. The purposes of the relevant legislation documented in this paper are praiseworthy and beautifully written, the challenge is to ensure decision-makers – Ministers, civil servants, advisors and related officials – exercise what is known as 'public probity' and act with political integrity. Public probity 'is often conceptualised as adherence to 'standards in public life.' These 'standards' centre around seven principles: selflessness, integrity, objectivity, accountability, openness, honesty and leadership. These standards are important, particularly if democratic nations are to steer through the social media and fake news environment and ensure decisions are made that benefit the public interest (Rose, 2014, pp. 10-11).

Public probity guides understanding of trustworthiness of decision-makers, and trust is a critical component of democracy. This is due to the fact that individuals in the public sector can and do wield considerable discretionary power, conferred on them by the purposes of the legislation from which they derive their power. These decision-makers – Ministers, civil servants, advisors and related officials – have a fiduciary obligation to exercise that power prudently in the public interest. That their political power, is executed ethically and in the public interest is of the utmost importance. A failure to discharge their fiduciary obligations with political and ethical integrity, can lead to a breakdown in public trust and confidence. Trust and confidence in decision-makers is essential for the effective functioning of democracy.

10. Reform

A National Objectives Framework must accurately reflect the challenges of contaminant complexity within New Zealand aquatic systems. Notions of 'rigour' should reflect the requirement to, above all, *protect freshwater*, using the best available science. 'Rigour' that demands that thresholds might only be established when readily definable thresholds (bands) can be set (on a national scale) – the single chemical approach – may be inadequate to inform policy and may not reflect best practice science. There is little room in this model for precaution due to uncertainty and mixture risk. The 'simplest' approach to transformation of freshwater systems would be to:

- harmonise with European decisions on hazardous substances
- integrate the precautionary principle in decision-making
- adopt a risk-based approach and screen freshwater and chemicals for

> 'The first step in a risk-based approach to water quality is to identify pollutants, their origin, timing and pathways, and their risks to water quality, including their likelihood and impact' (OECD, 2017b, p. 105).

The following sections include practical, scientific, technical, regulatory and legislative suggestions that might guide chemical reform.

10.1 Take Precaution to a meta-level

This paper has sought to summarise the issues outlined by Catherine Iorns, that result in the HSNO Act prescriptively guiding decision-makers to adopt a weak version of the precautionary principle (part 5.6) (Iorns, 2018). The effect is that a traditional risk assessment approach is adopted. There is no methodology in place to account for unknown uncertainties. In assessing hazardous substances, our regulations state that caution can be taken into account, and then rejected. This will still fulfill the requirements of regulation. The political practice of conducting cost-benefit analyses may create further barriers, as it is difficult to estimate unknown unknowns such as ecosystem interactions, and mixture effects. Iorns suggests measures to embed precaution into the regulatory framework:

1. Decision-makers can firstly, *actually exercise caution in the face of uncertainty about adverse effects from pesticides*, rather than just take the need for caution into account along with all the other factors that must be taken into account (p. 50).

2. Precautionary measures can be adopted to improve the *science framework* (see next section)

3. A precautionary approach, rather than sitting alongside social, cultural or economic considerations, might instead be elevated to a *meta-level* precautionary approach. As Iorns notes:

> 'we do not know where the tipping points for population or ecosystem collapse are. We should not have to get down to the "last 55" of a species before we realise we should not have let it get that low. Thus, ultimately, a precautionary approach in environmental law means not just enabling a decision-maker to choose to protect such life but, on occasion, requiring that they do so' (p. 52).

10.2 'Reasonable Precautionary Measures'

The ability to protect and safeguard environmental and human systems from toxic chemicals is directly related to the quality and integrity of the supporting legislation. Catherine Iorns has outlined issues arising from outdated pesticide regulation under the HSNO Act (Iorns, 2018). The criticisms included the failure to consider formulation and mixture toxicity, individual vulnerabilities, and to incorporate endocrine disruption in toxicological consideration (Iorns, 2018, pp. 11-13). These issues have not been raised by the NZEPA in recent NZEPA consultation/discussion activities, remaining outside the terms of reference (NZEPA, 2018; NZEPA, 2019b).

Biological systems are extraordinarily complex and it is particularly difficult to anticipate where and when unanticipated and irreversible events will occur. The limitations of current testing to identify pathways and disease causation reflect the difficulty of estimating combination synergies, dose, and duration of exposure (Gangemi, et al., 2016). Similar challenges apply to ecological systems and a precautionary approach may be an effective way of navigating uncertainties.

Catherine Iorns has suggested five 'reasonable precautionary measures' that might be taken to address current knowledge and data gaps:

a) a requirement to make (generous) allowances for long-term low-level effects such as endocrine disruption;
b) a requirement to either have information on or make generous allowance for effects of this pesticide in combination with other chemicals commonly observed in the environment;
c) a requirement to use a toxicology model or set of levels that makes allowance for individual sensitivity;
d) a requirement to seek information independent from that generated or provided by parties with a financial interest in the pesticide in question;
e) the explicit requirement to consider alternatives to the pesticide being assessed, particularly options for using no chemicals

Implementation of these precautionary measures may be assisted by the following.

1. Cut-off Criteria: Adoption of hazard based 'no-exposure logic' for EDCs

1. Pesticides that have carcinogenic, mutagenic, endocrine disrupting properties, and/or act as developmental neurotoxins or immunotoxins, should not be registered or used (Watts, 2013).

'The endocrine system is a delicately balanced system of glands and hormones that maintain homeostasis and regulate metabolism, growth, responses to stress, the function of the digestive, cardio-vascular, renal and immune systems, sexual development and reproduction, and neurobehavioural processes including intelligence. In fact, it governs "virtually every organ and process in the body"' (Watts, 2013, p. 40).

Risk assessments for chemicals found to exert carcinogenicity, reproductive/developmental toxicity, neurotoxicity and/or endocrine effects can, as with the EU, be hazard based. For vulnerable populations there can be no clear endpoint. No-exposure to such substances is a scientifically sound protective precautionary measure (Demeneix & Slama, 2019; Székács & Darvas, 2018).

2. Recognise risk from non-monotonic dose responses. Maternal, prenatal and early childhood exposures to endocrine disrupting chemicals can set the stage for disease years before disease is apparent and greater harm can occur at very delicate hormonally relevant levels, than at higher levels (the non-monotonic dose response). For endocrine disrupting substances, non-monotonic responses are reasonably common (Buonsante, Muilerman, Santos, Robinson, & Tweedale, 2014). Endocrine disrupting chemicals should be considered to have similar toxic risk as carcinogenic, and mutagenic substances (Demeneix & Slama, 2019; Gore, et al., 2015). In Europe pesticide regulation is hazard-based for carcinogenicity, reproductive/developmental toxicity, neurotoxicity and endocrine effects (Székács & Darvas, 2018).

3. Recognise individual vulnerabilities. Part of a hazard based rationale is due to the fact that it is extraordinarily difficult to pinpoint where health harm from hormone mimicking endocrine disruptors may cease – where the safe exposure level lies - particularly when individual vulnerabilities such as risk from prenatal and neonatal exposures are taken into account (Kelley, et al., 2019; Landrigan & Goldman, 2011).

4. EDC's harm humans and at-risk aquatic vertebrates. If civil society is to protect ecological communities from the sub-lethal effects of endocrine disruption, the field of toxicological endocrinology might evolve to become an integral component of ecological science. At risk of accusations that human and environmental health are conflated in this paper – chemicals can act to increase T3 and decrease T4 in fish, as well as people. This is why scientific papers discussing the potential for EDCs to impair neurodevelopment of the child will refer to fish studies (Ghassabian & Trasande, 2018). As another example, EDC pesticide negatively affected the fertility of frogs at environmental levels (Orton, et al., 2018). The possibility of deriving safe and accurate endpoints for a human child, a fish larvae or a tadpole in the near future, recognising that historical endpoints are based on adult populations and single chemical risk, is highly improbable.

2. Ensure formulation data is publicly available.

1. Data must be publicly available. The convention of 'commercial confidentiality agreements' to avoid declaration of formulant ingredients should cease. The IARC Preamble provides guidance for selecting publicly available data (IARC, 2019). A recent court case has drawn attention to the problem of favouring industry secrecy over the public interest. The court considered that the public right to examine data relating to:

'emissions into the environment' was 'deemed to be in the overriding public interest, compared with the interest in protecting the commercial interests of a particular natural or legal person, with the result that the protection of those commercial interests may not be invoked to preclude the disclosure of that information' (General Court of the European Union, 2019).

2. The classification of inert or active has no scientific basis (Mesnage & Antoniou, 2018). Greater awareness around formulation toxicity is creating cascading issues in regulatory environments (Székács & Darvas, 2018). Formulations have been found to be significantly more toxic than the active ingredient (Mesnage & Antoniou, 2018) (Mesnage, Defarge, de Vendômois, & Séralini, 2014). Adjuvants can include trace metals and petroleum by-products, creating unanticipated risks to human health and throughout the agricultural and commodity supply chain (Mesnage & Antoniou, 2018).

3. Science funding is required to test indigenous species. The current approximation that New Zealand species has the same risk profile of European or USA species may not be accurate.

4. It is recommended that formulation data is published in the scientific literature and that literature reviews are a component of initial authorisation and reassessment. This conforms to maxims of transparency, ensuring that appropriate scrutiny of the data from scientists and civil society outside the regulatory environment may be undertaken, and that trials are replicable. Risk assessment for new products that belong to an existing chemical class can require literature reviews of chemicals in the same class, and this may reduce the problem of 'regrettable substitutions' where similarly toxic substances are released.

5. GLP should not be used as an excuse to ignore peer reviewed scientific literature. Commercial confidentiality clauses rely on the convention of GLP (see section 5.3) a laboratory documentation protocol considered insensitive and artificial by academic researchers, who prefer to rely on data quality protocols.

6. Current adjuvant exclusions have no justifiable legal basis. The exemption in the ACVM Act that excludes adjuvants must be removed. The NZEPA are responsible for active ingredient toxicity and the Ministry for Primary Industries are responsible for approving formulations that are made available for sale under the Agricultural Compounds and Veterinary Medicines Act 1997. The New Zealand Agricultural compounds and veterinary medicines (ACVM) Act 1997 regulates the use of agricultural compounds, and trade-named compounds are registered under this Act. Adjuvants are listed as exempt within ACVM regulations (PCO, 2011). Applications to the Regulation Review Committee to ask that this is overturned, the first in Sept 2016, the second in April 2017 have been rejected as the Regulations Review Committee considered that the complaint did not relate to the identified standing order grounds (SO319(2)(a) and SO319(2)(c). (Parker, 2017). The ACVM Act requires MPI staff to prevent risks to public health, trade, animal welfare and agricultural security.

3. Enshrine the obligation for mixture risk assessment in legislation.

Authorisation and risk assessment to be based on full formulation toxicity. Expert scientists have expressed concern at the limitations of current regulatory approaches to identify so-called safe thresholds (Kortenkamp A., 2014), and the potential for cumulative effects from combined exposures to endocrine disruptors exert greater damage than recognised (Gore, et al., 2015). Chemicals exert damage through many pathways and regulatory scrutiny does not consider the potential for risk arising via toxicity to multiple pathways (Evans, Martin, Faust, & Kortenkamp, 2016).

Increase resourcing to understand mixture risk to native species. Current risk assessment contains knowledge gaps regarding mixture risk concerning environmentally relevant levels of chemicals in the environment. Scientific resourcing can draw attention to the potential for CEC (including pesticide) levels that are currently considered safe, to act additively or synergistically to drive biodiversity decline.

4. Lower all safety limits by a 'mixture assessment factor' of 10.

Recognise risk from synergies. This provides an additional level of safety that might allow for additive and synergistic effects of chemical mixtures including from formulation ingredients (Kortenkamp & Faust, 2018).

5. Harmonise single chemical testing requirements across all regulatory silos.

Collaborate internationally to recognise risk from different chemical exposures. Children are chronically exposed to pesticides, household chemicals, plasticisers, and petro-chemicals mixtures and recent studies indicate aquatic environments contain chemical mixtures. New Zealand authorities can supply resourcing for scientists to support international harmonisation of single chemical risk assessment to ensure comparable toxicity data will assist in integrated mixture assessment and that this data can then be used by New Zealand regulators (Kortenkamp & Faust, 2018).

6. Control cumulative exposures to chemical classes.

Chemicals can be monitored and regulated class by class. This can happen in different ways. For example, the bisphenol class might be banned from food containers nationally. As another example, forestry and agriculture use herbicides from the triazine class. The groundwater pollutant terbuthylazine may accumulate with other herbicides from that class in the same groundwater body (Close & Humphries, 2014; Close & Humphries, 2019; EFSA, 2017). As pesticides in the same class act similarly, class risk of the group herbicides from the triazine class:- atrazine, simazine, propazine, and their breakdown metabolites, can be reviewed in order to establish overall toxicity. The triazine pesticide class might be banned from applications in regional basins where groundwater is contaminated from both the accumulating active ingredient and the breakdown metabolites, or source water is threatened.

7. Prohibit trace metals in pesticide formulations.

Trace metals should not be in food – this is not just a 'legacy' problem. Arsenic is considered to arise from 'natural geochemical processes' (Mattingley & Nokes, 2019a) there has been little regulatory scrutiny of glyphosate formulations which are heavily applied to the New Zealand landscape by NZTA, councils, farmers and householders. A 2018 study identified the toxic, endocrine disrupting trace metals arsenic, chromium, cobalt, lead and nickel, which are known to be toxic and endocrine disruptors, as contaminants in 22 pesticides, eleven of which were glyphosate-based formulations (Defarge, de Vendômois, & Séralini, 2018). Phosphate fertiliser contains trace metals cadmium and arsenic (Jayasuma, et al., 2015). Cadmium levels in soil are of concern (Kim, 2005). Recent research appears to be funded by the fertiliser industry and minimum levels are voluntary. Authors have questioned whether current law and policy is adequate (Dearsley, 2015).

8. Recognise risk from AMR

Pesticides can cause bacteria to become less susceptible to antibiotics. Industrial chemicals from agriculture and urban sources are frequently detected in rivers and streams (Hageman, et al., 2019). Herbicides appear to create the conditions for bacteria to be more resistant to antibiotics at very low environmentally relevant levels. (Jun, et al., 2019; Kurenbach, et al., 2015; Kurenbach, et al., 2017; Kurenbach, Hill, Godsoe, van Hamelsveld, & Heinemann, 2018). Antibiotic-resistant E. coli has been detected in New Zealand streams (van Hamelsveld, et al., 2019). While studies are yet to determine whether antibiotic resistant E. coli populates streams outside of the Christchurch region the studies indicate visitors and locals may be frequently exposed to both AMR bacteria and the chemicals that influence antibiotic resistance.

9. Drinking Water: At a minimum - harmonise with European standards

1. Engage in leading research across chemical toxicology and endocrinology. New Zealand requires expert chemical toxicologists and endocrinologists to lead research to ensure chemical mixtures including their toxic metabolites in drinking water sources and in drinking water are restricted, and not picked off one by one in traditional linear risk assessment fashion. Similarly, impartial distance from industry is required so that toxic metabolites identified in the scientific literature but not counted in World Health Organisation drinking water regulations, (because industry has not provided the data on a specific toxic metabolite), might be included in screens, as a precautionary measure.

2. Monitor and protect drinking water sources. Source waters for drinking water suppliers must be monitored (and funded) at a national level and the suites must widely test for pesticides and their metabolites, trace metals and emerging organic contaminants. Ecological economics should be funded to understand cost benefits of freshwater for tourism, locals, and clean food (such as organic) systems, versus the benefits of traditional Pinus radiata plantations, whose pesticides end up in groundwater and may pollute drinking water, because nutrients and sediment are not the sole pollutant in New Zealand freshwater.

3. Harmonise with EU MAVS and test for the chemical and metabolites as identified in Europe. The current determinand attributes appear to be the only nationally monitored drinking water pollutant standards. There are gaps in MAVs - the science supporting them is frequently outdated and it is uncertain whether metabolites, for example recognised in European risk assessment, are screened for by contract laboratories. It appears up to individual drinking water suppliers as to whether to conduct broader pesticide and CEC screens and the privatised nature of laboratories may impose a greater cost on smaller suppliers (this needs to be confirmed). In the short term, harmonising with European standards may be the best option, as should be an obligation to place all results of chemical testing online in the public interest.

4. Maximum cumulative limit of chemicals (including metabolites) 0.5µg/L. For human health purposes, it is particularly important mixture effects of CECs and pesticides in drinking water are considered, and European limits to total pesticide contamination be restricted to not exceed 0.5µg/L (E.C., 1998).

5. Drinking Water: Monitor, evaluate and assess endocrinological loads. It is of the essence that transparent methodologies for assessing the oestrogenic, androgenic, thyroid, steroid loads in drinking water are developed, tested for, evaluated and monitored (Demeneix & Slama, 2019).

10. Guard the infant and child

'Ensure that pregnant women and children are not exposed to highly hazardous pesticides, or pesticides that have the potential for developmental toxicity or endocrine disruption, including through residues in food' (Watts, 2013, p. 122).

11. Ensure data & assessment is independent from the industry with the vested interest

Catherine Iorns has discussed the issue of industry control of data, noting that improvement to risk assessment would entail 'a requirement to seek information independent from that generated or provided by parties with a financial interest in the pesticide in question' (Iorns, 2018).

The current convention that industry supply their own private data to gain authorisation or re-authorisation undermines principles of administrative law which requires that decision-making must be unbiased. Further, authors of data used in risk assessment have failed to disclose conflicts of interest.

12. Maintain a public database of tonnages of active ingredients

Recording national production and import tonnages is standard practice in much of the world. Adjuvant ingredients can also be declared.

13. Alternatives to the pesticide treadmill: Regenerative Agriculture

Experts in regenerative agriculture consider that the notion that farmers cannot farm profitably without pesticides/biocides because crops would be low yielding and insect ridden deserves greater scrutiny. Instead, they point to the fact that New Zealand, while investing heavily in improving desirable genetic traits, has largely ignored the consequences to soil from industrial agriculture. They draw attention to the challenge farmers have in farming profitably when soil microbiology and the soil carbon sponge is degraded through the application of synthetic fertilisers and chemical inputs. New Zealand investment in soil science is poor in comparison to other countries.

1. Organic and low-input agriculture reduces chemical contamination of freshwater. Traditional approaches to agriculture include conventional 'industrial' farming systems which rely on synthetic chemical inputs; and organic systems, and which heavily restrict chemicals and prohibit synthetic chemicals.

   Agricultural chemicals migrate into freshwater environments. A 2013 study researched how farming practices on sheep and beef farms impact downstream pesticide levels. The study demonstrated that while mean pesticide concentrations were below recommended toxicity thresholds, a large proportion – 23% of the individual samples were above the toxicity thresholds. The study revealed that pesticides chlorpyrifos, endosulfan sulfate, DDT, dieldrin, or chlordane pollute New Zealand ecosystems (Shahpoury, Hageman, Matthaei, & Magbanua, 2013). These pesticides are all currently banned in the European Union, with the authorisation of chlorpyrifos ending in 2020.

   In another study, organic and low-input integrated management sheep and beef farming systems resulted in lower pesticides residues in stream environment than from conventional farming. The benefit from organic and low-input integrated management farming systems can flow on to benefit stream invertebrates, and organic farms can produce the lowest fine sediment loads (Magbanua, Townsend, Blackwell, Phillips, & Matthaei, 2010).

2. Farmers and pesticide applicators are at risk of disease and depression. New Zealand has an exceptionally high cancer rate (Bray, et al., 2018). Agricultural communities have higher risk of cancer, Parkinsons disease, respiratory, and arthritic problems, and this is associated with pesticide use (Mostafalou & Abdollahi, 2013) (Alavanja, Ross, & Bonner MR, 2013) (Amizadeh, Safari-Kamalabadi, Askari-Saryazdi, Amizadeh, & Reihani-Kermani, 2017). In addition, long term pesticide use is associated with farmer depression (2014) (Beseler, et al., 2008; Mackenzie Ross, Brewin, Curran, Abraham-Smith, & Harrison, 2010; Weisskopf, Moisan, Tzourio, Rathouz, & Elbaz, 2013). Practitioners in the related field of agroecology have noted that improvements include financial and wellbeing benefits (King, 2018).

3. Regenerative agriculture: Synergies from high pasture species variation and cover crops. Regenerative agriculture is receiving attention, in comparison the sustainability, proponents consider it involves 'repair, reform, recreate, reconstituting, improve and made better' (Merfield, 2019). As Charles Merfield notes, regenerative agriculture is a value system and science information-based movement that is responsive and solutions oriented. (Merfield, 2019) It is drawn from the understanding that current intensive agro-industrial practices degrade

farmland, polluting freshwater and marine environments; driving biodiversity loss, reducing access to potable water, damaging health and contribute multi-factorially to climate change (Sánchez-Bayo & Wyckhuys, 2019) (DiBartolomeis, Kegley, Radford, & Klein, 2019) (Lelieveld, Evans, Fnais, Giannadaki, & Pozzer, 2015) (Steffen, et al., 2015) (Lin, et al., 2011).

Key practices revolve around soil management, including no-till and avoidance of bare soil – living plants are a requisite of regenerative agriculture; integrated cropping and livestock management practices. Regenerative systems emphasise the management of soil fertility through use of mixed pasture species (20-60 species) with different level root systems, and the use of compost (Masters, 2019; Merfield, 2019). Landcare are developing an integrated framework for soil health (Landcare Research, 2019) and working with farmers. The interdisciplinary nature of regenerative agriculture does not fit historic 'science excellence' frameworks, and the sector is hopeful funding decision-makers recognise that both basic and applied sciences require harnessing. New Zealand farmers are active on social media sites WhatsApp and Facebook (Quorum Sense) discussing regenerative agriculture and 'quorum sensing' – the benefits that come from complex environmental synergies, such as increased drought tolerance from carbon retention in the soil, and potential to reduce polluting inputs.

4. Benefits of regenerative agriculture: higher nutrition and carbon sequestration. Regenerative agriculture's key difference appears to be the extremely high species variation in crops to achieve nutritional, dietary and soil carbon benefits. Historically, New Zealand pasture has revolved around ryegrass-clover mixes, and $25 million has been spent on developing a single patentable genetically engineered ryegrass species (Taunton, 2017).

5. Science based extension services working with key farmers as knowledge drivers. Agricultural extension was a common practice in New Zealand, and expert scientists could review the latest advances in the peer reviewed literature and disseminate this knowledge locally through New Zealand. This was disbanded after reforms in the 1980's, and privatisation meant that previously publicly available scientific resourcing was withdrawn.

   While some groups have continued with the extension model, such as the kiwifruit industry, DairyNZ and the Foundation for Arable Research, extension services could be accelerated, particularly in soil health and nutrition, in order to support farmers across the sectors as farm fertiliser use is restricted.

   The benefit of science-based information disseminated through the public sector might include scientific resourcing to identify and monitor individual and regional farm experience. Such resourcing would take into account long term trends and model short term and initially appealing solutions, alongside long term outcomes. Soil science and nutrition has been poorly funded for decades, and funding has been more successful for gene-based research. This has resulted in a significant body of international literature regarding soil and nutrition science without the local science expertise and funding to trial and implement.

Finally, public sector advice additionally might more readily account for downstream adverse consequences, that commercial information streams may be less willing to outline.

10.3 Hazardous Substances: Harmonise with European standards

As a minimum standard for reform, use European Commission as a trusted regulator and harmonise with European decisions.

This paper has discussed the thousands of chemicals in the environment, and the potential for chemical production to double by 2030. New Zealand simply cannot resource a chemical risk regulator to oversee this immense task, and transparency is a significant problem and reassessment practices are limited and out of date.

Harmonisation with best practice regulatory environment, using the European Commission as a trusted regulator, sends a message to trading partners. It also places New Zealand in a position to achieve SDG goals, protect biodiversity and protect source and drinking water.

10.4 Science for the environment – Resourcing science to recognise chemical pollution

1. Resourcing: Publicly owned laboratories – testing for the public good.

When regional councils test their water, they are charged for it. This acts as a disincentive. New Zealand has public laboratories. Frequently they develop their own screening methodology and the protocols are hidden by private IP and not available. It is unclear if these methodologies reflect European best practice, and if the levels of detection and reporting are at the lowest levels possible for public transparency.

In order to ensure civil society and science understand what is in freshwater and sediment, laboratories should be resourced with funding for:

- Latest generation of instrumentation
- Resourcing for a rotating national testing rounds with samples drawn late summer
- Protocols and methodologies should be transparently published and not hidden by IP
- Levels of detection levels and reporting should reflect international best practice

2. Resourcing: Endocrinology and the impact of environmental chemicals

Many endocrine disrupting substances are not reported nor detected due to lack of knowledge. Endocrine disrupting substances behave differently in the freshwater environments, and laboratory testing is not sufficiently predictive. Scientists have recognised that the key to past success, and to future advances is collaborative, multidisciplinary resourcing and engagement.

Complex biological systems respond differently to chemical mixtures, and this is beyond the capability of a single scientific field. Not all chemicals are harmful, but because EDCs can harm many different biological pathways, and contribute to the developmental origins of disease including cancer, it is important to identify EDCs and monitor for EDCs to provide transparency and guide decision-making and environmental and human health regulatory control.

A multidisciplinary approach can link the biological sciences with chemical toxicology and data analytics. There is a strong need for creative, cross-platform work to address complex issues and determine how biological systems interact to influence health and disease and also to reduce and eliminate extant EDC exposures (Schug, et al., 2016).

Experts have urged that funding should not be relegated to well researched, prominent chemicals but that it is necessary to promote a 'balance between delving ever further into the effects of known agents and diversifying their goals by casting a wider net that includes less well-known environmental hazards' (Schug, et al., 2016, p. 12). Further, adjuvants have been kept outside regulatory consideration. 'Catch up' work is required to understand the environmental and human body burden from adjuvant ingredients, and the contamination of food products (Mesnage & Antoniou, 2018).

Six areas for prioritising research has been flagged in a recent paper to the European Commission. They included: '(i) Epigenetic effects of EDs; (ii) Concern beyond the current generation; (iii) ED effects on the microbiome, an essential component of physiological and immune responses (iv) Green (safe) chemistry; (v) Novel ED modalities (vi) Characterization of dose-response functions for ED effects in human' (Demeneix & Slama, 2019, p. 98).

3. Resourcing: Game changing technology for complex systems analytics

Advances in predictive analytics and statistical techniques, including data mining, machine learning and predictive modelling should not be limited to the commercial sphere and social media. There is ample opportunity to utilise these technologies to drive knowledge to guide regulation and control for public and environmental health. Machine learning has increasing public health applications including in the healthcare sector (Kaur, Sharma, & Mittal, 2018) and in air pollution modelling (Kang, Gao, Chiao, Lu, & Xie, 2018).

Data modelling has limitations, and the OECD have noted 'Greater data collection and reliability can lead to continual improvements in the accuracy of models, and their capacity to make informed policy decisions. A concerted scientific effort can reduce uncertainties in predicting water quality and the consequence and benefits of current and alternative trends and scenarios' (OECD, 2017b, p. 75).

An informed data-led perspective can facilitate a wider policy debate that extends beyond environmental protection, and 'can connect water quality issues with issues of higher political value, or are readily associated with obvious benefits, such as health, ecosystem services, economics and food security' (OECD, 2017b, p. 107).

Chemical by chemical approaches may be infeasible from a resourcing perspective, impossible for identifying diffuse source points and cannot address the additive and synergistic toxicities exerted from ongoing, low level chronic synthetic chemical emissions. Stepping into high level analytics provides an opportunity shed light in this area. Logically, why should social media and 'gidget' sales be the beneficiaries of cutting edge technology – when New Zealand is faced with species extinction?

An authoritative body of science informs us that an enormous component of risk happens at the levels that hormones function, at parts per billion or trillion, - factors chemical regulators rarely consider (Gore, et al., 2015). Multidisciplinary approaches can bring together experts in ecology, toxicology and endocrinology. These experts can consult with leaders in neural network and algorithm design to formulate technical and scientific approaches to ecosystem and human health risk. Biodiversity loss and species extinction is deeply complex, and scientists and analysts require the funding and political support to transition a culture that has traditionally encouraged applied science research grants, to provide a mandate to comprehensively investigate the complex troubles that arise from environmental pollution. For what is the point of permitting pollution, if we lack the scientific expertise to address it?

In order for policy to be protective, funding to support research and monitoring techniques to guide knowledge around treatment efficacy; development of protocols to derive ecotoxicity and to understand additive and synergistic effects (Gorgoi, et al., 2018) would ensure science in New Zealand can keep pace and add to international knowledge.

Intelligent design and predictive modelling which can recognise the mixture effect from ongoing chemical stressors applied at a farm or industry level, can also draw attention to the complex networks that benefit from freshwater protection.

Artificial neural networks are a form of machine learning. Connective algorithms incorporate new data, mimicking the learning process. Scientists and analysts are incorporating predictive technologies, including fuzzy mathematics, stochastic mathematics, 3S technology, artificial neural networks (ANN) to improve water quality prediction models (Kadam, Wagh, Muley, Umrikar, & Sankhua, 2019; Liu, Wang, Sanglaiah, Xie, & Yin, 2019).

10.5 OECD recommendations

The OECD paper Diffuse Pollution, Degraded Waters: emerging policy solutions outlines a tiered framework (OECD, 2017b) to protect water from diffuse emissions. The OECD acknowledges the political resistance to regulation and application of the polluter pays principle.

The framework centres around a knowledge base – in order to implement effective policies and protect, the risks must be identified and known, taking into account time lags, historical pollution and planned land use change. Once stressors are identified risks can be assessed – particularly threats of serious or environmental damage - and targets established, then finally, this can step into informed policymaking to assign risks 'at least cost for society'.

> 'The first step in a risk-based approach to water quality is to identify pollutants, their origin, timing and pathways, and their risks to water quality, including their likelihood and impact' (OECD, 2017b, p. 105).

The discussion in section 3.6 on sediment noted the tendency of chemicals and trace metals to bind to sediment. Therefore it is of the essence that not only testing of water for diffuse chemical contaminants, but that chemical and trace metal testing of sediment is undertaken, in areas identified as degraded, dysbiotic and/or nutrient rich (including problems with toxic cyanobacteria growth).

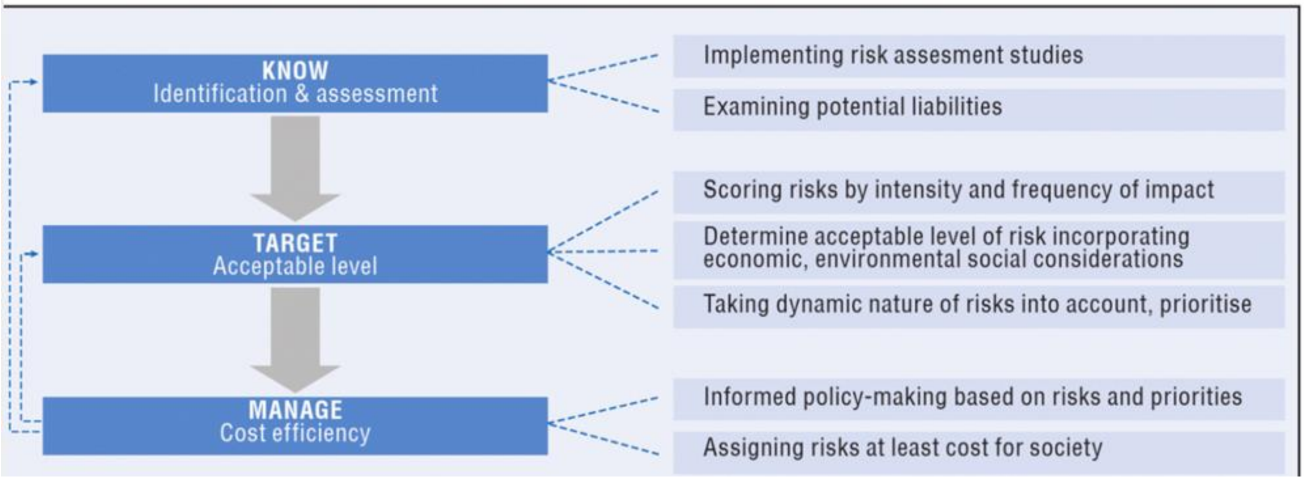
The OECD diffuse pollution framework acknowledges the inherent difficulty and complexity in regulating large numbers of small sources, but emphasises that:

> 'a science-based approach is essential to formulate a multidisciplinary approach to the complex issue of water quality; to manage water quality and quantity in unison, their shocks and tipping points, and their spill-overs to other locations, media (i.e. water, air, land) and sectors' (OECD, 2017b, pp. 105-106).

The OECD policy framework places knowledge at the heart of risk-management :

A risk-based approach to water quality utilises the OECD water security risk framework "Know the risks", "Target the risks" and "Manage the risks" (OECD, 2013) (Figure 4.1).

Figure 4.1 **A Risk-Based Approach to water quality management**



Once stressors are recognised, regulatory controls can be established at a national level or to restrict further emissions in freshwater basins. The OECD Environmental Performance Review of New Zealand noted that there will always be uncertainty around setting limits and that central government support can expedite limit setting:

> 'When water quality and quantity limits and trigger points are set, there will inevitably be a level of uncertainty, natural variability and risk around these values. However, a lack of absolute science should not be a barrier to making progress with setting limits. Uncertainties and risks need to be considered and built into policy development. In this way, if the values set are not conservative enough, or trigger points are reached, a mechanism can rectify this in a timely manner, and if necessary, before the ten-yearly regional plan review cycle. Central government could help expedite limit setting by developing and providing freshwater science and data to support regional policy design as well as by helping regional councils to assess, design and develop policy instruments.' (OECD, 2017a, p. 167)

The polluter pays principle is frequently not applied in the case of diffuse emissions – taxes have led to reduction in input use without loss of farm production.

Table 3.3. **Examples of features of pollution charges in selected OECD countries**

Country	Levied by	Tax name	Specific tax base	Tax structure
Australia	State	Water effluent charge	Volume, pollution content (types of pollutants)	per kg assessable load
Canada	Province	Charge on discharge	Volume and pollution content	per litre or per tonne
Denmark		Diffuse source	Chemical deterrents of insects and mammals	tax on retail price
France		Diffuse source	Pesticides	per kg
		Water effluent charges	Households	per m^3
Netherlands		Tax on the pollution of surface waters	BOD, COD and heavy metals, for large polluters	per pollution unit
Sweden	Municipality	Wastewater user charges	Wastewater and drinking water	varies by municipality; full cost charging
		Diffuse source	Pesticides	per whole kg active constituent

Source: OECD database on Policy Instruments for the Environment (Accessed 20/03/2016).

Norway has had a pesticides tax since 1999 with seven tax bands, adjustable for health and environment related risks, Denmark has applied a pesticides tax since 2013 targeted to the toxicity of the pesticides used and in France taxes are used to both finance and encourage reductions. (OECD, 2017b, p. 82) Regulations and taxes can be balanced by economic subsidies and incentives, as well as education and knowledge transfer, for example, via agricultural extension services.

The beneficiary pays principle as a Payment for Ecosystem Services schemes, downstream industries reward upstream users to reduce pollution, however this can be politically complex as best practice farmers might not be rewarded while polluting farmers are. The OECD has suggested meeting minimum regulatory standards may help overcome equity issues. (OECD, 2017b, p. 60)

Further the OECD paper notes that the grandparent approach, while the most frequently used approach to regulate outputs, is also the most inequitable, as it rewards historic polluters, who may also be the operators who can reduce pollution at lower cost.

The 2017 OECD paper outlines that political action can be activated if co-benefits are more comprehensively addressed (p.108):

Box 4.2. **Connect with higher level policy issues to trigger political action on water pollution** *(cont.)*

Identifying touchstones can make tangible connections with water quality improvements and support compelling stories. For example, restoration of otters, salmon and other fish in England's rivers has triggered a strong political coalition to improve water quality (Defra, 2011). Making the economic case, computing the cost of inaction, and strengthening valuations of diffuse water pollution in environmental impact assessments can support proposals for action. Information campaigns can rally public support.

Examples of co-benefits to governments for improved water quality management

Co-benefits of improving and protecting water quality	
• Secure water resources (increase water of useable quality). • Adapt to a changing climate. • Reduce flood risk (e.g. catchment protection management, permeable pavements, swales, wetlands). • Reduce health costs (e.g. cancers associated with nitrates). • Improve biodiversity, ecosystem health and the value of ecosystem services. • Improve long term sustainable agricultural, aquaculture and industrial productivity. • Energy production and utilisation of finite minerals and nutrients through wastewater reuse. • Increase cultural and social relations and trust in government.	• Reduce economic losses associated with sick days. • Sustain and increase food security. • Boost and protect tourism. • Improve marketing image/reputation for exports. • Reduce energy consumption (pumping stormwater, water treatment). • Reduce water treatment costs (reduce the need for upgrades or additional plants). • Improve amenity of waterfront properties and public spaces. • Mitigate climate change (e.g. forested catchments, wetlands and build-up of soil organic matter). • Increase recreational use of water bodies. • Increase value of water resources (economic, cultural, spiritual, environmental) and human wellbeing.

Sources: Authors own; Defra (2011).

Conclusion

Policy making is a messy business, but there is scientific evidence adverse pressure from chemical pollution will continue to stress environmental and human health and ultimately devalue life quality for future generations. The current NPS-FW can be put in place, and national reporting for chemical pollution can be restricted to bacterial, protozoa, cyanotoxin (for surface water supplies). These leaves stark policy gaps that ignores the evidence that chemical mixtures are in our environment, at levels banned in Europe and that they are accumulating. Source waters will continue to be a 'black hole' of regulation; and chemical compliance for drinking water will continue to be restricted to a select range of determinands - some trace metals, chlorine by-products and fluoride. The chemicals, absent of monitoring and control, will continue unabated.

This blinkered view cannot shape the kind of 'anticipatory governance' that Jonathan Boston suggests is appropriate to a robust and future-proofed society (Boston J. , 2017). It cannot safeguard water. A coordinated policy approach will integrate land use management, with air pollution control and water quality – using established scientific evidence from chemical toxicology and incorporating research on chemical risk to the endocrine and immune systems. It will detect creep – slow environmental accumulation – so that policy response and control might anticipate and prevent irreversible and unforeseen adverse effects. This is directly achievable.

As Sir Peter Gluckman has noted

> 'policy formed without consideration of the most relevant knowledge available is far less likely to serve the nation well' (Gluckman P. , 2011).

In such an environment, there remain many opportunities to ensure policy and regulation concerning freshwater are fit for purpose. Firstly, where degraded areas are identified, scientists can step into a suite of *national environment standard*, nationally regulated testing screens for chemical contaminants and publish this information for public debate. To manage we must measure. Secondly, New Zealand can resource scientist experts in chemical toxicology, endocrinology and environmental chemistry to evaluate the risk to both aquatic food chains and human health – at arms-length from industry, sound research questions have already been identified (Gaw, et al., 2019). Thirdly, where risk is identified, New Zealand can appropriately engage the precautionary principle, as Catherine Iorns has suggested, at a meta-level – as the key policy instrument, rather than retaining it where it currently sits in legislation and policy, alongside social, cultural and economic considerations where it is rarely called upon, and frequently ignored.

The suite of recommendations in section 10 may appear onerous – *a 'simpler' alternative is to harmonise with the most democratically accountable regulator, the European Commission*. This could be revised every 10-15 years. It would send a message to trading partners, and it would lift our regulatory system above the powerful industry networks that are the dominant content providers shaping regulatory risk assessment today. The HSNO Act needs a substantial amount of work, and we are a small country with a limited base of expertise. Structuring a framework that aligns with European legislation will tick many boxes, in the public interest.

This paper has at length, addressed our hazardous substances regulatory system. This is because capacity of our regulators to undertake risk assessment based on the latest scientific knowledge, separate from the influence of vested interests, is - *of the essence* - if our other statutory authorities that depend on NZEPA decisions, are to also protect human and environmental health and respect the obligations of government to the Treaty of Waitangi.

The capacity of regulators to safely control hazardous substances directly impacts human rights – the right to clean water, and to health. Government employees can actively ensure that the tail is not wagging the dog. The NZEPA reports to the MfE and the MfE has power to direct the NZEPA on policy. Expert scientists outside the NZEPA environment can similarly drive NZEPA change. There is little point in the NZEPA authorising substantial tonnages of chemical mixtures into the environment, if the science that informs the regulator cannot adequately guard against the toxicity of those chemical mixtures; and if the regulator cannot practise adequate reassessment as stewardship and kiatiakitanga - through a rigorous and impartial reassessment process.

Special attention has been paid to the greater vulnerability of the foetus, infant and child, and their inability to avoid toxic substances. The Special Rapporteur has emphasised the particular responsibilities of governments, stating: 'States have a human rights obligation and businesses a corresponding responsibility to prevent childhood exposure to toxic chemicals and pollution'.

This paper has attempted to persuade scientists, civil society and our decision-makers, that top down interdisciplinary resourcing to provide the scientific and knowledge framework to resource farmers to initiate evidence-based change. Furthermore, bottom up monitoring and predictive analytics to inform science, guide industry and help educate the civil sector, may be New Zealand's best opportunity to protect not only human and environmental health today, but the health of our grandchildren and our ecology tomorrow.

The decision to implement an integrated strategy and to step into innovative reform with actionable controls, is not *scientific*, it is *political*.

How else can we safeguard our environment for future generations so that we retain a 'safe operating space for humanity' (Steffen, et al., 2015)?

Bibliography

Alavanja, M., Ross, M., & Bonner MR. (2013). Increased cancer burden among pesticide applicators and others due to pesticide exposure. *CA Cancer J Clin., 63*(2), 120-42.

Allibone, R., & et al. (2010). Conservation status of New Zealand freshwater fish, 2009. *New Zealand Journal of, 44*(4), 271-287.

Amizadeh, M., Safari-Kamalabadi, M., Askari-Saryazdi, G., Amizadeh, M., & Reihani-Kermani, H. (2017). Pesticide Exposure and Head and Neck Cancers: A Case-Control Study in an Agricultural Region. *Iran J Otorhinolaryngol, 29*(94), 275-285.

ANZECC. (2000). *Australian and New Zealand Environment and Conservation Council. Australia and New Zealand guidelines for fresh and marine water quality.* Environment Australia.: Townsville.

Attina, T., Hauser, R., Sathyanarayana, S., Hunt, P., Bourguignon, J., Myers, J., . . . Trasande, L. (2016). Exposure to endocrine-disrupting chemicals in the USA: a population-based disease burden and cost analysis. Lancet Diabetes Endocrinol 2016; 4: 996–1003. *Lancet Diabetes and Endocrinology*, 996-1003.

Auyero, J., & Swistun, D. (2008). The Social Production of Toxic Uncertainty. *American Sociological Review*, 357-379.

Basu, K. (2016). *Beyond the Invisible Hand: Groundwork For A New Economics.* Princeton: Princeton University Press.

Baum Hedlund. (2019). *Jon Entine and Genetic Literacy Project are Monsanto Trolls. September 10 2019.* Retrieved from Baum Hedlund Aristei Goldman: https://www.baumhedlundlaw.com/9-19-entine-glp-monsanto-trolls/

Benbrook, C. (2016). Trends in glyphosate herbicide use in the United States and globally. *Environmental Sciences Europe*, *28*(1), 3.

Benbrook, C. (2019). How did the US EPA and IARC reach diametrically opposed conclusions on the genotoxicity of glyphosate-based herbicides. *Environmental Sciences Europe*, 1-16.

Beseler, C., Stallones, L., Hoppin, J., Alavanja, M., Blair, A., & Keefe, T. (2008). Depression and pesticide exposures among private pesticide applicators enrolled in the Agricultural Health Study. *Environ Health Perspect*, *116*, 1713–1719.

Bonmarito, P., Martin, E., & Fry, R. (2017). Effects of prenatal exposure to endocrine disruptors and toxic metals on the fetal epigenome. *Epigenomics*, *9*(3), 333-350.

BOPRC. (2018). *Proposed Plan Change 13 to the Regional Natural Resources Plan. Staff Recommendations with Submissions and Further Submissions By Section. Version 6.0 October 2018*. Whakatane: Bay of Plenty Regional Council.

BOPRC. (2019). *Air Quality Proposed Plan Change 13*. Retrieved from Bay of Plenty Regional Council: Submissions: https://www.boprc.govt.nz/your-council/plans-and-policies/plans/regional-plans/regional-air-plan/air-quality-proposed-plan-change-13/

Boston, J. (2017). *Safeguarding the Future, Governing in an Uncertain World.* Wellington: Bridget Williams Books.

Boston, J., Bagnall, D., & Barry, A. (2019). *Foresight, insight and oversight: Enhancing long-term governance through better parliamentary scrutiny. Institute for Governance and Policy Studies.* Wellington: School of Government Victoria University of Wellington.

Boyd, R. (2010). Heavy Metal Pollutants and Chemical Ecology: Exploring New Frontiers. *Journal of Chemical Ecology*, *36*(1), 46-58.

Braun, K., & Kropp, C. (2010). Introduction: Beyond Speaking Truth? Institutional Responses to Uncertainty in Scientific Governance. *Science, Technology, & Human Values*, *35*(6), 771-782.

Bray, F., Ferlay, J., Soerjomataram, I., Siegel, R., Torre, L., & Jemal, A. (2018). Global Cancer Statistics 2018: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. *CA: A Cancer Journal for Clinicians*, 68, 394-424.

Brown, M. (2017). *Last Line of Defence*. Wellington: Environmental Defence Society.

Bruning, J. (2018). *Transcript. Presentation to Hearing Committee for the BOPRC Proposed Plan Change 13 to the Regional Natural Resources Plan October, 17, 2018. Bay of Plenty Regional Natural.* Tauranga.

Bruning, J., & Browning, S. (2017). *Public Health Concern: Why did the NZ EPA ignore the world authority on cancer?* Wellington: Green Party of Aotearoa New Zealand.

Buonsante, V., Muilerman, H., Santos, T., Robinson, C., & Tweedale, A. (2014). Risk assessment's insensitive toxicity testing may cause it to fail. *Environmental Research*, 139-147.

Burton, G. (2002). Sediment quality criteria in use around the world. *Limnology*, *3*, 65-75.

Chen, J., Fine, J., & Mullin, C. (2018). Are organosilicon surfactants safe for bees or humans? *Science of the Total Environment, 612*, 415-421.

Clausing, P., Robinson, C., & Burtscher-Schaden, H. (2018). Essay: Pesticides and public health: an analysis of the regulatory approach to assessing the carcinogenicity of glyphosate in the European Union. *Journal of Epidemiology & Community Health, 72*(8), 1-5.

CLO. (2005). *The Judge over your shoulder. A guide to judicial review of administrative decisions.* . Wellington: Crown Law Office.

Close, M., & Humphries, B. (2014). National Survey of Pesticides in Groundwater 2014. *Journal of Hydrology, 55*(2), 73-88.

Close, M., & Humphries, B. (2019). National Survey of Pesticides and Emerging Organic Contaminants (EOCs) in Groundwater. Institute of Environmental Science and Research Limited. https://www.esr.cri.nz/home/about-esr/media-releases/groundwater-pesticide-survey-finds-organic-contaminantsnew-news-page/

CNIDWAU. (2019). *Report on Compliance with the Drinking-water Standards for New Zealand 2005 (Revised 2008) and duties under Health Act 1956. For Period: 1 July 2017 to 30 June 2018* . Tauranga: Central North Island Drinking Water Assessment Unit – Toi Te Ora . Retrieved from https://www.tauranga.govt.nz/Portals/0/data/council/water_services/water_supply/files/drinking_water_compliance_report2017-18.pdf

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., . . . van den Belt, M. (1997). The Value of the world's ecosystem services and natural capital. *Nature, 387*, 253-260.

Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., . . . Grasso, M. (2017). Twenty years of ecosystem services: How far have we come and how far do we still need to go? *Ecosystem Services*, 1-16.

Cozzens, S., & Woodhouse, W. (2001). Science, Government and the Politics of Knowledge. In S. Jasanoff, G. Markle, T. Pinch, & J. Peterson, *Handbook of Science and Technology Studies* (pp. 533-553). SAGE.

Davies-Colley, R. (2013). River Water Quality in New Zealand an Introduction and Overview. In J. Diamond, *Ecosystem services in New Zealand: conditions and trends* (pp. 432-446). Landcare Research.

Dearsley, C. (2015). Cadmium levels from fertiliser in soil and food: The adequacy of New Zealand's law and policy. *New Zealand Journal of Environmental Law, 19*, 241-280.

Defarge, N., de Vendômois, J., & Séralini, G. (2018). Toxicity of formulants and heavy metals in glyphosate-based herbicides. *Toxicology Reports*, 156-163.

Demeneix, B. (2017). *Toxic Cocktail. How chemical pollution is poisoning our brains.* New York: Oxford University Press.

Demeneix, B., & Slama, R. (2019). *Endocrine Disruptors: from Scientific Evidence to Human Health Protection. requested by the European Parliament's Committee on Petitions. PE 608.866 - March 2019.* Brussels: Policy Department for Citizens' Rights and Constitutional Affairs.

Dharmadasa, P., Kim, N., & Thunders, M. (2017). Maternal cadmium exposure and impact on foetal gene expression through methylation changes. *Food and Chemical Toxicology, 109*(1), 714-720.

DIA. (2019). *Three Waters Review*. Retrieved from Department of Internal Affairs: https://www.dia.govt.nz/Three-Waters-Review

Diamanti-Kandarakis, E., Bourguignon, J.-P., Giudice, L., Hauser, R., Prins, G., Soto, A., . . . Gore, A. (2009). Endocrine-Disrupting Chemicals: An Endocrine Society Scientific Statement. *Endocrine Reviews*, 293-2009.

DiBartolomeis, M., Kegley, S., Radford, R., & Klein, K. (2019). Research Article. An assessment of acute insecticide toxicity loading (AITL) of. PLoS ONE, 14(8), e0220029.

Dodson, J. (2006). The "Roll" of the State: Government, Neoliberalism and Housing Assistance in Four Advanced Economies. *Housing, Theory and Society*. doi:https://doi.org/10.1080/14036090601043540

Douwes, J., 't Mannetje, A., McLean, D., Pearce, N., Woodward, A., & Potter, J. (2018). Carcinogenicity of glyphosate: why is New Zealand's EPA lost in the weeds? *New Zealand Medical Journal*, 82-89.

Dulio, V., van Bavel, B., Brorström-Lundén,, E., Harmsen, J., Hollender, J., Schlabach, M., . . . Koschorreck, J. (2018). Emerging pollutants in the EU: 10 years of NORMAN in support of environmental. *Environ Sci Eur, 30*(1), 5.

Dunlap, R., & McCright, A. (2011). Chapter: Organized Climate Change Denial. In J. Dryzek, R. Norgaard, & D. Schlosberg, *Handbook of Climate Change and Society.* Oxford Handbooks Online.

Dunn, N., Allibone, R., Closs, G., Crow, S., David, B., Goodman, J., . . . Rolfe, J. (2018). *Conservation status of New Zealand freshwater fishes, 2017.* . Wellington: Department of Conservation.

E.C. (1998). European Directive 98/83/EC sets quality limits for pesticides and their relevant metabolites: 0.1 µg/L per individual substance and 0.5 µg/L for the sum of these compounds. 5.12.1998. *Official Journal of the European Communities*, L 330/32 - L 330/54. Retrieved from https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1998:330:0032:0054:EN:PDF

E.C. (2013). Directive 2013/39/EU of the European Parliament and of the Council of 12 August 2013 Amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy. *Official Journal of the European Union* , L 226/1 - L 226/17. Retrieved from https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:226:0001:0017:EN:PDF

E.C. (2018). *Updated surface water Watch List adopted by the Commission. July 03 2018*. Retrieved from EU Science Hub: https://ec.europa.eu/jrc/en/science-update/updated-surface-water-watch-list-adopted-commission

E.C. (2018d). *European Commission: Ten years of REACH: making chemicals safer for consumers, workers and the environment.* Brussels: European Commission. Retrieved from https://europa.eu/rapid/press-release_IP-18-1362_en.htm

E.C. (2019a, April). *EU Science Hub. Measuring pollutants in Europe's water resources.* Retrieved from European Commission: https://ec.europa.eu/jrc/en/science-update/measuring-pollutants-europes-water-resources

E.C. (2019b). *Search Active Substances.* Retrieved from European Commission EU Pesticides database.: https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=activesubstance.selection&language=EN

E.C. (2019c). *Strategies against chemical pollution of surface waters.* Retrieved from European Commission: https://ec.europa.eu/environment/water/water-dangersub/index.htm

ECHA. (2019). *REACH Registration Statistics.* European Chemicals Agency. Retrieved from https://echa.europa.eu/registration-statistics

EDS. (2019). Conference: Through New Eyes. Pre-conference Workshop: Tuesday 13 August 2019. http://www.eds.org.nz/keep-in-touch/blog/2019/through-new-eyes-conference-videos-available/: Environmental Defence Society.

EEA. (2018). *European waters. Assessment of status and pressures 2018. EEA Report No 7/2018.* European Environmental Agency.

EEA. (2018). *Chemicals in European Waters: Knowledge Developments. EEA Report 18/2018.* European Environmental Agency.

EEA. (2019, January 16). *More action needed to tackle mixtures of chemicals in Europe's waters.* Retrieved from European Environment Agency: https://www.eea.europa.eu/highlights/more-action-needed-to-tackle

EFSA. (2017). Peer review of the pesticide risk assessment for the active substance terbuthylazine in light of EFSA 2017. Peer review of the pesticide risk assessment for the active substance terbuthylazine in light of. *EFSA Journal, 15*(6), 20. Retrieved from https://doi.org/10.2903/j.efsa.2017.4868

EFSA. (2019, August 2). *Chlorpyrifos: assessment identifies human health effects*. Retrieved from European Food Safety Authority: https://www.efsa.europa.eu/en/press/news/chlorpyrifos-assessment-identifies-human-health-effects

ERMA. (2004). *NZS 8409: 2004 Management of Agrichemicals Code of Practice (Edict of Government) Text available at. Appendix N.* Wellington: Standards New Zealand. Retrieved from https://archive.org/stream/nzs.8409.2004/nzs.8409.2004_djvu.txt

Evans, R., Martin, O., Faust, M., & Kortenkamp, A. (2016). Should the scope of human mixture risk assessment span legislative/regulatory silos for chemicals? *Science of the Total Environment*, 757–764.

FAO. (2019). *FAOSTAT pesticides database. Food and Agriculture Organization* . Retrieved from Food and Agriculture Organization : http://www.fao.org/faostat/en/#home

Gangemi, S., Gofita, E., Costa, C., Teodoro, M., Briguglio, G., Nikitovic, D., . . . Fenga, C. (2016). Occupational and environmental exposure to pesticides and cytokine pathways in chronic diseases (Review). *International Journal of Molecular Medicine, 38*(4), 1012-1020.

Gaw, S., Harford, A., Pettigrove, V., Sevicke-Jones, G., Manning, T., Ataria, J., ... Moggridge, B. (2019). Towards Sustainable Environmental Quality: Priority Research Questions for the Australasian Region of Oceania. *Integrated environmental assessment and management* 10.1002/ieam.4180

General Court of the European Union. (2019). *Press Release No 25/19. Judgment in Cases T-716/14 Anthony C. Tweedale v European Food Safety Agency (EFSA) and T-329/17 Hautala and Others v EFSA.* Luxembourg: General Court of the European Union. Retrieved from https://curia.europa.eu/jcms/upload/docs/application/pdf/2019-03/cp190025en.pdf

Ghassabian, A., & Trasande, L. (2018). Disruption in Thyroid Signaling Pathway: A Mechanism for the Effect of Endocrine-Disrupting Chemicals on Child Neurodevelopment. *Frontiers in Endocrinology*, 204. doi:https://doi.org/10.3389/fendo.2018.00204

Gluckman, P. (2011). *Towards better use of evidence in policy formation: a discussion paper.* Wellington: PMSCA. Retrieved from http://www.pmcsa.org.nz/wp-content/uploads/Towards-better-use-of-evidence-in-policy-formation.pdf

Gluckman, P. (2017). *New Zealand's fresh waters: Values, state, trends and human impacts.* Auckland: Office of the Prime Minister's Chief Science Advisor. Retrieved from https://www.pmcsa.org.nz/wp-content/uploads/PMCSA-Freshwater-Report.pdf

Goodman, J., Dunn, N., Ravenscroft, P., Allibone, R., Boubee, J., David, B., . . . Hitchmough, R. (2013). *Conservation status of New Zealand freshwater fish, 2013.* . Wellington: Department of Conservation.

Gore, A., Chappell, V., Fenton, S., Flaws, J., Nadal, A., Prins, G., . . . Zoeller, R. (2015). 2015. EDC-2: The Endocrine Society's Second Scientific Statement on Endocrine-Disrupting Chemicals. *Endocr Rev, 36*(6), E1-E150.

Gorgoi, A., Mazumder, P., Tyagi, V., Chaminda, G., Kyoungjin An, A., & Kumar, M. (2018). Occurrence and fate of emerging contaminants in water environment: A review. *Groundwater for Sustainable Development, 6*, 169-180.

Hageman, K., Aebog, C., Luong, K., Kaserzon, S., Wong, C., Reeks, T., . . . Matthaei, C. (2019). Current-Use Pesticides in New Zealand Streams: Comparing Results from Grab Samples and Three Types of Passive Samplers. *Environmental Pollution, 254*, 112973. Retrieved from https://doi.org/10.1016/j.envpol.2019.112973

Hass, U., Christiansen, S., Andersson, A., Holbech, H., & Bjerregaard, P. (n.d.). *Report on Interpretation of knowledge on endocrine disrupting substances (EDs) – what is the risk?* Danish Centre on Endocrine Disruptors (CEHOS).

Hess, D. (2015). Undone Science, Industrial Innovation, and Social Movements. In M. Gross, & L. McGoey, *The Routledge International Handbook of Ignorance Studies* (pp. 141-154). London: Routledge. Retrieved from http://www.davidjhess.org/uploads/3/5/1/3/3513369/handbookignorance.finaldraft.pdf

Hill, M. (2019, September 29). *Abnormal Development - Heavy Metals*. Retrieved from Embryology: https://embryology.med.unsw.edu.au/embryology/index.php/Abnormal_Development_-_Heavy_Metals

Hills Laboratories. (2019, September 10). Response to email: 'We sub-contract 1080 testing to Landcare research and their price for soil testing is $981+GST per sample, and for water it's $661+GST.'.

Howard, G. (2018). *Howard G. From BPA to BPZ: a toxic soup? How companies switch from a known hazardous chemical to one with similar properties, and how regulators could stop them. March 2018 A ChemTrust Report.* ChemTrust.

IARC. (2015). *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. DDT, Lindane and 2,4-D. Volume 113.* Lyon: International Agency for Research on Cancer. Retrieved from https://monographs.iarc.fr/wp-content/uploads/2018/06/mono112-10.pdf

Iorns, C. (2018). Permitting Poison: Pesticide Regulation in Aotearoa New Zealand. *EPLJ*, 456-490.

IUPAC. (2019). *General Information for sodium monofluoroacetate*. Retrieved from International Union of Pure and Applied Chemistry : http://sitem.herts.ac.uk/aeru/iupac/Reports/3160.htm

Jayasuma, C., Fonseka, S., Fernando, A., Jayalath, K., Amarasinghe, M., & Siribaddana, S. (2015). Phosphate fertilizer is a main source of arsenic in areas affected with chronic kidney disease of unknown etiology in Sri Lanka. *SpringerPlus, 4*, 90.

Joseph, P. (2014). *Constitutional and Administrative Law in New Zealand, 4th Ed.* Wellington: Thomson Reuters.

Joy, M. & McLean, S. (2019) Despite its green image, NZ has world's highest proportion of species at risk. *The Conversation.* April 30, 2019. https://theconversation.com/despite-its-green-image-nz-has-worlds-highest-proportion-of-species-at-risk-116063

JRC (2018). *Something from nothing? Ensuring the safety of chemical mixtures.* JRC Science for Policy Brief. May 2018. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC111886/kjna29258enn.pdf

Jun, H., Kurenbach, B., Wasa, A., Remus-Emsermann, M., Godsoe, W., & Heinemann, J. (2019). Effects of sub-lethal concentrations of copper ammonium acetate, pyrethrins and atrazine on the response of Escherichia coli to antibiotics. *F1000Research, 8*.

Kadam, A., Wagh, V., Muley, A., Umrikar, B., & Sankhua, R. (2019). Prediction of water quality index using artificial neural network and multiple linear regression modelling approach in Shivganga River basin, India. *Modeling Earth Systems and Environment, 5*(3), 951-962.

Kang, G., Gao, J., Chiao, S., Lu, S., & Xie, G. (2018). Air Quality Prediction: Big Data and Machine Learning Approaches. *International Journal of Environmental Science and Development, 9*(1), 8-16.

Kaur, P., Sharma, M., & Mittal, M. (2018). Big Data and Machine Learning Based Secure Healthcare Framework. *Procedia Computer Science* , 1049-1059. doi:10.1016/j.procs.2018.05.020

Kelley, A., Banker, M., Goodrich, J., Dolinoy, D., Burant, C., Domino, S., . . . Padmanabhan, V. (2019). Early pregnancy exposure to endocrine disrupting chemical mixtures are associated with inflammatory changes in maternal and neonatal circulation. *Scientific Reports*, 5422.

Kelsey, J. (1997). *The New Zealand Experiment: A World Model for Structural Adjustment?* . Wellington: Bridget Williams Books.

Kim, N. (2005). *Cadmium Accumulation in Waikato Soils. Document #: 921188v2.* Hamilton East: Environment Waikato Technical Report 2005/51 .

King, J. (2018). *Regenerative Farming Enhances Finances the Environment and Farmer Mental Health*. Retrieved from Pure Advantage: https://pureadvantage.org/news/2018/11/07/regenerative-farming-enhances-finances-the-environment-and-farmer-mental-health/

Kippler, M., Engström, K., Jurković Mlakar, S., & Bottai, M. (2013). Sex-specific effects of early life cadmium exposure on DNA methylation and implications for birth weight. *Epigenetics*, 24401.

Klein, A., Byerley, C., & McEachern, T. (2009). Counterframing public dissent: An analysis of anti-war. *Critical Studies in Media Communication, 26*(4), 331-350.

Kleinmann, D., & Suryanarayanan, S. (2012). Dying Bees and the Social Production of Ignorance. Science. *Technology Human Values, 38*, 492.

Knight, C. (2019). A Potted History of Freshwater Management in New Zealand. *Policy Quarterly, 15*(3), 3-7.

Kortenkamp, A. (2014). Low dose mixture effects of endocrine disrupters and their implications for regulatory thresholds in chemical risk assessment. Curr. Opin. Pharmacol. 19, 105–111. *Current Opinion Pharmacology*, 105-111.

Kortenkamp, A., & Faust, M. (2018). Regulate to reduce chemical mixture risk. *Science*, 224-226.

Kubiszewski, I., Constanza, R., Anderson, S., & Sutton, P. (2017). The future value of ecosystem services: Global scenarios and national implications. *Ecosystem Services, 26*, 289-301.

Kubsad, D., Nilsson, E., King, S., Sadler-Riggleman, I., Beck, D., & Skinner, M. (2019). Assessment of Glyphosate Induced epigenetic transgenerational Inheritance of pathologies and sperm epimutations: Generational toxicology. *Nature Scientific Reports, 9*, 6372. Retrieved from https://doi.org/10.1038/s41598-019-42860-0

Kumar, R., Sarmah, A. K., & Padhye, L. P. (2019). Fate of pharmaceuticals and personal care products in a wastewater treatment plant with parallel secondary wastewater treatment train. JOURNAL OF ENVIRONMENTAL MANAGEMENT, 233, 649-659. 10.1016/j.jenvman.2018.12.062

Kumar, R., Tscharke, B., O'Brien J, Mueller, J. F., Wilkins, C., & Padhye, L. P. (2019). Assessment of drugs of abuse in a wastewater treatment plant with parallel secondary wastewater treatment train. *Science of the Total Environment*, 658, 947-957. 10.1016/j.scitotenv.2018.12.167

Kurenbach, B., Gibson, P., Hill, A., Bitzer, A., Silby, M., Godsoe, W., & Heinemann, J. (2017). Herbicide ingredients change Salmonella enterica sv. Typhimurium and Escherichia coli antibiotic responses.. *Microbiology*, 1-11. doi:10.1099/mic.0.000573

Kurenbach, B., Hill, A., Godsoe, W., van Hamelsveld, S., & Heinemann, J. (2018). Agrichemicals and antibiotics in combination increase antibiotic resistance evolution. 2018. *PeerJ*, *6*, e5801.

Kurenbach, B., Marjoshi, D., Amabile-Cuevas, C., Ferguson, G., Godsoe, W., Gibson, P., & Heinemann, J. (2015). Sublethal exposure to commercial formulations of the herbicides dicamba, 2,4-dichlorophenoxyacetic acid, and glyphosate cause changes in antibiotic susceptibility. *mBio*, *6*.

Lamoureaux, J. (2016). What if the Environment is a Person? Lineages of Epigenetic Science in a Toxic China. *Cultural Anthropology*, 188-214.

Landcare Research. (2019). *An Integrated Framework for Soil Health*. Retrieved from Manaaki Whenua Landcare Research: https://www.landcareresearch.co.nz/science/soils-and-landscapes/soil-health/framework

Landrigan, P., & Goldman, L. (2011). Children's Vulnerability To Toxic Chemicals: A Challenge And Opportunity To Strengthen Health And Environmental Policy. *Health Aff*, 842-50.

Larned, S., Snelder, T., Unwin, M., & McBride, G. (2016). Water quality in New Zealand rivers: current state and trends. *New Zealand Journal of Marine and Freshwater Research*, *50*(3), 389-417.

LAWF. (2018). *Land and Water Forum advice on improving water quality: preventing degradation and addressing sediment and nitrogen - May 2018 Advice to Ministers*. Wellington: Land and Water Forum.

Lee, D.-H. (2018). Evidence of the Possible Harm of Endocrine-Disrupting Chemicals in Humans: Ongoing Debates and Key Issues. *Endocrinology and Metabolism*, 44-52.

Lelieveld, J., Evans, J., Fnais, M., Giannadaki, D., & Pozzer, A. (2015). The contribution of outdoor air pollution sources to premature mortality on a global scale. *Nature*, *525*(7569), 367–371.

Lin, B., Chappell, J., Vandermeer, J., Smith, G., Quintero, E., Bezner-Kerr, R., . . . Perfecto, I. (2011). Effects of industrial agriculture on climate change and the mitigation potential of small-scale agroecological farms. CAB Reviews Perspectives in Agriculture Veterinary. *Science Nutrition and Natural Resources*, *20*, 1-18.

Liu, P., Wang, J., Sanglaiah, A., Xie, X., & Yin, X. (2019). Analysis and Prediction of Water Quality Using LSTM Deep Neural Networks in IoT. *Sustainability*, *11*, 2058. doi:10.3390/su11072058

Lozano, V., Defarge, N., Rocque, L.-M., Mesnage, R., Hennequin, D., Cassier, R., . . . Amiel, C. (2018). Sex-dependent impact of Roundup on the rat gut microbiome. *Toxicology Reports*, 96-107.

Mackenzie Ross, S., Brewin, C., Curran, H., Abraham-Smith, K., & Harrison, V. (2010). Neuropsychological and psychiatric functioning in sheep farmers exposed to low levels of organophosphate pesticides. *Neurotoxicol Teratol.*, *32*(4), 452-9.

Magbanua, F., Townsend, C., Blackwell, G., Phillips, N., & Matthaei, C. (2010). Responses of stream macroinvertebrates and ecosystem function to conventional, integrated and organic farming. *Journal of Applied Ecology*, *47*(5), 1014–1025.

Magbanua, F., Townsend, C., Hageman, K., & Matthaei, C. (2013). Individual and combined effects of fine sediment and the herbicide glyphosate on benthic macroinvertebrates and stream ecosystem function. *Freshwater Biology*, *58*, 1729-1744.

Martinez Alier, J. (2009). Socially Sustainable Economic De-growth. *Development and Change*, *40*(6).

Masters, N. (2019). *For the Love of Soil: Strategies to Regenerate Our Food Production Systems*. Printable Reality.

Mattingley, B., & Nokes, C. (2019a). *Changes in New Zealand drinking water quality since 2005. Prepared for Ministry for the Environment. Client Report No. FW18024. Released under the Official Information Act*. Wellington: ESR.

Mattingley, B., & Nokes, C. (2019b). *Changes in New Zealand drinking water quality since 2005. Excel document accompanying report. Appendix 4. P2 Compliance 2005 to 2016-17*. Wellington: ESR.

Merfield, C. (2019). *An analysis and overview of regenerative agriculture. Report number 2-2019*. Lincoln: The BHU Future Farming Centre. Retrieved from http://www.bhu.org.nz/future-farmingcentre/ffc/information/misc/an-analysis-and-overview-of-regenerative-agriculture-2019-ffcmerfield.pdf

Mesnage, R., & Antoniou, M. (2018). Ignoring Adjuvant Toxicity Falsifies the Safety Profile of Commercial Pesticides. *Frontiers in Public Health*, 361.

Mesnage, R., Arno, M., Costanzo, M., Malatesta, M., Séralini, G.-E., & Antoniou, M. (2015). Transcriptome analysis analysis reflects rat liver and kidney damage following chronic ultra-low dose Roundup exposure. *Environmental Health*, 1-14.

Mesnage, R., Defarge, N., de Vendômois, J., & Séralini, G. (2014). Major Pesticides Are More Toxic to Human Cells Than Their Declared Active Principles. *Biomed Res Int*, Article ID 179691.

MfE & Stats NZ. (2019). *New Zealand's Environmental Reporting Series: Environment Aotearoa. ME 1416*. Wellington: Ministry for the Environment and Stats NZ.

MfE. (2012a). *Water Reform: Draft Cabinet papers for Minister's review. 12-B-01869. 22 November 2012*. Wellington: Ministry for the Environment.

MfE. (2012b). *Water Reform : Draft Cabinet Paper: Managing within Water Quality Limits under the National Policy Statement for Freshwater Management. 12-B-01923*. Wellington.: Ministry for the Environment.

MfE. (2014). *Report and recommendations on the proposed amendments to the National Policy Statement for Freshwater Management and public submissions*. Wellington: Ministry for the Environment.

MfE. (2017a). *Proposed amendments to the National Policy Statement for Freshwater.* Wellington: Ministry for the Environment.

MfE. (2017b). *February 2017 Clean Water: 90% of rivers and lakes swimmable by 2040.* Wellington: Ministry for the Environment .

MfE. (2017c). *National Policy Statement for Freshwater Management 2014. Updated August 2017 to incorporate amendments from the National Policy Statement for Freshwater Amendment Order.* Wellington: Ministry for the Environment.

MfE. (2017d). *Submissions report and recommendations on proposed amendments to the National Policy Statement for Freshwater Management 2014.* Wellington: Ministry for the Environment.

MfE. (2017e). *Section 32AA Evaluation Report for proposed amendments to the National Policy Statement for Freshwater Management 2014. August 2017.* . Ministry for the Environment.

MfE. (2017f). *Summary of recommendations and the Minister for the Environment's decisions on amendments to the National Policy Statement for Freshwater Management 2014 as proposed through the Clean Water discussion document 2017.* Wellington: Ministry for the Environment.

MfE. (2018). *Regional information for setting draft targets for swimmable lakes and rivers. Published by the Ministry for the Environment on behalf of a joint taskforce of central and local government representatives. ME 1349.* Wellington: Ministry for the Environment.

MfE. (2018b). *Technical Guidelines for Drinking Water Source Protection Zones.* Christchurch: Pattle Delamore Partners for MfE https://www.mfe.govt.nz/sites/default/files/media/Fresh%20water/technical-guidelines-for-delineating-drinking-water-source-protection-zones.pdf

MfE. (2019a). *Action for healthy waterways: A discussion document on national direction for our essential freshwater. ME 1427*. Retrieved from Ministry for the Environment: https://www.mfe.govt.nz/consultation/action-for-healthy-waterways

MfE. (2019b). *Draft National Policy Statement for Freshwater Management. Proposals for consultation September 2019.* Wellington: Ministry for the Environment. Retrieved from https://www.mfe.govt.nz/sites/default/files/media/Fresh%20water/draft-npsfm.pdf

MfE. (2019c). *Fresh water. Science and Technical Advisory Group.* Ministry for the Environment. Retrieved from https://www.mfe.govt.nz/fresh-water/science-and-technical-advisory-group

MfE. (2019c). *Cross-government Water Taskforce: Science and Technical Advisory Group*. Retrieved from Ministry for the Environment: https://www.mfe.govt.nz/fresh-water/cross-government-water-taskforce

MoH. (2018). *Guidelines for Drinking-water Quality Management for New Zealand, Volume 3 Datasheets part 2.3, Chemical and Physical Determinands. June 2018.* Wellington: Ministry of Health.

Monsanto. (2015). *Product name: Concentrate Roundup® Weedkiller.* Retrieved from Monsanto Safety Data Sheet. HSR000767 New Zealand: https://roundup-garden.co.nz/files/download/67

Mostafalou, S., & Abdollahi, M. (2013). Pesticides and human chronic diseases: Evidences, mechanisms, and perspectives. *Toxicology and Applied Pharmacology*, *268*(2), 157-177.

MPI and MfE. (2018). *Essential Freshwater: Healthy Water, Fairly Allocated.* Wellington: Ministry for the Environment and Ministry for Primary Industries.

Muilerman, H., & Houkema, R. (2014). *A Poisonous Injection: How industry tries to water down the risk assessment of pesticide mixtures in everyday food.* Brussels: PAN Europe.

Munshi, D., Kurian, P., Fraser, R., & Rupar, V. (n.d.). 'Shadow publics' in the news coverage of socio-political issues. *Sage*, *1*(89), 89-108.

Myers, J., Antoniou, M., Blumberg, B., Carroll, L., Colburn, T., Everett, L., . . . Benbrook, C. (2016). Concerns over use of glyphosate-based herbicides and risks associated with exposures: a consensus statement. *Environmental Health*, 19.

Myers, J., vom Saal, F., Akingemi, B., Arizono, K., Belcher, S., ColbornT., . . . Zoeller, R. (2009). Why public health agencies cannot depend upon 'Good Laboratory Practices' as a criterion for selecting data: the case of bisphenol-A. *Environ Health Perspect*, 309-315.

Myllylahti , M. (2018). *New Zealand Media Ownership.* Auckland: AUT Research Center for Journalism, Media.

Neumann, H. (2009). Risk assessment of chemical carcinogens and thresholds. *Crit Rev Toxicol*, 449-61.

Nilsson, E., Sadler-Riggleman, I., & Skinner, M. (2018). Environmentally induced epigenetic transgenerational inheritance of disease . *Environmental Epigenetics*, 1-13.

Nisbet, N., Brossard, D., & Kroepsch, A. (2003). Framing science: The stem cell controversy in an age of press/politics. *Harvard International Journal of Press/Politics, 8*(2), 36070.

Northcott, G., Jensen, D., Ying, L., & Fisher, P. (2014). Degradation Rate of Sodium Fluoroacetate in three New Zealand Soils. *Environ Toxicol Chem.*, *33*(5), 1048-58.

NZEPA. (2017). *Annual Report on the aerial use of 1080 For the year ended 31 December 2017.* Wellington: New Zealand Environmental Protection Authority. Retrieved from https://www.epa.govt.nz/assets/RecordsAPI/072f42182e/EPA-annual-report-on-aerial-1080-operations-2017.pdf

NZEPA. (2018). *Proposed Risk Assessment Methodology for Hazardous Substances How to assess the risk, cost and benefit of new hazardous substances for use in New Zealand.* Wellington: New Zealand Environmental Protection Authority. Retrieved from https://www.epa.govt.nz/assets/Uploads/Documents/Hazardous-Substances/Risk-Assessment-methodology/2158878291/Risk-Management-Methodology-Consultation-Draft.pdf

NZEPA. (2019a). *Controls for Hazardous Substances*. Retrieved from Environment Protection Authority: https://www.epa.govt.nz/industry-areas/hazardous-substances/rules-for-hazardous-substances/controls-for-hazardous-substances/

NZEPA. (2019b). *Hazardous substances assessments: Improving decision-making – A discussion document on proposed improvements to assessments and reassessments of hazardous substances.* Wellington: Ministry for the Environment. Retrieved from https://www.mfe.govt.nz/sites/default/files/media/Hazards/hazardous-substances-discussion-document.pdf

NZEPA. (2019b). *NZ EPA Priority Chemicals List*. Retrieved from New Zealand Environmental Protection Authority: https://www.epa.govt.nz/industry-areas/hazardous-substances/chemical-reassessment-programme/priority-chemicals-list/

NZEPA. (2019c). *What we do.* Retrieved from New Zealand Environmental Protection Authority: https://www.epa.govt.nz/about-us/what-we-do/

NZEPA. (2019d). *Poster: He Whetū Mārama*. Retrieved from New Zealand Environmental Protection Authority: https://www.epa.govt.nz/assets/Uploads/Documents/Te-Hautu/620f474394/EPA-He-Whetu-Marama-English-poster.pdf

OECD. (2017a). *OECD Environmental Performance Reviews: New Zealand 2017.* Paris: OECD Publishing. Retrieved from https://doi.org/10.1787/9789264268203-en

OECD. (2017b). *Organisation, for Economic Co-Operation and Development (OECD). Diffuse Pollution, Degraded Waters:.* IWA Publishing.

OECD. (2019, May 5). *Organisation of the Environment, Health and Safety Programme*. Retrieved from Organization for Economic Co-operation and Development: https://www.oecd.org/env/ehs/organisationoftheenvironmenthealthandsafetyprogramme.htm

Olsson, E., & Gooch, P. (2019). The sustainability paradox and the conflicts on the use of natural resources. In E. Olsson, P. Gooch, & (Eds), *Natural Resource Conflicts and Sustainable Development.* Routledge.

Orton, F., Säfholm, M., Jansson, E., Carlsson, Y., Eriksson, A., Fick, J., . . . Berg, C. (2018). Exposure to an anti-androgenic herbicide negatively impacts reproductive physiology and fertility in Xenopus tropicalis. *Sci Rep., 8*, 9124.

Palmer, G. (2015, November 10). *Ruminations on the problems with the Resource Management Act.* Retrieved from Scoop: http://www.scoop.co.nz/stories/HL1511/S00029/ruminations-on-the-problems-with-the-resource-management-act.htm

Parker, D. (2017). *Letter from Chairperson David Parker. April 6, 2017.* Wellington: Regulations Review Committee.

PCE. (2012). *Water quality in New Zealand: Understanding the Science.* Wellington: Parliamentary Commissioner for the Environment.

PCO. (1956). *Health Act 1956. 3a Function of the Ministry.* Wellington: Parliamentary Counsel Office.

PCO. (1991). *Resource Management Act 1991. Section 5. Purpose.* Wellington: Parliamentary Counsel Office.

PCO. (1996, December 1). *Hazardous Substances and New Organisms Act 1996.* Wellington: Parliamentary Counsel Office. Retrieved from New Zealand Legislation: http://www.legislation.govt.nz/act/public/1996/0030/latest/whole.html?

PCO. (1996, December 1). *Hazardous Substances and New Organisms Act 1996. Part 2 Purpose of Act. Section 4.* Wellington: Parliamentary Counsel Office. Retrieved from Parliamentary Counsel Office - New Zealand Legislation: http://www.legislation.govt.nz/act/public/1996/0030/latest/whole.html#DLM384461

PCO. (2001, August 12). *Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001.* Retrieved from New Zealand Legislation: http://www.legislation.govt.nz/regulation/public/2001/0117/latest/whole.html#DLM39690

PCO. (2004). *Crown Entities Act 2004. Section 103*. Retrieved from Parliamentary Counsel Office: http://www.legislation.govt.nz/act/public/2004/0115/latest/DLM329631.html

PCO. (2007). *Resource Management (National Environmental Standards for Sources of Human Drinking Water) Regulations 2007.* Retrieved from Parliamentary Counsel Office: http://www.legislation.govt.nz/regulation/public/2007/0396/latest/whole.html?

PCO. (2011). *Agricultural Compounds and Veterinary Medicines (Exemptions and Prohibited Substances) Regulations 2011. Schedule 2. Part C. Exemptions for agricultural compounds used to manage plants or plant production (28).* Wellington: Parliamentary Counsel Office. Retrieved from http://www.legislation.govt.nz/regulation/pub

PCO. (2011b). *Environmental Protection Authority Act 2011.* Wellington: Parliamentary Counsel Office. Retrieved from http://www.legislation.govt.nz/act/public/2011/0014/latest/whole.html#DLM3366819

Peck, J., & Tickell, A. (2002). Neoliberalizing Space. *Antipode*, 380-404.

Pesticide exposure and depression among male private pesticide applicators in the agricultural health study. (2014). *Environ Health Perspect., 122*(9), 984-91.

Portier, C., Armstrong, B., Baguley, B., Baur, X., Belyaev, I., Belle, R., . . . et al. (2016). Differences in the carcinogenic evaluation of glyphosate between the International Agency for Research on Cancer (IARC) and the European Food Safety Authority (EFSA). *J Epidemiol Community Health, 70*(8), 741-5.

Qin, Y., & Wade, P. (2018). Crosstalk between the microbiome and epigenome: messages from bugs. *Journal of Biochemistry*, 105-112.

Raworth, K. (2017). *Doughnut Economics.* London: Random House Business Books.

Rolando, C. (2013). A survey of herbicide use and a review of environmental fate in New Zealand planted forests. *New Zealand Journal of Forestry Science, 43*(17), 17.

Rose, J. (2014). *The Public Understanding of Political Integrity: the case for probity perceptions.* Basingstoke: Palgrave MacMillan.

Ross, P. (2010). *The polluters : the making of our chemically altered environment.* New York: Oxford University Press.

Rothstein, H., Huber, M., & Gaskell, G. (2006). A theory of risk colonization: The spiralling regulatory logics of societal and institutional risk. *Economy and Society*, 91-112.

S.V., R. (2014). Perspectives in endocrine toxicity of heavy metals--a review. *Biol Trace Elem Res., 160*(1), 1-14.

Sánchez-Bayo, F., & Wyckhuys, K. (2019). Worldwide decline of the entomofauna: A review of its drivers. *Biological Conservation*, 8-27.

Sánchez-Bayo, F., Goka, K., & Hayasaka, D. (2016). Contamination of the Aquatic Environment with Neonicotinoids and its Implication for Ecosystems. *Frontiers in Environmental Science*, 71.

Sauvé S & Desrosiers, M., A review of what is an emerging contaminant. *Chemistry Central Journal* 2014 8:15.

Schug, T., Janesick, A., Blumberg, B., & Heindel, J. (2011). Endocrine Disrupting Chemicals and Disease Susceptibility. *J Steroid Biochem Mol Biol.*, 204-215.

Schug, T., Johnson, A., Birnbaum, L., Colborn, T., Guillette, L., Crews, D., . . . Heindel, J. (2016). Minireview: Endocrine Disruptors: Past Lessons and Future Directions. *Molecular Endocrinology*, 1096.

Shahpoury, P., Hageman, K., Matthaei, C., & Magbanua, F. (2013). Chlorinated pesticides in stream sediments from organic, integrated and conventional farms. *Environmental Pollution*, 219-225.

Singh, N., Gupta, V., Kumar, A., & Sharma, B. (2017). Synergistic Effects of Heavy Metals and Pesticides in Living System. *Frontiers in Chemistry, 11*(5), 70.

Slama, R., Bourguignon, J.-P., Demeneix, B., Ivell, R., Panzica, G., Kortenkamp, A., & Zoeller, R. (2016). Commentary: Scientific Issues Relevant to Setting Regulatory Criteria to Identify Endocrine-Disrupting Substances in the European Union. *Environmental Health Perspectives*, 1497-1503.

Solecki , R., Kortenkamp, A., Bergman, A., Chahoud, I., Degen, G., Dietrich, D., . . . Boobis, A. (2017). Scientific principles for the identification of endocrine-disrupting chemicals: a consensus statement. *Archives of Toxicology, 91*(2), 1001-1006.

Steffen, W., Richardson, K., Rockstrom, J., Cornell, S. E., Fetzer, I., Bennett, E. M., . . . Persson, L. M. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*.

Stewart, M., Northcott, G., Gaw, S., & Tremblay, L. (2016). *An update on emerging organic contaminants of concern for New Zealand with guidance on monitoring approaches for councils. Auckland Council technical report, TR2016/006.* Auckland: Auckland Council.

Székács, A., & Darvas, B. (2018). Re-registration Challenges of Glyphosate in the European Union. *Frontiers in Environmental Science*, 78.

Tainter, J. (2000). Problem Solving: Complexity, History, Sustainability. Population and Environment:. *A Journal of Interdisciplinary Studies*, 3-41.

Tainter, J., & Taylor, T. (2014). Complexity, problem-solving, sustainability and resilience. *Building Research and Information, 42*(2), 168-181.

Tasca, A., Puccini, M., & Fletcher, A. (2018). Terbuthylazine and desethylterbuthylazine: Recent occurrence, mobility and removal techniques. *Chemosphere, 202*, 94-104.

Taunton, E. (2017). *US testing begins on genetically modified ryegrass developed in NZ*. Retrieved from Stuff: https://www.stuff.co.nz/business/farming/93008490/us-testing-begins-on-genetically-modified-ryegrass-developed-in-nz

TCC. (2019). *Tauranga City Council June 2019 Comprehensive Analysis.* Tauranga City Council. Retrieved from https://www.tauranga.govt.nz/Portals/0/data/council/water_services/water_supply/files/june2019_6monthly.pdf

Temple, W. (2016). *Review of the evidence relating to Glyphosate and Carcinogenicity. August 2016.* Wellington: New Zealand Environmental Protection Authority. Retrieved from https://www.epa.govt.nz/assets/Uploads/Documents/Everyday-Environment/Publications/f2f72882a7/EPA-glyphosate-review.pdf

Thompson, L., & Darwish, W. (2019). Environmental Chemical Contaminants in Food: Review of a Global Problem. *Hindawi Journal of Toxicology.*, 1-14. doi:https://doi.org/10.1155/2019/2345283

Tourism New Zealand. (2019). *About the Tourism Industry. Figures for the year ended March 2018.* Retrieved from Tourism New Zealand: https://www.tourismnewzealand.com/about/about-the-tourism-industry/#targetText=Domestic%20tourism%20expenditure%20increased%207.4,or%204.3%20percent%20of%20GDP.

Trasande, L. (2019). *Sicker, Fatter, Poorer: The Urgent Threat of Hormone-Disrupting Chemicals to Our Health and Future . . . and What We Can Do About It.* Houghton Mifflin Harcourt.

Tuncat, B. (2016) Report to UN Human Rights Council on the Rights of Child and Toxics (A/HRC/33/41). http://www.srtoxics.org/2016/09/duty-prevent-childhood-exposure/

Trasande, L., Vandenberg, L., Bourguignon, J.-P., Myers, J., Slama, R., vom Saal, F., & Zoeller, R. (2016). Peer-reviewed and unbiased research, rather than 'sound science', should be used to evaluate endocrine-disrupting chemicals. *Epidemiology and Community Health*, 1051-1056.

UN. (1987). *Report of the World Commission on Environment and Development: Our Common Future.A/42/427 'Brundtland Commission'*. Oslo: United Natons. Retrieved from https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf or https://en.wikisource.org/wiki/Brundtland_Report

UN. (2019, 09 11). *United Nations 2030 Agenda for Sustainable Development.* Retrieved from UN Sustainable Development Goals Knowledge Platform: United Nations 2030 Agenda for Sustainable Development.

UN Human Rights Council. (2016). Report of the Special Rapporteur on the implications for human rights of the environmentally sound management and disposal of hazardous substances and wastes. *33rd Session* (p. A/HRC/33/41). UN Human Rights Council. Retrieved from http://www.srtoxics.org/wp-content/uploads/2016/09/Rights-of-Child-and-Toxics.pdf

UN Human Rights Council. (2017). Report of the Special Rapporteur on the right to food. *34th session* (p. A /HRC/34/48). UN Human Rights Council.

UNEP. (2019). *Global Chemicals Outlook II: From Legacies to Innovative Solutions. Implementing the 2030 agenda for sustainable development.* Nairobi: United Nations Environment Program.

United Nations. (1989). Article 24 of the 1989 UN Convention on the Rights of the Child (CRC). *Treaty Series, Vol 1577* (p. p.3). UN General Assembly.

United Nations. (2010). The human right to water and sanitation : resolution / adopted by the General Assembly. *Sixty-fourth session* (p. A/RES/64/292). UN General Assembly.

van Hamelsveld, S., Adelwale, M., Kurenbach, B., Godsoe, W., Harding, J., Remus-Emersmann, M., & Heinemann, J. (2019). Prevalence of antibiotic-resistant Escherichia coli isolated from urban and agricultural streams in Canterbury, New Zealand. *FEMS Microbiol Lett.*, *366*(8), fnz104.

Vandenberg, L., Colborn, T., Hayes, TB, Heindel, J., Jacobs, D., . . . Zoeller, R. (2013). Regulatory Decisions on Endocrine Disrupting Chemicals Should be Based on the Principles of Endocrinology. .38:1-5. *Reprod Toxicol*(38), 1-5.

Vandenberg, V., Blumberg, B., Antoniou, M., Benbrook, C., Carroll, L., Colborn, T., . . . Myers, J. (2017). Is it time to reassess current safety standards for glyphosate-based herbicides? *J Epidemiol Community Health*, *71*, 613-618. Retrieved from https://jech.bmj.com/content/jech/71/6/613.full.pdf

Varanasi, U., & Stein, J. (1991). Disposition of Xenobiotic Chemicals and Metabolites in Marine Organisms. *Environmental Health Perspective*, *90*, 93-100.

Veljanoska-Sarafiloska, E., Jordanoski, M., & Stafilov, T. (2013). Presence of DDT metabolites in water, sediment and fish muscle from Lake Prespa, Republic of Macedonia. *J Environ Sci Health B.*, *48*(7), 548-58.

Watts, M. (2013). *Poisoning our Future: Children and Pesticides.* Auckland: Pesticide Action Network Asia and the Pacific. Retrieved from https://www.panna.org/resources/poisoning-our-future-children-and-pesticides

Weeks, E., Death, R., Foote, K., Anderson-Lederer, R., Joy, M., & Boyce, P. (2015). Conservation Science Statement. The demise of New Zealand's freshwater flora and fauna: a forgotten treasure. *Pacific Conservation Biology*, *22*(2), 110-115.

Weis, T. (2010). The Accelerating Biophysical Contradictions of Industrial Capitalist Agriculture. *Journal of Agrarian Change*, *3*, 314-315.

Weisskopf, M., Moisan, F., Tzourio, C., Rathouz, P., & Elbaz, A. (2013). Pesticide Exposure and Depression Among Agricultural Workers in France. *American Journal of Epidemiology, 178*(7), 1051–1058.

Želježić, D., Žunec, S., Bjeliš, M., Benković , V., Mladinić, M., Lovaković, T., . . . Kopjar, N. (2018). Effects of the chloro-s-triazine herbicide terbuthylazine on DNA integrity in human and mouse cells. *Environ Sci Pollut Res Int, 25*(19), 19065-19081.

Zhang, X., & Ho, S.-M. (2011). Epigenetics meets endocrinology. *Molecular Endocrinology*, 1-39.

Zoeller, R., & Vandenberg, L. (2015). Assessing dose–response relationships for endocrine disrupting chemicals (EDCs(: a focus on non-monotonicity. *Environmental Health*, 2-5.

Appendix I. Priority 2 Determinands (March 2017)

Currently Assigned Official Priority 2 Determinands

This list will be updated weekly from the National DWO database.

Treatment Plants

Click on an abbreviation to see a list of Supplies receiving water from Plants with this P2 Determinand

Abbrev.	Determinand	Plants	for Zones	in Supplies	Zone Pop
As	Arsenic	2	3	2	10,393
F	Fluoride	50	135	43	2,509,370
MAVNOx	MAV sum ratio for NO3 and NO2	1	1	1	3,520
NO3	Nitrate (as NO3)	4	4	4	37,845

Distribution Zones

Click on an abbreviation to see a list of Distribution Zones with this P2 Determinand

Abbreviation	Determinand	Assigned	Population
As	Arsenic	8	24,510
CHBCl2	Bromodichloromethane	3	21,564
Cu	Copper	1	400
DCA	Dichloroacetic acid	6	8,909
Pb	Lead	6	17,867
Mn	Manganese	1	570
MAVHAA	MAV sum ratio for HAAs	14	88,422
MAVTHM	MAV sum ratio for THMs	18	138,236
Ni	Nickel	1	1,000
NO3	Nitrate (as NO3)	11	16,174
TCA	Trichloroacetic acid	5	5,462

Source: Drinking Water Online, as extracted from the National DWO database on 2 Sep 2019.

Appendix II. UN Human Rights Council. Obligation to protect children from toxics

Report of the Special Rapporteur on the implications for human rights of the environmentally sound management and disposal of hazardous substances and wastes.

Human Rights Council A/HRC/33/41

Thirty-third session, 2 August 2016

Agenda item 3

108. States have recognized their duty to protect and realize children's rights, from which derives an obligation to protect children from exposure to toxics. These rights include the right to life and childhood development, the right to health, the right to physical integrity, the right to be free from the worst forms of child labour, the rights to food, water and adequate housing, and others.

109. The Special Rapporteur offers the following recommendations to the various stakeholders to protect the rights of the child from toxic chemicals.

110. States should:

(a) Prevent childhood exposure to pollution and toxic chemicals as part of States' obligation to protect children, and guarantee an effective remedy for exposure and environmental contamination. States must ensure that this is reflected in laws and policies. States must also ensure the same protection to women and girls of reproductive age;

(b) Consider the best interests of the child as a priority when designing, implementing and monitoring public health, environmental, consumer and labour laws and policies. States must take into account the fact that specific groups of children are more likely to be exposed, and are thus at greater risk;

(c) Ensure the availability of and access to adequate and age-appropriate information on children's rights and toxics. States should promote education on toxic chemicals and pollution in primary schools' curricula;

(d) Strengthen childhood exposure-monitoring efforts in all countries, particularly for those in developing countries and high-risk situations, such as those living in extreme poverty or in low-income, minority, indigenous, stateless, migrant or refugee communities. States should also undertake longitudinal cohort studies that are harmonized, and other studies of pregnant women, infants, and children that capture exposures at critical windows and sensitive health endpoints along human development;

(e) Explicitly set out government expectations for business enterprises to not expose children to toxics in the context of their business activities and domestic and international business relationships, in line with the Guiding Principles on Business and Human Rights, within its guidance to the private sector on children's rights;

(f) Eliminate work by children where they are exposed to toxics and ensure safer alternative employment, and monitoring of children affected. States should ensure that children affected receive the necessary treatment and compensation. States should also ensure that women and girls of reproductive age are guaranteed protection from occupational exposure to toxics and the substitution of toxics with safer alternatives as the primary means of prevention;

(g) Conduct a national assessment of children's environmental health and identify priority concerns, including children in vulnerable situations, and develop and implement action plans to address those priority concerns;
(h) Ensure that children have access to justice and an effective remedy for violations due to toxics, including remediation of contaminated sites, preventative and precautionary measures, access to necessary medical and psychological care, and adequate compensation;
(i) Establish population-based surveillance systems for adverse health impacts linked to toxics and pollution;
(j) Strengthen regulatory agencies and ministries responsible for the oversight of standards relevant to children's rights implicated by toxics and pollution, such as health, consumer protection, education, environment, food, and labour. States should ensure that they have sufficient powers and resources to monitor and to investigate complaints and to provide and enforce remedies for abuses of children's rights. States should increase and strengthen intersectoral cooperation;
(k) Work with relevant national and international organizations on monitoring and identification systems for hazardous remnants of armed conflict. Governments must provide an effective remedy for hazardous remnants of conflict and other military activities, including funding for full remediation, comprehensive medical treatment and compensation for individuals experiencing the effects of exposure to these materials;
(l) Require businesses to undertake child rights due diligence to ensure businesses meet their obligation to adopt measures to respect children's rights;
(m) Include the issue of toxics and pollution within all national action plans on business and human rights, and within the national policy framework for implementation of the Convention on the Rights of the Child;
(n) Take up these recommendations in their review of their peers during the universal periodic review.

Appendix III. Hazardous Substances and New Organisms Act 1996 (Sections)

Part 2 Purpose of Act

4 Purpose of Act

The purpose of this Act is to protect the environment, and the health and safety of people and communities, by preventing or managing the adverse effects of hazardous substances and new organisms.

5 Principles relevant to purpose of Act

All persons exercising functions, powers, and duties under this Act shall, to achieve the purpose of this Act, recognise and provide for the following principles:

(a) the safeguarding of the life-supporting capacity of air, water, soil, and ecosystems:
(b) the maintenance and enhancement of the capacity of people and communities to provide for their own economic, social, and cultural well-being and for the reasonably foreseeable needs of future generations.

6 Matters relevant to purpose of Act

All persons exercising functions, powers, and duties under this Act shall, to achieve the purpose of this Act, take into account the following matters:
(a) the sustainability of all native and valued introduced flora and fauna:
(b) the intrinsic value of ecosystems:
(c) public health:
(d) the relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, valued flora and fauna, and other taonga:
(e) the economic and related benefits and costs of using a particular hazardous substance or new organism:
(f) New Zealand's international obligations.
Section 6(e): substituted, on 30 October 2003, by section 6 of the Hazardous Substances and New Organisms Amendment Act 2003 (2003 No 54).

7 Precautionary approach

All persons exercising functions, powers, and duties under this Act including, but not limited to, functions, powers, and duties under sections 28A, 29, 32, 38, 45, and 48, shall take into account the need for caution in managing adverse effects where there is scientific and technical uncertainty about those effects.
Section 7: amended, on 31 December 2000, by section 4 of the Hazardous Substances and New Organisms Amendment Act 2000 (2000 No 89).

8 Treaty of Waitangi

All persons exercising powers and functions under this Act shall take into account the principles of the Treaty of Waitangi (Te Tiriti o Waitangi).