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"HOW TO GET MORE BANG FOR YOUR BUCK" FROM MITIGATION INSTALLATIONS THAT REDUCE CONTAMINANTS ENTERING WATERWAYS

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Abstract

Land that receives farm dairy effluent, municipal or industrial wastewater (or any other waste products) requires potentially adverse effects to be mitigated to ensure the receiving environment can maintain sustainable healthy conditions. The receiving environment of concern generally refers to groundwater and surface waters (drains, streams, rivers or coastal waters), but equally soil conditions and air quality are important.

In addition to sound wastewater design, there are a range of mitigation technologies that can be implemented to minimise effects; but which ones should be chosen to get the 'best bang for your buck'?

Dealing with waste products on land includes several stages before components from the waste move from a property to the surrounding environment. The objective is to optimise treatment of the applied material to provide confidence to the land owner and the community that effects are minimised, or at least minimal.

Stage one of mitigating effects is prior to land application and is typically treatment, often in waste stabilisation ponds. The second stage is the design and management of the distribution system on to land, which is in accordance with good design practices and meeting consent requirements, and typically has limits on nutrients and volume application rates. A third stage may be required and applies where additional mitigation is needed if the water quality standards in groundwater or surface water require further protection and enhancement.

Within the stages above there are a range of technologies for mitigating effects and the impact on the receiving environment, which include:

Stage 1: waste treatment – ponds, high rate treatment plants, chemical dosing;

Stage 2: land application – appropriate nutrient and hydraulic loading rates, use of appropriate soil characteristics, plant species and irrigation infrastructure; land management and production types; application rates; application volumes; nutrient uptake rates; and

Stage 3: environmental mitigation - riparian margins, shade planting, denitrification walls and wetlands.

Similar to any investment, planning contributes to optimisation of outcomes. A mitigation strategy covering all three stages requires a long-term flexible vision because changes in water quality take time. In addition, new technology tried now may not provide the results expected

and another technology or improvement to that technology may be required in the future. Equally a technology or practice may become redundant if acceptable levels of improvement to the water quality are achieved, or the technology reaches its expected life.

The identification and selection of technologies for Stage 3's environmental mitigation can be further divided into 5 steps. The first steps as part of this third stage are to understand components of the system, including the waste product, the receiving environment, and the applicable mitigation technology options. The following steps are to design the mitigation approach, then monitor outcomes to determine ongoing developments and future required changes.

The Levin wastewater land treatment system provides an example of a mitigation strategy in practice.

Mitigation Strategy
A mitigation strategy is a future focused procedure demonstrating how mitigation options can be included into contaminant management. A long-term vision allows time for water quality to change and technologies to be changed or be modified as needed. Technologies can be simple land management techniques (e.g. drain management), or complex devices (e.g. water filtration and chemical dosing).

The 5 step process shown in Figure 1 starts with identifying the drivers for change and investigating the system as a whole. Understanding what is currently taking place is critical for identification of what needs to change. The following steps identify potential mitigation technologies based on step one's information. This is followed by installation then monitoring and reviews of the selected technologies. A wholistic review is undertaken in Step 5 to consider all factors influencing the receiving environment as well as the technologies installed.

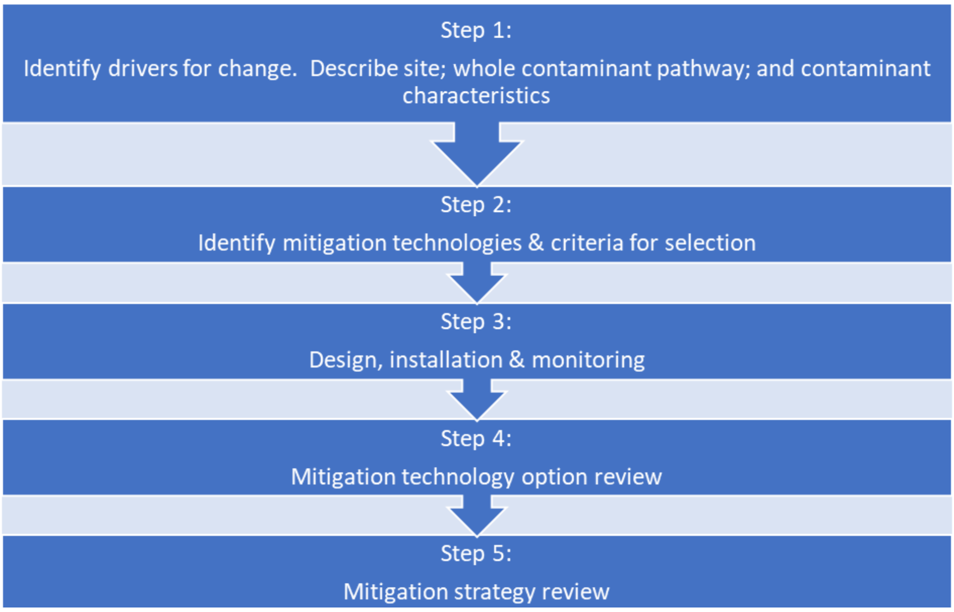

Fig. 1: Surface water effects mitigation 5 step strategy

The following sections describe each step of the strategy; followed by the mitigation strategy for the LWWLT.

Step One: Identify Drivers for Change - Describe site, whole contaminant pathway, and contaminant characteristics
Drivers for change stimulate the interest to invest time and resources. Without strong drivers it is difficult to promote any project. Clear objectives defined at the beginning of the project create a foundation to work on and a framework to work inside.

With clear drivers in place, step one then focuses on investigations that describe the physical parameters, such as contaminant quality and quantity, climate, land use, landscape characteristics and soil. The parameters described are selected if they are likely to influence the contaminant pathway through the site of concern. Further influences to the receiving groundwater and surface water from the whole catchment contribute to understanding the conditions. The more information gathered that assists describing the issues the greater the opportunities for appropriate mitigation selection. This framework is shown in Figure 2.

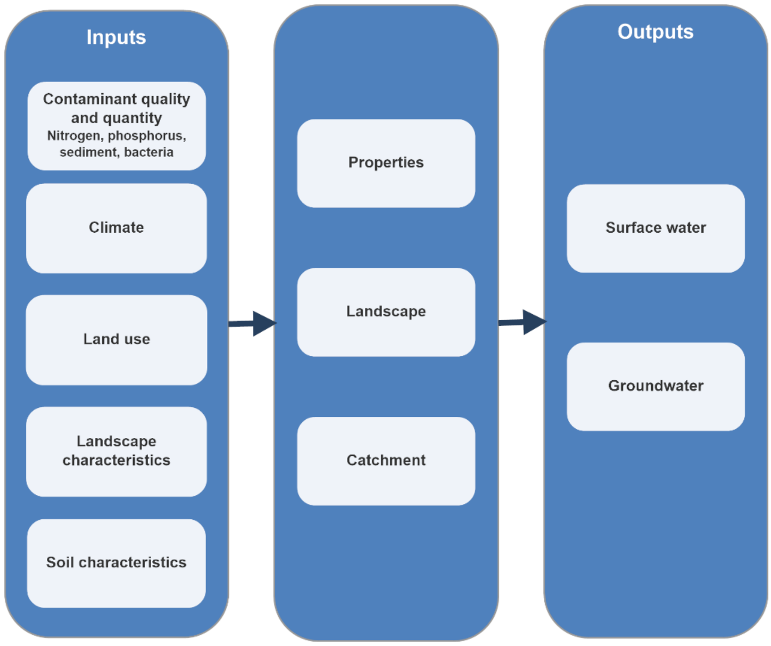

Fig. 2: Contaminant pathway framework

Step Two: Identify mitigation technologies and criteria for selection
The criteria for selection of mitigation options and technologies requires a rigorous process to confirm the following, as shown in Figure 3:

- Suitability to the site conditions;
- Level of reduction in contaminants likely to be achieved; and
- Affordability.

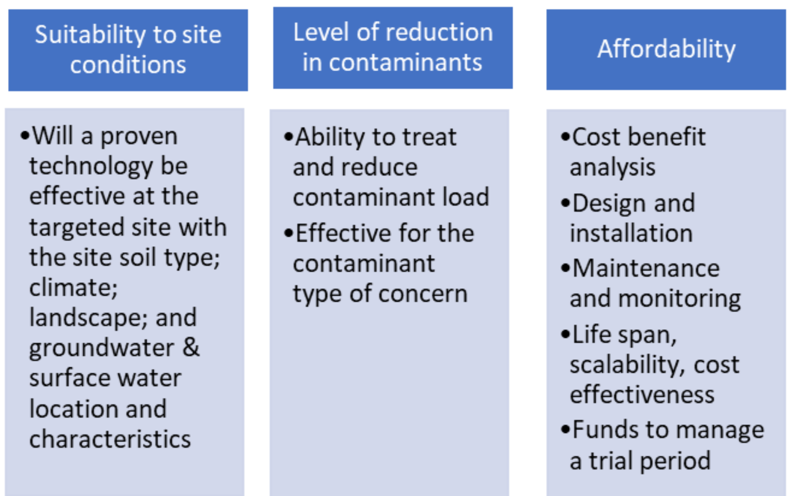

Fig. 3: Identification of suitable mitigation technology

Suitability to Site Conditions
A technology may operate and be effective at one location but when it is installed at a new location with different conditions, it may not achieve the outcomes required. For example, a denitrification wall may have been installed easily into a sandy soil and provided 50% reduction of nitrogen when concentrations began at 50 mg/L. However, transferring the denitrification wall to a gravelly soil may require expensive structures to enable installation

and twice the nitrogen concentrations may not gain a 50% reduction. The environmental conditions will require comparisons to examples that are used to guide the technology selection.

Level of Reduction in Contaminants
Examples of a proposed technology will require evidence of the following and interpretation of that evidence to demonstrate how the technology is predicted to perform at the proposed site:

- Potential reduction in contaminant concentration;
- Ability to treat the type of contaminants that occur;
- Ability to manage the contaminant loads; and
- Expected timeframe for improvements to be identified (including time to establish peak operational performance) and expected performance life.

Affordability
Affordability of the mitigation technology requires a range of factors to be taken into account to demonstrate a cost effective solution. These include:

- Level of funds budgeted to trials and ongoing mitigation efforts;
- Initial design and installation costs;
- Maintenance requirements;
- Ongoing cost and ease of operation, monitoring, and maintenance;
- Life span;
- Scalability, cost effectiveness as a trial as well as a larger expanded version for future installation; and
- The potential cost per unit of reduction in contaminant load to the receiving environment.

Step Three: Design, installation and monitoring
A positive outcome from Step 2 then requires the following work to be carried out:

- Detailed design of the technology to suit the site and the resources available;
- Detailed cost of the design;
- Confirmation costs are appropriate when considered against the anticipated level of mitigation achieved and is within the allocated budget;
- Installation;
- Prepare a maintenance and monitoring programme; and
- Operate and maintain and monitor.

Records will be required to inform the effectiveness of the technology, regarding both the maintenance of the technology and the water quality changes. Records of maintenance carried out should identify maintenance costs, including the time taken and frequency that maintenance is needed. Monitoring, as identified in the planning stage aims to provide information of the actual improvements in water quality achieved and efficacy of the system. This information will contribute to design improvements.

A trial approach at this step may prove a more cost effective approach in the long term. A trial would install a small scale example of the technology that could provide more information about its suitability to the specific circumstances of a site before it is either expanded across the site or discarded.

Step Four: Mitigation technology option review
Similar to Step 2 that outlined preliminary assessments for a technology, Step 4 assesses the performance of the technology working in situ. Once the technology is installed and operating with monitoring and maintenance data collected, the technology can be reviewed to decide its value and whether it is continued, expanded, modified or discontinued.

The review should include the following evaluations using records collected during Step 3:

- Surface water quality improvements;
- Groundwater quality improvements;
- The level of mitigation achieved over time (including changes and life expectancy);
- Costs (capital and operational); and
- The review process itself to inform the above 4 items.

Over time the regular reviews will identify progress towards the objectives but also determine if changes are needed or if the technology decreases effectiveness. If a trial approach has been installed the review phase will determine if a larger system is installed or the technology is discarded.

Step Five: Mitigation Strategy Review
Steps 1 – 4 concentrate on the individual mitigation technology while Step 5 brings all mitigations together. Such a review should focus on the effects in the receiving environment and determine what options and technologies to continue with and what are not valuable to land management in the catchment as well as the site they are located. The review should include but not be limited to the following information:

- Acknowledge all measures of contaminant mitigation that take place at the site, and the wider catchment;
- The need for a minimum of three to five years data that depict the effects from utilising mitigation technologies;
- Cost benefit analysis for each technology;
- The relevance of the strategy to water quality in the larger catchment; and
- Recommend changes to the strategy.

LEVIN LAND TREATMENT MITIGATION STRATEGY

Step One: Identify Drivers for Change

The community aspirations, regional policy (One Plan) and national policy direction (National Policy Statement for Freshwater Management 2014, amended 2017) to maintain or improve water quality, particularly nitrogen concentrations, in groundwater and the adjacent Waiwiri Stream all drive the need to make changes. The vision statement prepared at a catchment group meeting succinctly defines the drive to restore the Waiwiri Stream and catchment to health.

> *"Our hapu and community take pride as active Kaitiaki of the healthy Waiwiri Catchment and whenua. The pristine, beautiful lake and streams sustain us, are food baskets and ecological taonga for ourselves; future generation to manaaki manuhiri"*

Preparation of the re-consenting application for the LWWLT provided the investment towards an extensive investigation of the physical characteristics that has taken place over 8 years. The site investigations included descriptions of the ecology, climate, soils, landscape, groundwater and surface water. The history of data from the wastewater irrigation scheme provided the background data to assist interpretation of the monitoring that took place. The conclusions stated there is no technical water quality reason to make changes to the current treatment system. However, the conclusions also identified the water quality of the Waiwiri Stream is affected by the whole catchment not just The Pot activity.

Further detail to support the mitigation strategy will be investigations that define the nitrogen transformations and the pathways followed from the Levin wastewater treatment plant (WWTP) through to the Waiwiri Stream. Understanding the wider system involved compared to the focus on The Pot site that took place for the re-consenting investigations may provide scope for better placed mitigation technologies, such as potential changes in the pipe from the WWTP to The Pot infiltration pond.

Step Two: Identify mitigation technologies and criteria for selection

The LWWLT already has a range of mitigation practices that have been carried out for the 30 years of operation and more practices that are planned with the new consent. Additional mitigation technologies are also planned to follow the mitigation strategy approach described here. Table 1 identifies the existing, planned and strategic mitigation practices and technologies that contribute to the objectives of this mitigation strategy.

Table 1: Mitigation Technology for the LWWLT

Existing	Consent Application	Wider Strategy
• Irrigation to land; • Pine forest; • Infiltration pond.	• Increased land area for irrigation; • Increased frequency of irrigation combined with decreased application depth per application; • Replanting pine forest.	• Ecosystem trial; • Riparian margins planted in native species; • Denitrification walls and beds; • Creation or enhancement of wetlands.

The existing mitigation has proved effective, however with the increased population over the next 30 years and the improved land treatment approaches available today, changes at the site are planned. The changes include upgrades of the irrigation infrastructure and reduced application depths that will allow for greater soil treatment. The pine forest was mature and has been harvested. This allows for a new plantation with more active plant uptake from the growing trees by comparison to the mature forest.

The ecosystem trial has been established at the site and may provide further opportunities in the future when the results are known. The trial includes an area planted with manuka and kanuka dominated native trees. This was set up in response to significant results from a pot trial that indicated the bioactive antimicrobial compounds produced from native plants can inhibit ammonia converting to nitrate and nitrous oxide; plus enhance the reduction of pathogens. This mitigation technology has moved to Stage 3 at the LWWLT and will undergo Steps 3 to 5 as the trial progresses.

Three further mitigation options have been identified which are expected to reduce the effects of the Levin wastewater discharge on the quality of the Waiwiri Stream. The technologies recommended to trial include:

- Riparian planting along drains and the margin of Waiwiri Stream;
- Denitrification walls along the drain closest to the Pot pond; and
- A wetland on an inter-dunal area that intercepts surface drains before they reach Waiwiri Stream.

Each of these require further scrutiny of the suitability to the site, effectiveness towards nitrogen reduction and affordability before they are installed. If the three criteria prove satisfactory a trial approach as described for step 3 may prove more cost effective. Trials will provide more evidence towards the suitability to the sandy high nutrient loaded site conditions.

Step Three to Five:
These steps will follow the installation of the technologies identified in Step 2. The trial periods are hoped to provide improvements to the technology and potential options for the wider catchment.

LWWLT Summary
The mitigation strategy for the LWWLT is summarised in Figure 4. This shows the three contaminant pathways from the Levin community via the WWTP to the Waiwiri Stream, the other land use such as farm land in the catchment that enters the Waiwiri Stream, and the whole stream pathway from is source at Lake Papaitonga via the stream to the coast. Lake Papaitonga also contributes contaminants to the Waiwiri Stream from the sediment and particularly from avian sources.

Each mitigation technology chosen can influence the pathway at different stages, such as education of the community for what they put down the sewer and vegetation types such as manuka that can influence pathogens and the type nutrients entering the stream.

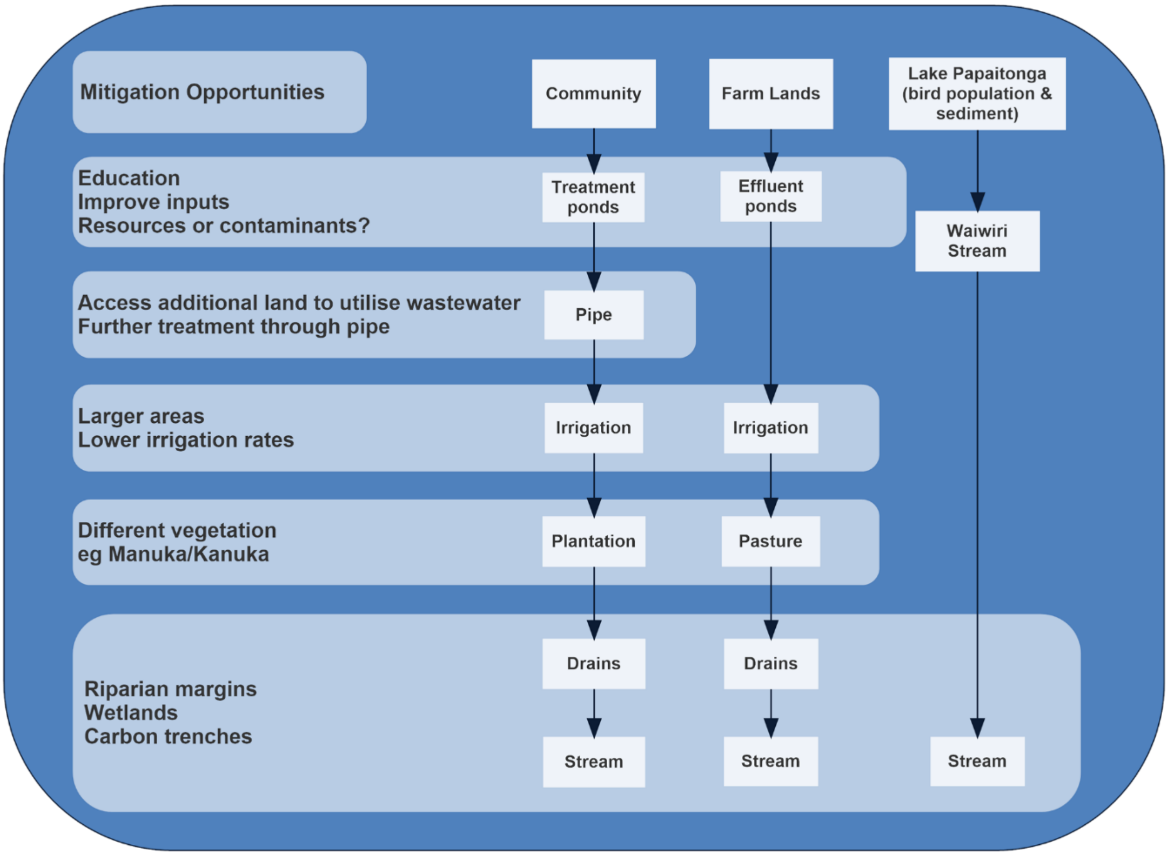

Fig. 4: Mitigation options for the contaminant pathways entering the Waiwiri Stream

Conclusion

This mitigation strategy aims to set out a process to implement changes that will lead to an improvement of water quality. The approach is thorough with provision of reviews and adequate timing to confirm the technology's performance and ensure that the time and money invested is managed to achieve the optimal outcomes.

Successful results from a technology and/or combination of technologies has far reaching opportunities for both individual sites, a catchment, and further afield. The strategy produces information that can support change towards an improved environment, healthy waterways and improved community wellbeing.

References

Ministry for the Environment (2017a). National Policy Statement for Freshwater Management 2014. Updated Aug 2017 to incorporate amendments from the National Policy Statement for Freshwater Amendment Order 2017. Wellington: Ministry for the Environment.

Ministry for the Environment (2017b). Lake Horowhenua Project. Sourced: http://www.mfe.govt.nz/fresh-water/clean-projects/lake-horowhenua

Stevens, LM. 2018. New River Estuary 2018 – Macroalgal Monitoring. Report prepared by Wriggle Coastal Management for Environment Southland. 29pp.