Using scale and the environmental consequences of technology choice to build sustainability criteria into Glenorchy’s sewerage decision

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1 Introduction

Finding the ‘best’ system for dealing with a community’s waste streams is not only a technology question but also a question of how we make technology choices. This paper begins with Glenorchy’s geographical and social contexts which identify nitrogen discharges into Lake Wakatipu and sustainability as priority considerations. The technology constraints that best satisfy these contexts identify the importance of toilet technology choice in achieving control of N discharges (as 95% of N arises from the toilet) while consuming least water and energy.

However, the cultural repercussions from this conclusion become a significant consideration as the type of toilet that achieves this is inconsistent with the cultural mores of a flush toilet. Two elements are considered crucial to resolve this:

- *Analysis scale*. Capturing N at the toilet necessitates the dwelling being the main focal point for achieving N discharge goals.
- Develop *information feedback loops* that carry the environmental consequences of technology choices to the person (dwelling owner) who is making these choices.

Navigating this cultural baggage is argued to be possible by using these two elements.

The best ‘system’ that achieves this is to retain onsite disposal, as this contains the necessary scale; and augment this with an information feedback loop that carries the environmental discharges of N from the various technologies. This information can be packaged in a form that is likely to influence the dwelling owner to choose technologies that have less N discharges. The council rating system is a convenient carrier for these information feedback loops.

Parts of the town that have insufficient land area to achieve the N reduction targets, particularly the commerce and visitor accommodation zones can be considered for reticulation. These information feedback loops apply equally well to a conventional reticulated sewerage system as onsite systems. Consequently, with a reticulation system those residents choosing the more sustainable technologies can pay less capital and operating costs and thereby be treated fairly.

Considering the polarising effect of a reticulation system being triggered by development and/or tourism pressures then setting up these information feedback loops at the start of the debate would be advantageous particularly if they utilise equity based on volume and pollution ‘Burden’ – the resulting debate would be information rich and perceived as fair.

With such an information feedback loop, Glenorchy could demonstrate a commitment to decrease its nitrogen discharges over time. Many mechanisms to achieve this are available and all can utilise the information in these feedback loops. These mechanisms are not explored in any depth here.

2 Context

In contrast to the use of context in Chapman (2011) within which microbial kinetics is scaled up from a particle to the technology surrounding the pile, this context begins at a geographical location in New Zealand. It is this community context that is required to separate the different technologies.

Glenorchy is a small town of only a few hundred people at the top end of Lake Wakatipu. The significance of this lake for tourism elevates the need to reduce nutrient discharges from the town's sewage. This debate is occurring within the wider political context of NZ which is suffering deteriorating river water quality (our rivers are becoming unswimable). This environmental context occurs within a governing legislation that defines sustainable management (Resource Management Act), from which the council focus is on reducing **nitrogen** discharges to Lake Wakatipu.

The town is located on a river fan and will, in due course, be landlocked as the Rees and Dart rivers are infilling the head of the lake – flooding is an issue for the lower parts. The town is only 40km from the alpine fault which is expected to generate a large magnitude earthquake (> 8) and has a 50% chance of rupturing in the next 50 years. The consequences of a rupture on infrastructure means resilience needs to form part of the context.

The community has recently completed a visioning forum that resulted in **sustainability** being the biggest 'wordle' (the term most frequently used when asked to: "provide two words that you would like to see included in a short aspirational vision statement for the Glenorchy community"). The town also contains a large development based on sustainability. This social context also includes the lengthy cultural history of sewerage systems; however this notion of centralised sewerage is being challenged by the sustainability emphasis. Indeed, the purpose of the R.M. Act should have provided this challenge to a conventional sewerage system long ago.

Glenorchy currently uses onsite systems so is well placed to build sustainability considerations into the debate.

Both proximity to the alpine fault and sustainability challenge the notion of a water-based (sewerage) system and this has produced a tension in the debate that sits alongside the affordability issue. The issue becomes too complex for people to process, in part because sustainability necessitates consideration of information outside of the cultural mores surrounding sewerage.

It follows that the sustainability context needs the evidence to be heard through the cacophony of social processes – particularly the cultural mores surrounding centralised sewerage.

There is a point at which everyone agrees and that is we want the 'best' system at the lowest CAPEX & OPEX.

It cannot be assumed that the 'system' that 'best' satisfies all of the above is necessarily a centralised system with reticulation. A 'system' can be any combination of technologies.

There are however, several discharge issues in the town that need to be resolved. These are primarily located in the commercial area (which includes the public toilets) and one development for which the system was never intended for the number of dwellings now constructed (~40).

The context for this decision is therefore a mix of legal requirements (in this case a mechanism for capturing excessive social, and environmental, impacts), local conditions, community aspirations, and a lengthy technology history.

3 Glenorchy's sewerage debate using the sustainability context

Given that the community aspiration for sustainability is also embedded in the intent of the governing Act, then this is sufficient to prioritise all technologies relative to sustainability perfection (called the Beacon in Chapman (2015c)). Considering also that the community's geographical location determines nitrogen as the priority *natural and physical resource* then, when applied to a dwelling on an 800m^2 section, the nitrogen from the technology (and the area required for plant uptake to remove residual N post technology) becomes visible in a graphical form (Figure 1). The best technologies for this task are those that capture urine and faeces.

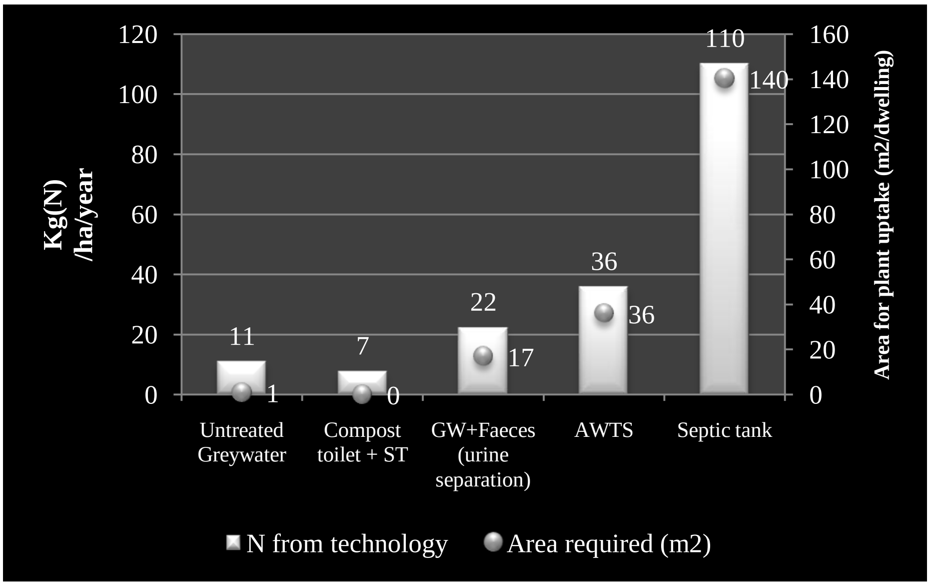

Figure 1 – Nitrogen discharges in wastewater from different technology types and untreated greywater from a dwelling containing 2.6 people on an 800 m^2 section. The *area required for plant uptake per dwelling* is based on 570 kg(N)/ha/yr plant uptake to remove the residual N (less the 10 kg/ha ORC target) from the technology. Note 1/ that the compost toilet technologies assume zero N discharges from reuse of the source material (faeces & urine); 2/ Both compost toilet and urine separation technologies assume a 30% reduction in N within the septic tank.

As 95% of the N is contained in 1% of the total volume then a focus on technologies that deal with this 1% makes sense and this is confirmed by Figure 1. Nitrogen as a priority *natural and physical resource* is sufficient to set the framework for Glenorchy's sewerage deliberations as there are logic linkages to all of: water, energy and nutrient recycle if these need to be considered.

However, a meaningful discussion around non-water-use toilets (of which compost toilets is one possibility) when we are so wedded to the flush toilet is a more difficult issue, but is necessary if the community wishes to pursue its sustainability goals (Chapman, 2015a). Not including non-water-use toilets in the debate extinguishes the possibility of the most sustainable solutions that the community desires.

Indeed, a focus on the toilet has other social consequences that need to be resolved before being able to incorporate sustainability into the debate:

- Toilet technologies are a personal choice usually made when a dwelling is constructed - introducing a time (and space) component to technology change.
- An analysis **scale** based on toilet technology choice (dwelling scale) becomes necessary for the community debate; particularly as:
- Community sewerage projects do not inherently accommodate the dwelling scale variability. In part because the three waste streams are mixed at the dwelling; and historically it was easier (and it remains industry practice) working with averages. Even the law contains this inherent average as it talks of wastewater – faeces are not water so there is an implicit assumption of a mixture. The advent of computers negates this information processing constraint.
- Mechanisms of social change also need consideration.

Social change mechanisms need to be considered in Glenorchy's case as the embedded technology does not pass the sustainability challenge and, considering that there are developments in town that focus on sustainability, it could become part of our identity. For a town with a strong vision statement embedding these values in our infrastructure is a no-brainer. Enabling the role of the primary adopter so these important individuals can exercise their choices (which are likely to be contrary to the cultural mores but highly desirable from the sustainability context) is possible within a conventional sewerage system (Chapman, 2015b).

4 Assembling the system

For Glenorchy's sewerage considerations to claim to be sustainable the technology implications, their consumption of *natural and physical resources*, and the social consequences of 95% of the nitrogen being in 1% of the total volume needs to be the primary consideration. There are two critical elements that need to be present to ensure this:

- First, the *analysis scale* that considering toilet technologies command (discussed above). The dwelling scale is proposed due to its links to both council administration and the technology decision maker. But also:
    - Mechanisms of social change attach to the dwelling scale via those individuals who are early adopters of new technologies. For moving towards sustainability these high value individuals need support in their role. This dwelling scale provides this support as it is directed to the **individual** who is making the technology decision.
- Second, convey the *environmental consequences* of technology choice to the decision maker. In effect, develop and implement information feedback loops.

4.1 Onsite disposal contains the necessary scale

Scale is crucial for Glenorchy's waste disposal considerations; for which the current onsite disposal systems contain the necessary **scale** for both: technology change and directing information to the individual decision maker. This attribute needs to be maintained if the community is serious about sustainability, as the full range of technology options (including separate treatment of each waste stream) for decreasing N into the lake are available.

The problem for a community wishing to reduce N discharges using onsite systems is how to fairly accommodate the technological diversity. Where fairness must contain elements of polluter pays as well as giving credit for those technologies that remove N.

The critical element that is missing in Glenorchy's onsite system is conveying the *environmental consequences* of technology choice to the decision maker.

These environmental consequences need to be carried by a set of effective information feedback loops; but to be effective these information feedback loops need:

- *Generation* of relevant signals for each technology in a form that has meaning to the human brain (Appendix A.2). For example: \$/g(N); \$/m^3 (discussed in Appendix A.1). Using the council's proposed costings to generate these signals has the added advantage that onsite can be more easily compared to a centralised system in the public debate.
- *Transmission*. These information signals can be sent via the rating system (or consent fees) to transfer the consequences of an individual's technology choice to the individual, in a useful form.

In addition, removing the toilet wastes makes it very easy to dispose of greywater onsite (see evidence in Figure 1). It follows that:

- The need for a central reticulation system can be questioned.
- Additional benefits of using greywater onsite arise from reduced potable water demand as greywater can be used for irrigation. There is a double benefit for water and energy consumption from reuse of greywater – systems thinking would call this a *high leverage feedback loop*.

Onsite systems with **information feedback loops** that internalise to the decision maker, the environmental consequences of a technology's N removal performance is the **system** that best meet the community's sustainability goals. However the cultural baggage that surrounds a conventional sewerage system cannot be ignored.

4.2 Negating the worst attributes of centralised reticulation

Centralised reticulation is not sustainability nirvana as it is dependent on water consumption and needs considerable energy to move and treat the sewage. The system needs a rethink.

However most in the community are not yet ready to consider technologies beyond the flush toilet and reticulation. There is value therefore in creating space for the more sustainable technologies within a conventional sewerage system. A number of tools are available based on the linkages to measurements that resulted in Figure 1:

- Equity is a powerful human value that is easily related to technology choice via the technology's performance measurements. Proportioning the centralised reticulation system's capital and operating costs on equality per unit **volume** accommodates current versus future residents and commerce versus domestic. While the consequences for the system of the effect of non-water-use toilets on sewage concentrations can be accommodated by cost proportioning based on **technology type** which avoids the need for regular monitoring (in Chapman (2015c)).
    - Using equity with volume and technology type therefore includes both the dwelling scale and the variability in the 3 sources.

- The same information feedback loops used to convey the environmental consequences of technology choice in onsite systems (discussed above) and sent via the rating system can be used with centralised reticulation to influence the person making toilet technology decisions enabling the **system** to move towards sustainability (Chapman, 2017b).
    - 'Burden'[1] is an example of such an information feedback tool as it can quantify the cost of removing the pollutant from the waste stream.

In all cases, the benefits of the reduced treatment load of a dwelling choosing toilet waste capturing technologies needs to be acknowledged if the *centralised system* is to move towards sustainability. The above mechanisms retain the evidence yet are unaffected by the cultural mores that surround centralised reticulation.

There is one further mechanism that can be considered:

- Treat the system as three parts:
    - Reticulation – a community asset so cost shared equitably.
    - Treatment – dependent on volume and Burden (N) therefore cost can be proportioned accordingly. This can include zero cost for someone who produces discharge quality sewage. Issues of increments (100 dwellings for the larger package treatment plant) need to be worked through.
    - Disposal – volume determines area with land disposal systems therefore costs can be proportioned by volume. Increasing disposal area can be done in smaller increments than those that apply to the treatment plant. An issue for Glenorchy is the land area available for discharge.

Treatment therefore can be separated from reticulation and disposal and the individual producing discharge quality effluent exempted from paying for the treatment station. Indeed, any share proportion between -1 and +1 is possible for concentrations different from the minimum discharge quality.

5 Recommendations for the Glenorchy 'system'

Community optimisation involves finding a mix of strategies that achieves the community's goals with the least compromises to technological perfection. Glenorchy has two technological goals: reducing N into the lake and sustainability. The community's sustainability goal is aided by the Act's definition of sustainable management and the *natural and physical resources* that need to be managed for future generations (this definition includes N however it is separated out here as local concerns are N in receiving water rather than maintaining soil fertility). The system that keeps N out of the lake while requiring the least water and energy will be the 'best' system that satisfies both of the community's goals. It will contain the two critical elements discussed above:

- Dwelling scale analysis unit.
- Information feedback loops that internalise the environmental consequences of a dwelling's nitrogen contribution to the lake.

[1] Burden is a measure of the pollution load of the sewage that can also accommodate the cost of removing the pollution load. In this form the cost efficacy of all technologies can be compared and this includes technologies that deal with each of the 3 waste streams separately. The councils costs ($273/g.d(N)) are used here.

Affordability has emerged as a significant issue that has links to technology and the timeframe in which the N problem is dealt with.

5.1 Preferred system – onsite disposal with information feedback loops

With the evidence of nitrogen loadings to the lake attaching most strongly to the type of toilet technology then retaining onsite disposal and augmenting this with information feedback loops that encourage households to move towards choosing the technologies that capture the N at source (which have the added advantage for sustainability of reducing water and energy consumption) will have the best long term trajectory for Glenorchy.

There is however, a housing density that may preclude this option as greywater disposal still requires some plant uptake (albeit < $1m^2/P$) and for section sizes smaller than the $800m^2$ size of Figure 1 then using plant uptake for the residual N may not be possible. However, this housing density is not desired due to the high risk profile arising from the town’s location on an alluvial fan with liquefaction and flooding issues. Retaining onsite systems with its natural limits on population density is a non-coercive way of contributing to the management of the risk profile.

The limits of onsite disposal from insufficient area for plant uptake of N are most likely to manifest in the commerce and visitor accommodation zones. Reticulation of these zones with a disposal area offsite need not impact on the type of system for the domestic dwelling zones.

Partial reticulation of the commerce and visitor accommodation zones is possible.

5.2 Community reticulation

For any community reticulation system that is being considered, an additional condition arises as there is a need to negate any adverse impact of the system on the adoption of the more sustainable toilet technologies. Maintaining fairness and equity values and ensuring there is no discrimination against those individuals choosing more sustainable technologies can be achieved by proportioning the costs (capital and operating) of the community system on:

- Volume contribution to the system.
- Nitrogen ‘Burden’ based on five technology types: raw sewage (centralised treatment), septic tank with flush toilet, AWTS with flush toilet, urine separation only, both faeces and urine capture (TWCT).

There are two main reticulation systems:

5.2.1 STEP/STEG

STEP/STEG is a centralised system in which each dwelling is responsible for primary treatment (sedimentation in a septic tank). Only liquids are carried by the reticulation system. This system least compromises adoption of the ‘best’ technologies as dwelling owners (and developers) are responsible for their primary treatment.

Augmenting a STEP/STEG system with the information carrying mechanism suggested for onsite (see above) would encourage:

- The technology decision maker to consider the balance between capturing N at the toilet versus using energy and oxygen to remove it from the sewage (AWTS).
- Fairly distinguish between septic tank, AWTS, urine separating toilet bowls and compost toilet technologies.

Indeed, the value of the settings ($/g(N) for example) can be used to influence the dividing line between onsite treatment and council responsibility. The cost efficacy of the different technologies and methods becomes transparent with this system structure.

5.2.2 Conventional gravity sewer

Unless information carrying feedback loops are implemented, a conventional gravity sewer (and its vacuum & pressure equivalents) is the worst system for moving towards sustainability. Without the feedback loops, a conventional sewer extinguishes any motivation to choose sustainable solutions (or indeed even to reduce water consumption).

However, a gravity sewer with capital and operating costs based on volume and Burden carried in information feedback loops would provide some incentive to reduce volumes and some residents may be motivated to capture their toilet wastes so is marginally more sustainable. That is, until volumes reduce to the point where solids are not carried by the flow and the system needs regular flushing.

A refinement for attaching these information feedback loops is to consider the system as three parts: reticulation, treatment and disposal.

It should not be surprising that a system that was never intended to control pollution (the first underground sewer was installed to control stench (Benidickson, 2007)), continues to demand water and energy and consequently fail sustainability criteria.

6 Conclusion

Glenorchy can think differently and open up paths that better fill both the community's sustainability vision statement, and the intent of the governing Act. To do so we need to let go of the assumption that centralised reticulation is sustainability nirvana.

However, in order to grasp the potential in the available technologies the debate needs to begin with the most sustainable technologies. These capture the toilet wastes separately and do not mix them with greywater. As this contradicts the functioning of conventional sewerage systems a major crisis is triggered for the industry and community.

It is argued here that a path through this crisis is possible by developing **information feedback loops** using the council rating system. The information for these feedback loops includes the differences between the three waste streams and the significance of toilet technology choice in moving towards sustainability. Mechanisms that convey the technology consequences of this information become an important means of enabling the purpose of the governing Act. The task for these information feedback loops is to send the technology significance of the variability in the three waste streams (the information) to the decision maker in a form that they will take notice of.

However, the choice of toilet technology necessitates consideration of the dwelling scale as an analysis unit. Mixing of the three waste streams occurs at the dwelling and as 95% of the N comes from the toilet it makes sense to capture this N at source.

Including a dwelling's volume and their pollution 'Burden' in these information feedback loops further improves their effectiveness as it means they apply to all of the different systems and recognises behaviour differences to which other management tools can be attached (such as polluter pays). Including volume and pollution 'Burden' means the information feedback loop applies to all of the different systems, hence onsite as well as centralised reticulation are included. Their information carrying role is beneficial whatever system the community chooses, though the information carried may be slightly different.

When applied to Glenorchy, retaining our onsite systems and forming information feedback loops that use the council's rating system to encourage individual dwellings to upgrade their systems (decrease their N into the environment) is an alternative to centralised reticulation.

However, if reticulation is pursued then acknowledging a dwelling's reduced volumes and reduced N 'Burden' that accrues from choosing more sustainable technologies is possible by a proportionate reduction in capital (and operating) cost contribution. This maintains fairness and equity with a slight contribution to sustainability.

Glenorchy could begin with a decreasing N load to the lake and use these information feedback loops to get the necessary technology change without necessarily needing a reticulated system. Funding mechanisms can also attach to these information feedback loops.

7 Bibliography

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Appendix

A.1 The technology interface

Sewage technologies occur in the interface between Nature, environmental impacts and our social goals. As their measurable performance determines their environmental impacts, the type of technology becomes important to satisfy this mix of social and environmental constraints. The fact that their performance is a measure of the processes (including microbial processes) occurring within the technology, opens up considerable possibilities in facilitating technology choice:

- From the sustainability context, the 'best' possible technology would use: zero energy, zero water and recycle all nutrients to the biosphere. This 'perfect' technology is called the Beacon in Chapman (2015c).
    - All technologies can be compared to the Beacon and, as the performance of sewerage technologies can be measured, their proximity to the Beacon can be determined. Consequently they can all be listed from best to worst. Any debate that claims to be sustainable must include those technologies that are closest to the Beacon.
- All technologies will have a manufactured cost. Combining this cost with the performance measurement forms an information package that includes Nature's behaviour **and** the human economic system. That is, a community's *social* as well as *environmental* well being can be assessed using these quantified measurements.
    - The linkages to the human economic system inherent in these cost/performance information packages, means that the economic system can be used to transfer information and assist the debate. Indeed using systems thinking, information feedback loops (which are a necessary mechanism for keeping a system on track) using this information package can be considered. The cost/performance economic tools have been shown to apply to our 3 waste streams and can internalise the environmental consequences of technology choice to the decision maker (Chapman, 2017b).
    - Information in this economic form can be sent through the council rating system to the decision maker. In this form it can also serve an advocacy role for this information and further improve the efficiency of social processes by limiting the distortions inherent in any advocacy role by humans.
    - This type of mechanism raises the possibility of self-organisation as being the most cost effective tool for achieving social and environmental goals.
- Equality is also very useful for cutting through the overwhelming complexity as equality has meaning in the social context (a fair and equitable society) and also in the mathematical context. This enables a small separation between the debate in the social context (such as: is it fair that everyone pays the same per unit volume?) and the application of equality to the relevant measured parameters. Using the mathematical context, equality can be applied to the measurement of any component of sewage; however, volume and 'Burden' (this being a measure of the amount of treatment needed before it can be discharged) is sufficient to accommodate all of: current versus future generations, commerce versus dwelling (Chapman, 2017a).
    - Fairness in the social context can be viewed in the mathematical context as a socially acceptable variation from equality. This is useful for the likes of public facilities that may be funded by, but not used by, locals.
- Basing capital and operating cost on a per dwelling basis (or legal title in the case of a business) using volume and 'Burden' would be perceived as fair and equitable by the

community (where volume/dwelling is easily measured and ‘Burden’ can be accommodated by considering the major technology types – e.g. AWTS v’s septic tank v’s compost toilet & greywater system).

There is considerable potential in building and using information structures based on a technology’s measured performance to simplify the overwhelming complexity that faces us. We need not fear the possibility of creative ways of dealing with our ‘wastes’. A higher quality decision is worth pursuing.

Some, or all, of these tools can be used to aid the passage of Nature’s information into the community decision of ‘best’.

A.2 Refining the social interface

For the evidence to influence the decision it needs to be **meaningfully** heard in the debate. Meaning is a brain function; it is not a property that can attach to a technology as measurement can. Meaningful in the context of a community desiring sustainability therefore needs the information that points to a certain type of technology for sustainability, to be heard through the cacophony of social processes. A part of the cacophony arises (in this case) from the cultural context of an embedded technology that doesn’t pass the sustainability criteria. Developing meaning around the measurements of sustainability would benefit from a carrier mechanism that penetrated the cultural baggage surrounding the embedded technology.

This mechanism will need two attributes: first, it must contain the evidence. In particular, the technological consequences of 95% of the N being in 1% of the sewage volume – discussed above; and the social (and administrative) consequences that result from this. The dwelling scale needs to be the analysis basis.

And second, it must trigger meaning in the human brain. Some examples:

- The graphical form of the evidence in Figure 1 is one way of facilitating meaning by using our visual faculties.
- Using the economic system to carry environmental data to the decision maker enables the environmental cost to be made visible in the same form as the technology’s manufactured cost (Section A1). Information in this form and can be processed by the same parts of the brain as the cost data.
- Mechanisms can also be built from the social side by using values-based terms, particularly fairness and equity (Section A1). Meaning in this case attaches, in the first instance, to our values. This enables a small separation of the information needed for the decision (fairness and equity values), from the cultural baggage that accompanies consideration of sewerage technologies. The result of this values-based decision can then be related to the measurement-based information (such as equal cost per unit volume) and the technology implications worked through (Chapman, 2017a).

A.3 The value of information structures!

Information is pervasive, it is needed to grow our food, develop the digital logic gates that underpin our computers and how to make the steel that strengthens our concrete. Indeed, who would have thought that the photons arriving at the earth contain information about the beginning of the universe; yet these are all examples of the pervasiveness of information.

The trick with using information is finding the useful stuff and using it effectively. When considering technology optimisation for a community sewerage system, three questions arise:

- *Which information needs to dominate the decision?* Nitrogen is clearly dominant for us, and most arises from the toilet (95% of this N is in 1% of the total volume). There are two consequential effects of this information:
    - The need to focus on technologies that capture N at the toilet.
    - The dwelling scale that considering toilet technologies implies.
- *Which information cannot be extinguished?* Mixing toilet wastes with greywater produces an average value and *extinguishes* the possibility of separate treatment of each waste stream. Unfortunately this is the council's starting position hence they fail to grasp the potential inherent in designing a sustainable infrastructure.
    - It is however possible to create 'information space' at the dwelling scale (where the 3 waste streams are initially separate) and not extinguish the information about the variability in the 3 waste streams. This technique can be used for individuals who aspire to think differently, if the community wishes to push ahead with a reticulated system.
    - As we live in a culture that has many decades of flush toilets then creating information space around the dwelling to facilitate change is even more important.
- *How to use this information meaningfully.* Meaning is a brain function that attaches more strongly to experience than to evidence. The evidence needs help in generating meaning.
    - The cost/g(N) for example makes information links between the economic system and the technology's actual performance. We daily participate in the economic system and understand the meaning of money so attaching the environmental cost of nitrogen to money means we have a mechanism by which environmental effects can influence decision making.
        - Fairness and equity values can also attach to these money based mechanisms – everyone should pay the same per unit volume for example.
    - Management tools also easily attach to information, particularly in the computer age.
        - The cost/g(N) can be either positive (paid by the polluter) or negative (received by the person who removes their N). The zero balance here can be the council's discharge standards. This leads to the possibility of:
        - Cross subsidisation further encourages consideration of alternative technologies and also generates a signal that can be picked up by commerce (manufacture this type of technology and you have a market for your product).
        - Indeed, self organisation is a possible alternative to legal coercion for effecting environmental improvement.
- *Affordability.* Community funding of incremental improvements is possible with onsite systems and the management tools mentioned above. This would avoid the interest payments inherent in a conventional sewer. Indeed, the significance of this effect can be seen in that if only the interest charged (6%) on the full upfront cost of the proposed sewerage system were used to incrementally update our onsite systems then in 16 years every house would be upgraded.

The potential inherent in using information feedback loops to influence environmental impacts in the wastewater industry is underutilised. Glenorchy is an excellent place to explore this potential as it is stated in its vision and has a large development based on sustainability.