CAN WORLDWIDE EXAMPLES GIVE NZ BIOSOLIDS BENEFICIAL USE WINGS?

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1. ABSTRACT

Despite encouragement through the MfE Waste Strategy (2002), the Waste Minimisation Bill (2008), The *Guidelines for the Safe Application of Biosolids to Land in New Zealand* (2003), and several specific Regional Rules, promulgation of biosolids application to land continues to be a hard-fought battle, with few outright successes.

This paper will examine global case studies sourced from the WEF Biosolids and Residuals Conference, held in Portland in May 2009, and compare and contrast these seemingly successful beneficial use systems with the handful of beneficial use systems and recently acquired consents currently operative in New Zealand. We'll look at the latest innovations that are coming through on the world stage, examining their merits in terms of advancing the abilities of Councils and Biosolids producers to more easily engage in beneficial use.

From these issues and case studies both here and abroad, we develop some simple "do's" based on the commonalities of successful systems, and similarly, a list of "don'ts" that have been discovered through efforts worldwide. These lists will assess a broad array of issues worth taking into account when assessing potential reuse options, including the current philosophical, scientific, and political and market climates.

Keywords: Biosolids, Sludge, Beneficial Use, Land Application, Reclamation,

2. Introduction

New Zealand produces in excess of 235,000 tonnes of sewage sludge annually from over 3 20 public wastewater treatment plants (Bradley 2008) . The WINFO wastewater information database developed by the Ministry for the Environment and NZWWA (now W ater NZ) indicates that less than 38,000 tonnes per year of the biosolids and sludge resource is benefic ially used (16%). The vast majority (almost 50%) is being applied to a long -term monofill storage which is questionably labeled as land reclamation, with the remainder (34%) being disposed of to landfill.

Based on these volumes, it is clear that land application and beneficial use of biosolids and sludges in New Zealand continues to lag behind other OECD countries. Biosolids recycling in New Zealand is a minority use, compared to overseas benchmarks like Oregon State, USA (94% beneficial use, 6% disposal) Washington State (77% beneficial use, 5% long -term storage, 18% disposal) or British Columbia, Canada (99% beneficial use, 1% disposal) . It is worthwhile to note that in the USA as a whole, beneficial use stands at approximately 49%, with 6% in long - term storage (Lono-Batura 2009).

Biosolids recycling and beneficial use has carried on with some success in the Pacific Northwest region of North Ame rica (PNW) since the inception of the Mountains to Sound Greenway Trust in 1973. In considering the New Zealand performance in comparison to the success of the PNW systems, it becomes a worthwhile exercise to take the time to examine the experiences overs eas, to compare and contrast key lessons that might assist New Zealand to achieve greater success in beneficial use, particularly in land application, which clearly makes up the majority of successful recycling initiatives in the PNW .

Recent attendance at the WEF Specialty Residuals and Biosolids Conference held in Portland, Oregon, suggests an assessment of differences in approach with respect to specific knowledge centres:

- Technical Knowled ge
- Regulation versus Guidelines
- Consultation and Process
- Outreach, Extension, and Communication
- Success stories

Agricultural, reclamation information drawn from the WEF conference will be used as examples for comparison with similar efforts here in NZ. The purpose is to determine if an approach to the beneficial u se of biosolids can be improved in NZ to achieve a greater degree of simplicity and success.

The goal of this paper is to u nderstanding why biosolids beneficial use continues to be a hurdle for NZ 5 years after the release of the *Guidelines for the Safe Application of Biosolids to Land in New Zealand* (2003, *The Guildelines*) and the Ministry for the Environment's Waste Strategy (2002) which championed 95% removal of organic waste from the landfill by 2007. Despite the kiwi tendency to "do it our way" some overseas assistance from an area with almost 40 years experience in this particular area would be valuable.

3. Technical Knowledge

In terms of the technical knowledge required to understand biosolids at a comprehensive level, the following headings are useful in partitioning the specific areas of technical knowledge:

- Nutrients
- Trace Elements (Heavy Metals)
- Pathogens and Vector Attraction
- Microconstituents

FRST funded research in New Zealand has provided (and continues to provide) the NZ scientific community with an excellent understanding of the dynamics of nutrients, trace elements, and pathogens in biosolids and their interactions with the environment. The science in these areas has been strong enough to be addressed in *The Guildelines*, providing a consistent approach to these areas based on best practice and current science knowledge.

From this research we understand that we can easily manage nutrients through the use of agronomic rates. We understand that we can manage trace metals through concentrations, and through management of soil pH. Land application of biosolids and incorporation increases the attenuation of pathogens, and reduces the likelihood for vector attraction, if the product was not treated as such prior to application. Semi-volatile organic compounds are also regulated to particular levels, but the majority of microconstituents form the core of a NZ information vacuum.

Microconstituents is the collective term for today's emerging contaminants of concern. These include all chemicals not part of the other three headings that are potentially found in biosolids, sometimes in quantities as minute as picograms per gram (pg g^{-1}). These include pesticides, priority pollutants, antimicrobials, pharmaceuticals, and endocrine disrupting compounds. New Zealand's home-grown knowledge of these microconstituents is in it's infancy, due in part to the extraordinary costs of the analytical work around many of these compounds. There has been some basic research undertaken in New Zealand with respect to biosolids and pharmaceuticals (Gielen 2008).

It is valuable that there is a large amount of work being undertaken to address the current paucity of information that surrounds many classes of microconstituents. Abundance information for various microconstituents in biosolids is being accumulated. But very little is known about the environmental fate and behaviour of these microconstituents in soils (O'Connor 2009). Many of the chemicals have long half-lives, are bioaccumulative, and are toxic to some species, but the information around the chemicals also suggests that their solid phase retention is great, their release or availability is small, and that leaching through soils to groundwater is also small meaning that "long-term persistence need not mean long-term risk to environmental or human health(O'Connor 2009). Closer examinations of pharmaceutical personal care products indicate that incorporation of biosolids in soil generally ensures that any leached pharmaceuticals are far below toxic thresholds for a variety of endpoints (Topp et al 2009). Data from Universtiy of Washington studies examining the effects of antimicrobials (triclosan) and Endocrine disrupters Estriol and 17β-estradiol) applied in biosolids suggest minimal negative impacts on soil or water quality (Brown and Devin-Clarke 2009).

Key common messages about microconstituents are particularly valuable. The first is that many issues surrounding the environmental fate of microconstituents are still at a "definition of problem" stage, and all researchers agree that more information is required. That said, most of the research seems to suggest that microconstituents are not an acute problem in biosolids application.

A key secondary message that arose from the WEF Residuals and Biosolids Conference is that context is very important when examining the microconstituent issue. The amount of triclosan in biosolids, for example, pales in comparison (by several orders of magnitude) to the amount of triclosan that we stick in our mouth on our toothbrush every day, when using an antibacterial toothpaste. The amounts of estrogen compounds in biosolids being applied to the agricultural environment is not likely to have a fraction of the impact expected from the adjacent paddock, where a herd of dairy cattle reside in a state of either pregnancy or lactation. These key messages of context need to be reinforced in the New Zealand context, where what we don't know often trumps what we do know when assessing potential and real effects on the environment.

4. Regulation versus Guidelines

In comparison to the information readily available to biosolids producers, councils and consultants in NZ, there is a vast amount of information available in North America. In the USA, the use and disposal of biosolids is governed from an environmental perspective jointly through several tiers of regulation:

- Federally, the Environmental Protection Agency's Title 40 Part 503 rule (Part 503) lays out the standards and minimum requirements for quality and usage of biosolids, be it disposal, land application, or other environmentally based use.

- State Departments of Enviromental Quality (DEQ's) are regulators similar to regional councils, assessing applications and issuing or declining permits based on the site specific proposals and conditions.

- Counties are also able to regulate, and have the ability to ban or endorse the application of biosolids to land, through county by-laws, similar in stature to district council authority in New Zealand.

A particular difference between the US and NZ is the nature of Part 503 as compared to New Zealand's counterpart, the *Guildelines*. Part 503 is the law of the land, prescribing in thorough detail what can and cannot be done with biosolids in the entirety of the United States. Part 503 provides an unequivocal baseline to biosolids application or disposal, and provides specific guidelines with respect to what is beneficial use, versus what is disposal.

The *Guidelines*, by comparison, were produced with the endorsement of the Ministry for the Environment, but are not a document with any legal authority or stature. The goal of the guidelines was to promote a consistent approach to the management of biosolids throughout New Zealand. The goals of the *Guidelines* and Part 503 are virtually the same: better management of biosolids. The key difference is that Part 503 provides *Requirements* for management, the *Guidelines* provides an *Approach.*

Based on the certainty with which state regulators and wastewater agencies can rely upon the Part 503 rule, and be assured that if they achieve the requirements of this rule they will be able to explore beneficial use for their product, is a reassuring contrast to the NZ situation. In some regions, the guidelines have been superceded by regional plan rules requiring ever stricter interpretations of analytical limits, and some of the intent and spirit intended by the *Guidelines* has been lost due to lack of ability to interpret the limits that have been imposed. In future, it is hoped that NZ would be able to move to a level of certainty that is provided through a rule such as Part 503, versus the *Guidelines.*

5. Consultation and Process Approach

Consultation and the process approach to stakeholder involvement in New Zealand is often criticized as a weak link in resource management processes. Disagreement between affected parties and an applicant is often the starting point for either a long, drawn out consent process, or difficulty in convincing the hearing or court that there will not be adverse effects on affected parties. Biosolids continues to be a polarizing issue for many people.

In examining successful consultation and stakeholder engagement overseas, it is worthwhile reviewing some New Zealand knowledge basis to remind ourselves of what good consultation means in New Zealand. The first example is a list of 10 keywords that define good consultation from a Local Authorities Upskilling Project Workshop held by Dr. Tom Fookes of the University of Auckland in 1996:

Consultation under the RMA – Ten Keywords

- Early
- Listening
- Informing
- Ongoing
- Waiting
- Balancing
- Feedback
- Mutual good faith
- Two way
- Open Minded

The second is the design process for a land-based effluent treatment system, from Robb and Barkle (2000):

Figure 1. Design Process from Robb and Barkle (2000)

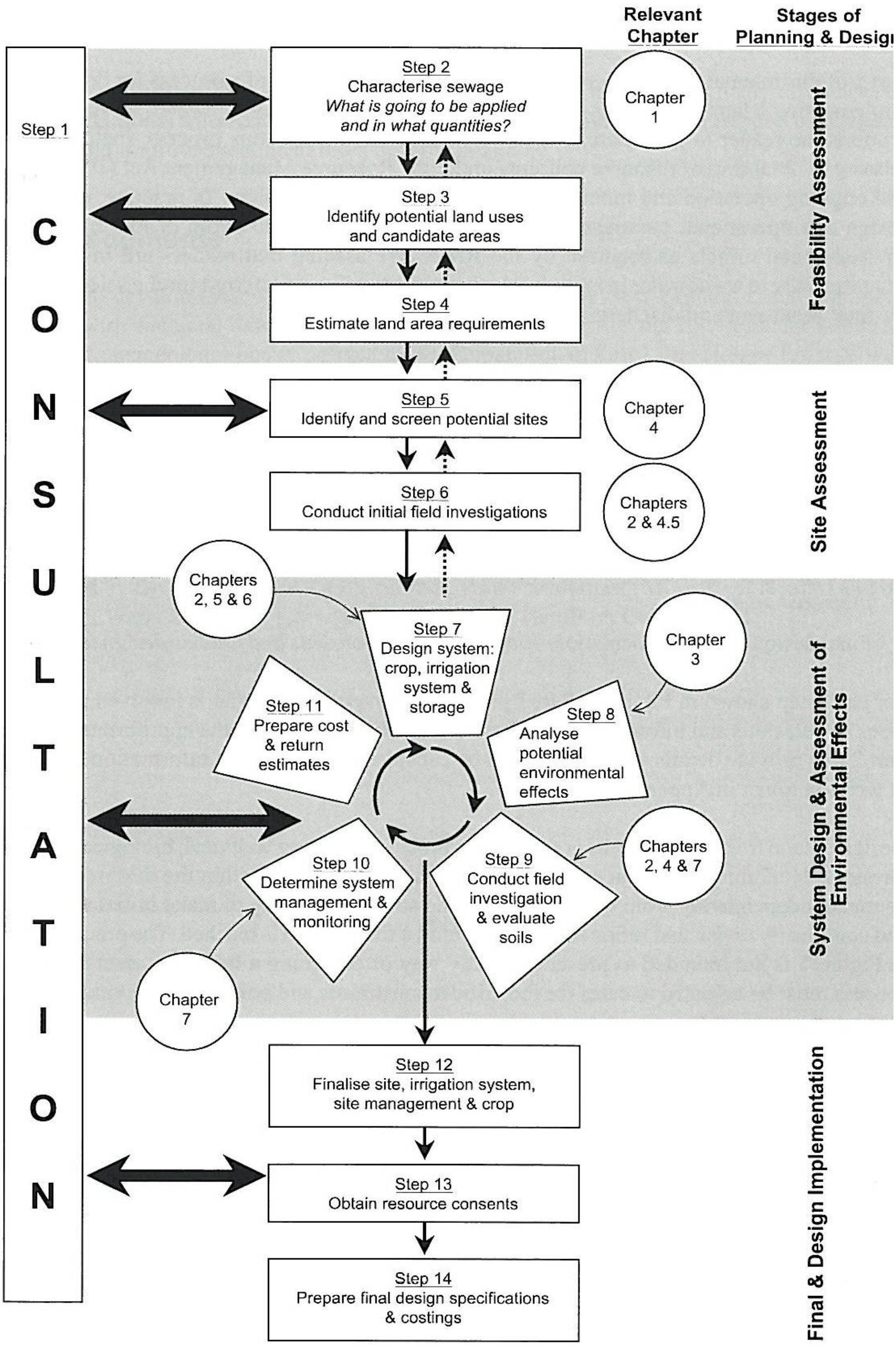


Figure 1: Design process for a land-based effluent treatment system.

The keywords and the figure remind us of the early and continuous role that consultation and ongoing communication play in the success of land application projects.

In re-examining these processes, it is no surprise that stakeholder engagement prior to commencing and during all stages of a biosolids program is paramount in developing and maintaining a successful, accepted biosolids management program (Viera *et. al* 2009). What is not readily apparent in New Zealand biosolids programmes is the ongoing nature of the consultation. Biosolids success stories in North America are effectively paired with parallel evidence of ongoing communication and verification of the information to stakeholders:

- Metro Vancouver addressed uncertainties surrounding Nutrifor, a biosolids amended soil product with a trial campaign: The "Soil Product Testing Initiative". Field trials of the product were instigated alongside conventional horticulture industry soils for horticulturalists, members of the public, municipalities within the region, and community groups to demonstrate the performance of Nutrifor. High profile landscaping jobs continue to be sought by the program, such as landscaping key areas related to the upcoming Winter Olympic Games Sites, to continue to keep Nutrifor in the public eye, allowing the Nutrifor landscaping soil program to sustainably recycle up to 15,000 tonnes of biosolids per year into soil products.
- Finding well-liked and well-respected local sponsors or "champions" was the secret to success for King County's (Seattle) move into agricultural land application in 1991. Targeting key people in the Boulder Park agricultural community, and providing them with both support and product to be trialled on their farms, King County cultivated relationships with the farmers to the point where they were willing to publicly speak to the benefits of the soil conditioning product and the biosolids themselves. The result is an 18-year old biosolids application programme without any permit violations, allowing King County to successfully land apply biosolids to agricultural land year-round.

(Viera *et. al* 2003)

It is rare that Stakeholder consultation and communication is so thorough in New Zealand. It is an expensive and time consuming process, but pays dividends to municipalities and biosolids producers through dedicated, long-term demand for the product. It is worthwhile to ensure that a large consultation programme is in place to effectively reduce the potential for consultation surprises during a consent process, as well as to develop strong relationships to ensure the demand for the product remains high.

Ensuring that all stakeholders are on board would be of immense value to larger applications. Using some of the techniques above, or adding novel methods to the mix, such as viral marketing, may allow for a more generalized acceptance for biosolids in the regions of New Zealand.

6. Outreach, Extension, Communication

New Zealand does not have a dedicated biosolids extension or coordination facility. In an industry where successes are few and far between, and a coordinated effort to simultaneously resolve issues for multiple councils could be considered an economically viable asset, few agencies have worked together to resolve their biosolids disposal issues. This does not mean that biosolids does not get a hearing.

New Zealand has several organizations through which biosolids information is extended to the wastewater commun ity at-large. Technical and scientific information is usually produced for the annual conference of the New Zealand Land Treatment Collective (NZLTC). Case study information and larger process issues are generally dealt with at the N ZWWA (Water NZ) confe rence. In addition, a FRST -required biosolids end user workshop is also held, usually in conjunction with the NZLTC conference. The workshop is a specific forum to provide scientists the forum for extension of results.

Australian Water Association has , with partner utilities, also developed the Australasian Biosolids Partnership, modelled on the National Biosolids Partnership in the U.S . While this group is open to membership or subscription to New Zealand members, the uptake has been extraordinarily low, with only two NZ utilities becoming members of the organisation. The information thus appears to be predominantly focused on the Australian biosolids environment.

The need for a dedicated collaborative approach to biosolids in New Zealand is worthy of closer examination. This can be vicariously obtained by looking at a strong example of a dedicated active education/outreach and communication group in the PNW, the Northwest Biosolids Management Association (NMBA). The NMBA is a cooperative that was formed in 1987 by 14 wastewater agencies, with the mission to 'advance environmental sustainability through beneficial use of biosolids' (Lono -Batura 2009). The cooperative (now 200 members strong) is an advocate group that assists its members to continue to capitalise on biosolids opportunities, producing publications, funding research and university involvement, and reviewing biosolids regulations with policymakers. The result is that the region influenced directly by the NMBA, which encompasses British Columbia, Wahsington, Idaho, and Oregon, is one of the areas of North America with the highest beneficial use of biosolids (88% average versus 49% average for North America), and includes some success stories where biosolids have been successfully applied to land for 20 years or more.

The levels of success that have been obtained by the NMBA provide a degree of evidence that perhaps it is time for NZ wastewater agencies to focus their collective efforts to develop a similarly sanctioned association or aut hority for New Zealand's biosolids community.

7. Success Stories

Not all biosolids management initiatives in North America are instant successes , and not all attempts in New Zealand have failed . Common ground with NZ biosolids application initiatives is plentiful, based in the requirements for time, effort, excellent communication, and a positive, enduring profile. Despite efforts in all of these areas, there are still failures.

In pinpointing the glowing and up -and-coming successes in North America, and in New Zealand, the most striking commonality seems to be the ability of the proposed management system to highlight an environ ment where the application of biosolids c an achieve the least-cost highest benefit beneficial end use, and use the principles of strong stakeholder engagement, consultation, and extension to ensure that the partnership is sound, and that valuable information continues to be extracted from the program, keeping the agency and the stakeholder on the front foot with respect to any potential challenges or questions. The end uses that are alighted upon are almost always of a land application type, and sometimes require lateral thinking to ensure that the biosolids are used for their unique beneficial traits, and managed to ensure that their drawbacks are virtually non-existent.

It is worthwhile to iterate some of the key traits of biosolids that make for good success stories:

- ***Nutrients***: Most biosolids have an excellent suite of macro - and micronutrients for plant growth.
- ***Organic matter***: The majority of biosolids solid matter is organic, which is beneficial in conditioning and buffering soils.
- ***Water Holding Capacity***: Biosolids added to soils in arid climates tend to allow the soils to retain more moisture, significantly improving vegetation growth.
- ***Carbon storage***: Biosolids are only beginning to be evaluated for their ability to trap and retain greenhouse gases, or to be used in carbon sequestration.
- ***Energy:*** various methods of digesting sludges prior to final production improve energy recovery, and reduce GHG emissions and volume for later application.

Several key case studies were presented at the WEF Residuals and Biosolids Conference that were particularly relevant to the potential that New Zealand embodies, from an environmental standpoint. A particularly valuable case for the New Zealand context is provided below, followed by a New Zealand example of a beneficial biosolids use system that will soon demonstrate 100% beneficial use to land:

7.1 Madison Farm

Madison Farm is a 7,000 ha farm in the semi-arid rangeland of north central Oregon. The land provides limited forage for drystock farming, and the area has previously been a ‘dustbowl’ of unvegetated sandy soils historically troubled by wind erosion.

The Madison family has been working with the City of Portland since 1990, applying a USEPA Class B biosolids product from the Columbia Boulevard wastewater treatment plant to the farm. The combination of added organic matter, nutrients, and water holding capacity have allowed animal stocking on the farm to improve from one steer per acre to 20 steers per acre. Additional improvements in water holding capacity have allowed for the installation of centre pivot irrigators to crop canola, which is used for biodiesel and food oil production, as well as winter wheat.

The research that has been undertaken by scientists from Oregon State University has demonstrated benefits for the City of Portland, too. The improvement in carbon sequestration within the farm site in crops, soils and livestock as a result of the biosolids applications is equivalent to eight times the amount of carbon emitted from diesel consumed to haul and apply the biosolids. Through operations, the application program is a carbon sequesterer, not an emitter.

Despite an 1 8 year application timeframe, the application of metals and overall metals in soils have remained low (See Figure 2). The forage production and nitrogen in forage is substantially improved over non -applied areas (Figure 3).

Considering the increasing dro ught prone nature of many areas of New Zealand, combined with young soils, the potential for vast improvements in productivity through long -term biosolids application are a worthwhile case study.

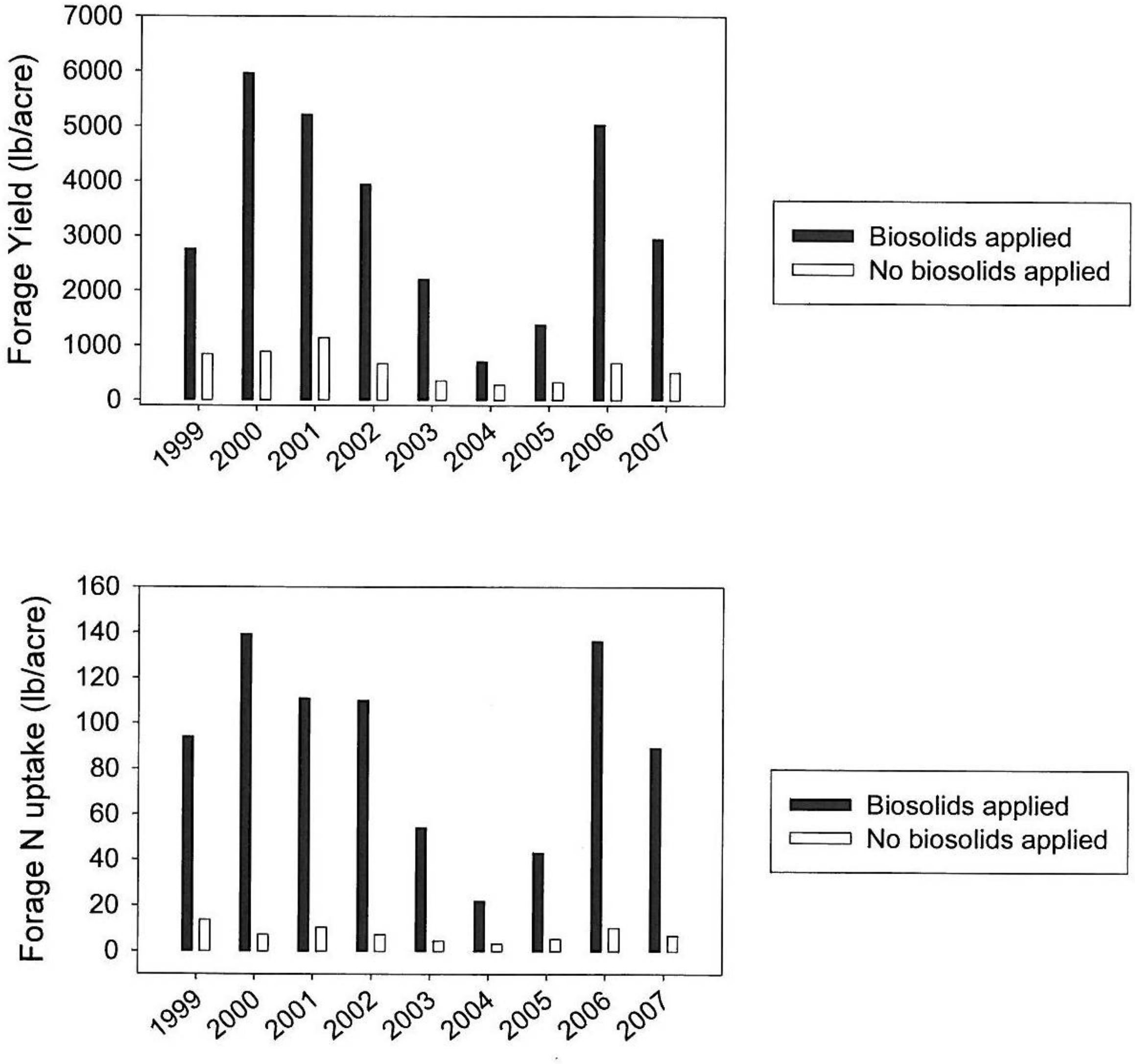
Figure 2. Organics and Nutrients applied to Madison Farms (Source: Ronayne et al. 2009)

Table 1. A Estimate of Organic Matter and Nutrients in Portland Biosolids Applied to Madison Farms-1990 to 2008[1&2]

Constituent	Percent dry weight	lb/dry ton	lb/ac/yr[3]	Tons/ac[4]
Organic matter	51.5	1,030	4,120	39.14
Total N	4.75	95	380	3.61
NH_4-N[5]	0.87	17.4	69.6	0.66
P_2O_5[6]	5.14 (2.25)	102.8 (44.9)	411.2 (179.7)	3.91 (1.71)
K_20[7]	0.39 (0.32)	7.8 (6.47)	31.2 (25.9)	0.3 (0.25)
Calcium	2.03	40.6	162.4	1.54
Magnesium	0.64	12.8	51.2	0.49
Sulfur	0.98	19.6	78.4	0.74
Iron	1.72	34.4	137.6	1.31
Copper	0.05	1	4	0.04
Zinc	0.56	11.2	44.8	0.43
Manganese	0.04	0.8	3.2	0.03
Boron	0.004	0.08	0.32	0.003

[1]Mean of three samples collected by Portland operations staff on August 19, 20 and 21, 2002 and May 14, 15 and 16, 2005.
[2]Samples tested by Agri-Check, Inc., on August 26, 2002 and May 17, 2005. Biosolids were acid digested pursuant to Soil Science Society of America Book Series 3; Soil Testing and Plant Analysis; 1990; p. 406. Cake P, K, Ca, Mg, S, Fe, Cu, Zn, Mn and B were analyzed on a Perkin Elmer ICP, Series 3000DV unit; OM was assessed using the Loss on Ignition method; TN was determined via the Kjeldahl method; and NH_4-N was analyzed via KCl extraction.
[3]Based on an average annual dryland pasture application rate of 4 dry tons biosolids per acre during 1990 to 2008.
[4]Estimate of the number of tons nutrient provided per acre at Madison Farms after 19 years at a rate of 4 dry tons per acre annually.
[5]The NH_4-N analysis was done after biosolids were dried. Thus, results are lower than typically found when biosolids are processed by Portland's WPCL pursuant to EPA Method 350.1.
[6]Upper value denotes P_2O_5 and lower value indicates total P.
[7]Upper value denotes K_2O and lower value indicates total K.

Figure 3: Comparisons of forage yield and N uptake: Madison Farms (Ronayne et al. 2009)



7.2 Hutt Valley Water Services Biosolids Programme

The HVWS case study is an example of a programme that has begun with searching out key stakeholders and potential champions, and working with those champions to develop a diverse biosolids land application programme. CPG, w orking with HVWS, has been able to aid them in assessing several different opportunities for the thermally dried NZ class Ab product they produce. The results of the search for potential stakeholders, which has been ongoing for two years has yielded the development of several worthwhile partnerships for HVWS. These include:

- A relationship with Timberlands, a forest management company based in Rotorua, who are now examining remediation of skid sites in forests, with trials already underway through a permitted activity in the Bay of Plenty Region.

- The development of a long-term soil conditioning and improvement programmes for a corporate dairy runoff. Discussions with Fonterra and the Meat Industry Association have provided agreements in principle, and these key players are considered essential to the programme, where the farm owners hope to improve the productivity of their sand-dune farm near Tangimoana through organic matter and nutrient sequestration, leading to improved water holding capacity. The same corporate farm is now examining multiple other locations where biosolids may also provide improvements to pastures and productivity. The farm anticipates a net savings on fertilizer expenditures of over $250,000 per year through the use of biosolids. Consents have been applied for.
- The application for consent for a site-wide one-time pasture renewal process for a large dairy farm. Despite being furthest from Hutt Valley, nearer to Hawke's Bay, this farm is awaiting consent to apply 3000 dry tonnes to their land over the course of one year, at which point the farmer will re-assess and potentially move to a longer term application system involving a rotating winter crop scheme.

The product now has multiple potential outlets that are all either in the consenting process, or agreed to having been established as a permitted activity. The process of seeking willing champions is not a fast process, but the resultant long-term interest and partnership developed with the landowners is intended to pay dividends for both parties, in terms of security for the producer, and product for the user.

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