Raglan Land Treatment Options: Evaluation of Five Alternative Options

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Appendices

1.0 Introduction

Pattle Delamore Partners Limited (PDP) have been requested to consider feasibility aspects of 5 alternative options for wastewater management at Raglan. The work has been commissioned by Waikato District Council (WDC) at the request of the Raglan Wastewater Working Group (Working Group).

Prior to this report PDP has undertaken a preliminary assessment of several potential land treatment sites for disposal of treated sewage (wastewater) from the Raglan municipal sewage treatment plant (STP). This work was presented in 'Raglan Land Treatment Options Report' (PDP, June 2001), and considered options of disposal by slow rate irrigation to pasture and forest, rapid infiltration to sand dunes and several combinations of these options along with use of the existing ocean discharge.

In this earlier work the sites studied for slow rate irrigation did not provide sufficient area for disposal of all of the wastewater flow. Hence, some discharge to the ocean was required in combination with this option. However, Rapid Infiltration (RI) to sand dunes appeared to be an option that could be satisfactory to handle the total flow subject to further technical evaluation.

Following presentation of the PDP June 2001 report to the Working Group, PDP was asked to consider an additional 5 alternative options, as proposed by Mr Steve Hart of the Working Group. Mr Hart presented these options to PDP staff at a meeting on 3 July 2001. Following this presentation, PDP has undertaken a preliminary evaluation of aspects of the 5 options with the aim being to evaluate whether or not the options are feasible and warrant further investigation. This report presents the findings of the evaluation of these 5 alternative options.

One of the key differences between the 5 alternative options and those evaluated earlier by PDP, is that the 5 alternative options all assume an average dry weather sewage flow (ADWF) equivalent to 140 litres per day (l/p/d) which is significantly below the assumed current ADWF of about 225 l/p/d. (Note that the average winter baseflow used for the earlier PDP report allowed for stormwater entry to the reticulation and above average rainfall on the ponds. This produced a flow of about 900 m^3/d or 310 l/p/d (PDP, June 2001)). Mr Hart has stated that a flow of considerably lower than 140 l/p/d could be achieved by a combination of water conservation, conservation education within the community and reduction of stormwater and groundwater infiltration and inflow to the existing sewage reticulation system. This is a significant assumption, especially as disposal of the final volume of treated wastewater is seen as a key factor in the viability of these options.

It should be noted that if a flow of 140 l/p/d were to be applied to the options evaluated in the earlier PDP report, the capital cost associated with these options would reduce significantly. The five alternative options considered in this report were evaluated using the reduced flow as Mr Hart's options all assumed lower flows. However, should these reduced flows not be achieved in the future the feasibility conclusions generally remain the same, except for the land area requirements, which as a rough order approximation could increase by 60% for the average rainfall year case.

PDP considers that whilst it may be possible to achieve an ADWF of 140 l/p/d in certain circumstances such as where new reticulation is in place and the entire community is committed to conservation, this goal is unlikely to be a reality for Raglan. In addition, it would likely take several years for the necessary measures to be implemented during which time the ADWF would still remain at about 225 l/p/d and wet weather flows would be substantially higher than this. The ongoing programme of repairs that WDC is undertaking to the existing reticulation is likely to produce flow reductions in the order of no more than 20%, based on general information from similar systems elsewhere.

In this report PDP has only considered aspects of the treatment systems that PDP is familiar with, and/or that published scientific research is available for. No site work or visits to any potential areas for the following options have been made by PDP.

2.0 Background/Explanation of Each Option

The following sections describe the alternatives and related information presented by Mr Hart to PDP. Further information on the options from Mr Hart is presented in Appendix 2. The data provided by Mr Hart was of a fairly general nature and did not include specific design data relating to Raglan in terms of flows, or sizes of treatment and disposal systems. The evaluation by PDP of elements of these alternatives follows in Section 3.0.

2.1 Satellite Systems Option

This option splits the area of Raglan into a number of different areas based on geographical location. For evaluation purposes 10 different catchments have been assumed although specific identification of these areas has not been undertaken. For each of the catchments a small scale system treats the wastewater and disposes it to land in the near vicinity. The existing reticulation would be utilised in part, however, additional reticulation is required for some areas. For example, additional reticulation would be required from the central collection point for a catchment (typically this would be an existing pump station) to the treatment and disposal area for that satellite. The wastewater is treated utilising a septic tank style of pre-treatment or other method such as a treatment pyramid (see Section 2.4), followed by a wetland/pond system before being discharged to an evapotranspiration field. The evaporation field would use plants to uptake some of the wastewater, and the remainder would soak into the surrounding ground.

2.2 Pre Treatment Option

This option proposes the separation of grey water from black water, with the grey water being treated in small septic tanks and then directed for disposal in soakage/evapotranspiration fields either on-site for individual houses or with larger fields for groups of houses. It is a requirement of Environment Waikato that grey water be treated prior to disposal on sites with a land area less than 2,500 m^2.

The separated black water could be pre treated by septic tank systems (see below), before any main treatment process.

2.3 Clusters Option

This option is a smaller scale version of the satellite option, with groups of say 8 or 9 houses connected to a septic tank followed by a wetland pond system and then an evapotranspiration/soakage field. The septic tank is an anaerobic treatment tank where solids are settled out and methane gas from anaerobic decomposition is collected and possibly used as an energy source.

2.4 Pyramid, Water Garden, Evapotranspiration System Option

This option proposed by Mr Hart takes the sewage from the entire municipal system and utilises an anaerobic tank (basically a large septic tank) to remove solids and produce methane, followed by one or two Romanian Pyramid treatment systems followed by a discharge to water gardens with flow forms. Wastewater then flows into an evapotranspiration/soakage field where it is disposed of. The water gardens and evapotranspiration/soakage field are located on the Raglan golf course, and the treatment pyramid is located on land above the golf course. A concept sketch and description of this option prepared by Mr Hart is included in Appendix 2.

The Romanian Pyramid utilises plants grown in a hydroponics type system to treat the sewage. The structure is a glass covered pyramid shape of approximately 32 m by 32 m at the base. Inside the pyramid are several floors containing planted channels. The sewage is pumped to the top of the pyramid and drains to the base through the channels containing the plants. The plants need to be harvested as they are removing the carbon and nutrients from the sewage thereby providing treatment to the sewage.

The pyramid treated water is further renovated by a wetland and series of ponds. The wetland is planted with a wide variety of plants some of which are harvested and removed at regular intervals. The ponds also contain crustacea and invertebrates.

Flow forms are located between the wetland ponds, connecting them to each other. The flow forms consist of channels shaped to cause a figure of eight flow pattern within a series of basins which the water cascades between. The turbulence caused in the cascades and flow pattern is used to aerate the water. Some of the water from the lower ponds can be recirculated by pumping to some of the higher ponds to further treat the water or provide water to maintain desired pond levels. Following the flow forms and wetland/pond system the water is disposed to an evapotranspiration/soakage field.

2.5 Koning Valley Option

This option involves the purchase of land in the valley that currently contains the existing sewage treatment ponds. A concept sketch prepared by Mr Hart is included as Figure 5 in Appendix 2. The entire valley is used as a wetland and evapotranspiration/soakage and overland flow system. The proposal involves using a similar treatment process to the Pyramid option. (See Appendix 2 for further details). Wastewater from the pyramid flows through wetlands and is disposed of by pumping to a series of evapotranspiration/soakage trenches constructed above the treatment plant along the contour just below the ridgeline of the catchment. Wastewater enters the ground via the trenches.

3.0 Pros and Cons of Each Option

For each option various aspects were considered by PDP. The detailed assumptions and calculation results are presented in Appendix 1, with a summary of the major advantages and limitations/requirements of each option presented below.

3.1 Assumptions

3.1.1 Discharge via Evapotranspiration/Soakage

The assumptions in the preliminary calculations undertaken include the underlying rationale that there shall be no direct discharge to receiving waters (streams or harbour). Therefore, disposal of wastewater for all options has assumed to be via an evapotranspiration/soakage (ETS) system. Calculation of the size of the ETS system has been undertaken based on average rainfall conditions only and does not make allowance for wetter than average conditions. Clearly this would require either provision of:

(a) additional treatment, wastewater storage and disposal capacity; or

(b) an alternative means of treatment and disposal for the surplus sewage.

The ETS system is limited by winter conditions when there is a net excess of rainfall over evapotranspiration, and soakage becomes the primary means of disposal. The ETS fields have been assumed to be planted with the highest water uptake crops available, such as banana plants, sugar cane, apple trees, and possibly some cereal crops (FAO, 1998). However, even with these high rate evapotranspiration plants, over the winter months the plants do not use more water than is added by rain, and so the wastewater must be disposed of solely by soakage into the ground.

3.1.2 Flow Reduction

The future sewage flows assumed in the following evaluations are based on the important assumption that a water conservation education programme and improved reticulation has led to a reduction in sewage production of 140 l/p/day (compared to the typical figure of about 225 l/p/day from other small community sewerage systems). The importance of this flow reduction assumption needs to be emphasised in considering the feasibility of the following options. As discussed in Section 1.0, it is considered unlikely that a flow as low as 140 l/p/d can realistically be achieved in the Raglan context. For each alternative option the flows used have been based on the above allowance with water conservation measures in place, and assuming the predicted Raglan population in year 2021 as outlined in the earlier PDP report (PDP, June 2001).

While the lower flow estimate (140l/p/d) may not be achieved in the future, the effect of this on the feasibility of the options is mainly in relation to land area required and overall capital and operating cost. The basic feasibility of an option is not likely to change with a higher flow, although obviously cost estimates would be highly sensitive to the flow. PDP have assumed the flows as stated above. However, if the lower flow was unachievable land area requirements could be expected to rise in the order of approximately 60% above the values listed below.

3.2 Satellite Systems Evaluation

3.2.1 Advantages

- Has the capacity to provide employment and job creation.
- Potential for different treatment systems in different areas depending on physical constraints of the location.
- Potential for growth of marketable tree crops in the evapotranspiration soakage area. Potential supply of green material for worm composting activities by the "Extreme Waste" venture.
- As future Raglan land development moves outside the currently developed area further systems can be built as required, without needing to upgrade one centralised treatment plant (assuming the centralised plant had not already been upgraded for a future demand).

3.2.2 Limitations and Requirements

From a public health and aesthetics viewpoint treatment using open water, ponds or wetlands is unlikely to be permitted or acceptable if undertaken immediately adjacent to existing homes. Other options such as a septic tank followed by recirculating sand filters and UV disinfection could be a more acceptable and compact option. WDC experience indicates that these typically have a higher capital and operating cost than pond type systems (pers comm M. Safey).

- Higher labour and administrative costs are likely to result in increased operating costs over a single centralised system. Mr Hart has estimated an operator requirement of 0.5 person/day, however, PDP considers that a staffing requirement of 0.5 to 1 person/day per satellite will be required. Overall, there will be higher staffing requirement likely than for a single centralised system.

- Individual Resource Consents (with associated requirements for monitoring and reporting) would be required for each satellite system or the regional plan would need to be changed to incorporate a specific rule.
- Final treated wastewater disposal is limited by winter flows when there is a net excess of rainfall over evapotranspiration. This is especially significant where the rainfall is onto the open areas of the system such as the proposed wetland/pond treatment system. This *increases* the amount of water to be disposed of in the final evapotranspiration/soakage field. If the treatment system had no open area then the resulting disposal area required is much smaller.
- Storage capacity for handling wet weather flows is limited in such a system to the extent that the option may not be feasible if no overflow discharge to any other system (for example no overflow to the existing treatment system) is available.
- The environmental effects of the disposal systems would need to be carefully evaluated to ensure there are no adverse impacts.
- The evaporation/soakage field will need careful management to avoid excessive nitrogen loading. It will be necessary to harvest plants from the field even if it is uneconomic to do so.
- A net land area of 5.0 ha is required per satellite system (assuming 10 satellite systems in total). This area allows for accommodating both treatment and disposal systems. These must be located in areas where the soils and local groundwater conditions are of suitable hydraulic capacity, especially over winter. Such conditions may be difficult to find based on existing published soils information. The feasibility of finding ten suitable sites of 5 ha around Raglan has not been investigated as part of this report. Sites that could be appropriately zoned from a Town Planning viewpoint are likely be difficult to find given the amount of existing urban development in Raglan.
- Construction of a new satellite treatment and disposal system within the existing urban area is unlikely to be economic given that there is already existing infrastructure in place.

3.2.3 Summary

This option may be technically feasible provided sewage flows could be matched to the available land area and that suitable land is available. However, there are a number of constraints and uncertainties that would need to be overcome:

- Soil types and groundwater conditions would need to be suitable;
- Capital and operating costs may be higher than other alternatives;
- Suitable sites of 5 ha in area would need to be found or made available;

- Additional storage may need to be provided or alternative disposal options provided in order to handle above average flows;
- Treatment systems could not allow public access (to avoid public health issues); and
- Proximity of treatment systems to public areas in relation to odour and public health issues would need to be evaluated.

Overall, for economic and practical reasons, it is considered the satellite option is unlikely to gain strong community wide support within a developed urban area that has existing sewerage infrastructure.

3.3 Pre Treatment Evaluation

3.3.1 Advantages

Grey Water Separation

- The option of separation of grey water with treatment and disposal to on-site soakage/evapotranspiration fields located at individual houses has a significant potential benefit by reducing the hydraulic load on the existing sewerage network and sewage treatment system. The potential reduction in flows to a municipal treatment and disposal system would reduce the size of the treatment plant and the land area required for disposal.
- The grey water disposal option is likely to reduce garden watering requirements and therefore assist in reducing total water consumption.

Black Water Separation

- Pretreatment of black water from households in a septic tank type system would remove a large proportion of the organic load on a conventional type treatment plant, e.g. the existing system.

3.3.2 Limitations and Requirements

- Suitable soil types and groundwater conditions are essential to prevent overland flow and ponding for the grey water disposal areas. Limited information on similar Australian experience suggests slopes above 10 degrees may not be suitable where several properties are located in a row down slope of each other (Knight, 2000).
- A resource consent would be required for new grey water systems on sites of area less than 2,500 m^2 (Environment Waikato, 2001).
- There are potential public health and environmental contamination issues from on-site disposal of grey water.
- For the grey water disposal system, land area requirements per house are in the order of 20 to 100 m^2/person depending on hydrogeological conditions. Lot sizes

of the order of 400 m^2 which are typical for infill housing development, may limit this option for some properties.

- Cost of the works, and public acceptance of funding the works through rates or levies would be a management issue needing consideration.
- Management options would need to be considered for how the charging would function for house lots with the system and those without. Also, issues such as who would be responsible for inspecting and maintaining the systems must be considered as these have an associated cost, e.g. sludge removal from the septic tanks. The removal and disposal of sludge from the tanks would need to be undertaken on a regular and controlled basis by WDC. Inspection and maintenance of these systems is likely to be a significant cost factor for consideration.
- A significant potential health and safety issue would arise for any methane collection system. As discussed in Section 2.3, energy production from the burning of methane gas is unlikely to be economic (considering the safety requirements and low yield) when compared with the relatively low energy costs for electricity. Economic uses of the collected methane/biogas would need further evaluation.
- Design and operation of a methane producing system would be easier to achieve on a larger scale (in a centralised municipal treatment system).
- A black water pre-treatment system will not reduce the volume of sewage discharged into the sewer.

3.3.3 Summary

Grey water disposal is likely to be feasible at some locations but is dependant on cost efficiency and the availability of suitable hydrogeological conditions. It is unlikely to be feasible at a number of locations in Raglan. However, if management issues such as wastewater charging could be satisfactorily addressed, this option has the potential to significantly reduce the hydraulic load handled by a municipal treatment system, especially over the summer period.

Separate black water pre-treatment through septic tanks is technically possible. However, a number of issues would need to be overcome:

- The capital and operating cost of a septic tank system, (which would be additional to the cost of upgrading the existing municipal reticulation and sewage treatment and disposal system)
- The cost of treating grey water on-site; and
- Suitability of site conditions for grey water disposal.

Overall, the black water pre-treatment option seems to have few advantages over a centralised pre-treatment system but has some major disadvantages.

3.4 Clusters Evaluation

3.4.1 Advantages

- Future land development can be handled by cluster systems built as required, without needing to upgrade one centralised treatment plant.
- Planted ET fields may provide aesthetic value.
- Cluster systems would increase community awareness and a sense of responsibility for their own sewage treatment and disposal.
- Water conservation measures would be easier to monitor.
- The new reticulation required for this scale of collection and treatment would reduce infiltration problems associated with the existing reticulation.

3.4.2 Limitations and Requirements

- Potentially high operational and maintenance requirements compared to a conventional system.
- Each system would require its own Resource Consents and would require regular monitoring and control with associated administrative costs.
- The amount of new reticulation required for this option would add to the capital cost.
- High impact on the public if a system malfunctions, due to the large number of such systems and their proximity to dwellings.
- Many suitable sites required rather than a few purpose selected sites for the satellites option.
- Land area requirements are likely to be between 2,650 m^2 to 3,620 m^2 for each cluster of approximately 9 houses.
- The smaller size of these systems makes them susceptible to changes in organic loading, and hydraulic loading changes, e.g. holiday induced population changes. There is a resulting higher likelihood of unacceptably low treatment levels as a result.
- The same storage requirement limitations as for the satellite systems apply to this option in the event of higher than average flows.
- Plants in the evapotranspiration/soakage field would need to be harvested, as for the satellite systems.

- PDP considers that the treatment process would require alteration because placing anaerobically treated wastewater directly into a wetland pond would be likely to create significant odour issues.
- The safety aspects, relatively low energy yield and practicality/cost associated with methane gas collection and use is also likely to rule methane gas collection and use unfeasible.

3.4.3 Summary

Cluster systems could be appropriate for new developments in more remote areas further from the centralised municipal system, however, their advantages do not outweigh their limitations (particularly in terms of additional capital and O and M costs, administrative difficulties and finding suitable sites) for the existing higher density populated areas of Raglan. It is possible that future advances in technology may provide advantages for cluster-type systems, and therefore specific treatment technology within a cluster could be evaluated further for specific new developments. The cluster option can be retrofitted to the existing municipal system but there are similar drawbacks to the satellite option. Further, the problems are multiplied because of the larger number of individual treatment and disposal systems required. Therefore this option does not warrant further investigation.

3.5 Pyramid, Water Garden, Evapotranspiration System Evaluation

The Romanian Pyramid component of the system has not been directly evaluated in this report, however, the following comments can be made. It has been claimed that the wastewater quality produced by the pyramid is high enough to not require significant further wetland treatment. At this stage PDP has not received any independent confirmation of this claim or found any scientific literature supporting the proposed pyramid performance.

A pyramid system with some similar aspects to the proposed Romanian pyramid has been documented in operation in Denmark. The details of the system are included from a summary description by Cardiff University in Appendix 3. The Danish system as a whole is reported to produce high quality wastewater except for phosphorus. However, the pyramid itself is only part of a larger and much more complex treatment system involving a separate mechanical-biological treatment plant, UV-Ozone sterilisation process prior to the pyramid, and a reed-bed wetland following the pyramid. The pyramid itself is reasonably complex with phytoplankton, zooplankton, crayfish and fish (carp, bream and roach) also involved in the process. Fern, ivy and bamboo are grown in the pyramid by irrigation with the wastewater and are harvested and sold. The Danish system serves a population of 250 people.

A comparison of the two systems suggests the Romanian Pyramid would have to work significantly better than the Danish system to achieve the performance suggested by the Romanian designers (Godeanu M 2001, email communication). In relation to nutrient removal it is considered that the level of performance suggested for the Romanian Pyramid may be difficult to achieve in practice. A removal performance of around 20 g/m^3 nitrogen for a flow of 800 m^3/day has been claimed, apparently achieved through uptake by plants such as water hyacinth and water lettuce. The removal of this quantity of nitrogen would result in around 2 tonnes of biomass that would have to be removed every day. It would be difficult to grow such a large quantity of plants in a small pyramid and the disposal of the biomass could pose significant problems. (Mr Hart suggests that this quantity of biomass would be accepted by the Extreme Waste composting venture). Furthermore, both water hyacinth and water lettuce are Grade B noxious weeds, and therefore would be unsuitable for use in New Zealand. It is understood that there are no native fast-growing floating plants that could be readily substituted (pers comm. K. Thompson, Waikato University, July 2001). These are problems that would have to be overcome if the Romanian Pyramid was to be considered further.

Overall, it is considered that while the Romanian Pyramid may be a potential treatment option, the performance is unlikely to be as high as claimed on a consistent basis for flows of the order needed for Raglan.

3.5.1 Advantages

Advantages not listed as the disposal component makes this option not feasible (see Section 3.5.2).

3.5.2 Limitations and Requirements

This option is not considered feasible in the proposed location on the golf course because of the large land area required for disposal. Based on the reduced sewage flow of 140 l/p/d, the ETS field is likely to require a net useable area of at least 7.3 to 8.6 ha, in addition to the wetland/pond treatment area. This disposal area has been calculated based on using average (not worst case) rainfall data and taking the month of the year (July) with maximum rainfall and minimum evapotranspiration. The average rainfall over the period 1990 – 2000 at Raglan was used along with the evapotranspiration data from Ruakura for the same period factored up to account for the proposed higher evapotranspiration rates (FAO, 1998) of plants such as banana plants, sugar cane, apple trees, and possibly some cereal crops that were proposed to be used in these areas. The surplus of rainfall minus evapotranspiration was assumed to be disposed through soakage into the ground. In practice, the volume soaking to ground is likely to be significant especially during winter conditions when successive days of heavy rainfall and cloudy weather provide little potential for disposal by evapotranspiration.

In practice, it is considered that an ETS field of at least 15 ha would need to be allowed for to take into account:

(a) days of particularly heavy rainfall when additional sewage flow and rainfall must be catered for;

(b) years when rainfall is higher than the average and ET lower than average;

(c) crop harvesting requirements (machinery access, and area out of use whilst under harvest/replanting);

(d) vehicle access tracks required to service the pipework and hardware associated with the wastewater distribution and ETS system;

(e) provision of a 'reserve' (or back-up) area required in the event of system malfunction or performance below expectations;

(f) to ensure annual nitrogen loading application rate falls within an acceptable range.

In addition, the feasibility and environmental impact of soakage to ground of wastewater and rainfall that is not evapotranspired via the plants/crop would need to be carefully considered. For example, for the month of July, the volume of wastewater evapotranspired by the plants is only about 13% of the sewage inflow and the assumption has been made that the remaining flow will soak to ground at an assumed rate of 10 mm/d (see calculation in Appendix 1). This soakage will introduce a nutrient component (particularly nitrogen) into the groundwater which will ultimately enter the adjacent tidal estuary. This could have an adverse environmental impact and would need to be carefully evaluated. Overall, a disposal area of at least 15 to 25 ha is likely to be required, which for this reason alone, makes this option unfeasible given that this area is currently used as a golf course.

3.5.3 Summary

This option is not considered feasible in the proposed location.

3.6 Koning Valley Option

This option has many similar features to the Pyramid option described in Section 3.5. However, because it is contained within a single valley, and there is a large land area available (the entire valley is assumed to be available) the option is more feasible. The option is similar to the previous systems, being inefficient in the sense that it combines wetland type treatment (large ponded areas that collect rainfall) with evapotranspiration/soakage disposal techniques.

The Koning Valley option contains elements that are not part of traditional sewage treatment such as the pyramid treatment unit, the flow forms and venturi cylinders and vertical energy shafts. These components have not been evaluated apart from the comments made above in Section 3.5.

The Koning Valley evaluation has focussed on the proposed wetland and disposal system as presented by Mr Hart and has assumed that the treatment units upstream will produce a suitable quality of wastewater. Based on the concept sketch (Figure 5) provided by Mr Hart, the wetland area is about 5.1 ha. Assuming that the treatment components prior to the wetland will remove at least 60% of BOD (cf 95% removal claimed), then the wetlands as shown would likely be sufficient in size to accommodate the sewage flow (based on 140 l/p/d) expected in a year with average rainfall.

It is considered likely there will be a significant proportion of overland flow of wastewater and stormwater from new springs that may develop downslope of the disposal trenches, particularly in winter when the ground is saturated. Whilst travelling overland, a high proportion of the wastewater will be evaporated and transpired by vegetation during fine weather conditions. The remaining water will discharge into the estuary and the effect of this would need to be carefully considered both from a public health and environmental viewpoint. The wastewater (prior to disposal) would probably require UV disinfection, and possibly additional filtration, to remove pathogens. The nutrient load discharged to the estuary could be a significant issue as it could lead to degradation of the water quality. A collection system may be required at the toe of the valley to channel the wastewater into the existing estuary. During periods of rainfall, the wastewater will combine with stormwater and the combined runoff will be channelled to the estuary.

The issue of geotechnical suitability of the valley and stability of the ground (slope stability) needs to be further considered given that the introduction of water into the slopes and construction of wetlands could lead to some ground instability. Previous geotechnical work undertaken by Works Consultancy (NIWA, 1996) found that one part of the site showed signs of previous land instability. Historical land instability has also been identified in the upper part of the catchment in the vicinity of the closed Raglan landfill (Beca, 1996). These geotechnical matters would need to be further evaluated if this option were to be progressed.

3.6.1 Advantages

- The hydraulic effects of the disposal system are kept within one catchment.
- The system is isolated from the majority of dwellings in Raglan affording a degree of protection from public impacts such as undesirable odours if a system failure occurred.
- The required planting on the valley sides around the disposal trenches could be used to produce a marketable crop in a single location making it more viable for harvesting and processing.
- This option may be feasible, subject to some modification to the treatment and disposal process, to accept the present sewage flow from the existing municipal system.

3.6.2 Limitations and Requirements

- A third row of soakage/evapotranspiration trench would be needed in addition to the two rows near the ridgeline as shown in Figure 5. A total of 4.8 km of trench is required (for a 140 l/p/d flow allowance), representing a soakage area of 7,200 m^2 based on an assumed allowable infiltration rate of 10 mm/hr based on PDP tests in the Wainui Reserve (PDP, June 2001). This is a very high rate to be sustained for the periods involved, and further infiltration capacity tests at the site and shallow groundwater effects modelling would be required to ascertain final feasibility. (Note that for a flow of 280 l/p/d, a total trench length of 9.6 km would be required which would have a significant cost implication).

- The proposed hydraulic loading on the valley sides would need evaluation for effects on slope stability.
- The proposed wetland geometry may create excessive organic loading on the upper section of the wetland, possibly requiring a more complex inlet design.
- There are pumping costs associated with pumping the final wetland treated wastewater back up to near the top of the catchment for soakage disposal. This is in effect a 'double-handling' of the water compared to a conventional wetland treatment system. Pumps would need to be sized to account for expected daily peak flows which is likely to mean significant pump capital costs. There would also need to be a significant design component to ensure storage within the system can handle these peak flows, and to assist the pump sizing design.
- Treatment ponds and wetland areas would require separation from the existing watercourse in the valley through the use of bunds and piping/culverts. This would allow an unimpeded natural stream flow over the full length of the valley for the existing watercourse.
- This option is likely to be more expensive than the Rapid Infiltration option discussed in the PDP June 2001 report.
- The land area would need to be available for purchase at an acceptable cost.

3.6.3 Summary

This option appears technically feasible, but would need further detailed evaluation of engineering, environmental, cost and land availability elements. The option has a higher level of risk associated with some of the non-conventional aspects of the treatment process compared to a traditional system. A positive feature of the disposal elements of this option is that it may be able to be modified to accept flows above the 140 l/p/d assumed for the other options.

4.0 Recommendations and Conclusions

Based on the above evaluation several aspects of the options suggested appear technically feasible. In general, due to the climate of the region where the annual rainfall is significantly higher than the annual evapotranspiration, the use of wetland type systems, which use large open areas that collect rainfall, is counter productive if final wastewater disposal is to land soakage (i.e. zero discharge to water ways). This is because there is a surplus of water during wet periods that must be disposed of.

This fact will tend to act negatively in any economic evaluations of the proposed systems. Their final acceptance will depend on many factors including community consensus, WDC acceptance and economic feasibility which should take account of both social and environmental costs.

It should be kept in mind that the preliminary feasibility of the options investigated above has assumed that water conservation measures and education had reduced flows to the equivalent of 140 l/p/d, and the population had risen to that predicted to occur in year 2021 as described in the PDP June 2001 report. For the interim period when sewage flow is still higher than 140 l/p/d, and for the case of wetter than average years, these options would likely still require additional disposal by some other means. As with any new system developed it would be a gradual move towards eliminating discharges to waterways and not a sudden complete elimination of all such discharges. Any system chosen would best be evaluated through trial sized applications, and this is especially relevant for less proven technology or methods.

Further work could be undertaken in:

- Evaluation of public support for elements of some options e.g. grey water disposal to lawns.
- Evaluation of public interest in a Koning Valley type system. This could include a gauge of support for community involvement in the project and participation in planting days, tree donations etc.
- Undertaking costings of those specific options or parts of options given backing by the working group, council and public consultation. Costings would require a reasonable level of final design to have been carried out. For example, if the Koning Valley option was to be followed further, the storage and handling of peak flows, and existing municipal sewage flows (above the average flow of 140 l/p/d considered in this report), together with other engineering and environmental considerations previously discussed would need to be considered.

Options that are worth considering further include:

- The grey water separation and disposal option, particularly for application to new housing developments on larger sites >2,500 m^2.
- The possibility of applying a cluster or satellite scale development for a new housing development.
- The Koning valley proposal, provided it is accepted that this option is not expected to be economically competitive with other land treatment options such as rapid infiltration. The Koning Valley option would need to be compared with the options evaluated in the PDP June 2001 report based on the same flow rates used in the June 2001 report.

5.0 References

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Environment Waikato 2001, *Proposed Waikato Regional Plan* [online, accessed 24 July 2001] URL: http://www.ew.govt.nz/policyandplans/wrpintro/wrp/WRP3.5.7.htm

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Knight M.J, Tomlin J.S, Paffard A.R, *Potential of Greywater Reuse for Irrigating Household Land in Sydney and Brisbane,* Proceedings of IWRA's Xth World Water Congress, Melbourne, Australia, March 12-16, 2000.

Ministry of Works and Development 1974, *Guidelines for the Design, Construction and Operation of Oxidation Ponds*, MWD, Wellington.

NIWA, 1996, *National Institute of Water and Atmospheric Research – Raglan Sewage Upgrade Study, Feasibility Investigation Geotechnical Report No. 1995.* Prepared for NIWA by Works Consultancy Services Ltd.

PDP, June 2001, *Raglan Land Treatment Options Report*, Pattle Delamore Partners Limited Report to Waikato District Council.

USEPA 2000, *Constructed Wetlands Treatment of Municipal Wastewaters*, United States Environmental Protection Agency (report EPA/625/R-99/010), Ohio.

Appendix 1

Calculations and Assumptions for Option Evaluations

Appendix 2

Information Provided by Mr Steve Hart

Appendix 3

Information on the Danish version of a pyramid treatment system.

Appendix 1: Tables of Calculations

Satellite Option

The area required for each component of the satellite option is shown in Table 1.

Table 1: Areas Required for Satellite Option

Component	Area Required (ha)
Septic Tank and Sand Filters	<0.1
Wetland	1.0
Wastewater Disposal Field	3.0
Buffer Zone, Access Track	1.0
Total	**5 ha**

Areas have been sized based on a monthly rainfall of 175 mm and monthly evapotranspiration of 27 mm. These are the average rates for July measured over the period of 1990 – 2000 at Raglan (rainfall) and Ruakura (evapotranspiration). In addition, the following values were used as a basis for the calculations:

- A flow of 140 l/p/day, reflecting that water conservation measures had taken effect.
- Wetland area requirement based on 50 kg BOD_5/ha/day (EPA, 2000) for peak flows.
- A wastewater disposal field size based on an areal loading rate of 5 mm/day over the total disposal field area (ARC 1994).
- An evapotranspiration crop coefficient of 1.2 was assumed (FAO, 1998). This is equivalent to assuming the wetland is completely covered in fully grown wetland plants with a high rate of evapotranspiration, and similarly that the highest rate plants are used in the evapotranspiration field.
- Nitrogen loading rates on the wastewater disposal field of 300 kg/N/ha/year have been for. This loading rate is considered likely to be the maximum permitted under a Resource Consent. The loading rate assumes that 40% of influent nitrogen is removed in the treatment plant.
- Population predictions were based on the values presented in the PDP June 2001 report.

Cluster Option

Two treatment alternatives were considered for this option; one with a septic tank only, and one with a septic tank followed by a wetland. The area required for the first alternative is shown in Table 2.

Table 2: Areas Required for Cluster System Option Without a Wetland

Component	Area Required (m^2)
Septic Tank System	10
Wastewater Disposal Field	2,500
Buffer Zone, Access Track	1,110
Total	**3,620 m^2**

The area required for the second alternative is shown in Table 3:

Table 3: Areas Required for Cluster System Option With Wetland

Component	Area Required (m^2)
Septic Tank System	10
Wetland	550
Wastewater Disposal Field	950
Buffer Zone, Access Track	1,140
Total	**2,650 m^2**

The following values have been used as a basis for the calculations:

- A flow of 140 l/p/day.
- A total nitrogen loading rate to the wastewater disposal fields for both alternatives of 300 kg/ha/year was assumed.
- Wetland area requirement based on 50 kg BOD_5/ha/day (EPA 2000) for peak flows. Additional open-water areas were added to ensure the system could achieve the same nitrogen removal as the treatment plant system for the satellite option. The wastewater disposal field for the wetland option was based on an areal loading rate of 5 mm/day (ARC 1994).
- An evapotranspiration crop coefficient of 1.1 was assumed for the wetland option. This is equivalent to assuming the wetland is half covered in fully grown wetland plants with a high rate of evapotranspiration.

- Population predictions were based on the values presented in the PDP June 2001 report.

Pyramid Option

This option was considered using similar calculations to those for Koning Valley (see the following section). A water balance was calculated for July conditions, based on the fact that these conditions were critical for the Koning Valley option. The resulting values are shown in Table 4.

Table 4: July Water Balance for Golf Course Option

Component	Water Added (m^3)	Water Removed (m^3)
Trench Infiltration		22,710
Trench Evapotranspiration		2,370
Wetland Evapotranspiration		1,650
Wetland Precipitation	8,930	
Sewage Inflow	17,800	
Totals	**26,730**	**26,730**

The following values were used as a basis for the calculations:

- A flow of 140 l/p/day.
- 175 mm precipitation and 27 mm evapotranspiration. These values are 10 year averages for July, measured at Ruakura (NIWA 2001).
- The infiltration trench size was based on a loading rate of 10 mm/day (ARC 1994).
- An evapotranspiration crop coefficient of 1.2 was assumed. This is equivalent to assuming the wetland is completely covered in fully-grown wetland plants with a high rate of evapotranspiration.
- The total water surface of the wetland was estimated to be 51,000 m^2.
- The calculations were based on a total evapotranspiration field area of 73,000 m^2.
- Population predictions were based on PDP (June 2001).

Koning Valley

A water balance was completed to see if this option was physically feasible during the limiting months of July and December. The monthly water balances are shown in Tables 5 and 6, and a copy of the original design is shown in Figure 5.

Table 5: July Water Balance for Koning Valley

Component	Water Added (m^3)	Water Removed (m^3)
Trench Infiltration		26,780
Trench Evapotranspiration		310
Wetland Evapotranspiration		1,650
Wetland Precipitation	8,930	
Sewage Inflow	17,800	
Totals	**26,730**	**28,740**

Table 6: December Water Balance for Koning Valley

Component	Water Added (m^3)	Water Removed (m^3)
Trench Infiltration		26,780
Trench Evapotranspiration		1,050
Wetland Evapotranspiration		7,470
Wetland Precipitation	4,740	
Sewage Inflow	24,060	
Totals	**28,800**	**35,300**

The following values were used as a basis for the calculations:

- A flow of 140 l/p/day.
- 175 mm precipitation and 27 mm evapotranspiration for July. 93 mm precipitation and 122 mm evapotranspiration for December. These values are 10 year averages for July and December, with rainfall data from Raglan and evapotranspiration data from Ruakura (NIWA 2001).
- Seepage rates from the evapotranspiration trench were estimated to be 10 mm/hour, based on infiltration tests performed by PDP at Raglan (PDP June 2001). A 12 hour 'rest period' was allowed for each 24 hours of operation.

- It has been assumed there will be overland flow of wastewater at the proposed seepage trench loading rates.
- An evapotranspiration coefficient of 1.2 was assumed. This is equivalent to assuming the wetland is completely covered in fully-grown wetland plants with a high rate of evapotranspiration.
- The total water surface of the wetland was estimated to be 51,000 m^2.
- It was assumed there would be 3 evapotranspiration trenches, with a total length of 4.8 km.
- Population predictions were based on PDP (June 2001). It was assumed that a 2 week peak summer population occurred with one week during December and one week in January.

Appendix 2:
Information Provided by Mr Steve Hart

OPTION 4

Received from Steve Hart on 27/6/01 RAQ

The Pyramid , Water Garden, Evapotranspiration System.

The sewage comes into a processing plant located at the existing recycle centre on Te Hutewai Rd by way of the existing reticulated pipework throughout Raglan into a Pyramid Methane Digester. This methane digester draws off the methane and solids which can both be utilised as an energy source. The pyramid is the first stage of treatment . The Pyramid facility will treat the effluent to 95% purity. This is an extremely high level of treatment standard world-wide.
The solids from the digester can be incorporated with biodegradable matter from the "xtreme waste" recycle centre and processed into valuable compost utilising worms. The worms have a significant effect in assisting the break down of pathogens and toxins.

The residue water from the system runs through a series of cascading ponds that are designed to incorporate dozens of varieties of plants, crustacea and invertebrates. These plants cover ten or more ecological zones. Many of these plants can be harvested e.g. iris. All of the plant species selected feed on the nutrients in the water as they do in nature and in doing so extract the contaminants.

The ponds are designed to extend the edge. With as great an edge as is practicable the more space is available for planting. The pond bottoms are also shelved and benched to assist the flow and circulation of water around the ponds rather than straight through them. Ponds may also incorporate islands to assist in both these processes.

The cascades are "flow form" dishes specifically designed to enhance the life force within water. The cascades also incorporate venturie cylinders that further rejuvenate the electromagnetic mineralisation quality and life force of the water. Vertical radionic energy cylinders will be linked to this system to further enhance the life force of the water.

Pond waters can be pumped back into or recirculated into preceeding ponds where and when necessary. This assists in the management of water levels, plant feeding and purification processing, airating, oxygenating and life force re-juvenation.

These ponds will be located above the golf course and along an evapotranspiration trench throughout the course. This trench will be extensively planted with leafy plants such as banana and canna that absorb the water and transpire it to air. These ponds will also act as settlement detention ponds to utilise the water for summer reticulation to the fairways of the golf course. The discharge water will be totally absorbed with no outflow.

June 2001

These cost estimates based on a flow of 800 m^3/d

24 m x 24 m base } Pyramid size
16 m high.

PYRAMID , WATER GARDEN , EVAPOTRANSPIRATION

COSTING ESTIMATE 20-6-1

Pipeline	$100,000	
Methane Digester	$80,000	
Pyramid	$720,000	
Discharge Pipe	$25,000	
Ponds	$7,000	
E/T Field	$65,000	
Planting	$40,000	
Flowforms	$35,000	
Radionic Units	$5,000	
Sub Total		M$1.077
Design	$100,000	
Supervision	$100,000	
Consents	$50,000	
Sub Total		M$1.327
Land Purchase	$300,000	
Total		M$1.627

Cost estimates by Steve Hart

From: "Mihai Godeanu" <bucura@xnet.ro>
To: "Steve Hart" <steveh@wave.co.nz>
Subject: Re: DATA
Date: Mon, 2 Jul 2001 22:00:23 +0300
Organization: BUCURA MOND

Faecal coliform:
before pyramid = 297.000 cfu/100 ml
after pyramid = 8 cfu/100 ml

Enterococci:
before pyramid = 104.000 /100 ml
after pyramid = 3 /100 ml

E.coli:
before pyramid = 145.000 /100 ml
after pyramid = 6 /100 ml

b. The sewage plant estimate will flow 2,500 cubic meters per day.

The dimensions of a pyramid for this qauntity, there will be necessary 2 pyramids, 32 m base each
(1250 m3/day each)

Godeanu family

3. What are the Phosphorous, Nitrogen, Nitrate Ammonia, BOD, Suspense Solids, Fecal coliforms, Enterococi concentrations before and after treatment?

* Phosphorous before 2.74 mg/l after treatment 0.14 mg/l
  Nitrogen before 19.9 mg/l after treatment 0.99 mg/l
  Nitrate Ammonia before 24.3 mg/l after treatment 1.21 mg/l
  BOD before 205 mg/l after treatment 10.2 mg/l
  Suspended Solids before 247 mg/l after treatment 12.3 mg/l

4. I did hear the number 2-3 Faecal coliforms per liter quoted on Monday however this is not a real measurement. Faecal coliforms are measured in counts (cfu) per 100 lLs. Please clarify the measurement and number given

* We'll send you the data in the next days

5. What is the minimum amount of time the effluent is required to remain within the root system of the plants at a maximum capacity of 2500 cubic meters?

* between 13 and 30 hours depending of the organic load

6. Is the flow rate constant or intermittently dosed into system?

* Constant

7. If it is intermittently dosed does the system require some sort of holding capacity before entering the pyramid?

* Buffer tank

8. What is the maximum flow rate the system can handle that still gives the drinking water standards mentioned?

* Water become drinkable only if treated with O3 and UV after the exit from pyramid

9. Is there a minimum flow rate required to ensure successful plant growth?

* No

10. Does the system require the temperature within the pyramid to be constant?

* No, it should be between 20 and 35 centigrade

11. The references to drinking water standards made at the presentation - which standards are these?

* see point 8, EC standards

12. Water hyacinth is a plant pest here, what alternative native plants have you considered and what is the evaporation rate of effluent water uptake of these plants?

* Can be used Pistia, Salvinia, Nasturtium, Mentha and other

13. What is the maximum capacity the system can cope with?

* Is established during the design process depending on the needs

14. Is there a storage capacity with the system for the water?

* Yes, the buffer tank

15. I understand that the system requires a finishing tank if sufficient water quality is not achieved. What does this finishing tank consist of?

* We do not use a finishing tank.

16. The pretreatment tank what does this consist of?

* Partial retention of SS and oils

17. What volume of effluent water can the pyramid itself hold at any one time?

* see point 13

SHERYL ROA

From: "Mihai Godeanu" <bucura@bx.logicnet.ro>
To: "Steve Hart" <steveh@wave.co.nz>
Subject: Sewage Data
Date: Sun, 21 Jan 2001 21:39:51 +0200
MIME-Version: 1.0
X-Priority: 3
X-MSMail-Priority: Normal
X-MimeOLE: Produced By Microsoft MimeOLE V5.50.4522.1200

Hi Steve

I send you the answers at the questions of Sheryl Roa:

1. The pamphlet does not give any detail in how any of the nutrients etc are removed. How does the system remove BOD? SS? FC? EC? N? Inorganic P? Organic P? Heavy metals?
   * BOD up to 95%
     SS up to 95% retained in the primary settlement tank and on the roots.
     FC up to 98%
     EC up to 98%
     Total N up to 95%
     Inorganic P up to 95%
     Organic P up to 95%
     Heavy metals up to 93%

2. Are there any chemicals added in this process?
   * No

3. Does this method involve incineration at any step in the process?
   * No

4. What is their definition of PURE WATER?
   * EC standards for effluents from sewage treatment plants

5. Does this method still involve a water discharge to any waterbody?
   * Yes

6. If not where does the water go?
   * N/A

7. At what rate is the water taken up by the plants? Evaporation rate?
   * Very low

8. What volumes can the system handle?
   * 800 m3/24 hours for a pyramid with 24 m base. Dimensions / volumes are chosen when we realize the design of the plant depending on needs.

9. Can the system handle short high periods of inflow? E.g. when it rains
   * Yes, using a buffer tank

10. Does this method get rid of the oxidation pond?
    * Yes

11. Are aerated lagoons still required?
    * No

And the answers to the questions of the second page:

1. Are sediment tanks required prior to the effluent entering the pyramid?
   * Yes and there are included in the basement of the pyramid

2. How is the methane removed from the system?

From: Steve Hart [steveh@wave.co.nz]
Sent: Saturday, 13 November 2027 22:38
To: andrew.sussex@pdp.co.nz
Subject: Re: Raglan Sewage Treatment Proposals

Monday 2-7-1...Andrew....I was waiting for your phone call to discuss these questions but you must have gone surfing.....these questions clearly can not be answered so simply as you may be expecting but consider these. Included here is data sent to Rob this morning also. This will allow you to realise the complexities of design options.

1) What is the size of the area of the soakage zone, where the water enters the ground?

This is an equation that needs to be very extensively developed for there are many many elements to consider. Obviously the greater the diversity the better the system and the absorption capacity of the plants and the soils will see a huge range of plants and other components that will realise this is not a simple arithmetic exercise.

2) What daily sewage flow have you based your system on?

Your report "Raglan Land Treatment Options Report June 2001" states approx 2,500cum/day. However there are once again so many variables to the equation that we can not again use a simple exercise of arithmetic to figure this out.

3) Does the system work year round? What happens in winter?

What ever made you think it did not work all year round....do you shit all year round ?

4) How are stormwater induced peaks handled/stored?

It has been an expectation from this community that the stormwater infiltartion be taken out. As for rain falling directly into the ponds and onto the evapotranspirating fields we simply take the met office figures and include them into the equation.

Regarding the other 4 options, can you send us them before Monday (or so that they arrive on Monday morning)

Enclosed here in this email below.

I look forward to a round table with you and Rob all day tuesday to go right through these option in enough detail to offer them the respect they deserve.

Preferred OPTIONS for Research
Steve Hart ...SEPT. 21st ...2000
The following is a list of options of complete sewage treatment systems or parts of systems that have been forwarded for assesment for Raglan Wastewater Workshop 2000. Detail of each of these can be obtained from Steve Hart who has researched options worldwide for 20 years. Video footage, photographs and reports are available to inspect.

1. The Lemna System by Mr Viet Ngo. This is a wetland system that utilises the plant Lemna commonly known as Duck Weed. Successful systems operate in several countries at present. It develops revenue by farming the lemna.

2. Ocean Arks, by Mr John Todd. This is a system that is predominantly indoor aquaculture. Systems of varying size successfully operate. It develops revenue by utilising the heat and farming aquaculture systems. Similar systems to this have been developed by Stensund College in Sweden and at the Findhorn Institute in Scotland.

and will be developed here in NZ at Little River on the Banks Peninsula in association with Andrew dakers of Christchurch.

3. Chanoxy by Mr George Chan. This is an integrated wetland aquaculture system. It is an integrated farming system that has active revenue generation.

4. Pyramid by Mr Stanley Mishuda. This is a system that operates on natural energy fields and a multiple array of water plants set inside a glass pyramid. Originally developed by the Romanian military now available commercially. Systems are fully operational in Europe.

5. Camphill Waters by Mr Uwe Burke. This is a complex array of wetlands using multiple species of plants. Many successful systems are operating at differing scales throughout Europe .

6. Arcata by Mr Bob Gherhart. This is an open wetland system that incorporates the use of many varied plant species and aquacultures. This is a fully functioning system in the city of Arcata California.

7. Jarna. This system is a series of cascading wetlands that incorporate the use of a copious number plant species and "flow form" dishes. Within professional arenas this is a highly regarded model that has been operating for near on two decades.

8. Natural Wetlands by Mr Billy Wolverton. These systems are open wetlands that incorporate the use of a wide range of plant species especially surface plants like Lemna. Many successful plants have been operating for over ten years throughout the eastern seaboard of USA.

9. Internal sub-surface plant beds by Mr Billy Wolverton. This system is incorporated within the house or office complex and utilises a variety of plants in a bed of porous rock. It is a successful option that can operate successfully within a confined space.

10. Methane / Worm Digesters by Dr Bhiday and Nayan Mistry. These systems vary considerably in scale from a single domestic unit to large metropolitan systems.

11. Systems that could be specifically developed as either satellites or cluster or individual sites need to be fully explored as well. These range from:

a. - the single compost loo

b. - methane digesting septic tanks for clusters of houses with small scale integrated wetlands

c. -suburban satellites of pyramid stations with the residue waters flowing into the existing reticulation

d. - efficient septic tank systems from the "everard" design incorporating "Wolverton" plant absorption beds.

I feel all the 14 models above need to be fully investigated and I am available to offer my expertise to assist the workshop approved independent researcher in this research.

I have not made available to the workshop copy of the information I have on these systems for they are far from complete or comprehensive enough to give a sound interpretation of what may be best suitable for Raglan.

It is my firm belief that the future system for the entire Raglan regionwill be one that incorporates many of the design elememts in the above list. However the most economic will be an adaption of my original design of 1994 that will include worm digesting, the energy pyramid and reticultion to an extensively planted absorption channel that will be constructed high on the contour of the catchment.

Steve Hart
ecology architect
21st Sept 2000

The Integrated Wetlands Concept

ammended 19-10-00
Designer Steve Hart 1994

Permaculture is a system of design that lends from natural ecological patterns to enhance our efficiencies. It is a design philosophy that works with nature.

I have been researching sewage systems throughout the world for two decades. The first realisation that I came to was that sewage is not a waste but a valuable resource. From my extensive understanding and practice of Permaculture I have put together an incorporation of the designed ecology of sewage. I believe by having sewage in a water-carrying system society can gain considerably from the resources that are inherent in this nutrient rich body.

The schematic design of the Integrated Wetlands Concept was developed upon the request of Raglan Councillor Olive Gallagher. It was specifically designed as an option within the catchment valley of the existing ponds.

I suggest that for the entire Raglan area a variety of systems specific to each zone is perhaps the best option to follow, but I am a firm believer that the community can develop revenue and gain considerable other advantages from this under-utilised resource. If designed to full potential Raglan sewage could return a dividend not cost.

The Integrated Wetland Concept option as presented incorporates the entire valley catchment and takes in the leachate from the landfill which could be highly toxic.

The System.
The sewage comes into pond no. 1 by way of the existing reticulated pipewok throughout Raglan into a Biotechnolgy Pyramid Methane Digester. This methane digester draws off the methane which can be utilised as an energy source. The pyramid is the first staage of treatment it also takes out the solids.
The solids from the digester can be incorporated with biodegradable matter from the resource recovery park (dump) and processed into valuable compost utilising worms. The worms have a significant effect in breaking down pathogens and toxins.

The residue water from the system runs through a series of seven cascading ponds that are designed to incorporate dozens of varieties of plants, crustacea and invertebrates. These plants cover ten or more ecological zones. Many of these plants can be harvested e.g. iris. All of the plant species selected feed on the nutrients in the water as they do in nature and in doing so extract the contaminants.

The ponds are designed to extend the edge. With as great an edge as is practicable the more space is available for planting. The pond bottoms are also shelved and benched to assist the flow and circulation of water around the ponds rather than straight through them. Ponds may also incorporate islands to assist in both these processes.

The cascades are "flow form" dishes specifically designed to enhance the life force within water. The cascades also incorporate venturie cylinders that further rejuvenate the electromagnetic mineralisation quality and life force of the water. Vertical energy shafts will be linked to this system to further enhance the life force of the water.

Pond waters can be pumped back into or recirculated into preceeding ponds where and when necessary. This assists in the management of water levels, plant feeding and purification processing, airating, oxygenating and life force re-juvenation.

From pond 7 the buffer pond the water is drip fed around the ridge line of the catchment and filters through the soil back into the natural watercourse via wide shallow gravel filled trenches that have an average soil cover of 300mm. These trenches are intensively planted with gross transpirating plants.

The entire catchment is planted out. Beyond the pond systems a variety of tree belts underplanted with bulbs and shrubs that will also absorb the trickle . There is no discharge to natural water courses all the discharge is taken up by plants specifically selected for this transpiration demand.

This system becomes a botanical garden without odour or insect nuisance that can be extensively farmed. It will become an education facility that will generate both enterprise and revenue back into the community. There is adequate provision within the RMA for this efficient and cost effective land based treatment facility to be managed via a community trust.

Steve Hart
ecology architect
21st Sept. 2000

The options that were agreed to be considered by the Technical Working Group are as follows:

1. Satellites
2. Pre treatment
3. Clusters
4. Pyramid
5. Koning Valley.

Clearly the rationale for Raglans sewage is:

a. No discharge to any natural waterways. This is a cultural demand. This is non negotiable.
b. The overall economics takes in all full true cost accounting.
c. The systems be sustainablto
d. Economics is a very high priority.
e. The life span be indefinite.
f. Return benefits to the community in jobs,, enterprise and product.
g. Be aesthetic features.
h. The spiritual domain of the taniwha be reinstated

1. SATELLITES: This will require detailed study of the entire sewage reticulation infrastructure both existing and proposed. A conceptual design could be developed from the existing reticulation plans to assess the zones. These zones could consider a specific design solution that would be particular to that zone. Or we could consider one design that could function in each zone. e.g. a pyramid of 10mx10m square base with a wetland and evapotransirating subsurface field attached.

2. PRE TREATMENT: this could be achieved by;
a. separting black water from grey water where the grey water is absorbed into individaul gardens or be clustered. By clusters we wil see 3, 5, 7 or 9 houses grey water feeding one well planted evapotranspirating field.
Plus-
b Taking the black water of every house into a methane digesting septic tank. these tanks could also service 3, 5, 7 or 9 houses.

3. CLUSTERS: We take option two above and extend this by dealing with the effluent from the clustered methane digesting septic tank (mdst). With 7 or 9 houses on one mdst the discharge will be through a series of small wetland ponds and totally absorbed by an evapotranspirating sub-surface field.

This design would be the preferred solution for any future subdivision development. eg. the 70 house development off Violet St.

4. PYRAMID: as presented

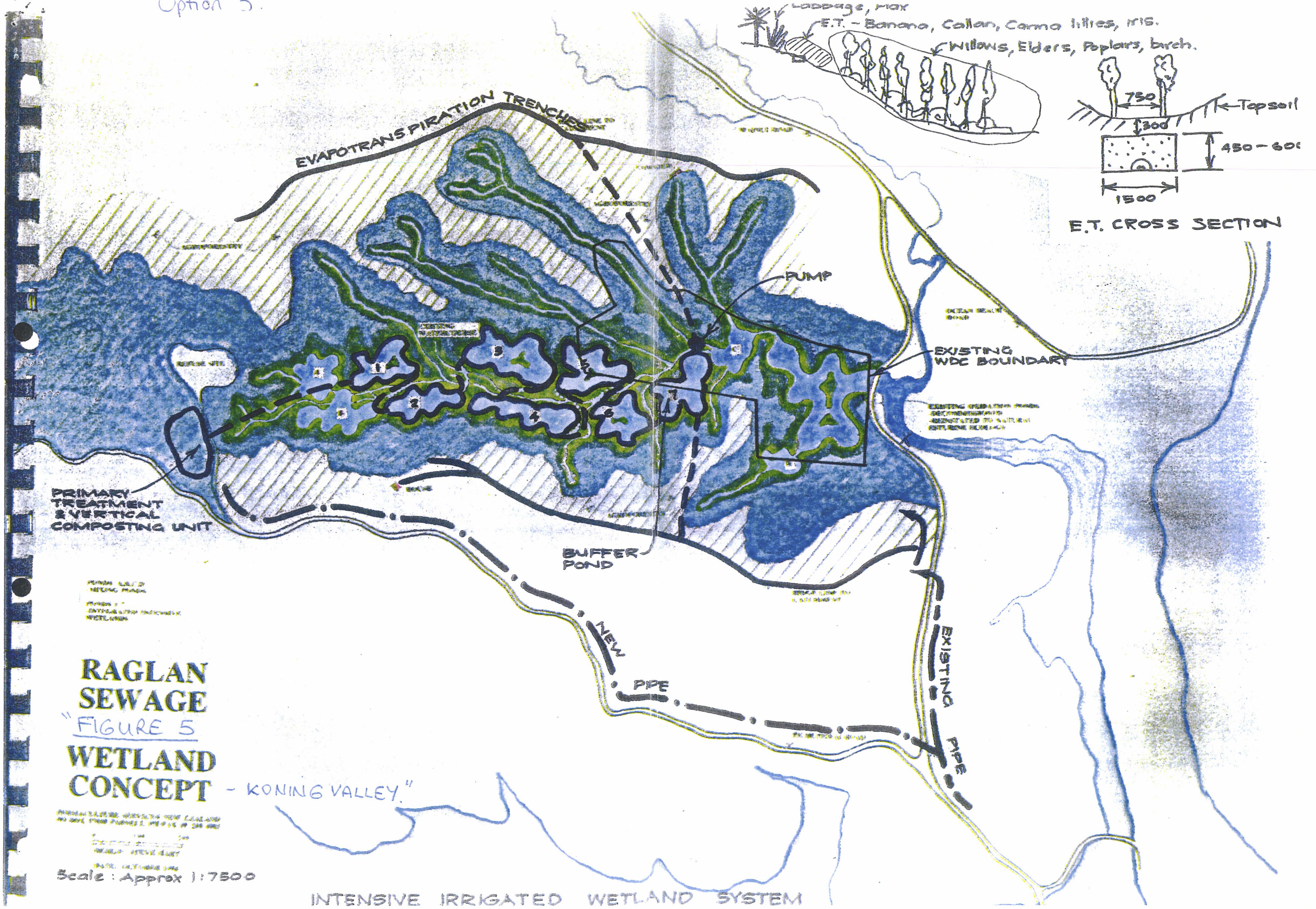
5: KONING VALLEY. The Integrated Wetlands Concept........ as described above. The cost of the land needs to be assessed carefully and the redevelement of the balance of the land not included in the functioning of this option. One farmer owns all the land that is required and it would be sensible and good economics to buy his entire farm so he can take up another opportubnitry in farming another block. The balance could be developed into residential lots. It could be conceivable that the sale of these lots would pay for a large percentage if not all and possibly more of the entire sewage development.

Personally I support the satellites option for this offers:

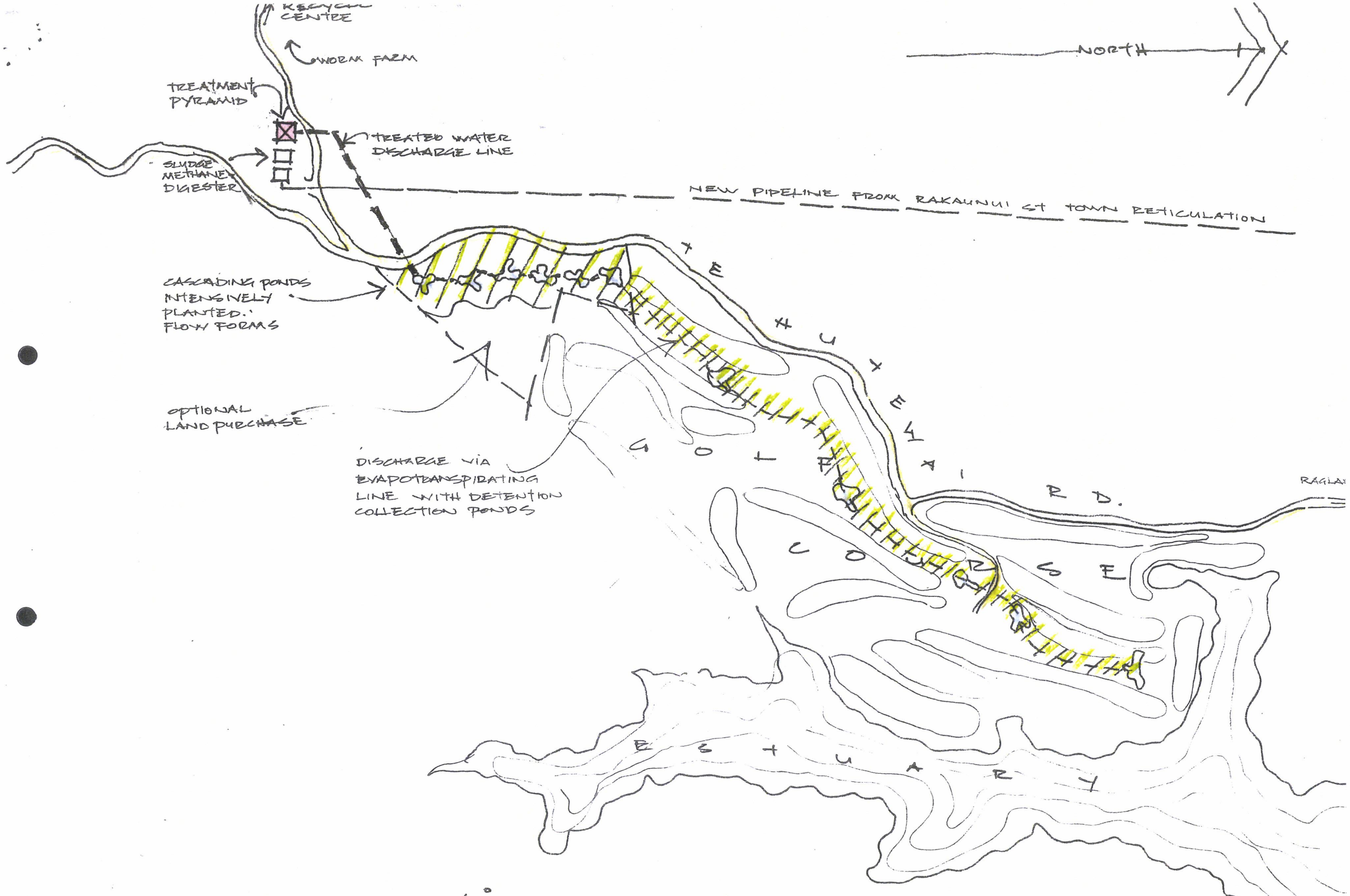
1. more to the community in gardens, products, jobs, business enterprise, and tourism
2. it is flexible
3. Further nodes can be developed as the town grows
4. Reduces the cost of retculation and associated infrastructures

Steve Hart
Ecology Architect
P.O. Box 64 Raglan
mobile: 025 48 21 48
ph/fax: 07 825 8250

Option 5.



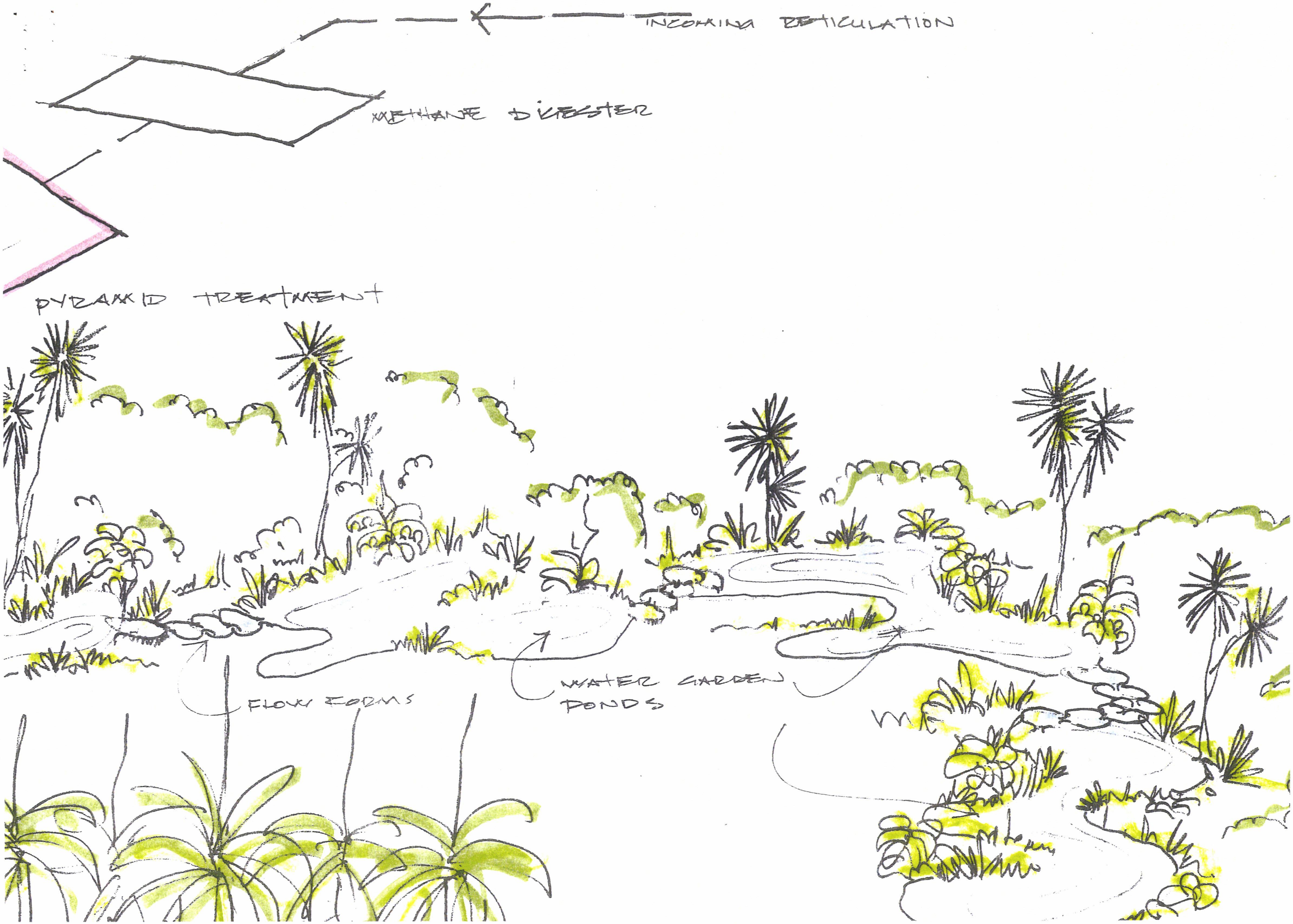
Cabbage, Flax
E.T. - Banana, Callan, Canna lillies, iris.
Willows, Elders, Poplars, birch.
750
Topsoil
300
450 - 600
1500
E.T. CROSS SECTION
EVAPOTRANSPIRATION TRENCHES
PUMP
EXISTING WDC BOUNDARY
PRIMARY TREATMENT & VERTICAL COMPOSTING UNIT
BUFFER POND
NEW PIPE
EXISTING PIPE
RAGLAN SEWAGE
"FIGURE 5
WETLAND CONCEPT - KONING VALLEY."
Scale : Approx 1:7500
INTENSIVE IRRIGATED WETLAND SYSTEM



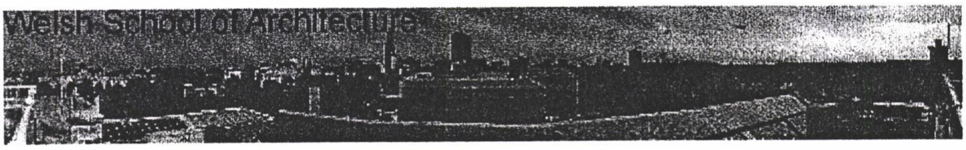
CONCEPTUAL SCHEMATIC

PYRAMID WATER GARDEN EVAPOTRANSPIRATION

STEVE HART JUNE 2001


INCOMING RETICULATION
METHANE DIGESTER
PYRAMID TREATMENT
FLOW FORMS
WATER GARDEN
PONDS

Appendix 3:
Information on the Danish Version of a Pyramid Treatment System



Case Studies

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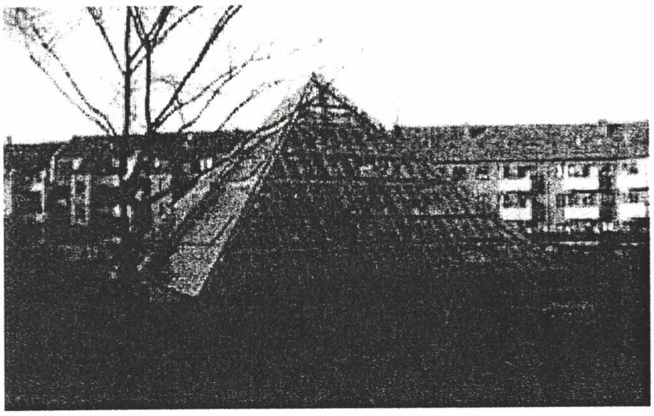
CASE STUDY: The Kolding Pyramid

SECTOR - Waste Water , **COUNTRY** - Denmark

BACKGROUND

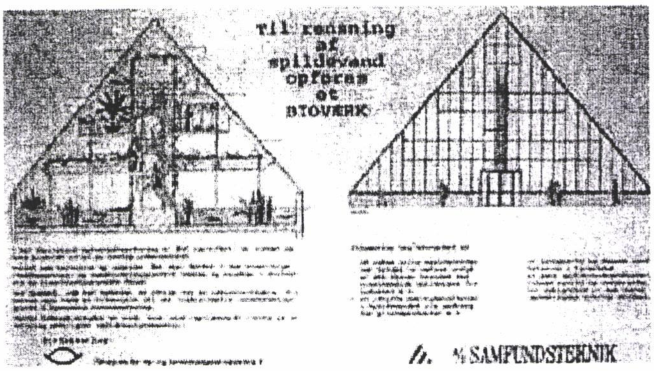
Urban ecology -the creation of more sustainable cities -was discussed much Denmark in the late 80ties. Most of the initiatives to project were taken by private persons and NGOs. These initiatives were characterised by being:

- Small scale
- Transparent, simple technology with great symbolic value
- Single sector- not integrated -efforts
- .Lack of documentation and evaluation of results
- .Lack of systematic recording of experiences and collection of knowled



The Pyramid is situated in the courtyard of a midsize Danish town

This project can be seen as a reaction to this. It is a top-down, large scale, integrated project with emphasis on documentation. The Pyramid is situated the Hollandervej/Fredensgade block in Kolding. All sewage in the block is collected, pre-treated in a small underground mechanical-biological sewage treatment plant, sterilised in an uv-ozone filter, pumped to the Pyramid, whe the sewage are further cleaned by algae and plants. The total surface of the tanks is 840 m2 and the total tank volume is 460 m3. From Pyramid, the sewage is 'polished' in a reed-bed and infiltrated in the ground. In principle, wastewater leaves the block. The Pyramid was operational in 1994

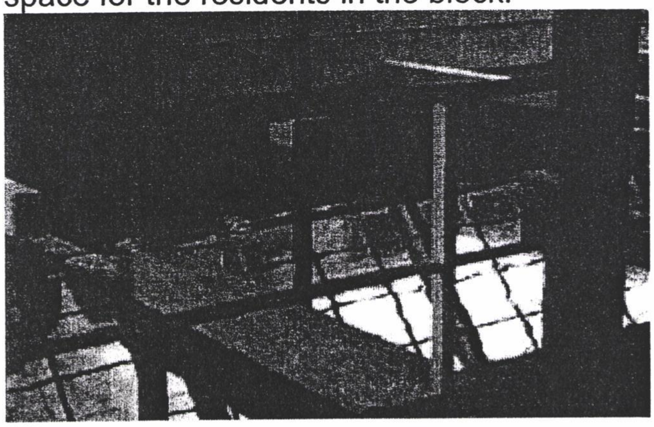


Poster in the courtyard showing the principle of the Pyramid 'green' sewage treatment plant: Plants and algae the cleaning the sewage

The block comprises of 129 apartments with approximately 250 residents. T Pyramid 'green' sewage treatment plant is the most spectacular element in t entire project. However, the project comprises of

- Energy savings in the dwellings
- Passive solar heating
- Photovoltaics
- Water saving installations
- Use of rainwater for toilet flushing
- Renewed courtyard
- Use of sustainable materials
- Composting of organic waste
- Recycling of paper, glass etc

One of the original basic ideas was to use the Pyramid as part of the commc space for the residents in the block.



Phytoplankton, zooplankton, crayfish and fish play a decisive role in the was water treatment. Danish fish like roach and bream are grown in the pond - together with imported carps.

INDICATORS
For the waste water part of the part the project a number of indicators are used:

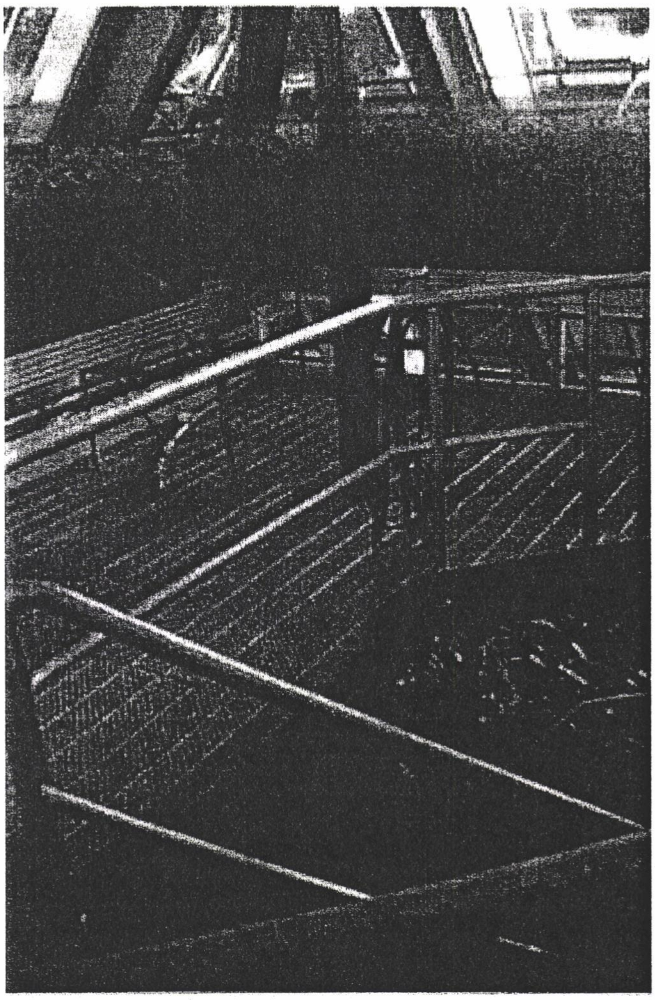
- Use of heat
- Use of electricity
- Nutrients in the water
- Bacteria in the water
- Visits and media coverage

Visits and media coverage was used to illustrate the impact in the surroundii society.

EVALUATION

The evaluation of the project is still going on. Most of the following facts are based on an early official evaluation in 1997. However, the Pyramid has bee subject to a number of rather critical evaluations, mostly carried out by senio students.

All the sewage from the block has been cleaned and infiltrated. The block produces approximately 11000 m3 of sewage per year. The sewage is cleaned sufficiently to satisfy the rather strict Danish regulation -except for phosphorus. Approximately 40000 plants have been produced per year.



Plants are being irrigated with the sewage and thus reducing the content of

nutrients
Fern, ivy and bamboo grow in the Pyramid. The plants are sold for decoratic in private homes.

The quality of the air was corresponding to the quality in a clean room. The energy used for heating was 237 MWh per year -with a temperature of 19.5 °C in the room. The electricity consumption is not mentioned in the offic evaluation report, but it can be estimated to approximately 65 to 75 MWh per year. However, the evaluation report suggest that the plant lights and the UV-ozone filter are dropped, reducing the use of electricity to 35 MV per year.

BENCHMARK DATA
There are no agreed benchmark data. An estimate of the energy consumed a traditional central sewage treatment plant is 0,5 kWh per m3 of sewage. In the early period, the estimated electricity use in the Pyramid is 6 times highe than in a traditional facility -and the minimum is approximately 3 times highe The heating and the electricity used for plant lights would have been used in another greenhouse if it had not been used in the Pyramid.

DRIVERS
The Kolding Municipality, The Ministry of Housing, the Danish Town Renewa Company and two consulting firms took the initiative to make a more integrated solution, demonstrating the state of the art, back in 1991. The blo Hollrendervej IFredensgade was chosen, because it was the next block in Kolding entering the town renewal process.
The marine aquatic environment was much in focus in Denmark in the late 1980'es. Hence, there was focus on sewage treatment plants too, and a nee for demonstration and full scale testing of 'alternative' technologies. It was decisive for the team to demonstrate a 'green' sewage treatment technology the block. Lack of space in the courtyard forced the team to build a greenhouse in several stories, ending up with the pyramid shape.

LESSONS LEARNT
Much can be learned from the Pyramid case. The point of view is decisive when the Pyramid is evaluated: is it a project, demonstrating possible 'alternative' technologies, or is it the best solution for the sewage problem in the Hollrendervej/Fredensgade block. It is quite obvious that the project has be seen as a demonstration project, demonstrating a technology that could l used in other places -places without possibilities of connection with a central sewage treatment plant, for instance remote villages and villages on small islands.
An important lesson learnt is about the conflicts between visions of sustainability and health hazards. The original vision was that the Pyramid could be used of the local residents for growing their own vegetables. Healtr authorities, however, would only let people with an exam in sewage handling enter the Pyramid. Furthermore, they would not let any kind of human food grow there due to the risk of epidemics (even though the sewage is sterilisec before it enters the Pyramid)

A lot has been learnt about how to treat the algae, the plants and the fish. O
of the
general lessons learnt is that the persons responsible for the Pyramid have t
be very well trained and it takes time before they have sufficient experience
running the facility.
The rather extensive use of energy suggests that the winter in Denmark is tc
dark and to cold for a technology based on growing algae and plants.
The residents have accepted the project, but it has proved very difficult to engage them fully in this basically top-down driven project.
The Pyramid project has meant a lot of PR for the Municipality of Kolding an
the other actors involved in the project. It was used as one of the examples
sustainable urban renewal in the Danish National Report to Habitat II.
The final, but perhaps most important lesson learnt, is about transferability. Some kinds of urban infrastructure technologies are rather sensitive to the specific local conditions. Not only the climate, but also the sunlight condition in wintertime and the soil structure is quite important here.

APPLICATION

The Pyramid project has not been copied directly in any other Danish town, but there is still focus on a number of different 'green' sewage treatment technologies.

TRANSFERABILITY

The local conditions have to be taken into consideration, when transferabilit
is discussed. However, it seems like conditions further South in Europe coul
be more favourable for the Pyramid project, with less need for artificial light and heating in wintertime.

IMPACT ON SUSTAINABILITY AREAS

Environmental -High, if placed on the right locality.
Social -Medium, no direct involvement, but basis for local network
Economic -Unknown, -the prototype rather expensive
Institutional -High, creating platform for discussions between departments

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