CASE STUDY
Wetland Biomass Wastewater Utilisation

Introduction

In 1995 two members of Stroud District Council Environment Committee asked for an investigation of alternative schemes in order to resolve long-standing gross sewage pollution in a ditch (see picture below) flowing from the unsewered Claypits hamlet. A .76 hectare field adjacent to Puddleworth Lane, Claypits, Eastington, Gloucestershire was to be made available for an innovative approach to this problem.

Claypits was one of five villages in Stroud District where sewage discharges were causing pollution and a public nuisance. It was rated as #1 worst case in the district by a National Rivers Authority Report - *Rural Sewage Pollution In The '90s* (NRA, now Environment Agency).

There was confusion over who was responsible for the problems here. The NRA suggested this was deemed a public sewer through historic usage and therefore Severn Trent Water had responsibility as local sewage undertaker, though they disputed this. Stroud District Council also had statutory responsibilities.

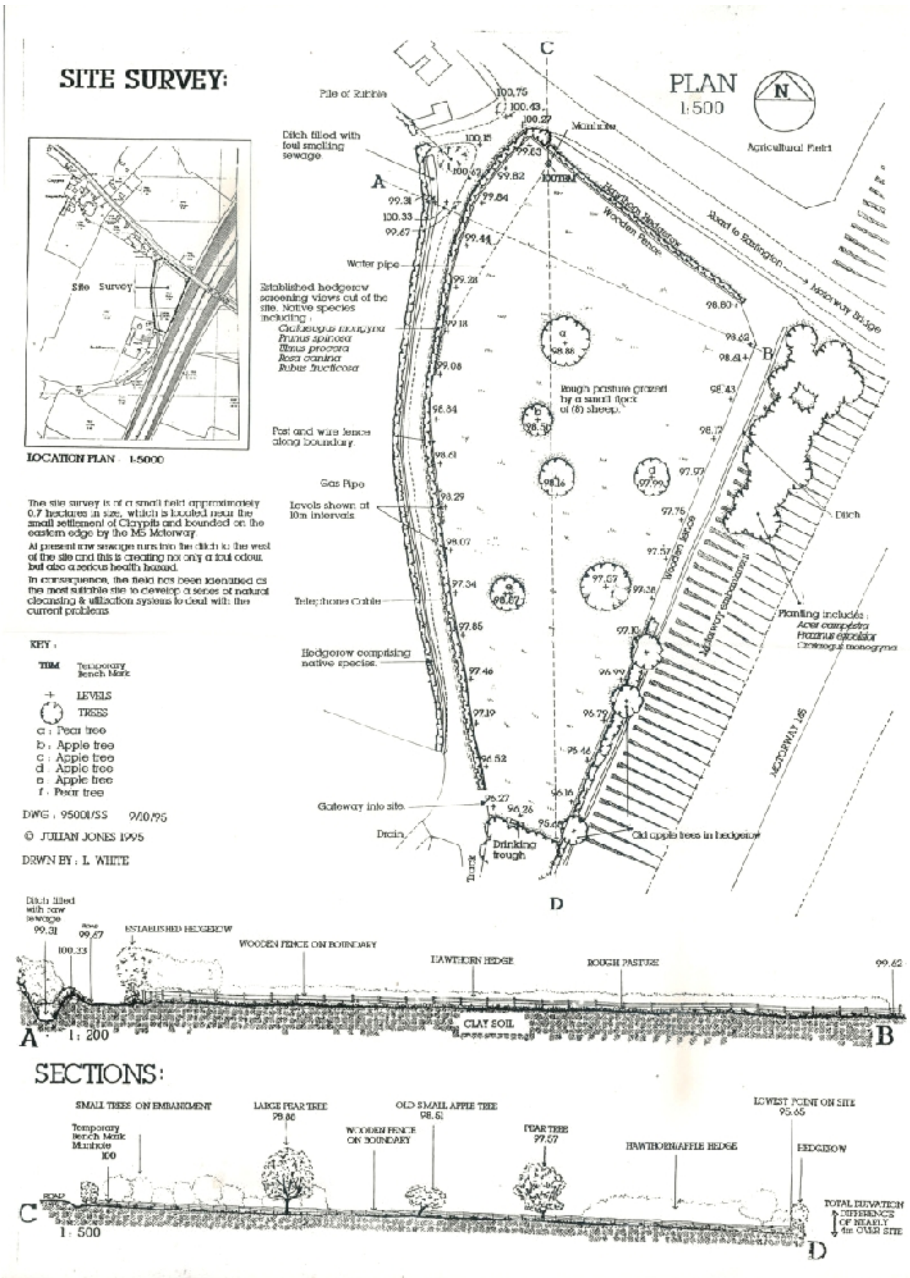
It was representative of the many other unsewered sites (NRA 1995 estimate approx. 2000) throughout the UK, both rural and urban, where such problems were occurring more frequently. Existing infrastructure proving unable to cope because of increased loadings resulting from increasing housing development, raised water usage and declining standards of infrastructure integrity.

Similarly, declines in sewer performance have for these reasons to those above caused increasing discharges to the environment from water company sewers, via ‘storm overflows’. The EA estimates that there are around 25,000 into UK watercourses. (In 2005 an estimated total of 38 million gallons of raw sewage was discharged into the River Thames, on around 50 occasions, via storm overflows. In 2004 EA had described the river as ‘safe to swim in’).

Sewage 'disposal' technologies generally entail a high cost of implementation and this, compounded by a conventional wisdom that ‘mains sewerage is preferable’, leads to often high costs for resolution of the problems. This proposal examines a different approach, utilizing rather than disposing of the sewage, offering robust cleansing performance that is not prone to catastrophic failure, while creating resources, energy, employment, and agricultural diversification within an attractive functioning landscape as a community amenity. And perhaps most importantly, a source of high quality treated (non potable) water for re-use.

Feasibility Analysis

A detailed site survey was carried out (below).



A range of civil & agriculturally engineered options existed to deal with sewage at Claypits:

1. Mains sewerage. A study for a mains sewerage connection was conducted on behalf of Severn Trent Water. This indicated a cost at that time of at least £250,000 for a system that would comprise pumping station(s) and sewer mains to connect with Stanley Downton Swg. Wks., some 2 kilometres distant. The high cost of this scheme had previously been a major factor in preventing this. There are also other negative aspects associated with such a scheme that should be considered:

- Stanley Downton Swg. Wks. Already degraded the environment with its discharge to the River Frome, though normally at standards agreed by the NRA, but also regularly could not provide full treatment during rainfall.

- The watercourses and watertable local to Claypits would be deprived of the benefit of the existing discharges. In prolonged dry weather this could cause structural damage to the properties in the hamlet through shrinkage of clay foundations. This problem could arise with any scheme that completely sewered the village.

- Constant pumping requirements to the sewage works would waste energy and pose the potential for problems of reliability at times of pump failure. Stormwater typically also causes problems with such systems.

- Severn Trent Water might not have proceeded for many years with such a scheme.

2. Local 'Packaged' Treatment. There were other conventional methods of sewage disposal that could have been utilized here to provide *in situ* treatment; septic tank/ soak away and packaged RBC systems. These could be provided for upwards of £40,000 and negate some of the problems associated with mains sewerage detailed above. However, they do not allow for a high discharge standard and a conventional soak away system to resolve this aspect would be problematic in this area owing to the poor soil porosity. Such packaged systems are the cause of many localized pollution problems through poor maintenance and reliability - they were categorized by the NRA as generally 'inadequate' for this location.

3. Reedbed or Functioning Landscape. A further method of *in situ* treatment using a range of hydrophytes (water plants) that utilize the sewage nutrient, planted in an effective water garden context. The poor soil porosity at this site becomes a positive benefit in reducing system cost here. Construction according to agricultural engineered methods could provide a long-term solution at this site for under £25,000.

The inherent robustness of such natural water cleansing methods, when placed in a properly conceived design can also effectively exclude the possibility of catastrophic failure. Problems can occur, only on a more gradual basis, arising over a period of years, and only poorly designed and if maintenance were not being carried out. The 'garden' or 'park' setting within which such a system operates encourages a duty of care, furthermore it can provide a realizable cash (energy) crop, whose harvesting becomes part of the ongoing maintenance.

Design Brief

Severn Trent Water (the sewerage undertaker for this District) and Lower Severn Region of the National Rivers Authority were formally offered on privatisation (1989), an improved, more 'natural' decentralised approach to water management (with functioning landscapes, wetlands, reedbeds, hydropower etc.). This would have allowed for reduced charges to customers, low cost resolution to sewage pollution at sites like Claypits, as well as larger towns, improved reliability and discharge quality to watercourses, very significant resilience to flood and drought, while also creating resources and local employment.

Severn Trent did make limited use of reedbeds, first by using these for final stage (tertiary) polishing at a 2,000 persons sewage works at Avening, thereafter at over 250 small treatment works. More reedbeds than all other water companies combined.

Reedbeds were included into the NRA's Catchment Management Plan - with regard to providing treatment for unsewered rural properties, such as Claypits and also for straining of stormwater.

The NRA responded favourably to the suggestion of an independent implementation of such a 'Waste Water Utilization System' to resolve the gross sewage pollution at Claypits. NRA Pollution Control visited the site and agreed outline recommendations which were incorporated into proposals :

- Design and construction standards normally applied to Agricultural Waste would be suitable here.

- A septic tank should provide primary settlement. (Placed in the NE corner of the site, furthest and down-wind from the settlement).

- Vertical (Downflow, low retention time) Reedbeds be used for suspended solids reduction prior to nutrient rich discharge to sub-surface irrigation system, feeding a Willow Biomass Crop.

- A Stormwater bypass (with straining provision) be provided for at least 6 x dry weather flows (DWF).

There were 23 properties and several businesses in the Claypits settlement and these proposals allowed for the treatment and resource recovery of the waste water and sewage from the total population here, upwards of 100 persons. The loading in the sewage filled ditch was thought to approximate to 50 persons.

DESIGN PROPOSALS: SEWAGE CLEANSING AND UTILIZATION SYSTEM - CLAYPITS
PLAN
Scale
5
10
15
m
N
TBM
MH
Road to Eckington
Motorway bridge
Existing native hedgerow
Underground telephone cable alongside road
Existing ditch
Water pipe
Site boundary
Existing ditch
Established trees on M5 motorway embankment
MOTORWAY EMBANKMENT
Existing native hedgerow
Post & wire fence
Pathway to reedbeds
Existing entrance to site
Existing native hedgerow
KEY
STORMWATER DRAINAGE SYSTEM
a . Covered ditch
b . Gravel filled filtration stormwater filtration pond
c . Ditch
d . Winter lake collecting stormwater & filtered water
CLEANSING AND UTILIZATION SYSTEM
1 . Septic tank - butyl lined and covered with railway sleepers
2 . Settlement tank
3 . Reedbed - vertical flow twin bed
4 . Smaller Reedbed - vertical flow twin bed
LEVELS AND DRAINAGE
MH – Manhole
9" pipe leading to septic tank
150mm Pipe
Corrugated plastic divider in reedbeds
Gravel filled irrigation channels
perforated guttering pipe
indicates flow direction
TBM Temporary Bench Mark
VEGETATION
Existing trees on site
a . Pear tree b . Apple tree
c . Apple tree d . Apple tree
e . Apple tree f . Pear tree
Tree & shrub planting on earth mounding - including wetland sp. and willow var.
Groups of willow biomass crop allowed to mature & managed as woodland
Short Rotation Coppice S.R.C. Willow var. irrigated and filtering nutrient rich water from cleansing system producing fast growing biomass crop to be cut every 1 - 3 years
Short Rotation Coppice S.R.C. - Fast growing willow varieties to be cut every 3 years as biomass crop
DESIGN PROPOSALS : CLAYPITS © JULIAN P. JONES 19
DWG : 96001/DP DRWN BY : L. WHITE

Design Criteria

Septic Tank

A simple septic (settlement) tank was designed for a 100 persons loading, as this allows for superior settlement characteristics and simple construction, utilizing timber railway sleepers as a secure and durable cover. (Developments with small scale biogas equipment could now make this a preferable if more expensive alternative to a septic tank).

Reedbeds

Secondary removal of suspended solids and humus provided by two vertical, down flow reedbeds. These sized at $1m^2$/PE. Thus a total area of $100m^2$ is provided for, with two sets of beds in series, both planted out with *Phragmites* reeds (at 10 rhizomes/ 1 m^2). Minimal retention time of effluent in these was to maintain nutrient loadings for later (willow) stages. (Had this proposal not included the large willow plantation a greater area of reedbed would have been required, the normal sizing being $5m^2$/PE, thus the first bed at $66m^2$, the second at $33m^2$, both 0.6m deep. The beds lined with butyl and preferably filled with a proprietary reedbed soil planting medium.

Gravel, though used by many for reedbeds, does not enable a complete ‘chemistry’ of the treatment processes required. The original proprietary soil planting method for reedbeds (Oceans-ESU) is very superior to gravel, in many important respects.

The intended siting of the reedbeds to the NE of the site and the required levels of inflow and outflow to the field biomass irrigation header drain, required extensive earthworks. The spoil was to be utilized for landscaping and the creation of embankments around the reedbeds. These have created a different environment, providing shelter with added interest and aesthetic, whilst containing any minimal odours from the aerobic cleansing in the reedbeds.

Planting with wetland species, trees and shrubs. Additional earth banking around the septic tank to provide screening here (with separate fitted odour control of septic processes here).

Gravity flow used throughout the system, saving energy, reducing installation and operating costs, whilst enhancing reliability.

Sub-surface Irrigated Willow Plantation for Biomass

The nutrient-rich effluent would pass from the final reedbed and settlement tank into a level (irrigation header) header drain that traversed the maximum width available of the lower region of the site. This would distribute flows through a series of irrigation channels (covering 50% of the site area).

Willows are notable as 'hungry' consumers of both water and nutrient - in summer months and periods of low rainfall there could be no discharge from the willow plantation. A final stage seasonal lake, immediately prior to exit of the effluent from the site - this would buffer and stabilise any remaining nutrients. As an option this could have been butyl lined, or simply puddled, to retain levels during dry periods.

A secondary benefit of this project would be the significant rainwater retention and flood water buffering property in the lake and right across the biomass planting area that the accumulation of leaf mulch from the willows would create. Additionally improved soil infiltration of rainwater would result from the pathways opened into the soil/clay by the willow roots.

Recommended planting with, for resistance against disease mixed fast growing willow varieties *(S. viminalis lanceolata, S. viminalis* var. *gigantea* and *S. viminalis* var. *regalis)* for Biomass, , with a cropping regime of 3-5 years, at a density of 10-20,000 plants per hectare. (For Basketry a 1 year cropping regime, at a density of 40,000 plants per hectare).

The planting pattern was in accordance with the requirements for Grant Aid. This primarily attended to aesthetic considerations, allowing for 'islands' of mature trees (existing fruit and new plantings) to soften the visual effects of the periodic cropping.

Remaining areas of the site, though un-irrigated would also be planted with Willows for biomass, though these will not achieve the rapidity of growth of those that receive effluent. They would still be a viable commercial crop and would illustrate the typical 50% increased growth rates of willow achieved by sewage irrigation. They could also receive periodic applications of septic tank sludge.

The totality of this system, a diverse and functioning landscape well offer further resource realization possibilities in addition to climatic control, conservation, recreation and educational benefits.

Composting of the septic tank sludge could provide a further useful product. Alternatively the sludges could be conveyed by tanker to additional willow biomass plantations on fallow set-aside land. Just 32 hectares of planting could provide over 100% of the Claypits settlement potential energy needs.

Installation of kitchen sink "waste-disposal" units in all Claypits properties could have enhanced the organic humus loading of the system. Facilities could have been arranged to receive all garden waste from the settlement, for centralized composting.

A local Willow Biomass Electricity Generating Plant would be required to create electricity, transport over distances greater than 10 or so mile would reduce efficiency. A fully maximised implementation of these proposals would have created upwards of £5,000.00 of resources annually (1995 market prices) and employment.

Stormwater

A Stormwater diversion allowed for at least 20 x Dry Weather Flow to bypass the treatment system. This discharged into a ditch covered in cut down railway sleepers for reasons of safety and to prevent growth of vegetation.

This covered ditch discharged into two coarse aggregate filled, free draining, straining beds. These would have built up sides with excavated material and planted with wetland tree varieties. Water would not be retained in the beds, but would have been buffered for slow release through to a ditch passing down the eastern periphery of the site, to exit at the SE corner by the final pond.

Fencing

Fenced protection of the entire site would be preferred during the willow sapling establishment phase for protection against rabbit infestation. Additional fencing could be required around the reed bed and septic tank area.

Maintenance

This scheme was proposed as a proving stage for a wider implementation at other sites, within the local district (and elsewhere). The durability and resilience of this system would minimise maintenance to periodic septic tank emptying, inspection & weeding of reedbeds and willow cropping.

Further options for ongoing maintenance could include:

- Requisitioning of the system by local council and/or formation of dedicated not-for-profit community water trust and/or parish water action groups with ongoing management on a contracted out basis, or within Parks and Gardens responsibilities.

- Involvement of local community groups (Stroud Valleys Project, Wildlife Trusts etc) using volunteers

- Severn Trent might have wished to properly compete* for the sewerage business here, implementing and operating their own design of excellence to maximise the community resources here. (*as intended by the Water Acts).

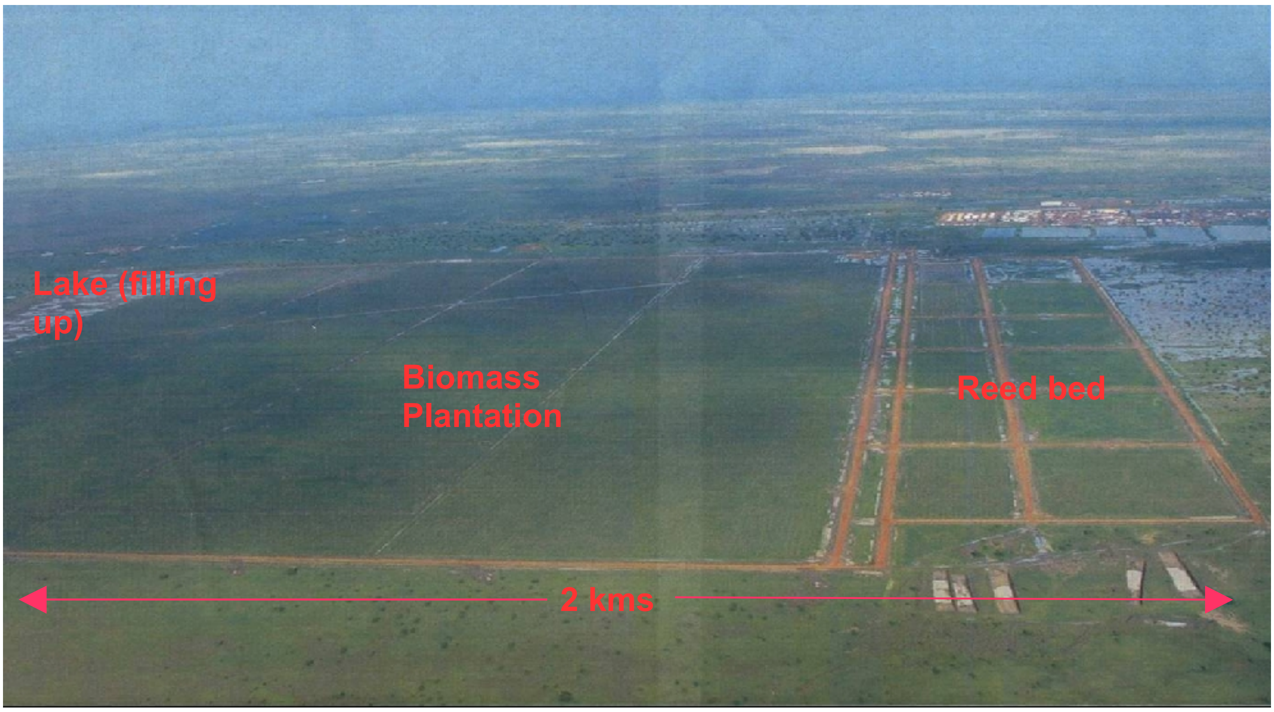
Lessons Learned

Stroud District Council Environment Committee commissioned a feasibility study here which cost, together with their officers time, around as much (or more than) it would cost to have installed a reedbed / biomass / lake scheme at Claypits. Their study bizarrely concluded there was no space locally for a reedbed system.

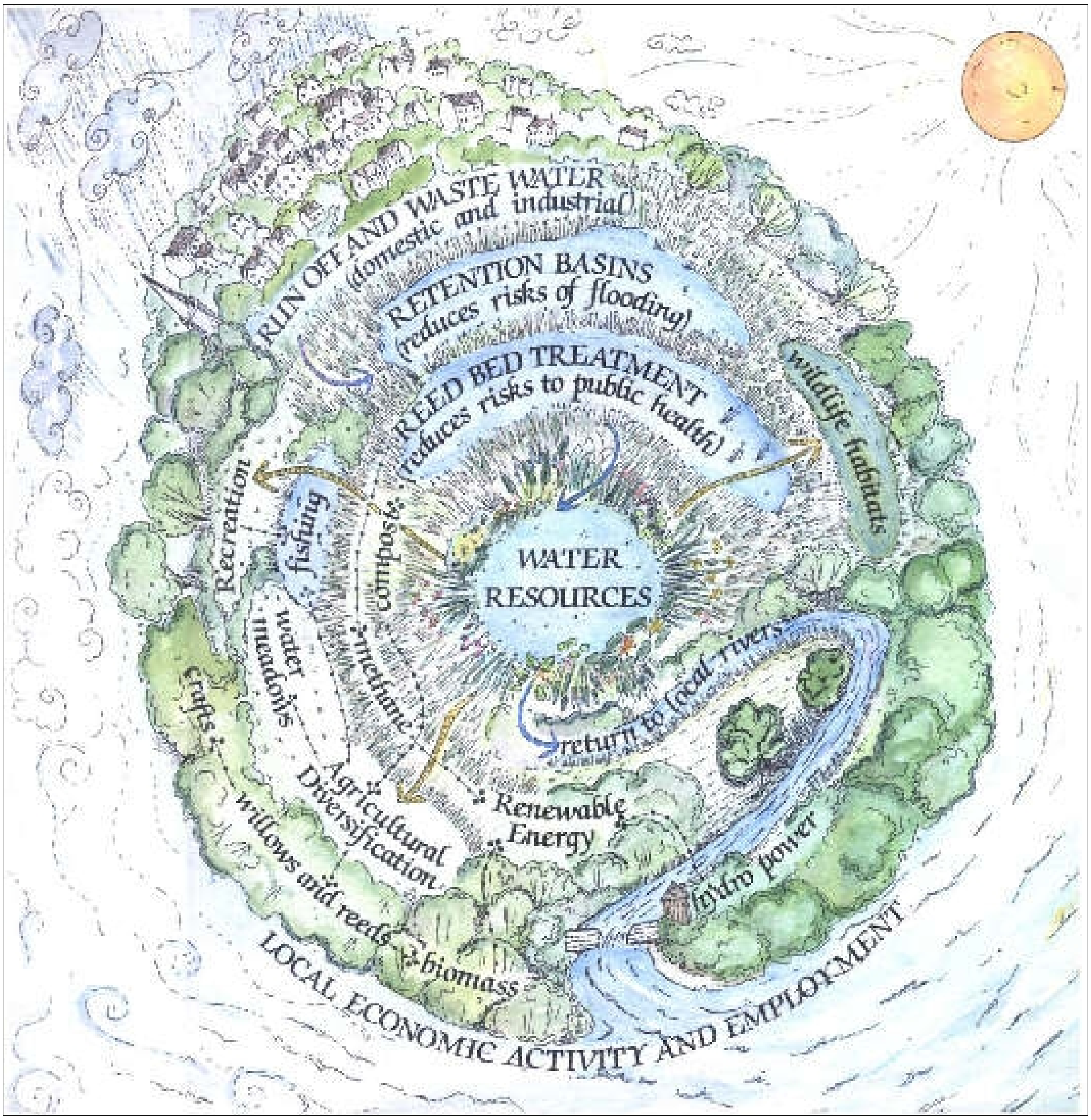
Severn Trent adopted the site and installed a large concrete tank with pumps supplying via new sewer the waste water to their local sewage treatment works, over 2 kms away. Technical problems arose with their installation and residents were charged large connection fees. This cost well over the estimated £250,000, wastes energy, completely fails to realise full resource value of the sewage and has numerous negative climatic and other implications - some serious.

The reedbed / biomass / lake design principles explored in this study have now been adopted for the world's largest natural water cleansing systems. The UK originators of reedbed treatment, Oceans-ESU, are using this approach cleansing oilfield waste in Sudan, and 16 such systems are built or being constructed, each up to 2 kms across and treating 8 million gallons a day – very successfully to an effective drinking water standard (though W21 does not recommend this). And at an estimated 90% cost saving over conventional treatment.

These natural cleansing methods are universally appropriate for domestic sewage or industrial waste effluent, they can be placed in urban fringe areas of town and cities, with profound and far reaching benefits.



Continuous discharge to Lake (8 million gallons/24hrs)



SEWAGE TREATMENT & REUSE

Treatment alternatives for rural communities

Carl Myers says that alternative methods such as reed beds and willow coppices could soon be used as a means of domestic effluent treatment in the UK.

Water supply and sewage treatment have generally been viewed as a natural monopoly in the UK. Following privatisation of the water industry in England and Wales, the 1991 Water Industry Act allows firms to compete for the provision of services around the country.

The industry regulator, Ofwat, is now considering one water company's application to supply drinking water through another's pipes. This is provided for in principle, but there are complicated practical hurdles to overcome.

Sewage treatment, however, is not subject to the same concerns and seems much easier to open up to competition. Any firm can now apply to Ofwat for the status of an 'inset company', to compete for the provision of certain effluent treatment services.

Ofwat is currently processing 15 inset applications, 11 for sewerage, and one for sewerage and water supply. This element of competition could reduce costs for consumers, and also give them more say in the choice of treatment technology.

Stroud District Council is commissioning a feasibility study into the use of alternative methods, such as reed beds and willow coppices, for the decentralized treatment of domestic effluent from three villages in the area.

Appalled by the local water company's failure to resolve sewage problems, the Council is meeting Ofwat to discuss the possibility of setting up a cooperative based inset company to provide local sewage treatment services.

According to District Councillor, Doug Booth, some 30% of households in the area are not connected to a main sewer, and many of the septic tank systems installed after WWII are now inadequate.

The District has had problems with overflows of sewage onto land and into rivers, due to high rainfall. When the overflow occurs during rainfall, the sewage is quickly washed away, but when it occurs after rainfall or due to a collapsed sewer, it can linger and cause greater risk to the environment and public health.

It is well known that the District has suffered outbreaks of meningitis, a virus commonly found in sewage. Although there is no direct evidence, the possibility of a link between the cases of meningitis and sewage problems has raised some local concern. According to Booth, as the water company appears reluctant to invest money and more concerned about profits for its shareholders than issues of public service and public health, a local initiative is attempting to provide an appropriate solution.

In one of the villages in question, Claypits, which has a population of about 100, the overflow from septic tanks runs down a ditch that drains into a local stream. It is estimated that construction of a trunk sewer and pumping station to carry effluent to the nearest STW would cost at least £250,000.

Functioning landscape system

Local water consultant, and former UK sales director of Bauer, Julian Jones, has proposed a 'functioning landscape' system using reed beds and willow coppices to treat the village's effluent. Jones estimates the system would cost less than £25,000, and could provide a substantial proportion of the village's energy needs in willow biomass.

According to the NRA, the 'proposals appear adequate...reed bed treatment for small communities is a well established alternative to existing treatment methods'.

In the view of Booth, 'the project seems both economically and environmentally very sound'. He is keen to set up the scheme and prove that it works since it could have potential for many other locations with similar problems.

According to the Water Research Council (WRc), the use of willow coppices has only really started attracting research over the last couple of years, hence at present such systems are likely to be designed with a high safety margin in mind.

In cooperation with other European companies, WRc is currently applying for EU funding for a research project involving the application of sewage effluent to willow coppices in four large scale field trials in Europe.

There are many arguments in favour of using functioning landscapes such as reed beds and wetlands for sewage treatment on a localised basis.

Firstly, investment and operating costs are substantially less than for conventional methods. Secondly, separating sewage from industrial effluent and stormwater would mean it could be used as fertilizer instead of being disposed of at a higher cost while farmers buy artificial fertilizers.

As well as being costly, pumping sewage and stormwater to centralized treatment stations short-circuits the hydrological system, reducing river flow and aquifer recharge and contributing to 'artificial drought' conditions.

Returning cleaned water to the eco-system close to where it is used increases aquifer recharge and river flow and allows for more natural cleansing through the river system.

The main argument used against the use of reed beds is lack of space, yet UK taxpayers are currently paying for farmers to set aside 10% of the nation's arable land to lay idle.

Centralized sewage treatment and disposal dates back to the 19th Century, and such an ingrained concept is slow to change. Wetlands have always served as 'nature's kidneys', but their potential for effluent treatment is only recently starting to be recognised.

Yet with most towns of over 2000 inhabitants required by EU law to install secondary sewage treatment by 2005, there could be ample scope for application of the decentralised approach in areas like Stroud.

Reader Enquiry No: 11

Reed beds: sewage treatment technology for the 21st Century?

Water21 Limited is a not-for-profit company limited by guarantee

Registered Office
135 Aztec West
Bristol BS32 4UB
Registered No. 9098337 in England & Wales

http://www.water21.org.uk/contact