# BILLET D'ÉTAT

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2006

## WEDNESDAY, 25th JANUARY, 2006

**PUBLIC SERVICES AND ENVIRONMENT DEPARTMENTS**

SEWERAGE AND WASTEWATER TREATMENT

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# *B I L L E T  D'É T A T*

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## TO THE MEMBERS OF THE STATES OF

## THE ISLAND OF GUERNSEY

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I have the honour to inform you that a Meeting of the States of Deliberation will be held at **THE ROYAL COURT HOUSE, on WEDNESDAY,** the **25th JANUARY, 2006,** at 9.30am, to consider the item contained in this Billet d'État which has been submitted for debate by the Policy Council.

G. R. ROWLAND
Bailiff and Presiding Officer

The Royal Court House
Guernsey
16 December 2005

# PUBLIC SERVICES AND ENVIRONMENT DEPARTMENTS

SEWERAGE AND WASTEWATER TREATMENT

The Chief Minister
Policy Council
Sir Charles Frossard House
La Charroterie
St Peter Port

27th September 2005

Dear Sir

## 1. Executive Summary

1.1 Political responsibility for sewage disposal services passed from the former Public Thoroughfares Committee to the Public Services Department with effect from 1st May 2004. The new Environment Department has political responsibility for overall environmental policy, including land use planning.

1.2 In this context, the Departments have agreed that the role of the Environment Department is to recommend environmental policy whilst the role of the Public Services Department is to procure and commission the associated infra-structure.

1.3 This joint report outlines the development of current strategy for sewerage and sewage disposal, reports progress and sets out options for the future with resources required to deliver each alternative. It has been prepared in the format of a 'Green Paper' to stimulate discussion and debate both by the States and the public.

1.4 The Departments intend to listen very carefully to all discussion and reflect upon the various issues and concerns that are raised. It is hoped that within 12 months a further report will be submitted on the way forward with clear recommendations for consideration by the States.

1.5 After a brief introduction in section 2, the report reviews the development of Liquid Waste Strategy in section 3, commencing with the comprehensive Waste Strategy Assessment. This section also reports the Liquid Waste Strategy approved by the States in June 1997 and subsequent development of that strategy. The Executive Summary of the Waste Strategy Assessment is attached in full for further reference.

1.6 The key points arising from extensive research undertaken for the Waste Strategy Assessment are:

- WRc plc (formerly the UK Water Research Centre) developed a computerised model, proven by associated tracer studies, showing the dispersion and decay of sewage discharged through each of the four outfalls currently in continuous use (Belle Greve, Creux Mahie, Fort George and Herm); the impact of polluted surface water was also modelled;
- The project established a consensus that inland pollution of streams and ground water affected natural water resources and bathing beaches, was more damaging and justified higher priority than the impact of sewage discharges to the marine environment from existing outfalls;
- A comprehensive strategy was developed to improve the collection and transfer of sewage for treatment;
- The need identified to plan for treatment and disposal of biosolid sludge arising from any future sewage treatment processes.

1.7 In summary the States has previously:

- approved sewage treatment in principle and agreed standards for discharge of treated effluent;
- decided that sewage treatment would be centralised in one location, unless there were overriding reasons to provide local treatment;
- prioritised other liquid waste works on the assumption and understanding that sewage treatment would follow thereafter.

1.8 Section 4 of the report reviews natural marine processes that mitigate the environmental impact of discharges from the long sea outfall into Belle Greve Bay. The existing long sea outfall was designed and engineered to dilute sewage so that the natural marine processes available in the Little Russel were not overloaded. Unlike accelerated artificial treatment plants, the natural marine processes require no additional chemicals or energy input.

1.9 Regular inspections of the outfall, bathing water quality and shellfish are undertaken. These reveal the present abundance and diversity of marine flora and fauna, which is considered to be indicative of water quality in the Little Russel. However, the report notes that a Benthic survey would provide further evidence to assess the long term impact of sewage discharge on the marine environment.

1.10 Approximately 90% of all sewage arising throughout the Island already flows to Belle Greve Headworks. Since July 2003, further investigations have demonstrated that centralised treatment will be more cost effective for sewage currently discharged at Creux Mahie and Fort George. The current objective is to transfer all Guernsey sewage to Belle Greve by 2008. If considered necessary, the robustness of this strategy could be reviewed as part of any Environmental Impact Assessment. Sewage arising in Herm will require local treatment.

1.11 Implementation and progress of the sewerage and sewage disposal strategy approved by the States are also reviewed in Section 4. This section outlines progress and future plans for the following major capital programmes:

- Network Extension Plan, new foul sewers to replace cesspit drainage systems;
- Drainage Area Plan, incorporating rehabilitation of old foul sewers and separation of surface water;
- Plans to cease regular discharge from the Creux Mahie and Fort George and to rehabilitate the Belle Greve outfall by 2008.
- The report advises that after 33 years continuous service, the Belle Greve wastewater disposal facility requires major refurbishment to ensure that reliable and effective wastewater disposal facilities can be maintained and that rehabilitation of this facility would be required, even if sewage treatment were advanced.

1.12 Section 5 explores the provision of sewage treatment, including a preliminary assessment of alternative treatment processes that may be appropriate to treat wastewater from the whole Island, based on a new report from WRc that is appended in full. Table 1 read in conjunction with the WRc report offers an overview of the main stages and sequence of sewage treatment. The report emphasises the importance of treating sludge generated by sewage treatment and the risks of sludge disposal. It has been suggested that some treatment plants can operate without producing traditional amounts or types of sludge. Further consultation with sources of expertise and innovation within the UK water industry has not revealed any reliable new information that would significantly change the broad outline presented in Section 5.

1.13 An Environmental Impact Assessment will be required before any decisions are taken on accelerated sewage treatment, and would need to be undertaken in several stages. Even if resources were available, site selection and acquisition, planning, design and construction of sewage treatment facilities is unlikely to be completed in this decade, if recent project timescales are representative.

1.14 The most likely scenario for full sewage treatment, based on the information currently available, is set out in Table 3 which summarises the estimated resources required to provide sewage treatment.

1.15 In Section 6 the Public Services Department reports discussion of options for future funding of foul drainage services and the possibility of levying direct charges for wastewater services.

1.16 At present, customers with cess pit drainage systems pay a subsidised charge for sewage collection and disposal, with the cost of the sewerage infrastructure partially recovered by an element of the occupier rates for properties. The Public Services Department suggests that all properties that generate foul water should be making a contribution to the sewer infrastructure and in addition those who are on cesspits should pay an economic charge for cesspit emptying.

1.17 The two main options for collecting such payments are through the Tax on Rateable Value or a specific household charge that would feature as part of the quarterly water bill. The latter is the system used most commonly in the UK and where a property is on a water meter the waste water removal charge is based on a pre-set percentage of the water consumed. The principle being that sooner or later most of the water that goes into a house is disposed of into the drainage system.

1.18 Other Departments with Mandates relevant to sewage treatment have been consulted and the comments received from the Department of Health and Social Services are attached as Appendix K and summarised in Section 7 of this report. Internal consultation demonstrated the importance of public perception, both within and outside the Island.

1.19 Section 8 reports on worldwide standards for marine disposal of sewage including developing and developed countries, and refers to a Review undertaken for the States by WRc plc [attached as Appendix L]. There has been rapid development in standards and practice in recent years. The Island's long sea outfall may comply with best practice for developing counties but would no longer be considered an acceptable permanent means of sewage disposal in any developed country.

1.20 The current strategy and future options are summarised in Section 9. The report identifies that a budget in the region of £1.5 million would be required to undertake the full Environmental Impact Assessment (EIA). This would be necessary to determine the best environmental option for sewage disposal, including evaluation of the potential sites, treatment processes and water quality standards. The report confirms that a full EIA would be necessary before any decisions are taken on accelerated sewage treatment.

1.21 The Departments suggest that the environmental impact of existing marine discharges should first be scientifically assessed at a cost in the region of £300,000. A full EIA would only be required if it was decided to improve sewage treatment, a decision that may depend upon the findings of the initial study.

## 2. Introduction

2.1 Political responsibility for sewage disposal services passed from the former Public Thoroughfares Committee to the Public Services Department with effect from 1st May 2004. The new Environment Department has political responsibility for overall environmental policy, including land use planning. In this context, the role of the Environment Department is to recommend environmental policy; the role of the Public Services Department is to procure and commission the associated infra-structure.

2.2 This report outlines the development of current strategy for sewerage and sewage disposal, reports progress and sets out options for the future with resources required to deliver each alternative. It has been prepared in the format of a 'Green Paper' to stimulate discussion and debate both by the States and the public.

2.3 The paper reviews natural marine processes, the sewerage network and the procedures that would need to be followed should an accelerated method of sewage treatment be required, but the report does not seek to make any recommendations. Instead the Public Services Department and the Environment Department will listen very carefully to all discussion and reflect upon the various issues and concerns that are raised. It is hoped that within 12 months a further report will be submitted on the way forward with clear recommendations for consideration by the States.

2.4 This green paper sets out the need for an assessment of current impacts and a full Environmental Impact Assessment before any decisions are taken on accelerated sewage treatment and invites public consultation.

## 3. Development of Liquid Waste Strategy

WASTE STRATEGY ASSESSMENT 1994 – 1997

3.1 In June 1994 the States resolved to conduct an assessment of the Island's long-term strategy for all waste, both solid and liquid. Due to the overlapping nature of the issues, political responsibility for this corporate project was allocated to the Advisory and Finance Committee in July 1996 (Billet d'Etat XIV).

3.2 Extensive research and consultation was undertaken, drawing upon external specialists and internal resources from several departments, led by the Waste Services Section of the former Department of Engineering, now Guernsey Technical Services. The research phase of this project resulted in two separate reports, the first focussing on liquid waste and the second on solid waste. In respect to sewage the most significant findings were:

- WRc plc (formerly the UK Water Research Centre) developed a computerised model, proven by associated tracer studies, showing the dispersion and decay of sewage discharged through each of the four outfalls currently in continuous use (Belle Greve, Creux Mahie, Fort George and Herm); the impact of polluted surface water was also modelled;
- The project established a consensus that inland pollution of streams and ground water affected natural water resources and bathing beaches, was more damaging and justified higher priority than the negligible impact of sewage discharges to the marine environment from existing outfalls;
- Proposed a comprehensive strategy for improving the collection and transfer of sewage for treatment;
- Addressed the need to plan for treatment and disposal of biosolid sludge arising from future sewage treatment.

3.3 Appendix A shows the maximum bacterial concentrations for each of the existing sewage outfalls predicted by the WRc sewage dispersal model, as one example of many scenarios modelled. The Executive Summary of Waste Strategy Assessment Report No 1 is also attached as Appendix N of this States Report.

LIQUID WASTE STRATEGY APPROVED BY THE STATES IN JUNE 1997

3.4 The project report dealing with Liquid Waste was summarised in a policy letter from the Advisory and Finance Committee dated 23 May 1997 (Billet XI). The States decisions in respect of sewage were as follows:

- *"To approve in principle the adoption of Environmental Quality Objectives and Standards for the Island's surface and groundwaters, as set out in paragraph 5.2"* of the policy letter [Paragraph 5.2 refers to "compliance with European Union guideline standards of water intended for the abstraction of drinking water"].

- *"To direct the States Public Thoroughfares Committee"... "to report to the States with a plan for the continued rehabilitation, future maintenance and extension of the sewerage infrastructure, as detailed in paragraph 5.10"* of the policy letter.[The PTC Business Plan – see section 5 of this report]

- *"To direct the Advisory and Finance, in consultation with the Public Thoroughfares Committee, to investigate the possibility and desirability of levying an equitable charge on owners of property... connected to the foul sewer network, such charge to be used for the maintenance of the network, and to report back to the States as soon as possible".*

- *"To approve in principle the adoption of Environmental Quality Objectives and Standards as detailed in paragraph 5.20(a)" of the policy letter* [see Section 4.3].

- *"To agree in principle that the introduction of sewage treatment measures be brought forward for implementation as soon as is practicable and to direct the States Advisory and Finance Committee to give consideration to the means for achieving this, within the resources available to the Island, and to report to the States as appropriate and with reference to the issues raised in paragraphs 5.18 and 5.20 (b)"* of the policy letter. [See Strategic and Corporate Plan 2002 & 2003 – Section 6 of this report]

3.5 In paragraph 5.18 of the 1997 policy letter the Advisory and Finance Committee confirmed that " highest priority should be given to the containment of pollution of the Island's ground and surface water systems" Paragraph 5.18 ends "the Committee considers that sewage treatment should come into operation within a five to ten year timescale".

3.6 Paragraph 5.20(a) of the 1997 policy letter determines objectives and standards for sewage treatment, *"to achieve:*

- *the maintenance of the highest standards for designated shellfish beds, in accordance with European guidelines and requirements;*
- *compliance with guideline standards of the Bathing Waters Directive in all inshore bathing waters;*
- *compliance with the appropriate internationally recognised standards in remaining coastal waters, including the Little Russel"*

<u>DEVELOPMENT OF SEWAGE TREATMENT AND SEWERAGE STRATEGY 1998 – 2000</u>

3.7 In April 1998 the former Public Thoroughfares Committee presented a comprehensive Business Plan to the States (Billet d'Etat VII). In accordance with States Resolution of June 1997 (6 above), the PTC Business Plan included an option for the construction of sewage treatment facilities by 2002, subject to availability of funds.

3.8 The Business Plan included the following two major capital plans to reduce pollution within the Island and prepare for future sewage treatment:

<u>Drainage Area Plan</u>

3.9 This comprehensive Plan addressed deficiencies in existing sewerage infrastructure and provides for planned development. The Plan was based on a CCTV survey of all sewers undertaken during 1993, flow measurement, analysis and assessment of projected future development. Capital programmes included renewal and rehabilitation of sewers and pumping stations to meet hydraulic, structural and service requirements.

3.10 Septic waste from cess pits releases hydrogen sulphide, a toxic gas which forms sulphuric acid in wet conditions that can destroy the concrete and mortar and ancillary metalwork used in sewerage systems. Rehabilitation of damage caused by hydrogen sulphide to relatively new sewers, manholes and pumping stations was a significant part of the necessary capital programme.

3.11 The environmental and economic impact of this programme included reduced infiltration into sewers, minimising flows and future operating costs, less traffic disruption and reduced pollution due to breakdown, overflow or leakage.

3.12 Reduction in surface water and saline water flows in the sewerage system is fundamental to obtaining an efficient and effective treatment process prior to the discharge of effluent to the receiving waters (Note: considerable progress has been made since 1997 by installing new separate surface water sewers and relining old foul sewers).

3.13 Intermittent Saline intrusion associated with high tides entering the sewerage network would adversely affect the microbiological balance of a conventional sewage treatment works. Modern systems can be designed to operate with relatively consistent levels of salinity, but react badly to sudden shock loadings that can adversely affect the beneficial organism environment in the process

(Explanatory Note: microbiological communities capable of treating sewage exist in fresh water and also in saline water but the microbiological organisms that develop in saline water are not the same organisms that thrive in fresh water).

3.14 Surface water flows in the sewerage system can have a similar impact by flushing the organisms through the works, but more importantly these high flows and volumes require larger pumping capacity, storage tanks and energy consumption to deal with these conditions. Infiltration of groundwater reduces dry weather flow in the island's streams and thereby reduces water resources.

3.15 The Drainage Area Plan included separation of surface water drainage from foul sewers.

Network Extension Plan

3.16 The objective of the second plan was to extend main drain to 95% of Island homes within 20 years. The plan commenced with three traditional contracts that were awarded to provide sewers in the Cobo area, L'Islet Phase IV and Les Nouettes in the Forest.

3.17 The key States Resolutions arising from that policy letter were as follows:

- *"To note the States Public Thoroughfares Business Plan"*
- *"That the Public Thoroughfares Committee be required to appoint appropriately experienced consultants to investigate the viability and technical possibility of a distributed treatment system for the Island's waste water ....... And report back to the States within 12 months."*

3.18 The Public Thoroughfares Committee returned to the States in April 1999 with a policy letter entitled "Investigation into the Viability and Technical Possibility of a Distributed Treatment System for the Island's Wastewater" (Billet XI). This policy letter summarised the consultant's conclusions and expanded on some of the programmes included in the Business Plan. The States decided:

- *"......To centralise sewage treatment unless there is an overriding reason to consider localised treatment."*
- *"To approve in principle the future programme of the States Public Thoroughfares Committee as outlined in Section 5 of that Report"*

3.19 A detailed long-term programme for sewer construction was prepared and published in July 2000, to be undertaken as a rolling programme under a term contract. This programme would eliminate most of the pollution caused by leaking cess pit drainage systems, which would become redundant if the property owners connect to main drain. Damage to sewerage infrastructure and offensive odour from septic sewage would also be minimised.

STRATEGIC AND CORPORATE PLAN 2002 / 2003

3.20 In 2002 the States were advised " a report is to be prepared which will review the priority of sewage treatment within the Capital Works programme" (Section 8.8.8 on page 1245 of Billet d' Etat XV).

3.21 In 2003 the States approved a revised Strategic and Corporate Plan, which concluded .... " Provision of sewage treatment will therefore offer minimal environmental benefits, compared with other liquid waste priorities." (Section 10.8.8 on page 19 of the 2003 Plan published as an appendix to Billet XXI 2003). Although Strategic Policy 27 refers to identification of sites for sewage treatment, the text of the revised Plan indefinitely deferred provision of wastewater treatment in favour of an "action plan", agreed between the former Advisory and Finance and Public Thoroughfares Committees. This Action Plan comprised the following three components:

- *"For the PTC to liase with the Board of Health's Environmental Health Department to establish a regular sampling programme to monitor the discharge effects of the long sea outfall at Belgrave Bay on surrounding waters". (Note: Appendix B provides summary results for 2004 water quality on the east coast shore at Fermain, Havelet, St Sampsons and Bordeaux)*
- *"For the PTC to maintain a watching brief on proven technical innovation within the waste water treatment industry in order to keep under review the best environmental option for the Island's sewage disposal, until such time as provision can be made within the Capital Works Programme for these works".*
- *"For the PTC to investigate, and report back as appropriate, on the possibility of executing inexpensive works to end discharge of untreated sewage from the waste water effluent discharges at Fort George and Creux Mahie ( and for the Board of Administration to do likewise in relation to Herm), together with upgrading of the existing headworks and preliminary treatment facility at Belgrave."*

3.22 The approved Strategic Land Use Policy (27) reads "The identification of sites for sewage treatment works may be incorporated into the relevant Detailed Development Plans and technical assessments of methods of sewage treatment shall be taken into account in the identification of those sites"

THE ENVIRONMENTAL POLLUTION (GUERNSEY) LAW 2004

3.23 The Environmental Pollution (Guernsey) Law 2004 provides a comprehensive legal framework to prevent pollution of air, land and water. This Law establishes the post of "Director of Environmental Health and Pollution" as an environmental regulator responsible for implementing the provisions of this new Law. A "Director Designate" has been appointed; the new Law is expected to come into force during 2005, subject to States approval of a commencing Ordinance.

3.24 The new primary legislation was drafted as a framework for more detailed regulations on specific issues to be enacted by Ordinance. The first substantive Ordinance under this Law is being prepared to regulate management and disposal of solid waste. The secondary legislation on solid waste has already been approved in principle and is being drafted for approval by the States to come into force simultaneously with The Environmental Pollution (Guernsey) Law 2004.

The legislation anticipates a parallel future Ordinance regulating disposal of liquid waste to the marine environment. Subject to the enactment of further secondary legislation, the "Director of Environmental Health and Pollution" would enforce the prescribed standards for discharge of treated sewage.

## 4. Implementation of the Approved Wastewater Strategy – Progress since 1997 and the current position:

DRAINAGE AREA PLAN:

4.1 The Drainage Area Plan is required to maintain existing assets and meet future demand on the existing sewerage network that comprises sewers, pumping stations and outfalls. A considerable length of sewer has been relined within a rolling rehabilitation programme; pumping stations at Cobo, Lowlands and St Sampson's have already been replaced and others refurbished.

4.2 Although good progress has been made, parts of the sewerage network remain in an unsatisfactory condition and further deterioration will have occurred since the 1993 survey. Further inspection of critical sewers is overdue. The Public Services Department are currently updating the Drainage Area Plan as the strategic plan for the future maintenance and capital investment to sustain the Island's ageing sewerage network. A schematic diagram of the sewerage network is attached as Appendix F1; this shows the outfalls, trunk sewers, pumping stations and pumping mains.

Foul Sewer Rehabilitation Programme

4.3 Rehabilitation work commenced in 1997 based on the results of a comprehensive survey undertaken during 1993; Appendices D1 and D2 provide a full list of planned and emergency sewer rehabilitation projects completed since 1997.

4.4 The Public Services Department has approved a comprehensive condition survey of the gravity sewer network to be undertaken during 2005 at a cost of £200,000. This survey will provide accurate information on the current structural, hydraulic and service condition of the foul sewerage network. Guernsey Technical Services will use the comparative information from the two surveys to assess the rate of sewer deterioration and revise flow models. Survey results will also be used to refine maintenance operations.

4.5 It is already clear that the current Sewer Rehabilitation Programme funded from the Department's revenue budget will need to continue at the current rate of £1 million per annum to provide a sustainable sewerage network. A programme for rehabilitation of pumping stations and rising mains will also be required to supplement the current maintenance budget.

Surface Water Separation Programme

4.6 New surface water sewers have been constructed within the heart of St Peter Port. The diversion of Charroterie stream overflow away from the foul sewer was a significant achievement. Further work is required to protect the harbour areas from polluting overflows under storm conditions and to minimise the volume. Appendix E provides the equivalent list of completed surface water separation projects.

4.7 At the peak of high spring tides, up to 30% of the flow pumped through Belle Greve outfall is still derived from infiltration of saline water. In wet weather, up to 80% of the flow may be derived from surface or ground water including potential water resources diverted from the Water Catchment. The surface water separation and sewer rehabilitation programmes are targeted to reduce this problem.

4.8 At present, large quantities of surface water are discharged into the older sewers, mainly within the urban area. This causes foul sewers to overflow under storm conditions and will increase the cost of sewage treatment. The Public Services Department has been laying new surface water sewers to divert surface water away from the foul sewer; these are generally laid in conjunction with road surfacing or refurbishment of housing estates. This Surface Water Separation Programme, costing £500,000 per annum, has also been funded from the Department's revenue budget.

4.9 In order to complete the primary surface water drainage network to supplement the existing combined sewers, the Surface Water Separation Programme will need to continue for the foreseeable future. The current level of funding is the minimum necessary to take advantage of road surfacing, housing refurbishment programmes and similar opportunities to install new surface water drains. Increased expenditure will be required to make significant progress towards full segregation of foul and surface water drainage.

NETWORK EXTENSION PLAN

4.10 The objective of the Network Extension Plan was to extend the main drain to 95% of homes by 2020. The Plan was approved in 2000, commenced in 2001 and has progressed in accordance with the resources allocated. One fifth of this project will have been completed by the end of 2005, enabling some 1,175 properties previously draining to cess pit to connect to new public sewers, constructed at a projected total cost of £16.55 million or £14,085 per property (see Appendix C).

4.11 In addition to the convenience and value for those able to connect to new public sewers, the whole community will benefit from reducing the number of cess pits and the consequent odour nuisance. Completion of this Plan will avoid further damage to the Island's sewerage infrastructure from septic sewage and almost totally eliminate a major source of water pollution arising from leaking or overflowing cess pits (estimates in the waste strategy assessment suggest that, of the properties with cess pit drainage systems, some 22% are leaking). It will also greatly reduce the fleet of 40 tankers currently required to empty cess pits at an annual gross cost of £1.9 million (Tanker drivers, maintenance and replacement). Of this cost, approximately £1,150,000 is recovered by charges to customers for cess pit emptying, and the balance of £750,000 is currently funded from general tax revenues.

4.12 Prior to 2001 the volume of sewage to be transported by road was increasing at 1.5% per annum; 187,573 tanker loads were collected during the peak year, 2001. This increase was mainly due to the collection of water from washing machines and bathrooms that was previously discharged to soakaway and now discharged to cess pit as required by current Building Regulations. Water consumption for domestic purposes is also increasing.

4.13 When a new public sewer has been laid to the boundary of a property, the Public Services Department promotes early transfer from cess pit to "main drain". Financial incentives for owner-occupiers to connect currently includes a grant towards the cost of laying connecting sewers within domestic property of up to £1,000, supplemented by a low interest loan of up to £5,000. If the opportunity to connect to the public sewer is not taken up, charges for emptying cess pits are applied at penal rates, three times the standard rate.

4.14 As new sewers have been completed under the Network Extension Plan more properties have been connected to the public sewer, reversing the previous growth in road transport. Since 2001 the number of sewage tanker loads has reduced by 1.8% per annum. The Network Extension Plan has therefore reduced the potential volume of sewage to be collected from cess pits by 3.3% per annum.

4.15 However, the volume of sewage to be transported by road tanker remains substantially higher than in 1997 when the Waste Strategy was first approved. Allocated resources have been insufficient to make a major impact on the volume of sewage to be collected; the Department has to run hard in order to stand still. The Public Services Department is therefore of the opinion that significant development should not be permitted in areas where provision of main drain is not practical.

4.16 The Public Services Department has reviewed priorities for future sewer construction and has revised the order of work so that sewage currently discharged at Creux Mahie may be transferred to Belle Greve by 2008. In addition to the environmental benefits at Creux Mahie, this phase of the Plan will avoid the substantial cost of replacing the Creux Mahie sewage disposal facility and will enable connection of approximately 500 properties in the western parishes. To achieve this limited objective, continued funding at the rate of £3 million per annum has been agreed in principle with the Treasury and Resources Department, reducing to £1 million in 2008.

4.17 The Public Services Department considers that the Network Extension Plan should be completed at the earliest opportunity. Some 5,700 properties have yet to be connected and will remain on cess pit until the necessary resources can be allocated.

CURRENT SEWAGE TREATMENT FACILITIES AT BELLE GREVE

4.18 A complex network of gravity sewers and pumping mains deliver 90% of the Island's sewage to Belle Greve Headworks, located at Marais Rise, off Les Banques near to the Red Lion road junction. Flows received at Belle Greve vary from less than 200 litres per second (4 million gallons per day) to over 1,000 litres per second under storm conditions (20 million gallons per day).

4.19 Sewage currently receives preliminary treatment comprising maceration and grit removal and is then pumped through a long sea outfall to discharge over a mile from shore in the Little Russel, where it is subject to natural marine processes. It is important to note that, unlike more intensive sewage treatment processes, natural marine processes do not generate any biosolid sludge requiring further treatment and disposal, other than a small quantity of grit. This natural process is described in the following paragraphs.

Natural Marine Processes

4.20 The existing preliminary treatment at Belle Greve reduces the solids in the sewage to a size less than 6mm (1/4inch) diameter prior to discharge over a mile offshore. Good dispersion is achieved by discharging partially treated sewage into the tidal currents through 5 diffusers at a minimum depth of 10 metres at low tide.

4.21 The Public Services Department sets out its current understanding of natural treatment processes in the following two paragraphs, based on the best available information and advice including WRc plc (1996 and 2005) and the Waste Strategy Assessment (1997), prior to formal Environmental Impact Assessment.

4.22 Guernsey sewage is mainly domestic in origin and organic in nature, with very little industrial contamination. Being less saline and generally warmer than the sea, the sewage plume rises after discharge towards the upper layers of the sea. The depth of water, wave action and swift tidal currents in the Little Russel provide massive dilution and sufficient oxygen for the organic matter to biodegrade naturally. Harmful bacteria and viruses in well diluted sewage are rendered harmless by the combination of temperature, salinity and sunlight. Regular underwater inspection for structural integrity of the outfall shows no evidence of deposition on the seabed. A Benthic survey of the sedentary animal and plant life living on the sea bed and the sea bed habitat would provide scientific evidence of the current situation in that area.

4.23 It is important to emphasise the significant advantage that Guernsey has in the favourable conditions that exist in the Little Russel for self purification of sewage by natural marine processes due to the strong tidal flows, wave action and dispersal into the open waters where the natural self purification is completed. The Board understands that the position of Gibraltar is not dissimilar due its position on a peninsular and the current flowing through the Straights of Gibraltar. By comparison, it has been necessary for Jersey to provide a high standard of treatment because all the Island's sewage must be discharged into the shallow, enclosed bathing waters of St Aubin's Bay where it is retained for several days, only gradually interchanging with the open sea.

4.24 The Public Services Department regrets that the present use of natural marine processes (described in paragraphs 4.20 – 4.23 above) has been misconstrued as "no treatment" and hence a proportion of the community see this situation as being unacceptable in the 21$^{st}$ century. The European Urban Wastewater Treatment Directive requires accelerated artificial sewage treatment because environmental conditions in most coastal areas of the European Union are less favourable or unsuitable for natural marine processes.

4.25 The WRc mathematical model (see Appendix A) was verified by measuring the dispersion patterns of natural spores and artificial dye discharged through the outfall. The model demonstrates that:

- The Belle Greve Outfall has no influence upon the quality of water at the south, west and north coast beaches as natural marine processes take place offshore in a defined area of the sea shown in Appendix A;
- water quality at east coast bathing beaches normally meets EU mandatory standards for bathing water, but may occasionally fail the more stringent guideline standard (see Appendix B);
- water quality in parts of the Little Russel falls below the EU guideline standard for shellfish (see appendix A).

4.26 The discharge position of the current long sea outfall was checked using the WRc sewage dispersion model and the original design confirmed it to be in the optimum position.

4.27 **Regular inspections reveal the present abundance and diversity of marine flora and fauna, which is considered to be indicative of water quality in the Little Russel. A Benthic survey would provide evidence to assess the long term impact of sewage discharge on the marine environment.**

UPGRADING AND REHABILITATION OF THE BELLE GREVE FACILITY

Future Provision of Sewage Treatment

4.28 Prior to commissioning any preparatory works or seeking expressions of interest to provide sewage treatment facilities, an Environmental Impact Assessment (EIA) should be undertaken. An EIA would assess and compare the impacts of the current system of sewage disposal against the impacts of viable alternatives. The EIA would also compare the impacts of the viable alternatives if it were considered that a more intensive sewage treatment system was required.

4.29 It is important that the EIA is carried out in a timeframe that is representative of the state of the sewage treatment industry. To carry out an EIA now and not procure sewage treatment works for in excess of a decade would render the EIA redundant. As a consequence, if the EIA is to be carried out, there must be a strong commitment in principle to proceed with the procurement of sewage treatment facilities should that prove to be the recommendation of the EIA.

4.30 In order to assist a decision on accelerating treatment and avoid abortive expenditure, the EIA should be undertaken in two stages, commencing with an assessment of impact of existing discharges into the Little Russel. The second more expensive stage of EIA would only need to be undertaken if a decision to improve treatment were made based on the findings of the initial study.

Belle Greve Headworks, Pumping Station and Outfall

4.31 Even if a decision to construct a sewage treatment plant were made today, it is unlikely to be commissioned during this decade. In the short to medium term there is no alternative to continued use of the Belle Greve Outfall, which provides more effective use of natural marine processes than the shorter outfalls at Creux Mahie, Herm and Fort George.

4.32 If or when accelerated sewage treatment is provided, the existing Belle Greve plant will still be required to transfer sewage flows to the site of the treatment plant and may also provide preliminary and storm treatment prior to transfer.

4.33 **After 33 years continuous service, the Belle Greve Facility requires major refurbishment to ensure that reliable and effective wastewater disposal facilities can be maintained.**

4.34 The Public Services Department is therefore conducting a comprehensive review to address known deficiencies at this vital strategic asset including:

- storm flow exceeding discharge capacity, which is a priority;
- odour nuisance
- operational resilience;
- outfall maintenance;
- risk analysis and contingency planning

4.35 Refurbishment of the Belle Greve Wastewater Facility will also ensure adequate capacity for planned future increases in sewage flows.

CREUX MAHIE HEADWORKS, PUMPING STATION AND OUTFALL

4.36 Creux Mahie receives approximately 10% of the Island's sewage, collected from the parishes of Torteval, St Peters, and the Forest, and also from parts of St Saviours and St Andrews. There is a gravity sewer from the Airport to Creux Mahie that also conveys pumped discharges from sewers in the built up areas immediately to the north and south of the Airport. However, a high proportion of the total flow in this catchment comprises septic sewage transported by road tanker from areas where public sewers have not yet been installed.

4.37 The Creux Mahie Headworks and Pumping Station are discreetly located in a Torteval valley, adjacent to the south coast cliffs. Sewage is macerated and discharged through a pipe down the face of the cliffs to a short outfall designed to discharge at least three metres below low water. However, this outfall is exposed to severe wave action and repair of the resulting damage is difficult because there is no safe access to it from either sea or land. The cliffside pipe and outfall are known to be in poor condition.

4.38 In April 1999 the States decided "To centralise sewage treatment unless there is an overriding reason to consider localised treatment". MWH UK Limited (formerly Montgomery Watson) was appointed during 2003 to advise on "Strategy for Disposal of Wastewater in Southwest Guernsey". MWH considered provision of local sewage treatment facilities at Creux Mahie and the alternative of transferring flows to Belle Greve for treatment and disposal. The consultants concluded that it would be more cost effective to transfer flows to Belle Greve where the additional costs of treating a slightly larger flow would be relatively small.

4.39 The former Public Thoroughfares Committee approved the strategy recommended by MWH and, taking account of the poor condition of the present outfall, set a target of 2008 for ending discharge of sewage from Creux Mahie. The Public Services Department has emphasised the need for completion of this trunk sewer, which will also collect sewage from many houses and hotels that are currently served by cess pits close to west coast beaches. If considered necessary the robustness of this policy could be reviewed as part of any Environmental Impact Assessment.

4.40 Sewer Laying commenced at Vazon during 2003 and is now progressing towards Perelle, and subject to continued funding, is intended to progress via St Pierre du Bois to Creux Mahie by 2008. This project also includes upgrading the Vazon pumping station and replacing the rising main constructed in 1974.

FORT GEORGE HEADWORKS AND OUTFALL

4.41 The existing outfall discharges macerated foul and surface water from approximately 70 properties, less than 1% of the Island total. The Public Thoroughfares Committee has evaluated both in situ treatment and pumped transfer options, taking into account the nature of the constricted site, cliff stability, environmental impact and future operating costs. Designs were prepared, tenders obtained and evaluated and legal advice obtained (tender less than £500,000 in Nov 2002).

4.42 The Committee decided, and the Public Services Department agrees, that the best long term solution would be to pump sewage to an existing sewer for centralised treatment, in accordance with the States Resolution of April 1999 (see section 5.10). The execution of this scheme has been delayed pending completion of complex wayleave negotiations that appear to have reached a stalemate. The Environment and Public Services Departments recognise the importance of resolving this issue.

4.43 The existing outfall would be retained for discharge of surface water and storm flows exceeding transfer or treatment capacity. As an interim measure until a permanent solution can be implemented, the outfall has been extended to discharge three metres below Mean Low Water Spring Tide. This short outfall has a disproportionately high impact as a source of pollution close to east coast bathing beaches.

HERM OUTFALL

4.44 The WRc model (see section 3.2) shows that water quality in the Little Russel, adjacent to the west coast of Herm, is affected by the discharge of untreated sewage from that Island. The volume of sewage discharged from Herm will fluctuate, maximum discharge to bathing waters occurs in the tourist season.

4.45 The Treasury and Resources Department now has responsibility for the lease and built environment of Herm, having taken over the property functions undertaken by the former Board of Administration. Arrangements for provision of appropriate sewage treatment are under discussion between the Treasury and Resources Department and the tenant of Herm.

OTHER SEWAGE DISCHARGES TO SEA

4.46 In addition to the four main outfalls noted above there are minor sewage discharges from the smaller inhabited islands and marine craft. There are no other regular discharges to sea.

4.47 During storms foul sewage flooding is prevented by discharging excess storm water through a number of short outfalls located mainly in St Peter Port and St Sampsons; such outfalls are also used for emergency flow diversion (see Appendices F1 and F2). The Public Services Department has adopted a risk assessment policy and instructed that emergency outfalls shall only be used when there is no practical alternative and, in the case of planned or scheduled maintenance, not before prior notification. Capital Investment will be required to provide alternative pumping capacity during maintenance or breakdown of key pumping stations; the Department has recently purchased two large mobile pumps to enhance previous capacity. The use of storm and emergency outfalls will be minimised by the completion of the Drainage Area Plan.

## 5 Sewage Treatment Strategy

SEWAGE TREATMENT STRATEGY

5.1 The evolution of sewage treatment strategy is set out in the preceding sections of this report. In summary the States has:

- approved sewage treatment in principle and agreed standards for discharge of treated effluent;

- decided that sewage treatment would be centralised in one location, unless there were overriding reasons to provide local treatment;
- placed a low priority on sewage treatment, due to the minimal environmental benefits compared to other liquid waste priorities.

5.2 Since July 2003, further investigations have demonstrated that centralised treatment will be more cost effective for sewage currently discharged at Creux Mahie and Fort George. Approximately 90% of all sewage arising throughout the Island already flows to Belle Greve Headworks. The current objective is to transfer all Guernsey sewage to Belle Greve by 2008. Sewage arising in Herm will require local treatment.

5.3 To progress sewage treatment would require the commitment of substantial resources: financial, staff, land, and electrical energy.

SITE FOR SEWAGE TREATMENT

5.4 The 1997 Waste Strategy Report on Liquid Waste estimated the overall size of site required for sewage treatment as between 4.6 and 11.0 vergees (7,500 to 18,000 square metres), depending on the treatment process and standard of effluent required. Using the latest technology full treatment may now be achieved on a site of 3.7 vergees (6,000 square metres). If a sewage treatment plant can not be constructed on land adjacent to the existing headworks, a suitable site may have to be purchased, reclaimed from the sea or identified from other land already in public ownership, with due regard to the impact on neighbouring properties.

5.5 The cost of outline design and site investigation will depend on the number and complexity of sites to be investigated and the engineering support required during site acquisition and planning approval processes. At this stage it would be prudent to allow a budget of £1 million to prepare and price the most cost effective and environmentally suitable options for States approval.

5.6 Preliminary studies have shown that a suitable site may need to be reclaimed from the sea. The necessary breakwater could cost in the region of £10 - £15 million plus the substantial cost of fill to raise the site above sea level. However, if provision of sewage treatment could be deferred, the necessary land could be gradually reclaimed and funded by disposal of locally generated inert waste.

5.7 When a site is available, site infrastructure will be required, to include access roads, fencing, landscaping and utility connections. Sewage will need to be transferred to the treatment site and treated effluent discharged. To make maximum use of existing sewerage infrastructure and avoid significant additional cost, the site must be located as close to the existing Belle Greve Headworks as is practical. At this stage a provisional budget of £5 million would be appropriate to allow for site infrastructure, sewage transfer to the treatment site and discharge of treated effluent.

## ENVIRONMENTAL IMPACT ASSESSMENT AND PLANNING INQUIRY

5.8 The provision of sewage treatment is a major development requiring an amendment to the Urban Area Plan. A full Environmental Impact Assessment and Planning Inquiry will be required.

5.9 **The existing long sea outfall was designed and engineered to dilute sewage so that the natural marine processes, uniquely provided in the Little Russel, were not overloaded. The natural marine processes require no chemicals or energy input.**

5.10 The arguments for accelerating natural sewage treatment processes include seawater quality for recreational use, public and visitor perception, compliance with European standards and potential reuse by recycling treated effluent as a source of water. Natural marine processes do not meet the high water quality standards agreed by the States in 1997 but the States may wish to reappraise the situation.

5.11 The arguments against include the financial, land and staff resources required. Although sewage treatment uses energy, some energy may be reclaimed from sludge treatment or incineration of bio solids; many large treatment plants generate some power and heat from methane, but this may not be cost effective in Guernsey. Modern plants may be constructed within a building and can be designed for low noise and odour emissions suitable for an urban environment.

5.12 It would be necessary through an EIA to demonstrate to the Planning Inspector that future sewage treatment is necessary and that it is the Best Practical Environmental Option for sewage disposal

5.13 Although bathing water quality is monitored at certain designated beaches, the impact of sewage discharges on water quality and marine life have not been closely monitored. A long-term programme of baseline environmental monitoring will be necessary.

5.14 Based on previous experience, the current cost of Environmental Impact Assessment and Planning Inquiry procedures including the necessary sampling and testing of sewage and sea water is likely to cost in the region of £500,000.

5.15 Further information about an Environmental Impact Assessment is given in Appendix G.

## SEWAGE TREATMENT PROCESSES

5.16 There are many sewage treatment processes, some available from only one supplier. Factors to be taken into account when selecting the most appropriate combination of available processes include the influent quality, available site and effluent standard required. Process selection and outline design will need to take into account information from site investigation and the need to minimise environmental impact on adjacent properties. Outline design, process selection and Environmental Impact Assessment will need to be undertaken in parallel with site selection.

5.17 The main stages and sequence of sewage treatment are identified pages 4 to 19 of the attached report from WRc [N] and summarised in the Table 1:

**TABLE 1**

| Sequence | Stage | Purpose | Processes | Main Impact on Water Quality |
|---|---|---|---|---|
| 1 | Preliminary | To protect plant and prepare sewage for treatment | Screening to remove large items, maceration: Grit removal: separation of storm flows in excess of treatment capacity | Aesthetic- No identifiable solids or floating debris. |
| 2 | Primary | Remove suspended solids (as liquid bio solid sludge) | Settlement | Most solids removed; Reduced oxygen demand on receiving water; |
| | Sludge Treatment | Prepare Bio solids for safe disposal | Thickening, dewatering digestion, drying | N/A |
| 3 | Secondary | Remove colloidal and dissolved organic matter | Biological treatment | Further reduction in oxygen demand; Clearer effluent |
| 4 | Tertiary | Achieve Required Quality | Biological, chemical or physical e.g. UV or Membranes | Bacteria and virus numbers reduced; Nutrient removal if required |
| | Storm | Treat excess flows arising during heavy rainfall | Storage and subsequent return or settlement and discharge | Reduce frequency of untreated discharges |
| Note: whatever solution is selected, in extreme conditions or breakdowns, flows could still be discharged to sea | | | | |

WRC REVIEW OF GENERIC TREATMENT PROCESS OPTIONS

5.18 WRc plc was appointed by the Public Services Department to undertake an independent comprehensive overview of potential treatment processes including typical capital costs and minimum land areas required. The review is based on generic treatment processes for which there are independent sources of cost and performance data. This review does not attempt to identify and evaluate the many patented or branded variations of generic treatment processes because available information is generally limited to unverified promotional material or restricted by commercial agreements.

5.19 Sewage treatment process options considered were limited to those suitable to treat waste from an equivalent population of 75,000, including allowance for visitors and trade effluent. The review was undertaken in advance of site selection procedures, engineering appraisal, environmental impact assessment and planning. The conclusions of the review therefore remain subject to broad margins of uncertainty, including the capital cost and land area required.

5.20 Capital costs quoted by WRc are for construction of core treatment processes based on average UK costs relevant to a large client with a substantial programme of similar work. Capital costs shown in this report have therefore been increased by 50 % to provide realistic local construction costs on a one off project. Separate allowance has also been made for other site specific and project management costs.

5.21 Land areas quoted by WRc are the net area of the process units required without allowance for space between units, access and associated infrastructure requirements. Allowance must also be made for practical restrictions dictated by the shape and topography of the site. Gross site areas have been estimated by doubling the theoretical net areas shown in the WRc report.

Preliminary Treatment

5.22 Preliminary Treatment, including fine screening and grit removal, is essential for all options to protect plant and improve the aesthetic quality of sewage prior to further treatment and discharge, as currently performed at the Belle Greve facility. If it were necessary to construct a new preliminary treatment plant, the capital budget required would be in the region of £4.5 million and the gross land take would be about 0.25 vergees (400 square metres).

Sewage Treatment Process Options (see Appendix H)

5.23 WRc identified six potential sewage treatment solutions for Guernsey. These are described in Appendix H. Preliminary estimates of capital costs and site area required to treat and disinfect all Guernsey sewage in a single plant are shown in Table 2.

5.24 **The cost and areas shown below exclude the substantial associated costs of preliminary, sludge and odour treatment, site acquisition, general infrastructure and other project costs. In addition to the capital cost, the operating cost of a plant is likely to be in excess of £1 million per annum.**

5.25 With the exception of some Sequencing Batch Reactors, biological sewage treatment processes may be inhibited by the current high and varying salinity of sewage in Guernsey. The WRc report assumes that ingress of saline water will be greatly reduced prior to commissioning sewage treatment, to be achieved by rehabilitation of the sewerage network under the Drainage Area Plan. It should be noted that reducing saline ingress will take substantial time and investment.

5.26 At this stage it would appear that the compact processes (A2 - Lamella Separators/Biological Aerated Flooded Filters) and (B4 – Membrane Biological

Reactors) may offer considerable advantage over the other treatment processes. However, future revenue costs and operating factors will also need to be taken into account when the site and environmental restraints have been determined.

**TABLE 2**

| Option | Description | Gross Site Area | | Capital Cost £ |
|---|---|---|---|---|
| | | Vergees | Square metres | |
| A1 | Biological Filtration | 5.6 | 9,100 | 14,715,000 |
| A2 | Lamella Separators and Biological Aerated Flooded Filters | 0.7 | 1,100 | 10,755,000 |
| B1 | Activated Sludge | 4.7 | 7,660 | 12,285,000 |
| B2 | Oxidation Ditch | 3.8 | 6,220 | 9,165,000 |
| B3 | Sequencing Batch Reactors | 2.6 | 4,260 | 9,345,000 |
| B4 | Membrane Bio Reactors | 0.5 | 800 | 9,945,000 |

**The above processes are described in appendix H.** Treatment processes with the prefix "A" utilise biological cultures in a fixed film attached to media with a large surface area; treatment processes prefixed "B" are variations of the activated sludge process utilising biological cultures as a suspension in the wastewater to be treated.

Sludge Treatment

5.27 Biosolid wastes arise from sewage treatment options other than natural marine processes and some Sequencing Batch Reactors, in the form of a liquid sludge that has to be treated prior to disposal. The need to treat and dispose of sewage sludge would be a continuing challenge, very costly and a major disadvantage in comparison to the present natural marine processes.

5.28 Treatment of sludge must be appropriate for the selected method of ultimate disposal. Disposal options include recycling as fuel or soil conditioner, landfill or incineration. Treatment for all disposal options commences with gravity or mechanical thickening to reduce the volume of water in the liquid sludge. Liquid released during sludge treatment is returned to the sewage treatment processes for treatment; the greatly reduced volume of thickened sludge progresses to the next stage of sludge treatment.

5.29 If sludge is to be recycled to land, it must be stabilised and pathogens reduced by anaerobic digestion or composting. Anaerobic digestion reduces the volume of sludge and generates methane gas that may be used as a fuel. Composting requires large areas of land and has not been widely adopted on a commercial scale. There are strict regulations controlling disposal of treated sludge to land in order to protect public health and the environment.

5.30 There are limited areas of land suitable for spreading treated sludge and most of these are already used for disposal of organic waste produced by the Island's dairy herd. It is important to avoid adding to nitrate and bacterial pollution of surface and groundwater.

5.31 Recycling biosolids as an alternative to importation of peat and artificial fertiliser may be a desirable aspiration but at present it would not offer a sustainable and secure disposal route for all the sewage sludge that would be produced throughout the year. Commercial experience shows that there is a very limited market for digested or composted sewage sludge.

5.32 During the final stages of sludge treatment it is necessary to further reduce water content of the sludge by chemical conditioning and compressing or centrifuging to achieve suitable solids content in the range 20 – 25%. If necessary for storage or fuel preparation, sludge can then be thermally dried to 85% solids concentration, subject to particular care to minimise odour, dust, and risks of fire or explosion.

5.33 An area of approximately 0.6 vergees (1,000 square metres) will be required for sludge treatment. Preliminary estimates of capital cost for sludge treatment range from £4.5 million for disposal with domestic solid waste by incineration or landfill to £8 million if anaerobic digestion is provided to facilitate recycling sludge to land.

Odour Control and Treatment

5.34 Sewage treatment in open tanks can generate odours that are likely to be unacceptable to neighbours. To control odours, treatment plants in urban areas are now tending to be covered or enclosed within a low-pressure envelope so that air flows inward rather than outward. Air within the envelope is treated to remove odour before discharge to the atmosphere.

5.35 Selection of a compact treatment process reduces the cost of covering treatment plant. The standard of odour control required will depend on the site and process selected and the outcome of the Planning Inquiry and Environmental Impact Assessment. At this stage it would be prudent to budget £4.5 million for odour control and treatment.

Storm Treatment

5.36 The flow of waste water to be treated increases during wet weather and maximum flow is more than six times the flow during dry weather. It is normal to provide full treatment for flows up to three times dry weather flow. Higher flows receive partial treatment or are retained in storage and treated after peak flows subside. However, it may not be economically practical to provide treatment for the highest flows that occur only infrequently. Excess flow must be discharged after preliminary treatment.

5.37 In St Helier, Jersey, storm treatment has been provided by diverting excess flows to storage in a massive artificial cavern constructed deep under Fort Regent, for subsequent treatment after storm conditions subside. The cavern has substantially reduced the frequency of storm discharges and provides partial treatment of excess flows. However, substantial investment to create this underground storage capacity has not totally eliminated the need for occasional discharge of partially treated dilute sewage into St Aubin's Bay during the most intense rainfall.

5.38 Guernsey is pursuing an alternative approach. Maximum flows under storm conditions have already been greatly reduced, and could be further reduced by provision of separate surface water sewers in the urban areas that are currently served by combined sewers. Preventing ingress of groundwater into foul sewers can also reduce flows for treatment. The Drainage Area Plan includes rehabilitation of sewers and a surface water separation programme that will reduce groundwater ingress and storm flows. Keeping fresh water out of foul sewers can also boost water resources for the public supply.

5.39 Some of the key decisions that would have to be made include the maximum flow for which full treatment and storm treatment must be provided and where excess flows would be discharged. These decisions will have material impact on the overall cost and area of a treatment plant. The existing Belle Greve outfall would in any case be retained for discharge of storm water flows.

5.40 If storm treatment is to be provided, a capital budget in the region of £3.25 million and a gross land area of 1.8 vergees (3,000 square metres) are indicated.

Contingencies

5.41 The preliminary estimates shown in previous paragraphs are based on the assumption that the plant would be constructed on a green field site with ideal shape, topography and ground conditions. In practice, available sites will not be ideal. At this stage it would be prudent to make substantial allowance for the unforeseen risks associated with a major construction project.

SUMMARY OF SEWAGE TREATMENT PROJECT

5.42 Restrictions on the availability of land for development and the requirement to minimise odour will drive the choice of treatment process for Guernsey. The capital cost of the compact modern treatment process is competitive but further consideration will need to be given to potential sites, operating factors and whole life costs before a final recommendation could be made.

5.43 Preliminary estimates of the capital cost and land required may be summarised as shown in the following Table 3:

| TABLE 3: Summary of Sewage Treatment Resource Requirements | | | |
|---|---|---|---|
| **Project Element** | **Capital Cost £** | **Gross Site Area** | |
| | | **Vergees** | **Square Metres** |
| Water Quality Monitoring | 300,000 | N/A | |
| Site Appraisal / Outline Design | 1,000,000 | N/A | |
| Environmental Impact Assessment / Planning Inquiry | 500,000 | N/A | |
| Site acquisition / reclamation - say | 10,000,000 | N/A | |
| Sewage transfer and site infrastructure | 5,000,000 | Included | |
| Preliminary treatment | 4,500,000 | 0.2 | 400 |
| Storm treatment | 3,250,000 | 1.8 | 3,000 |
| Sewage treatment – compact process (Lamella + Biological Aerated Flooded Filters or Membrane Biological Reactors) | 10,000,000 | 0.6 | 1,000 |
| Sludge treatment prior to incineration | 4,500,000 | 0.6 | 1,000 |
| Odour control | 4,500,000 | N/A | |
| Design, Supervision and Project Management Fees | 1,500,000 | N/A | |
| Contingencies | 5,000,000 | 0.4 | 600 |
| **Project Total** | **50,050,000** | **3.6** | **6,000** |

## 6. Funding for Foul Drainage Services

Note: Section 6 of this report does not fall within the mandate of, and is not endorsed by, the Environment Department

6.1 The Public Services Department has established an officer level Working Party to consider long-term strategy with regard to the funding for the removal of foul water from properties.

6.2 It is generally accepted that the infrastructure for removal of foul water is a States responsibility; it does, however have a cost. At present the community pays for this service in two ways; first through taxation in that the Public

Services Department has an annual budget to support the costs of running the sewer system; secondly home-owners pay either cesspit emptying charges, averaging in the region of £200 per annum, or, if they are connected to the main drain, their tax on rateable value is increased by 15% generating on average an additional charge to each household of £40 per annum, which is considered inequitable.

6.3 In planning for the future, the Public Services Department:-

- is continuing with the strategy of the former Public Thoroughfares Committee with the target of 95% of the Island's properties being connected to the main drain system by 2020; and
- seeking to operate a charging regime which is equitable and recovers sufficient to cover the cost of the foul sewer system (see Appendix J).

6.4 The income from the sewage collection service is approximately £1.2m per annum, whereas the cost of providing the service is in the region of £1.8m.

6.5 The income from the increased rateable value of properties connected to the main drain raises approximately £0.5m for the Treasury, but this is compared to the annual cost of £2.2m for maintaining the sewer system (excluding the cost of extensions to the network c. £3m p.a.).

6.6 **In reality, everyone benefits from the foul sewer system and therefore everyone should pay for it. Thus there is a case that all properties that generate foul water should be making a contribution to the sewer infrastructure and in addition those who are on cesspits should pay an economic charge for cesspit emptying. The difficulty is that most people on cesspits would much rather be connected to the main drain but are denied the opportunity because the final decision about where sections of the sewer are laid and which properties are connected is a matter determined by the States and not by individual householders.**

6.7 Concerns about the disparity of charging exist even though the full economic cost of the sewage collection service is unlikely to be charged. The reason for this is partly because of the need to minimise the risk of ground water pollution. It has been and remains a concern that the higher the price of emptying a cesspit the greater the incentive for residents to leave it too late to empty the pit, such that it overflows, or to seek alternative means of disposing of excess material.

6.8 As an example to illustrate concerns about pollution, the Public Services Department is aware of cases where material has been taken from a cesspit and deposited in a stream or buried. This is illegal and totally unacceptable, given the Island's dependence upon ground water for its potable water supplies. When such instances are discovered the Public Services Department will of course vigorously pursue the matter using existing legal powers. However, this does not address the fundamental point that in the interests of the whole community, people on cesspits need to be encouraged to have them emptied frequently.

6.9 The Public Services Department believes there is a strong argument for introducing a Waste Water Removal Charge. This exists in a number of other countries around the world, including France, some States of America and the UK. The principle being that as individuals create foul water they should meet the fair and reasonable cost of its disposal.

6.10 The Public Services Department therefore believes it appropriate to develop a system whereby everybody pays a fair contribution to the cost of sewerage and sewage disposal, either by way of a waste water removal charge or a reasonable rate. However, it will be important to retain a charge for collection of sewage by tanker from cess pits to maintain efficient use of this service and provide a financial incentive to connect to the main drain when it is available close to the property.

6.11 **The two main options for collecting such payments are through the Tax on Rateable Value or a specific household charge that would feature as part of the quarterly water bill. The latter is the system used most commonly in the UK and where a property is on a water meter the waste water removal charge is based on a pre-set percentage of the water consumed. The principle being that sooner or later most of the water that goes into a house is disposed of into the drainage system.**

6.12 The Public Services Department has yet to reach any final conclusions but believes the introduction of Waste Water Removal Charge is worthy of further consideration. The Public Services Department will continue its investigations into this possibility.

## 7. Consultations

7.1 A draft of this report was sent to those Departments with Mandates relevant to sewage treatment. Consultation demonstrated the importance of public perception, both within and outside the Island. It is not sufficient to protect public health and bathing water quality, the Island has to demonstrate that an adequate means of sewage disposal is in place to protect the Environment. Further research has therefore been undertaken to review the worldwide status and practice in the use of natural marine processes for sewage treatment.

7.2 The comments received from the Health and Social Services Department are attached in full as Appendix K and summarised below.

7.3 The Health and Social Services Department [HSSD] recognises the need to prioritise expenditure and supported "priority being given to closing the short outfalls and centralising all sewage discharge to Belle Greve, excluding rainwater and sea water from the sewers and monitoring the impact of the existing discharge on the marine environment".

7.4 HSSD noted the need to plan for the disposal of sludge any produced as a consequence of treating sewage and commented that the recent States decision not to proceed with the planned 'waste to energy' incinerator had reduced the options for sludge disposal. HSSD added that, on the available evidence, the provision of a proper system for disposal of solid waste was a higher priority than the provision of a liquid waste treatment plant.

## 8. Review of Marine Treatment Policy and Practice

8.1 In this context, Marine Treatment is defined as the preliminary treatment of domestic wastewater followed by discharge to sea through a properly designed long sea outfall [such as the outfall into the Little Russel]. Marine Treatment utilises the natural marine treatment processes to protect public health and the environment.

8.2 The minimum standards for sewage treatment within the EU are determined by the Urban Waste Water Directive. Compliance with this Directive would not allow the Island to take full advantage of the favourable conditions for Marine Treatment using natural marine processes. WRc plc was therefore commissioned to undertake a brief review of Marine Treatment Policy and Practice in developed countries outside the European Union. The WRc Review of Marine Treatment is attached as Appendix L

8.3 In 2004, the United Nations Environmental Programme, in collaboration with the World Health Organisation, published guidelines for municipal wastewater management, which recommended using the 'cleaning capacity of natural systems as a first step' in selecting sewage treatment technology. These Guidelines cite Marine Treatment as a natural system and recommend that conventional [i.e. artificial] treatment systems should only be used as a last resort. The Guidelines form part of the 'Global Programme of Action for the Protection of the Marine Environment from Land based Activities'. It is clear from the contents of these Guidelines that they are intended for developing countries where infrastructure and resources are inadequate to prevent serious pollution.

8.4 Developed countries outside the European Union have each developed their own standards for wastewater disposal; it would appear that there is no global standard. However, the WRc Review has identified a global convergence in standards adopted by developed counties, including the European Union. Secondary treatment of sewage is now regarded as the minimum standard. In general, where secondary treatment has not yet been implemented, investment is planned to bring treatment up to secondary standard.

8.5 It is not surprising that higher standards of wastewater treatment are required in many locations where the sewage load exceeds that which could be treated by natural marine processes and where marine conditions are not as favourable as in the Little Russel. In countries where water resources are at a premium, used water is regarded as a resource and is recycled after appropriate treatment, often for irrigation. However, these factors are not sufficient to explain the near universal adoption of, and investment in, higher standards of wastewater treatment.

8.6 It would appear that, in developed countries with democratic forms of government, adverse public perception of Marine Treatment may be driving investment to provide more intensive forms of wastewater treatment, irrespective of the health and environmental benefits.

8.7 There has been significant and rapid change in wastewater treatment standards in recent years; it is only 15 years since significant numbers of new long sea outfalls were constructed in the UK, using Marine Treatment principles to replace short sea outfalls built in the Victorian era. Since then secondary treatment has been installed at all significant outfalls with the exception of a few sites that will be completed shortly.

8.8 **The findings of the WRc Review indicate a general view in the developed countries that 'Marine Treatment is not an acceptable long term practice. Aspirations and, in some cases, legislation indicate secondary treatment as the default minimum technology'.**

## 9. Summary and Conclusions

CURRENT STRATEGY

9.1 It is considered essential to maintain existing infrastructure in effective condition and to provide for increasing flows and new development. The Public Service Department's current strategy includes continued execution of the Drainage Area Plan programmes for rehabilitation of the existing sewerage system and separation of surface water.

9.2 Refurbishment and upgrading the existing Belle Greve wastewater facility is fundamental to the sewage disposal service and this forms a vital part of the current strategy.

9.3 The Creux Mahie outfall is nearing the end of its useful life and will need to be replaced. After further consideration of technical and economic factors, the Public Services Department has concluded that sewage flows should be transferred to Belle Greve for centralised treatment and disposal in accordance with the April 1999 Resolution of the States. The current strategy therefore includes continuation of the Network Extension Programme to link Creux Mahie to the existing sewerage network currently under construction at Perelle Bay.

MONITORING THE EFFECTS OF NATURAL MARINE PROCESSES

9.4 Although water quality has been modelled, the effects of discharging sewage into the Little Russel have not been measured. Assessing the impact of current discharges would better inform future debates on the need for accelerated sewage treatment on land and may support the case for continued use of the current outfall.

9.5 An additional budget in the region of £300,000 would be required to undertake a thorough environmental appraisal including systematic sampling and testing of water quality, Benthic surveys (seabed environment for animal and plant life) and toxicity testing.

PREPARATIONS FOR FUTURE SEWAGE TREATMENT.

9.6 As yet, no site has been identified in the Island Development Plans for sewage treatment. If sewage treatment may be required, it is important to identify and preserve a suitable site.

9.7 An additional budget in the region of £1.5 million would be required to investigate potential sites, undertake site investigations, prepare outline designs, estimate budget costs, undertake full environmental impact assessments and support a public planning inquiry.

SEWAGE TREATMENT

9.8 In Section 5 of this report, the Public Services Department has provided a preliminary assessment of sewage treatment with the best available estimate of resources required to implement full treatment.

9.9 If full sewage treatment is required, on the most likely scenario based on information currently available, an additional capital budget in the region of £50 million and an estimated future operating budget in excess of £1 million per annum would be required.

CONCLUSIONS

9.10 The Environment and Public Services Departments agree in principle and subject to States approval that the way forward should commence with monitoring the impact of existing marine discharges, before considering whether to undertake a full Environmental Impact Assessment. A full EIA would be needed to assess the potential environmental impact of sewage treatment, the alternative sites, treatment processes and water quality standards.

9.11 A separate report will be submitted to the States taking into account the response to this consultation document.

**10. Recommendation**

10.1 The Public Services and Environment Departments recommend that the States note this report.

Yours faithfully

William M Bell
Minister
Public Services Department

Bernard Flouquet
Minister
Environment Department

**APPENDIX: A**

EXAMPLE OF OUTPUT FROM THE WRc WATER QUALITY MATHEMATICAL MODEL: Figure 5 from Waste Strategy Assessment Report dated March 1997, modified to remove drying areas for clarity.

**THE MAXIMUM EFFECT OF SEWAGE DISCHARGES FROM OUTFALLS AT BELLE GREVE, CREUX MAHIE, FORT GEORGE AND HERM (spring tides)**

***Colours indicate predicted concentrations of Faecal Coliform bacteria - see legend below right***

***NB: Mandatory standard for bathing water quality per 100ml: 2000 F. Coli***
***Standard required for shellfisheries: 300 F. Coli***
***Guideline Standard for bathing water quality per 100 ml: 100 F.Coli***

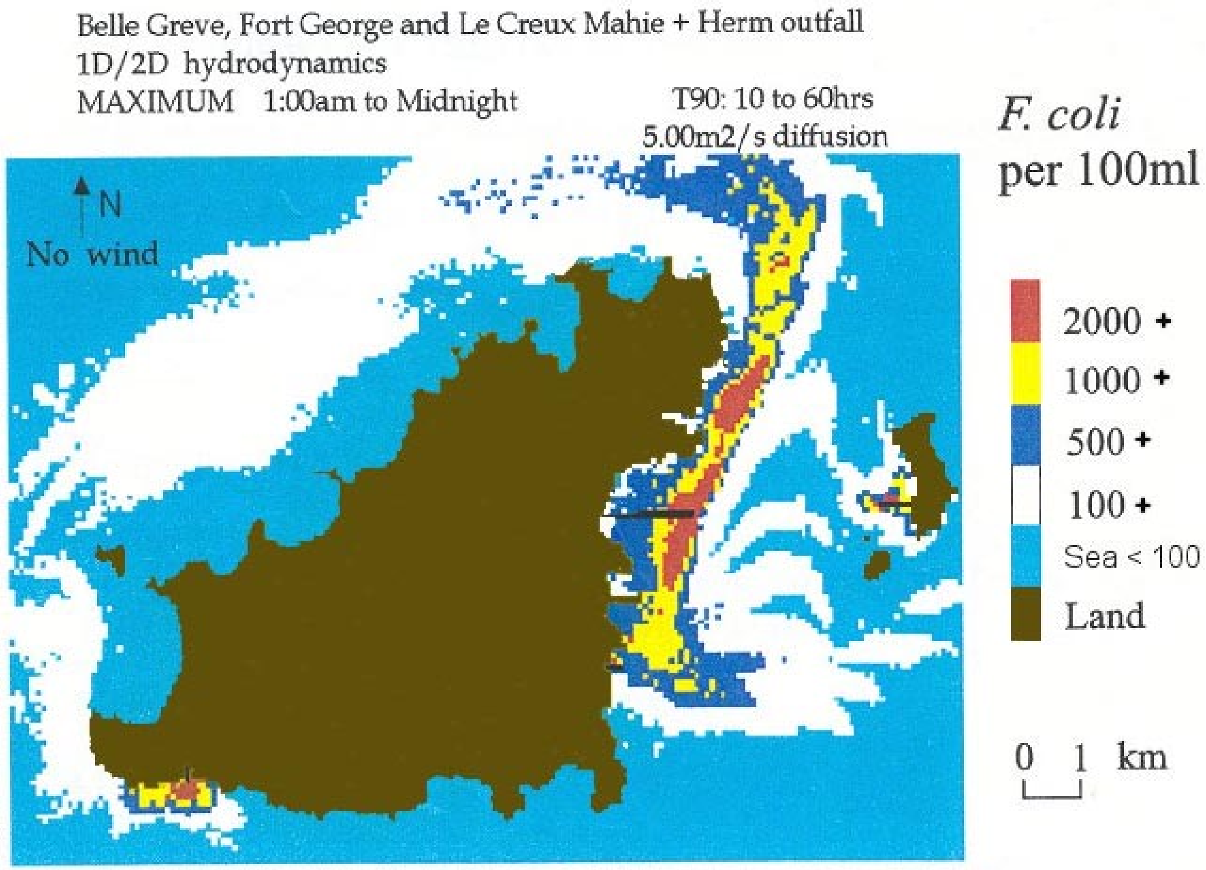



FIGURE 5 - Sewage Discharges from Belle Greve, Creux Mahie, Fort George and Herm. Maximum Bacterial Concentration for Spring Tide.

**2004 Bathing Water Quality Sampling Results on the East Coast of Guernsey.** **APPENDIX B**

| Havelet Bay | | | | | Fermain Bay | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Date* | *Coliforms* | *Faecal coliforms* | *Faecal Streptococci* | *Quality* | *Date* | *Coliforms* | *Faecal coliforms* | *Faecal Streptococci* | *Quality* |
| 19.04.04 | 192 | 25 | 4 | Excellent | 19.04.04 | 120 | 58 | 7 | Excellent |
| 26.04.04 | 11 | 3 | 1 | Excellent | 26.04.04 | 2 | 0 | 0 | Excellent |
| 10.05.04 | 10 | 1 | 0 | Excellent | 10.05.04 | 21 | 14 | 5 | Excellent |
| 17.05.04 | 5 | 2 | 2 | Excellent | 17.05.04 | 87 | 74 | 13 | Excellent |
| 24.05.04 | 36 | 25 | 3 | Excellent | 24.05.04 | 33 | 13 | 10 | Excellent |
| 07.06.04 | 18 | 10 | 0 | Excellent | 07.06.04 | 4 | 2 | 1 | Excellent |
| 14.06.04 | 8 | 2 | 28 | Excellent | 14.06.04 | 38 | 38 | 6 | Excellent |
| 21.06.04 | 40 | 0 | 4 | Excellent | 21.06.04 | 18 | 2 | 1 | Excellent |
| 28.06.04 | 2 | 0 | 0 | Excellent | 28.06.04 | 2 | 2 | 1 | Excellent |
| 05.07.04 | 30 | 4 | 1 | Excellent | 05.07.04 | 136 | 64 | 80 | Excellent |
| 12.07.04 | 4 | 1 | 32 | Excellent | 12.07.04 | 0 | 0 | 1 | Excellent |
| 19.07.04 | 270 | 38 | 16 | Excellent | 19.07.04 | 310 | 43 | 2 | Excellent |
| 26.07.04 | 1 | 1 | 0 | Excellent | 26.07.04 | 9 | 1 | 1 | Excellent |
| 02.08.04 | 58 | 22 | 10 | Excellent | 02.08.04 | 35 | 18 | 20 | Excellent |
| 09.08.04 | 56 | 45 | 8 | Excellent | 09.08.04 | 24 | 11 | 5 | Excellent |
| 16.08.04 | 31 | 31 | 16 | Excellent | 16.08.04 | 300 | 104 | 31 | Good |
| 23.08.04 | 50 | 50 | 10 | Excellent | 23.08.04 | 48 | 19 | 16 | Excellent |
| 06.09.04 | 40 | 14 | 7 | Excellent | 06.09.04 | 59 | 32 | 12 | Excellent |
| 13.09.04 | 99 | 27 | 24 | Excellent | 13.09.04 | 6100 | 4500 | >1000 | Poor |
| 20.09.04 | 88 | 80 | 2 | Excellent | 20.09.04 | 124 | 61 | 5 | Excellent |
| 27.09.04 | | 512 | | Good | 27.09.04 | | 180 | | Good |
| 04.10.04 | 88 | 73 | 8 | Excellent | 04.10.04 | 320 | 90 | 14 | Excellent |
| 11.10.04 | 1800 | 424 | 88 | Good | 11.10.04 | 460 | 72 | 28 | Excellent |
| 18.10.04 | 290 | 64 | 7 | Excellent | 18.10.04 | 56 | 35 | 7 | Excellent |
| 25.10.04 | 112 | 22 | 16 | Excellent | 25.10.04 | 290 | 106 | 26 | Good |

| Bordeaux Harbour | | | | | St Sampson's Harbour | | | |
|---|---|---|---|---|---|---|---|---|
| *Date* | *Coliforms* | *Faecal coliforms* | *Faecal Streptococci* | *Quality* | *Date* | *Coliforms* | *Faecal coliforms* | *Quality* |
| 21.04.04 | 90 | 30 | 29 | Excellent | 06/01/2004 | 160 | 47 | Excellent |
| 28.04.04 | 496 | 420 | 310 | Good | 03/02/2004 | 440 | 150 | Good |
| 12.05.04 | 4 | 2 | 3 | Excellent | 03/03/2004 | 6 | 3 | Excellent |
| 19.05.04 | 10 | 5 | 1 | Excellent | 05/04/2004 | 66 | 14 | Excellent |
| 26.05.04 | 0 | 0 | 0 | Excellent | 07/07/2004 | 200 | 80 | Excellent |
| 09.06.04 | 2 | 2 | 2 | Excellent | 02/08/2004 | 210 | 72 | Excellent |
| 16.06.04 | 77 | 77 | 29 | Excellent | 01/09/2004 | 296 | 200 | Good |
| 23.06.04 | 52 | 7 | 17 | Excellent | 05/10/2004 | 9 | 3 | Excellent |
| 30.06.04 | 66 | 48 | 21 | Excellent | 02/11/2004 | 48 | 28 | Excellent |
| 07.07.04 | 150 | 72 | 280 | Good | 02/12/2004 | 136 | 60 | Excellent |
| 14.07.04 | 70 | 70 | 30 | Excellent | | | | |
| 21.07.04 | 36 | 26 | 7 | Excellent | | | | |
| 28.07.04 | 180 | 110 | 41 | Good | | | | |
| 04.08.04 | 71 | 47 | 16 | Excellent | | | | |
| 11.08.04 | 70 | 70 | 35 | Excellent | | | | |
| 18.08.04 | 228 | 190 | 28 | Good | | | | |
| 25.08.04 | 56 | 45 | 18 | Excellent | | | | |
| 08.09.04 | 48 | 33 | 8 | Excellent | | | | |
| 15.09.04 | 67 | 34 | 8 | Excellent | | | | |
| 22.09.04 | 15 | 14 | 5 | Excellent | | | | |

Units: presumptive count /100ml sea water

Note: shaded results have been influenced by temporary discharges from White Rock Outfall

EC Standards: <u>Directive 76/160/EEC Concerning the quality of Bathing Waters</u>

| | Coliforms /100ml | Feacal Coliforms /100ml | Feacal streptococci /100ml |
|---|---|---|---|
| Guide Value | 500 | 100 | 100 |
| Mandatory Value | 10,000 | 2,000 | Not Specified |

Quality Criteria:

| | |
|---|---|
| Excellent | Complies with EC Guide Values |
| Good | Complies with EC Mandatory Values |
| Poor | Exceeds EC Guide and Mandatory Values. |

Sampling of Havelet Bay, Fermain Bay and Bordeaux Harbour is carried out by Environmental Health, on behalf of the Environment Department, in accordance with EA Sampling Protocols.
Sampling of St Sampson's Harbour is carried out by Guernsey Technical Services.

APPENDIX: C

## NETWORK EXTENSION PLAN: MAJOR FOUL SEWERS LAID 2001 TO 2004 AND UNDER CONSTRUCTION, PROJECTED TO END 2005

| Network Extension Phase | Year | Properties | Cost (£) |
|---|---|---|---|
| Completed Phases | | | |
| L'Islet Phase 5 | 2001 | 105 | 1,452,655 |
| Colborne Road | 2001 | 10 | 104,032 |
| Salines Lane | 2001 | 18 | 217,697 |
| Rue du Preel | 2002 | 67 | 989,890 |
| Landes du Marche | 2002 | 200 | 2,049,509 |
| Route Militaire Phase 1 | 2003 | 165 | 1,859,276 |
| Port Soif Phase 1 | 2003 | 55 | 885,417 |
| L'Islet Phase 6 | 2004 | 88 | 1,420,000 |
| Vazon Phase 1 | 2004 | 112 | 2,150,000 |
| L'Islet Phase 7 | 2004 | 71 | 990,000 |
| **Sub Total Completed Phases** | | **891** | **12,118,476** |
| Under Construction projected to end 2005 | | | |
| Richmond Phase 1 | 2004/5 | 86 | 1,110,000 |
| Route Militaire | 2005 | 93 | 1,361,000 |
| Perelle Phase 1a | 2005/6 | 105 | 1,960,000 |
| **Total Network Extension to end 2005** | | **1,175** | **16,549,476** |

**APPENDIX: D 1**

## MAJOR FOUL SEWER REHABILITATION PROJECTS – JUNE 1997 TO JUNE 2004

The table below provides details of completed projects and those where civil engineering works (Civils) have been carried out in preparation for sewer renovation.

| Location | Structural Grade | Sewer Category | Status 2004 | Length Metres |
|---|---|---|---|---|
| La Charroterie, SPP | 5+ | A | Complete | 350 |
| Rue du Pre | 5+ | A | Complete | 200 |
| Upper Mansell Street, SPP | 5 | A | Complete | 65 |
| Mansell Street, SPP | 4+ | A | Complete | 180 |
| Market Street, SPP | 4+ | A | Complete | 145 |
| Fountain Street, SPP | 5- | A | Complete | 160 |
| Bordage, SPP | 4+ | A | Complete | 275 |
| Lowlands Road, STS | 5+ | B | Complete | 290 |
| Nocq Road, ST | 5- | A | Complete | 300 |
| Braye Road, VAL | 5 | A | Complete | 730 |
| Vale Avenue, VAL | 5- | A | Complete | 260 |
| Mount Row, SPP | 5- | A | Complete | 445 |
| Prince Albert's Road, SPP | 5 | B | Complete | 390 |
| Vauquiedor, SPP | 4 | A | Complete | 150 |
| Kings Road, SPP | 4+ | B | Complete | 390 |
| Doyle Road, SPP | 5- | A | Civils | |
| Vauvert, SPP | 5 | B | Civils | |
| Brock Road, SPP | 4- | B | Civils | |
| St Georges Esplnade, SPP | 5- | A | Complete | 375 |
| St Julian's Avenue, SPP | 4+ | A | Civils | |
| Smith Street, SPP | 4- | A | Civils | |
| Rue Maze, STM | 4 | A | Complete | 415 |
| Gibauderie, SPP | 4- | A | Civils | |
| Piette Road, SPP | 4+ | B | Complete | 165 |
| Ronde Cheminee, CAT | 5- | B | Complete | 475 |
| | | | **Total** | **5,760** |

Notes:

Structural Grade 5 sewers have sections that are already collapsed or in danger of imminent collapse, Grade 4 sewers have sections that are seriously damaged or deformed with collapse likely in the near future

Category A sewers are those where failure is likely to be particularly expensive and will result in severe disruption Category B are those where failure is less critical but where financial considerations and potential disruption make pre-emptive action the best economic and practical option.

**APPENDIX: D 2**

Rehabilitation works at the locations detailed below have been undertaken as a result of severe structural failure or collapse:

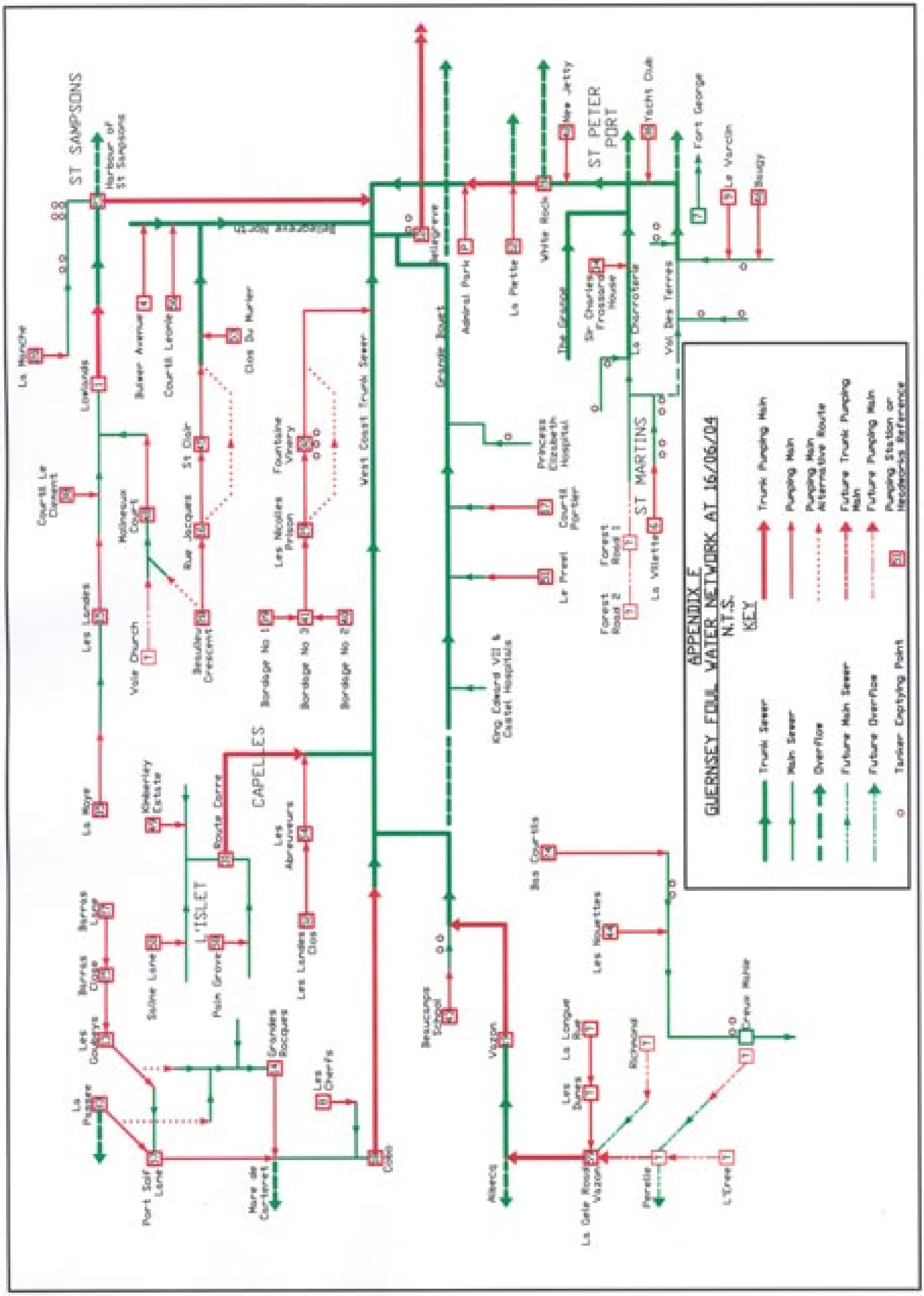
| Location | Defect | Date |
|---|---|---|
| L'Aumone, CAT | Severe structural failure | 2002 |
| Rue du Manoir, SPP | Collapse | 2003 |
| Hubits de Bas, SPP | Collapse | 2002 |
| Castle Emplacement, SPP | Collapse | 2001 |
| North Esplanade, SPP | Tidal infiltration | 2002 |
| South Esplande, SPP | Flooding | 2000 |
| Rue es Ronces, CAT | Severe structural failure | 2002 |
| Arcade Steps, SPP | Severe structural failure | 2002 |
| Commercial Road, STS | Severe structural failure | 2002 |
| Fosse Andre, SPP | Localised structural failure | 2002 |
| Vieille Mare, CAT | Localised structural failure | 2002 |
| Bosq Lane, SPP | Collapse | 2004 |
| Trunk Sewer, Villocq, CAT | Severe structural failure | 2004 |
| Route Isabelle, SPP | Collapse | 2005 |

**APPENDIX: E**

## MAJOR SURFACE WATER SEPARATION PROJECTS – JUNE 1997 TO JUNE 2004

| Location | Description of Works |
|---|---|
| Charroterie, SPP | New Surface Water Sewer and Diversion of Drains |
| Albert Pier, SPP | New Surface Water Outfall |
| North Side, VAL | Separation of Surface Water Drains |
| South Side, STS | Separation of Surface Water Drains |
| Fountain Street, Bordage, Rue du Pre, SPP | New Surface Water Sewer and Diversion of Drains |
| Lowlands, STS | New Surface Water Pumping Station, Sewer and Diversion of Drains |
| St Jacques, SPP | New Surface Water Sewer |
| Quay Street, Church Square, Church Hill, SPP | New Surface Water Sewer and Diversion of Drains |
| North Esplanade, SPP | Separation of Surface Water Drains |
| Crossways, STS | New Surface Water Pumping Station, Sewer and Diversion of Drains |
| Havilland Vale, STM | New Surface Water Sewer |
| College Street, SPP | New SurfaceWater Sewer and Diversion of Drains |
| Weighbridge, SPP | New Surface Water Outfall |
| St Julian's Avenue, SPP | New Surface Water Sewer and Diversion of Drains |
| Victoria Road, SPP | New Surface Water Sewer and Diversion of Drains |

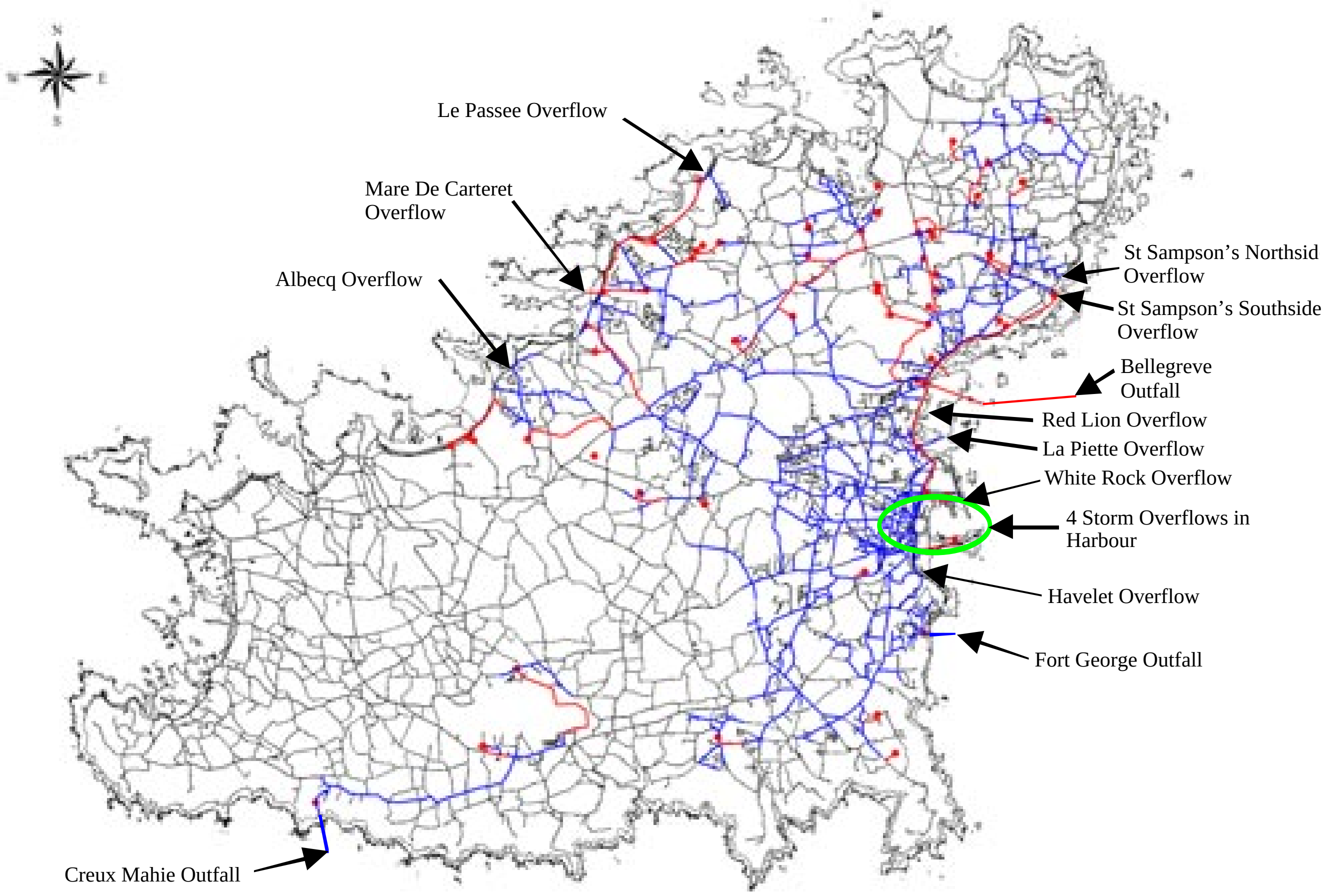
FOUL SEWER NETWORK AT 16 JUNE 2004 **APPENDIX: F 1**



**APPENDIX: F 2**

## LOCATIONS OF FOUL SEWAGE DISCHARGES AND POTENTIAL OVERFLOWS AT SEPTEMBER 2004

**Legend**:
Pumping station
Pumping Main
Gravity Sewer



**APPENDIX: G**

**Environmental Impact Assessment Specification**

Should the States wish to proceed with procurement of a sewage treatment plant, an Environmental Impact Assessment (EIA) will be conducted in accordance with the Environment Department EIA Code of Practice. The EIA is an essential piece of research to ensure that the plant will meet required standards and is also necessary to secure planning permission.

A Scoping Opinion will be prepared by the Environment Department in consultation with other stakeholders to determine the exact content of the EIA but in broad terms the EIA would determine the impacts of a sewage treatment plant in terms of:

- Emissions to air, land and sea, including noise and odour
- Residues arising from the process and options for their management
- Aesthetic and visual effects
- Socioeconomic effects
- Ecological issues such as the protection or alteration of habitats

An evaluation of engineering options will be also undertaken in order to quantify the cost and effectiveness of various measures to mitigate the impact of the plant. Examples of topics for consideration by an engineering analysis are:

- to ensure the plant is sized appropriately to the sewage collection network
- concealment by constructing some or all of the plant below ground level
- architectural approaches to blend in with surrounding landscape and buildings
- feasibility and cost of alternative locations
- use of technologies that minimise land requirement

The investigations undertaken in the course of the EIA will determine whether the proposed site is suitable and will also recommend measures for further mitigating those impacts. The results would be presented as an Environmental Statement necessary to make a Planning Application for the plant. A Compliance Document would also be submitted which sets out how the plant will be constructed and operated in a manner that satisfies the requirements of the regulatory authorities.

**Sewage Treatment Options identified and costed by WRc: APPENDIX: H**

| Option | Primary | Secondary | Tertiary |
|---|---|---|---|
| A1 | Sedimentation – Removal of settleable biosolids by settlement in a large tank | Biological Filtration - conventional biological treatment. Settled sewage treated by trickling through filter media in beds designed to develop and aerate fixed microbiological film. Effluent settled to remove resulting humus. | Disinfection using Ultra Violet light |
| B1 | Sedimentation as for option A | Activated Sludge- accelerated natural biological treatment using forced air and recycled bacterial cultures in suspension. Surplus activated sludge drawn off as waste for treatment. | Disinfection using Ultra Violet light |
| A2 | Sedimentation using Lamella Separator – using inclined plates to reduce area required for settlement. | BAF – Biological Aerated Filters combine processes A & B above – uses flooded fixed film filter media with forced air to accelerate treatment in a smaller area. Excess biological film removed by backwashing – this waste stream requires treatment. | Disinfection using Ultra Violet light |
| B2 | Oxidation Ditch – a variation of the activated sludge process for smaller plants that does not require primary treatment. Air is entrained as sewage and bacterial cultures circulate around a continuous loop. Final settlement required to remove excess suspended activated sludge for separate treatment. | | Disinfection using Ultra Violet light |
| B3 | SBR – Sequencing Batch Reactor – another variation of the activated sludge process that does not require primary treatment or final settlement. Sewage is treated in batches rather than a continuous stream, using forced air and a bacterial culture retained by settlement of the previous batch. | | Disinfection using Ultra Violet light |
| B4 | MBR – Membrane Biological Reactor uses membranes to filter and disinfect final effluent after sewage treatment using the activated sludge process. Surplus activated sludge drawn off as waste for treatment. | | |

**APPENDIX: J**

**PUBLIC SERVICES DEPARTMENT**

**WASTE WATER REMOVAL COSTS (BASED UPON 2005 BUDGET)**

| INCOME | | EXPENDITURE | |
|---|---|---|---|
| Sewage Tanker Income | 1,150,000 | General Revenue: | |
| | | Sewage Tanker - Maintenance | 475,000 |
| | | Sewage Tanker - Staff Costs | 1,163,200 |
| | | Pumping Station - Maintenance | 645,000 |
| | | Sewer Maintenance Costs | 315,000 |
| | | Sewer Rehabilitation | 1,000,000 |
| | | Consultants | 80,000 |
| | | | 3,678,200 |
| | | Capital Costs: | |
| | | Network Extension Plan | 3,000,000 |
| | | Sewage Tanker Replacement Programme | 275,000 |
| | | Sewer Connection Grants | 100,000 |
| | | | 3,375,000 |
| Total Income | 1,150,000 | Total Expenditure | 7,053,200 |
| Shortfall to Fund Expenditure | 5,903,200 | | |
| | 7,053,200 | | 7,053,200 |

**NB There is no Appendix: I**

**APPENDIX: K**

**CONSULTATION**
**RESPONSE FROM THE HEALTH AND SOCIAL SERVICES DEPARTMENT**

MEMORANDUM

| | | | |
|---|---|---|---|
| To: | Chief Officer, Public Services Department | | |
| From: | Chief Officer, Health and Social Services Department | | |
| Date: | 15 July 2005 | Or Ref: | DH/sk |

---

Sewerage and Wastewater Treatment Report

Thank you for your memorandum of 11 July 2005. As promised in my memorandum of 28 June, I can now let you have my Department's comments on the above report.

We recognise the current difficult financial situation and the need to prioritise. In this context, the Health and Social Services Department would support priority being given to closing the short outfalls and centralising all sewage discharge to Belle Greve, excluding rainwater and sea water from the sewers and monitoring the impact of the existing discharge on the marine environment.

On the evidence available to us, the above issues, together with the provision of a proper system for the disposal of the Island's solid waste, must be of a higher priority than the provision of a liquid waste treatment plant. In fact, before a sewage treatment system could be introduced, consideration would have to be given to the method of disposal of the sludge produced. Following the recent States decision not to proceed with the planned 'waste to energy' incinerator, one of the options for disposing of such sludge has, obviously, been put in abeyance.

In summary, in the light of the evidence available and the need to prioritise, we would support the stepped approach suggested in the report. I trust this will be of assistance to you.

DAVID HUGHES

**APPENDIX: L**

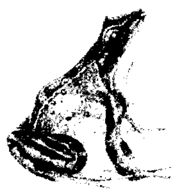
# REPORT: REVIEW OF MARINE TREATMENT POLICY AND PRACTICE

**Undertaken for the States of Guernsey by WRc plc**

# GUERNSEY PUBLIC SERVICES DEPARTMENT

# REVIEW OF MARINE TREATMENT POLICY AND PRACTICE

WRc Ref: UC6943 v1
AUGUST 2005



# REVIEW OF MARINE TREATMENT POLICY AND PRACTICE

Report No.: UC6943 v1

8 August 2005

Authors: Roberto Celestini, Paul Dempsey

Contract Manager: Paul Dempsey

Contract No.: 14361-0

RESTRICTION: This report has the following limited distribution:

External: Client

Any enquiries relating to this report should be referred to the authors at the following address:

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# CONTENTS

## SUMMARY

This brief review has investigated the current policy and practice regarding 'Marine Treatment' in developed countries outside Europe. In this context, Marine Treatment is defined as the preliminary treatment of domestic wastewater followed by discharge to sea through a properly designed long sea outfall.

The review has involved an extensive internet search and targeted email enquiries. Information has been gained for US, Canada, Israel, Gibraltar, Malaysia, Singapore, Hong Kong, Australia and New Zealand.

The findings indicate a general view in all these countries that Marine Treatment is not an acceptable long term practice. Aspirations and, in some cases, legislation indicate secondary treatment as the 'default' minimum technology for all domestic wastewater before discharge to coastal or inland waters. There appears to be an implicit belief that communities should, as a minimum, remove a substantial proportion of the municipal pollutant load before discharge to the environment, regardless of the dilution/dispersion capacity of the receiving waters.

In addition, there is a strong argument advanced by many countries (particularly those with limited water resources, e.g. Singapore, Israel, Australia) that wastewater should be seen as a resource rather than a waste product. Singapore refers to wastewater as 'used water' and to wastewater treatment plants as 'water reclamation plants'. The provision of secondary treatment is thus seen a first step towards recycling the water, regardless of the environmental impact considerations.

In some cases, the legislation allows for the possibility of less stringent treatment than secondary (in a similar way to the 'primary treatment'/'less sensitive areas' clauses in the EU Urban Wastewater Treatment Directive). For example, in the US, wastewater treatment is controlled by the Clean Water Act (1977), which requires secondary treatment for all publicly owned treatment works. In addition, for marine discharges, the Act requires an ecological risk assessment to ensure no unreasonable degradation of the marine environment. The legislation (Section 301(h)) also allows a case-by-case review of treatment facilities for marine discharges whereby the secondary treatment requirement can be 'waived' in specific circumstances – subject to a demonstration that marine life would not be adversely affected. In 2002 there were approximately 36 wastewater treatment works with 301(h) waivers. In all the waiver cases, the wastewater facilities had at least primary treatment.

In contrast, while developed countries expect secondary treatment as a minimum, the United Nations Environment Programme (2004[1]) have prepared guidelines for municipal wastewater management which recommend using the 'cleaning capacity of natural systems as a first step' in selecting a treatment technology. The guidelines cite Marine Treatment as a natural system and recommend that 'conventional' treatment systems (e.g. primary/secondary) should only be used as a last resort.

---

[1] UNEP/WHO/HABITAT/WSSCC Guidelines on Municipal Wastewater Management. UNEP/GPA Coordination Office, The Hague, The Netherlands 2004.

# 1. INTRODUCTION

This report presents the findings of a brief review of the current policy and practice regarding 'Marine Treatment' in developed countries outside Europe. In this context, Marine Treatment is defined as the preliminary treatment of domestic wastewater followed by discharge to sea through a properly designed long sea outfall.

The review has involved an extensive internet search and targeted email enquiries. Information has been gained for US, Canada, Israel, Malaysia, Singapore, Hong Kong, Australia and New Zealand. In addition, information relating to wastewater treatment for some European islands has also been included.

# 2. FINDINGS

The following sections summarise the key findings by country.

## 2.1 United States

Commonly known as the Clean Water Act from 1977, the Federal Water Pollution Control Act Amendments passed in 1972 established the basic structure for regulating discharges of pollutants into the waters of the United States. They required publicly owned sewage treatment works to achieve secondary treatment capability by 1977. Subsequently modified by other laws, the Clean Water Act still defines the requirements to set water quality standards for all contaminants in surface waters.

Although, after the law was passed, some municipalities with publicly owned treatment works discharging into marine waters found the secondary treatment requirement unnecessary because they discharged via long outfalls into deeper waters with large tides and substantial currents. After that, Congress added section 301(h) to the Clean Water Act in 1977, introducing waivers, which allow for a case-by-case review of treatment requirements for marine dischargers. Any Wastewater Treatment Works (WwTW) granted a 301 (h) waiver must meet a number of criteria, including:

- Primary or equivalent treatment to remove at least 30 percent of BOD and 30 percent of SS.
- Compliance with water quality standards.
- Protection and propagation of a balanced indigenous population of fish, shellfish, and wildlife.
- Allowance of recreational activities.
- Establishment of a monitoring program.
- Satisfactory toxics control programs, including an approved pretreatment program.

In 2002, there were approximately 36 WwTW with 301(h) waivers approved by the EPA. Most of these are for small WwTWs (less than 5 million gallons per day (MGD)), mostly in Alaska, Maine and Puerto Rico, but the two largest by far are in California:

- Orange County. About 234 MGD, that is a mixture of secondary and enhanced primary treated effluent discharged through a long sea outfall.
- San Diego. The Point Loma facility provides chemically-enhanced primary treatment for about 175 MGD before discharge through a 4.5 mile outfall.

The persistence of 301(h) waivers is a matter of considerable public interest and debate and there are many dissents and protests and the continuation of this practice.

## 2.2 Canada

In Canada, responsibility for the collection and treatment of municipal wastewater, the administration and performance of wastewater facilities, and the control of environmental and health impacts of municipal wastewater is shared across all levels of government.

Municipal governments have the most direct responsibility for wastewater by having the statutory mandate to provide sewage treatment. The provincial/territorial governments are primarily responsible for the regulation of municipal sewage treatment operations, and most provinces/territories maintain legislative control through waste control statutes that apply directly to sewage effluent. Operators of wastewater systems are required to seek approval from their provincial/territorial governments, and these provincial/ territorial permits or licences may specify maintenance and treatment requirements on top of what is already stipulated in regulations. The approvals may also contain specific limits on the discharge of effluents. For example, British Columbia's Waste Management Act requires all municipalities to have a provincially approved Liquid Waste Management Plan. Discharges without such a plan are illegal in this province. Currently, there is no federal legislation directly governing the deposit of harmful substances by municipalities into their wastewater. There are two acts, however, that do have the potential to apply to municipal wastewater. The Fisheries Act is enforced federally by both Fisheries and Oceans Canada and Environment Canada and addresses a general prohibition against the release of a "deleterious substance" into waters frequented by fish. The Canadian Environmental Protection Act governs the release of toxic substances to the environment and allows the federal government to create regulations to control or eliminate the use of such substances.

Federal guidelines for wastewater effluent quality for discharge to open coastlines suggests 30 mg/l for both BOD and SS levels.

In 1999, many coastal municipalities served by sewers had only primary or secondary treatment, while some had no treatment at all. Of the municipalities discharging directly into Pacific coastal waters, about 80% of the population served by sewers received primary treatment and 15% received secondary treatment. Among municipalities discharging to Atlantic coastal waters and the St. Lawrence estuary, about 18% of the population served by sewers received primary treatment, about 34% received secondary treatment, while 48% had no treatment (adapted from Environment Canada 1999b).

### 2.2.1 British Columbia (Pacific coast)

Wastewater quality parameters are defined in the *Waste Management Act*. In the current situation *Ministry of Environments, Lands and Parks* can issue permits to operate and discharge treated effluent to the receiving waters under the provisions of the Waste Management Act.

The Greater Vancouver Regional District (a partnership of 21 municipalities and one electoral area that make up the metropolitan area of Greater Vancouver) operates five wastewater treatment plants in the region (the Annacis Island, Iona Island, Lulu Island, Lions Gate, and Northwest Langley wastewater treatment plants). The three plants discharging to the Fraser River, the Annacis, Lulu and Northwest Langley plants, are providing full secondary treatment. The remaining two wastewater treatment plants, Iona and Lions Gate, discharge to Georgia Strait and First Narrows respectively and provide primary treatment.

For coastal communities in British Columbia with populations greater than 5,000, 70% (by population) have primary sewage treatment, 14% secondary treatment and 16% have no treatment at all.

### 2.2.2 Atlantic coast

A number of significant coastal communities on the Atlantic coast have no treatment at present – e.g. Halifax, St Johns and Sydney. However, this is not considered acceptable and plans are in hand to provide treatment. At St John's, Phase 2 of the Harbour Clean-Up project is underway by which primary treatment facilities plus outfall will be provided for a population of about 150,000 by 2007. Similarly plans for new primary treatment facilities at Halifax are at an advanced stage.

## 2.3 Australia

In Australia, the marine discharge of effluents is usually viewed as 'disposal' rather than treatment and the emphasis in planning studies is to demonstrate appropriate dilution and that the environmental effects are minor.

In general, regulations are tending to move things towards recycling of wastewater in preference to discharge. As a result there is a strong move towards phasing out ocean outfalls. Some politicians have a policy of 'no ocean outfalls'. Water utilities that have marine discharge are subject to licence agreements that are requiring higher levels of treatment before discharge.

### 2.3.1 Sydney

Sydney Water operates ten coastal treatment plants. The three largest are located at North Head, Bondi and Malabar and treat most of Sydney's sewage (about 3.5 million pop) by a high rate primary process before discharging via deep ocean outfalls.

The smaller coastal treatment plants - Warriewood, Cronulla, Bombo, Wollongong, Port Kembla, Shellharbour and Bellambi, discharge treated effluent closer to the shore. Two of these (Bellambi (85000 pop) and Port Kembla (55000 pop)) use chemically assisted primary treatment with disinfection while the others use secondary treatment or better. Approximately 0.5 per cent of Sydney's sewage is discharged untreated to the ocean at Vaucluse, Diamond Bay and Diamond Bay South.

Sydney Water is upgrading the Wollongong WwTW to take flows from Port Kembla and Bellambi and to provide higher treatment for recycling. The water recycling plant at Wollongong will use micro-filtration and reverse osmosis membrane treatment processes to produce high quality water suitable for a range of non-drinking industrial processes - ie: for cooling systems. Initially, 20 million litres per day of recycled water will be redirected to BlueScope Steel's Port Kembla steelworks, with further potential opportunities to expand this volume to other local industries in the future. This project is expected to reduce the use of drinking water across the total Illawarra region by 17 per cent.

### 2.3.2 Perth, Western Australia

The three main treatment works serving Perth provide secondary treatment before discharge to sea via ocean outfalls. Other coastal treatment works in the region provide a similar (or higher) level of treatment and much of the effluent is reused for irrigation purposes.

## 2.4 Hong Kong

The *Environmental Protection Department* is developing an extensive program for cleaning up Hong Kong's waters, which includes the *Harbour Area Treatment Scheme* (HATS) to reduce the pollution levels from sewage entering Victoria Harbour.

To cope with population growth and to improve the water quality of Victoria Harbour, the Hong Kong Government invested more than US$2.5 billion to implement *Stage 1* of the Harbour Area Treatment Scheme and plans further investments in the subsequent stages. This stage of the HATS was completed in 2001, and its target was to collect, treat and discharge the sewage generated around the harbour building a 23 km deep tunnel conveyance system, a centralized primary treatment plant at Stonecutters Island and a 1.7 km submarine discharge oceanic outfall. In the current situation 75% of sewage around the Victoria Harbour receives treatment. After further studies, the Government is moving forward to HATS subsequent stages and plans are revised to take into account a projected population increase of about two million by 2016.

## 2.5 Singapore

In Singapore three government ministries are directly involved in environmental management: the *Ministry of the Environment* (ENV), the *Ministry of National Development* (MND), and the *Ministry of Trade and Industry* (MTI) for the land-base management; the *Port of Singapore Authority* (PSA) manages marine pollution.

Over the last few decades there has been a rapid development of the wastewater infrastructure to serve the equally rapid development of Singapore. In 2000, Singapore's sewerage system served 100% of the population and wastewater from the various catchments was treated to secondary standard at 6 water reclamation plants - Bedok, Jurong, Kim Chuan, Kranji, Seletar and Ulu Pandan . As a result of cooperation between the *Singapore National Environmental Agency* and the *Public Utilities Board*, Singapore has started a project - The Deep Tunnel Sewerage System (DTSS) - to radically improve the island's sewerage and treatment system. The ultimate aim is to achieve the marine and domestic water quality standards defined in the *Sea Act* (1971) and in the *Water Pollution Control and Drainage Act* (1975).

The Deep Tunnel Sewerage System (DTSS) was conceived as a long term solution to meet the needs for used water collection, treatment and disposal to serve the development of Singapore through the 21st Century. This long term project, which will be implemented in 2 phases, consists of two large, deep tunnels crisscrossing the island, two centralised water reclamation plants, deep sea outfalls and a link-sewer network.

The 2 deep tunnels and a network of smaller link-sewers will be built. Used water from the existing sewers will flow into the deep tunnels via the link sewers. The deep tunnels will convey the used water to two new centralised water reclamation plants to be built on reclaimed land in Changi and Tuas. The treated effluent from the new water reclamation plant will be discharged through deep sea outfalls into the Straits Of Singapore. With the DTSS in place, the existing water reclamation plants and pumping stations, which are located all over the island, will be phased out eventually.

The DTSS will be constructed in two phases. The first phase of the project, being implemented now, covers the eastern half of the island and will transfer flows to Changi; a 800,000 cubic metres per day water reclamation plant with a 5 kilometres long sea outfall. It is scheduled for completion in 2008. The second phase will link the rest of the island to a water reclamation plant at Tuas and a sea outfall into the Straits of Singapore.

The need to reclaim and recycle water – largely for non-potable uses – is a major driver in the overall collection and treatment scheme. Any used water, which is not recycled, will receive at least secondary treatment prior to its discharge to the sea.

## 2.6 New Zealand

In 2002 the *Ministry for the Environment* of New Zealand (MfE) and *Local Government New Zealand* (LGNZ) launched the *New Zealand Waste Strategy*, an environmental initiative covering all forms of waste and supposed to have a big impact on the way the all sectors of the community address waste issues. In particular, about marine water quality management, there is a New Zealand Coastal Policy Statement, which is then interpreted at a Regional level. Within the regional plan, the relevant section for discharges of human sewage and wastes from commercial, industrial or production activities states that discharge to the coastal marine area which has not passed through soil or wetland, is a discretionary, restricted coastal activity. This means that sewage can only be discharged to a marine area if a coastal permit has been obtained. In the case of a restricted coastal activity, the only body which can issue coastal permits is the Minister of Conservation and consultation would be needed with local community groups and Maori groups. Maori see the discharge of human effluent to be against their beliefs and want it treated on land.

The *New Zealand Waste Strategy* has a target requiring all substandard wastewater treatment plants to be upgraded, closed or replaced by December 2020. 'Marine treatment' is not considered an acceptable form of wastewater treatment. As the upgrading of sewage plants to a suitable standard is expensive and difficult for many territorial authorities, a number of councils have already provided for this expenditure in their Long Term Financial Strategies. The Ministry for the Environment's Wastewater programme is also looking at a range of tools to assist the wastewater sector in meeting the principles and targets contained within the Waste Strategy.

In most of the communities in New Zealand there is general acceptance that the government may have to increase spending in the area of water and wastewater treatment, and the current local councils' opinion is generally that at least secondary treatment should be the norm. There are still many occurrences of discharges to the coast of untreated/primary treated effluent. However, these are being phased out – although there is no specific timeframe. Dunedin is a good case in point – a peak population of 125,000 and only primary treatment is currently given. In 2003 the Dunedin City Council proposal was to extend the outfall to 1100 m but not upgrade the treatment – a proposal at odds with the Otago Regional Council position. After several arguments and an Environment Court ruling, Dunedin City Council is to extend the outfall by 2007 and supply tertiary treatment by 2011.

## 2.7 Israel

Wastewater treatment and water reuse are a high priority in Israel because of the combination of severe water shortage, contamination of water resources, densely populated areas and highly sensitive marine environment. Accordingly, Israel water policy is principally orientated to the development of water recycling systems.

There is a continuous effort to remove all municipal wastewater from the sea to a land-based non-polluting alternative. Of the total volume of municipal wastewater produced by Israel, about 90% is collected by means of central sewage systems, 80% is treated and nearly 70% of it is reclaimed for reuse, mainly for the irrigation of non-food crops and animal fodder. Most of the reused water is from secondary and tertiary treatment plants. During recent years, modern treatment plants have been built for most of Israel's major cities like Jerusalem, Haifa, Netanya, Raanana and Hadera.

There are still some cities without proper treatment plants though, like Naharia and Acko in the north, and there are still flows of industrial wastewater through some of the rivers such as the Kishon, Naaman, Soreq, Poleg and Yarkon that are transferring contaminants into the sea. However, there are plans for these cities to provide adequate treatment.

## 2.8 Malaysia

The Malaysian policy about wastewater treatment for coastal areas is not well defined; there are no real standards or specific legislations. There are only two standards for sewage treatment: the *Standard A* related to discharges upstream of water extraction points, and the *Standard B* related to discharges downstream of water extraction points. Standard A is much more stringent than the latter in terms of consent limits and is equivalent to secondary treatment.

In the particular case of discharges to the sea, normally a full Standard A is required; Standard A sometimes also requires disinfection. More stringent conditions could be imposed site-by-site depending upon the sensitivity of the marine environment and this is dictated by *Environmental Impact Assessment* studies.

However in Malaysia the only formal marine outfall is the Penang Island outfall and there is no treatment, as the design for this 90 years old outfall was for the marine environment to treat sewage via dilution and dispersion. This situation is no longer seen as acceptable for Malaysia's marine environment, and after a long delay the upgrading project has just started this year. The project is a full-scale inland plant with capacity of 800,000 pop, able to ensure treatment quality better than Standard A and with the discharge close to the coast.

## 2.9 Some European island examples

### 2.9.1 Gibraltar

Currently, Gibraltar's wastewater from a population of about 28,000 discharges untreated into the sea at Europa Point on the southernmost tip of the island. The Gibraltar sewage system is unique in that seawater is used for sanitary purposes. This creates a unique problem in terms of sewage treatment as there is no proven process capable of operating in this environment.

Nonetheless, the Government is progressing technical preparatory work to make Gibraltar compliant with the EU Urban Wastewater Treatment Directive (91/271/EEC) - UWWTD.

### 2.9.2 Cyprus

Wastewater treatment plants are in operation for the four large agglomerations on the coast of Cyprus. The UWWTD is under full implementation and there is an increasing emphasis on reusing wastewater effluent for irrigation. There is a government policy to eliminate all effluent discharge to sea and to reuse effluent after tertiary treatment. For example, tertiary treatment is provided for Limmasol (150,000 pop) and the treated water is used for irrigation to the west of the city.

### 2.9.3 Isle of Wight, UK

All wastewater from the Isle of Wight's coastal towns (pop 140,000) receives secondary treatment at the new Sandown Wastewater Treatment Works before discharge to sea via a 3 km outfall. The works at Sandown are part of Southern Water's Seaclean Wight scheme, which also includes a number of pumping stations and pipelines to convey most of the island's wastewater to this centralised facility.

### 2.9.4 Balearic Islands (Mallorca)

The Balearic Islands are an Autonomous Community under Spain's Water Law and as such are responsible for setting standards for wastewater treatment, within the overall framework provided by the UWWTD.

The main town in Mallorca, Palma, has two treatment works serving a combined population of about 370,000. In 2003 a tertiary treatment extension in Palma 2 was constructed, using the public-private funding model, and used to confirm the use of recycled water as a positive means to promote sustainable development. In 2004, a new tertiary treatment plant was built to replace the old one, which will treat the whole wastewater flow, and the construction of a pipe from wastewater Treatment Plant 2 to the new wastewater Treatment Plant 1 will mean that almost 100% of the wastewater generated in Palma will be put under tertiary treatment to be reused.

## 2.10 UNEP Report

In 2004, the United Nations Environment Programme (UNEP) published a report entitled 'GUIDELINES ON MUNICIPAL WASTEWATER MANAGEMENT - A practical guide for decision-makers and professionals on how to plan, design, and finance appropriate and environmentally sound municipal wastewater discharge systems.' (UNEP 2004). The Foreword (see box) explains the background and purpose of the report.

**Foreword to UNEP (2004)**

Since the adoption of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) in 1995, UNEP has pioneered the development of tools addressing marine pollution originating from land-based activities. GPA is the only global action programme addressing the interface between the fresh water and coastal environment. One of the problems the GPA address's is the uncontrolled discharge of wastewater into the fresh water and coastal environment.

A priority also identified by UNEP and reconfirmed at the 2002 Millennium Summit and the World Summit on Sustainable Development. Indeed in many parts of the world sewage is still discharged directly into open water without treatment. Such uncontrolled discharge is one of the most serious threats to the productivity and biodiversity of the world's oceans. At the same time it causes serious environmental and human health problems and threatens sustainable coastal development.

In response to the daunting challenge faced by many governments in addressing municipal wastewater problems, the GPA has developed guidelines for municipal wastewater management, jointly with WHO, UN-Habitat, and WSSCC.

The guidelines provide practical guidance on how to plan appropriate and environmentally sound municipal wastewater management systems. The guidelines are meant for decision-makers, operational professionals in government institutions, and in the private sector, development banks and related organizations. The guidelines focus on four elements: approaches and policies, institutional arrangements, technological choices, and financing options. Each element is supported by a practical checklist.

The guidelines address and stress the need to link water supply and the provision of household sanitation, wastewater collection, treatment and re-use, cost-recovery, and re-allocation to the natural environment. Local participation is advocated and stepwise approach to technology and financing, starting at modest levels, expanding if and when more resources become available.

Recognising the high cost of wastewater treatment systems, the guidelines advocate a step-by-step approach, which allows for the implementation of feasible, tailor-made and cost-effective measures that will help to reach long-term management objectives. After considering options for pollution prevention at source and the efficient use and re-use of water, the guidelines point to the application of appropriate low-cost treatment technologies. In this regard the guidelines state that '*Use of the cleaning capacity of natural systems should be considered as the next step for treatment of collected wastewater.*' And '*An example of natural self-purification technology is marine wastewater outfall: raw, pre-treated wastewater is discharged in coastal waters which are deep and dynamic enough to achieve a proper dilution.*' And '*Only after all options described above have been considered and rejected, the use of conventional systems should be considered.*'

# REFERENCES

UNEP/WHO/HABITAT/WSSCC Guidelines on Municipal Wastewater Management. UNEP/GPA Coordination Office, The Hague, The Netherlands 2004.

# APPENDIX A LINKS AND CONTACTS

## Australia

A paper, which explores the current philosophy of sewage treatment choices.

http://www.uow.edu.au/arts/sts/sbeder/sewage/technoparadigm.html

Sydney Water

http://www.sydneywater.com.au/

## US

Good site explaining US EPA National Pollutant Discharge Elimination Scheme

http://cfpub.epa.gov/npdes/home.cfm?program_id=45

Example of opposition to 301(h) waivers in the US

http://www.StopTheWaiver.com/

Explanation of the waiver system

http://www.surfrider.org/a-z/waivers.asp

List of waivers

http://www.epa.gov/OWOW/oceans/discharges/301list.html

## Canada

Environment Canada site. Report on assessing and managing wastewater effluents 2000.

http://www.ec.gc.ca/emsinfo/wastewater_e.htm

Environment Canada site. Report on the state of Municipal Wastewater effluents in Canada 1999

http://www.ec.gc.ca/soer-ree/english/SOER/MWWE.cfm

Canada's **National Programme Action** for the Protection of the Marine Environment from Land-Based Activities

http://www.npa-pan.ca/index_e.htm

Greater Vancouver Sewerage and Drainage report 2001 http://www.gvrd.bc.ca/sewerage/pdf/2001qcannsewrptv1.pdf

Example of petition in relation to inadequate treatment. The arguments put forward in the petition are of interest.

http://www.oag-bvg.gc.ca/domino/petitions.nsf/viewe1.0/CB5A8A2DC76CD57985256F0F0050A588

Example of opposition to inadequately treated marine discharges

http://www.georgiastrait.org/CAW/sewage1.php

## Hong Kong

Environment Education site with Links to master plans on sewerage and treatment in Hong Kong

http://resources.emb.gov.hk/envir-ed/text/lifewide/e_m3_2_3_n1.htm

Environmental Protection Department site. Information on current water quality and the HATs scheme

http://www.epd.gov.hk/epd/english/environmentinhk/water/water_maincontent.html

New Zealand

Ministry of Environment Site describing strategy for wastewater

http://www.mfe.govt.nz/issues/waste/wastewater/

Water and Wastes Association

http://www.nzwwa.org.nz/

WaterCare Project Hobson - Auckland

http://www.watercare.co.nz/default,229.sm

North Shore (follow links Our Environment/Water Wastewater) for description of treatment/outfall scheme

http://www.northshorecity.govt.nz/

## Singapore

Singapore's National Environment Agency site.

http://app.nea.gov.sg/

Public Utility Board site, section on the DTSS and Changi water reclamation works

http://www.pub.gov.sg/our_services/changi_outfall.php?l1=2&l2=9&l3=11&l4=26

## New Zealand

Details of Auckland's wastewater services

www.watercare.co.nz

Details of North Shore City wastewater – follow links under a-z and 'wastewater'

www.northshorecity.govt.nz

NZ Coastal Policy Statement

http://www.doc.govt.nz/Conservation/Marine-and-Coastal/NZ-Coastal-Policy-Statement.pdf

An example of a Costal Regional Plan - Auckland Regional Council

http://www.arc.govt.nz/arc/index.cfm?8F63A557-E018-8BD1-3272-6389C78E7174

NZ Water and Waste Association

www.nzwwa.org.nz

## UNEP

Guidelines on Municipal Wastewater Management

http://www.pub.gov.sg/our_services/changi_outfall.php?l1=2&l2=9&l3=11&l4=26

## Email Contacts

Sustainable Industry and Climate Change Group, Ministry for the Environment, NZ

CSIRO, Australia

Harrison Grierson, civil engineering consultant, Auckland NZ

Public Utility Board, Singapore

Planning and Engineering Dept, Indah Water (a Govt national sewerage Agency), Malaysia

D&B, LLC Environment Engineers, Pennsylvania, US

**APPENDIX: M**

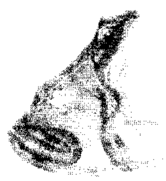
# REVIEW OF PROCESS OPTIONS FOR WASTEWATER TREATMENT ON GUERNSEY

**Report Undertaken for the States of Guernsey by WRc plc**

**STATES OF GUERNSEY**

# REVIEW OF PROCESS OPTIONS FOR WASTEWATER TREATMENT ON GUERNSEY

WRc Ref: UC6783
JANUARY 2005



# REVIEW OF PROCESS OPTIONS FOR WASTEWATER TREATMENT ON GUERNSEY

Report No.: UC6783

January 2005

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Contract No.: 13621-0

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# SUMMARY

## I OBJECTIVES

The objective of this report is to provide a non-technical description of processes for wastewater and sludge treatment which might be suitable for installation on Guernsey to meet the approved Water Quality Objectives. The report includes a discussion of the factors which must be taken into account during selection of the optimum process, such as capital cost and area requirements.

## II CONCLUSIONS

The Water Quality Objectives approved by the States of Guernsey can be met by a number of options for wastewater treatment. Some of these options are based on the use of conventional process sequences while others rely on compact plant, which can be installed at sites where construction area is limited.

The area required by compact plant such as MBR and BAF processes is only about 10-12% of the area required by some conventional treatment processes.

A disinfection process would be required as a final stage of treatment for all but the MBR treatment option. A system based on the use of UV irradiation would be cost-effective.

The provision of stormwater treatment by conventionally designed settling tanks requires a large land area and could be a problem at a confined site. The cost of preliminary and stormwater treatment is a significant fraction of the total capital costs of wastewater treatment.

Sludge disposal by incineration would appear to be a viable option. Disposal by recycling depends on the availability of a sustainable market for the sludge product. The capital cost of sludge treatment prior to disposal by incineration is considerably less than the cost of sludge treatment prior to recycling. This is because anaerobic digestion is not required if the sludge is to be incinerated.

The capital cost of the entire treatment process is likely to be in the range £17.2 M to £23.3 M, depending on the selected options for wastewater and sludge treatment.

# 1. INTRODUCTION

The implementation of a number of EU Directives has resulted in legislation which has had far-reaching implications for wastewater treatment at coastal sites throughout Europe.

The Urban Wastewater Treatment Directive (UWWTD) has resulted in the construction of several wastewater treatment plants at coastal sites because higher standards of treatment are now required for coastal sewage discharges. In addition, sludge disposal to sea is no longer permitted and the Regulations which must be met to secure other disposal routes have become more stringent.

Coastal sewage treatment plants may also be subject to legislation which sets limits on bacterial numbers in designated bathing waters. (Bathing Water Directive), or in the vicinity of shellfish beds, (Shellfisheries Directive). Disinfection processes can be required in these circumstances and the overall cost and complexity of the treatment sequence is increased.

The sites available for sewage treatment in coastal areas are often limited in size and many are located in the centre of resorts, or in areas of high amenity value where there is a need to reduce the environmental impact of the treatment processes. It is especially important in such areas to avoid odour nuisance and to construct plants which are not visually obtrusive. In recent years the number of treatment processes available has increased significantly and compact, high-rate treatment plants have been developed for installation at environmentally sensitive sites where space is restricted. The entire sequence of processes is often enclosed in a building or underground structure with facilities for efficient control of odour nuisance.

The performance of several plants constructed in coastal catchments has been found to be adversely affected by high levels of wastewater salinity. It is important that salinity in coastal sewer systems is determined and the information used in process selection and design.

The States of Guernsey are not part of the UK or the EU and are therefore not bound by the legislation which derives from any of the Directives mentioned above. However, water quality objectives have been approved which are intended to ensure compliance with EU guidelines and standards for designated shellfisheries and inshore bathing waters. Hence, this report makes reference to the Regulatory framework which currently exists in the UK, as a result of the implementation of EU Directives, as a convenient basis for discussion of treatment plant performance. The implications of these Directives in relation to the provision of wastewater treatment on Guernsey are broadly similar to those which have been addressed at several sites in the UK.

This report reviews wastewater treatment processes which are capable of producing effluent of the quality required by the relevant EU Directives, for a single site in Guernsey serving a population equivalent of 75000. The design features and characteristics of a number of compact treatment processes, suitable for construction at sites where space is restricted, are given and reference is made to a number of operational plants in the UK where such processes have been installed.

The report includes a discussion of the factors which must be taken into account in the selection of an appropriate sequence of sewage treatment processes. These factors include effluent quality, capital and operating costs, environmental impact and sludge disposal. The advantages and disadvantages, including capital costs and area requirements, of a number of suitable treatment sequences are described.

It is emphasised that this report is not intended to provide a detailed description of the characteristics and performance of every proprietary process which is commercially available for wastewater and sludge treatment. Treatment processes are described instead in terms of their generic characteristics. This approach facilitates a rapid understanding of the main features of the different systems and also allows any claimed performance advantages of commercial variants to be compared with conventional plant.

# 2. WASTEWATER TREATMENT PROCESSES

## 2.1 Introduction

The sequence of processes installed at sewage treatment plants has always followed a logical progression of unit operations arranged in order of increasing complexity. The stages involved in sewage treatment have traditionally been identified as preliminary, primary, secondary and tertiary.

The wastewater which is delivered to a treatment plant by a sewer system derives from domestic and industrial sources and may contain surface run-off water and groundwater which has infiltrated the sewer system. As a result, the composition and flowrate of wastewater is typically extremely variable. Wastewater treatment is performed by a series of processes arranged successively so that the effluent from one becomes the influent to the next in the sequence. The number and complexity of the processes is a function of the effluent quality required and also, to a lesser extent, on the size of the overall treatment plant. Physical chemical and biological processes are involved and it is convenient to group them together as preliminary, primary. secondary and, perhaps, tertiary. Generally speaking, the simplest processes are located earliest in the treatment sequence. The additional processes required to achieve the highest quality effluent are quite complex and correspondingly expensive to operate.

The standards for individual discharges are usually set as concentration limits on quality indicators such as Biochemical Oxygen Demand, (BOD), Chemical Oxygen Demand, (COD), suspended solids (SS) and perhaps, ammonia nitrogen. In some instances, limits are also set on total nitrogen and phosphorus if the receiving water is classified as sensitive. Compliance with the EU UWWTD is normally based only on BOD and COD concentration limits and the standards required can be met by a number of process combinations. Compliance with the BOD limit should ensure compliance with the COD limit unless the wastewater to be treated contains an unusually high proportion of relatively non-biodegradable industrial effluent. The types of industry which exist on Guernsey would not be expected to produce effluents which would lead to wastewater treatability problems.

Coastal discharges in the vicinity of designated bathing beaches and shellfisheries in the UK must also comply with bacterial and viral standards in order to meet the requirements of the EU Bathing Water and Shellfisheries Directives. The standards are complex in detail but in simple terms they are set as maximum permitted numbers of specific bacteria and viruses per 100 ml of water. The bacteria to which standards apply are indicators of sewage discharges such as total and faecal coliforms and both mandatory and guideline standards have been established. Samples for compliance are taken from the receiving water, not from the treatment plant effluent. Compliance therefore depends on dispersion in the receiving water and the frequency of stormwater discharges, in addition to the bacterial quality of the treated effluent.

## 2.2 Preliminary Treatment Processes

Preliminary treatment consists of screening and grit removal processes. Both are invariably installed at all sites.

Screening involves the removal of rags and visually objectionable material by mechanical equipment. Sewage is passed through apertures of specified dimensions and material which is larger than the apertures is captured and removed from the sewage flow. Screens traditionally consisted of vertical bars separated by apertures of about 15 mm in width. This type of screen allowed significant quantities of material to pass through the apertures, causing problems in downstream processes and objectionable visual pollution of watercourses and bathing beaches. Towards the end of the 1980's, the performance of screens was dramatically improved by the development and installation of screening systems with apertures of about 5 mm. This type of equipment removes virtually all visually objectionable material and is now routinely installed throughout the UK. Discharge consents for bathing beaches and receiving waters of high amenity value often stipulate that all material must be removed which is larger than 6mm in two dimensions.

Several variations of these so-called 'fine-screens' are commercially available and all either include, or are associated with, ancillary equipment for washing and dewatering the screenings in preparation for disposal. Failure of screening plant can result in blockage of downstream pumps and valves and aesthetic pollution of coastal waters.

All screening installations are usually sized according to the maximum flow to be treated. It is normal to use a number of units in parallel to allow routine increases in flow to be dealt with and to allow equipment to be taken out of service for maintenance and repair.

Selection of suitable screening equipment does not usually involve any detailed process design considerations, and is usually made based on cost and ease of installation at a particular site. However, headloss can be important in screen selection, and most manufacturers will quote headloss as a function of flowrate.

At wastewater treatment plants the discharge of persistent and objectionable materials from storm overflows is now also regulated. Traditionally storm discharges were not subjected to screening and pollution of receiving waters and the surrounding areas occurred during their operation. Storm overflows at treatment plants usually consist of an appropriately designed side weir constructed in the wall of the influent sewage channel. Specialised fine screen designs have been developed for such applications.

Grit removal is performed by allowing the wastewater to flow at a sufficiently low velocity through a specially designed tank. Grit and sand is relatively dense (S.G. about 2.5) and settles out by sedimentation, but lighter organic matter remains in suspension for treatment in downstream processes.

Grit removal plant is normally installed immediately downstream of the screening equipment. If grit is not removed here, then it is certain to be removed with the sludge produced by primary sedimentation, from where it can accumulate in digestion plant, or cause rapid abrasion of pump impellers and dewatering equipment such as centrifuges.

Modern fine-screens and grit removal plants are compact and suitable for installation in buildings to facilitate odour control and minimise visual impact. The screenings and grit removed from wastewater are usually washed and dewatered prior to ultimate disposal by off-site landfill. Transport of screenings and grit by road in uncovered skips can result in odour nuisance.

Neither screening nor grit removal plant reduce the BOD concentration or bacterial content of wastewater to any appreciable extent.

## 2.3 Primary Treatment Processes

### 2.3.1 Introduction

Typical wastewaters contain only a small proportion of pollutant material and this material can be divided into settleable and non-settleable fractions. The basic principle of primary treatment involves removing the settleable material by gravity settlement.

Primary treatment processes follow the initial processes of screening and grit removal and are installed at nearly every wastewater treatment site. There are a few exceptions, usually at smaller sites where influent sewage passes directly from preliminary treatment to a secondary stage. At confined sites, where there is limited area for construction, it can also be necessary to omit conventional primary treatment processes. Primary treatment is a relatively simple process to operate. It can provide an inexpensive method for removing significant proportions of the BOD and suspended solids concentrations in the wastewaters which arrive at treatment plants.

### 2.3.2 Conventional Primary Sedimentation

Conventional primary treatment is carried out in large tanks which allow suspended material to be removed from the wastewater by gravity settlement. The tanks may be either rectangular or circular in plan and both types are known to be capable of similar performance. The basis of design is to promote conditions which allow the settleable material to fall to the bottom of the tank.

Primary sedimentation has been used in wastewater treatment for over a century, and over the years a fairly simple set of empirical rules for calculating the major dimensions of primary tanks has been developed. These rules result in a reasonable balance between cost and performance and define nominal retention times at specified wastewater flowrates, percentage removals of BOD and SS, tank depths, surface areas and, perhaps, weir overflow rates. Well-designed and properly operated primary tanks should achieve reductions in SS of between 50-70% and BOD removals of between 30-50%, depending on the fractions of settleable organic material in the wastewater.

Primary treatment typically reduces bacterial numbers by about 99%. However, the numbers of bacteria normally present in crude sewage are so large, say, 1,000,000,000 per 100 ml, that this degree of reduction still leaves 10,000,000 per 100 ml in the settled wastewater leaving the sedimentation tank. The disinfection effect is therefore negligible.

The settled material which accumulates on the floor of the tank is known as primary sludge and is periodically removed and sent for further treatment before ultimate disposal. Sludge removal is invariably carried out by various types of scraper, which push the settled sludge into collection hoppers in the tank floor. Sludge is then drawn off from these hoppers periodically. The sludge removed from primary sedimentation tanks normally has a solids concentration in the range 2% to 4%. (20 to 40 $kg/m^3$).

At some treatment plants it is normal practice to recycle surplus secondary sludges to the primary sedimentation tanks and allow them to settle for removal with the primary sludge. This practice of 'co-settlement' usually results in the production of sludges with lower solids concentrations than would be obtained from the settlement of primary solids alone, but should have no measurable effect on primary effluent BOD and suspended solids concentrations. Co-settled sludges from a single treatment site normally consist either of primary plus surplus activated sludge (SAS) or primary plus humus sludge (from biological filters). Mixtures of primary and secondary sludge have different settling and dewatering properties to primary sludge alone. SAS in particular, is known to result in a deterioration in settling properties when co-settled and it is now increasingly common to treat SAS and primary sludge separately during the initial stages of treatment. The liquors produced in various downstream sludge treatment processes are also often recycled to primary sedimentation tanks.

Enhanced treatment can be achieved, at considerable extra operating cost, by adding various chemicals to the process to promote flocculation of fine particulate material and further settlement of solids. Such modifications can be useful where an effluent quality is required which is better than can be achieved by conventional primary treatment but not stringent enough to justify secondary treatment. However, these effluent quality requirements are not common and chemically enhanced primary treatment is not normally considered for new treatment schemes in the UK.

It is normal practice to convert the overall design dimensions of primary tanks into an appropriate number of equal-sized units. The minimum number of tanks should not be less than two and the actual number should take into account hydraulic considerations such as the requirement for accurate flow splitting between downstream processes.

Primary sedimentation processes require a relatively large land area for installation and this is their main disadvantage at sites where the area available for construction is limited. Various proprietary systems have been proposed which offer improved performance in a relatively small volume. These systems have been installed at several coastal sites where space is limited but conventional primary treatment processes are usually preferred at inland sites with adequate land area for construction.

### 2.3.3 Primary Sedimentation Using Lamella Separators

The rate of solids separation in primary sedimentation can be increased by the installation of inclined plates (lamellae) or tubes in the settling tank. This provides a larger effective surface area for settlement in a relatively small volume. This type of process has become generically known as a lamella separator. The plates or tubes are usually inclined at an angle of about 60 degrees to the horizontal and wastewater flows upwards through them in a well-defined and uniform manner. Suspended solids settle onto the large surface area available and slide downward into a collection hopper in the bottom of the tank. The common feature of the several proprietary designs which are available is the care taken to ensure that the flow distribution is equal across the plates or tubes. Hydraulic short-circuiting greatly reduces the solids removal efficiency. It is also important to prevent the settling solids from being disturbed by the influent wastewater. An illustration of a typical lamella unit, indicating the general direction of flow, is given in Figure 2.1

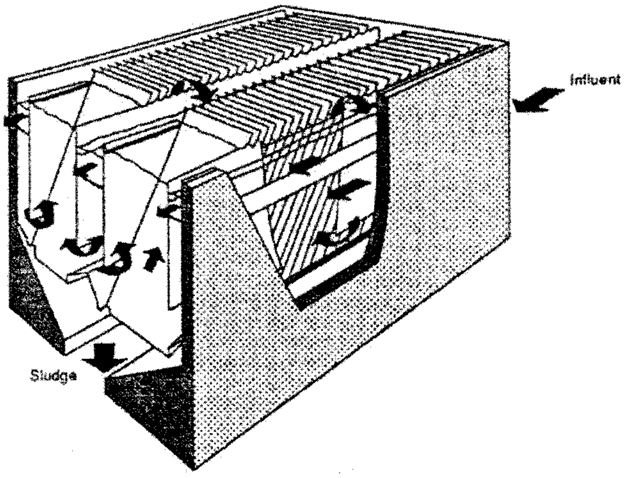



**Figure 2.1 Flow Patterns in a Typical Lamella Separator**

Well-designed and operated lamella separators can achieve suspended solids and BOD removal performance which is similar to conventional primary tanks. However, the plan area required is only about 10-15% of that required for a conventional plant. A characteristic disadvantage of lamella separators is the production of primary sludge of comparatively low solids concentration. Some manufacturers promote the use of chemical additives to enhance solids removal and produce a thicker sludge. It is important that the implications of lamella sludge characteristics are considered in the selection of an overall sludge treatment and disposal strategy.

Plant construction and operating costs are generally low but maintenance costs can increase if sludge sticks to the plates instead of sliding down to the collection hopper. Frequent cleaning is then required which also results in the affected tank being temporarily removed from service.

Lamella separators were originally developed for wastewater treatment applications in France. The technology is now widely used at all sizes of site throughout Europe. There are several installations at coastal sites in the UK where compact primary treatment processes are required. It should be noted that manufacturers' performance claims for lamella separators have not always been achieved in practice. At several sites in the UK it has been necessary to make unplanned use of chemical additions to maintain BOD and SS removals at the required levels.

The spiral separator is a relatively new primary treatment process which has recently been evaluated by Southern Water in the UK. It is a development of lamella technology but has an even smaller 'footprint' – about 40-50% of the equivalent lamella separator. The lamellae are arranged in a spiral which rotates about the centre of a circular tank. BOD and suspended solids removal performance is similar to a conventional lamella process but it is claimed that the settled sludge is produced at a higher solids concentration.

Lamella separators are often used in conjunction with BAF processes, which are described in section 2.4.3. Information on lamella installations is given in that section.

## 2.4 Secondary Treatment Processes

### 2.4.1 Introduction

The effluent from primary treatment processes is inadequate for discharge under most circumstances and a further (secondary) stage of treatment is therefore required.

Secondary treatment processes are invariably biological systems and can be conveniently classified as 'fixed-film' or 'suspended growth', depending on how the micro-organisms which perform the treatment are held within the system. Until recently secondary treatment processes consisted either of biological filtration (fixed-film), or some type of activated sludge system (suspended growth). Biological filtration is more expensive in terms of capital cost, and occupies a greater land area than activated sludge but is much cheaper in terms of operating cost. It is now generally accepted that a properly designed and operated activated sludge process is more effective in producing a higher quality effluent than a biological filtration process and older filtration installations are gradually being replaced. Most of the largest treatment sites in the UK now use some variant of the activated sludge process for secondary treatment. Biological filtration is still widely used at smaller sites but it is not always the system selected at such sites when a replacement installation is required.

Treatment in biological filters is achieved by trickling the wastewater over a fixed bed of suitable medium which supports a film of micro-organisms which remove the BOD and ammonia. In contrast, the basic activated sludge process consists of an aeration tank in which the influent wastewater is mixed with a suspension of micro-organisms, and a settling tank, where the suspension is separated from the treated effluent and recycled back to the aeration tank.

The biological reactions which occur in both types of process are extremely complex and are influenced by a large number of external factors and process design variables.

The requirements of new legislation and the need to provide secondary treatment at sites where space is restricted has resulted in several alternatives to activated sludge processes (or biological filtration) being proposed. Many of these alternatives are, in fact, new variations of the basic processes, often of a proprietary nature, but some are based on entirely different principles.

The effluent from appropriately designed secondary treatment processes can be of very high quality expressed in terms of BOD, COD etc. but is not usually reduced in bacterial numbers to any great extent – the exception to this statement is the MBR process which is described in section 2.4.2. The effluent from a conventional secondary treatment plant will typically contain about 100,000 to 1,000,000 bacteria per 100 ml.

### 2.4.2 Activated Sludge Processes

#### Conventional Processes

The activated sludge process was first discovered and developed over 85 years ago. The advantages of this process in comparison with existing methods of wastewater treatment soon became apparent, and full-scale facilities were installed in several countries within a few years. Since that time, many variations of the basic process have been developed and activated sludge systems are commonly used world-wide wherever a high standard of wastewater treatment is required. Tens of thousands of installations are in existence and these range from sites which serve populations of a few hundred to those which serve the largest cities in the world.

The microbial reactions that occur in activated sludge systems are extremely complex but the overall process is sufficiently well understood to allow confident design of suitable systems for a wide range of effluent quality and a variety of site conditions. This flexibility has resulted in the development of a large number of variations of the process and it is not unusual for separate installations designed to produce similar effluent quality being quite different in terms of tank geometry. It is therefore difficult to define what is meant by a conventional process. For the purposes of this report a conventional plant can be considered to conform to the principles described below. Process variants which are markedly different and which may be appropriate for wastewater treatment on Guernsey are described separately later in this section.

Activated sludge systems make use of a few important principles which are common to every 'conventional' process variation which has been developed.

- All activated sludge plants must provide a suitable environment for naturally occurring micro-organisms to grow and reproduce using the organic material in wastewater as a food source. Except in certain specialised applications, the micro-organisms which perform this function require oxygen for respiration and this must be supplied, usually from air. This mixture of respiring micro-organisms and wastewater, (known as mixed-liquor), is therefore held in an aeration tank for sufficient time to provide the degree of treatment required.

- Following aeration, a separation stage (final settling tank) is provided, which allows the micro-organisms to settle under the action of gravity, leaving behind a clarified effluent which is discharged. The separated micro-organisms are recycled to the beginning of the process where they are continuously mixed with influent wastewater. The aeration and settlement stages are therefore connected by the recycle line and the performance of each process is dependent on the other. The correct design of final settling tanks is vital to the overall performance of an activated sludge process

- As the micro-organisms grow, they reproduce and the mass of microbial cells increases. In order to control the process and maintain the proper degree of treatment, it is necessary to remove a fraction of the micro-organisms from the system so that the concentration of microbial cells remains reasonably constant. The sludge removed is known as 'surplus activated sludge', (often abbreviated as SAS) and it must be treated and disposed of in an appropriate manner.

The essential features of a 'conventional' activated sludge process are therefore:

- An aeration tank where the influent wastewater is mixed with a population of micro-organisms and supplied with oxygen.

- A settling tank, which separates the microbial cell mass from the treated effluent.

- A system for recycling the separated micro-organisms to the aeration tank.

- Some means of removing excess micro-organisms from the system so that the process can continue to operate under reasonably constant conditions.

The basic flow sheet of a conventional activated sludge plant is illustrated in Figure 2.2. Appropriate process design procedures can be used to establish aeration tank volumes, final tank surface areas and sludge production rates, all of which are compatible with the required effluent quality.

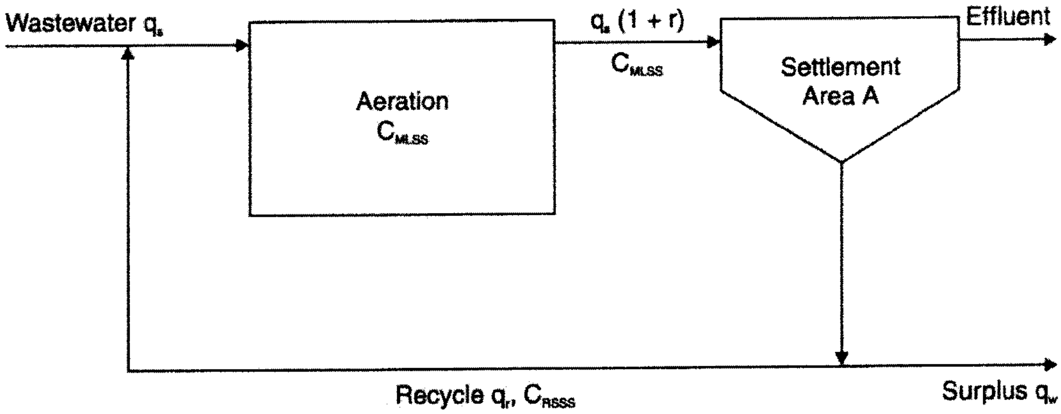



**Figure 2.2 Activated Sludge Flow Sheet**

The operating costs of activated sludge systems are high and these costs are associated with the energy required to supply air to the process. The need to reduce these costs without affecting the effluent quality achieved has led to the introduction of many innovative aeration systems of greater efficiency.

There are no real limits on the size of aeration tanks but in practice it is usual to strike a balance between the cost of multiple parallel units and the need to be able to take a unit out of service for maintenance without affecting treatment performance.

Site constraints may demand the use of very deep tanks. In such cases it may be necessary to use specific process variants or a particular type of aeration equipment.

The importance of efficient final settlement to the overall performance of activated sludge systems is such that a large number of design variations exist for the purpose of promoting effective solids separation. The most important and obvious variation is the choice between rectangular and circular tanks. In the UK there are hardly any rectangular final tanks at sites treating domestic wastewater but this shape is widely used in the rest of Europe and the USA. For circular final tanks the most common design involves feeding mixed liquor to the centre of the tank into a circular "stilling well". Settled sludge is removed centrally from the bottom of the tank which is usually constructed to slope towards the centre in order to facilitate sludge removal. Clarified effluent is removed from the periphery of the tank.

To ensure operational flexibility, a minimum of two settling tanks are normally required and the spacing between tanks should not be less than 3 m to permit access for maintenance and repairs.

One of the most important operating problems which affects the performance of activated sludge plants is poor sludge settleability, or sludge bulking. Sludge bulking is caused by the excessive development of various filamentous types of micro-organism, which, although capable of performing wastewater treatment, do not settle readily. The development of filamentous micro-organisms can be prevented or controlled by incorporating various features into the process design of the aeration tank, which are known to exert a 'selector' effect. Thus, micro-organisms with good settling properties are selected in preference to filamentous species, usually by exploiting known differences in their metabolic requirements. Aeration tank geometry is an important aspect of selector design.

**The oxidation ditch**

At small sites, activated sludge plants with aeration tanks constructed on the oxidation ditch principle are often more cost-effective than conventional designs. The aeration tank in an oxidation ditch process is like a 'race track' in plan and the principle of operation involves continuous re-circulation of mixed liquor as indicated in Figure 2.3. In most designs of oxidation ditch the aeration tank is only aerated at specific points in the circuit. Oxidation ditches are normally used to treat crude sewage at sites where primary tanks have not been installed. Hence, the main design difference between an oxidation ditch and a conventional aeration tank is the aeration tank volume, which is typically much larger in an oxidation ditch in order to deal with the higher concentration of BOD in crude sewage. The overall cost of treatment is increased since it is more expensive to remove BOD by aeration than by sedimentation in a primary tank. In addition, it is more difficult and expensive to treat the SAS from an oxidation ditch when there is no primary sludge available to improve overall sludge dewatering characteristics.

The final settling tanks associated with oxidation ditches are identical, in principle, with those installed with conventional processes.

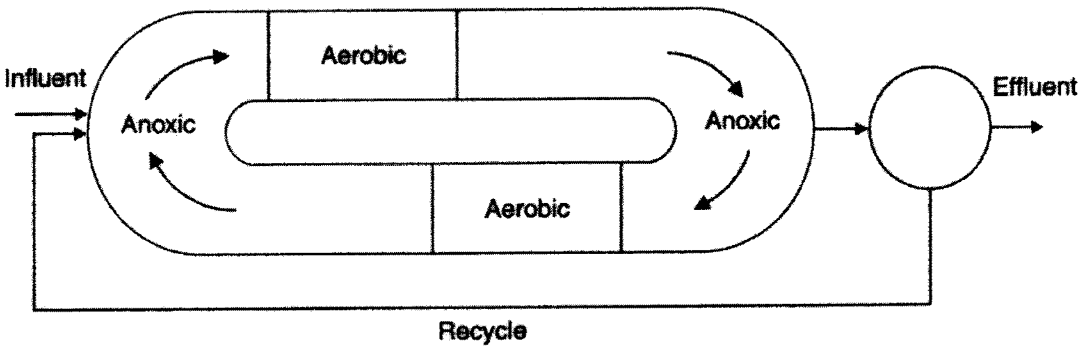



**Figure 2.3 Oxidation Ditch Configuration of Activated Sludge Process**

**Deep Shaft Process**

The deep shaft process was originally developed as a high-rate activated sludge variant suitable for the treatment of strong, biodegradable industrial effluents. The 'aeration tank' is constructed in the form of two concentric vertical shafts with the wastewater passing down one shaft and up the other. The shafts might typically be up to 50 m in depth and this feature was required to enhance the rate of transfer of the large amounts of oxygen needed for the treatment of concentrated wastewaters. An additional advantage follows from the arrangement of the aeration tank in this way. Deep shaft aeration tanks occupy a small area in relation to conventional systems. This advantage is offset to some extent by the need for an above ground tank for 'degassing' of the highly aerated mixed liquor. This prevents sludge settlement problems. Deep shaft processes also require conventionally sized final settling tanks. A deep shaft system has been installed at Southport in the UK to treat domestic sewage at a confined coastal site. The deep shaft process does not appear to offer any advantages in comparison with other compact activated sludge variants and is not considered further in this report.

**Sequencing Batch Reactors (SBR)**

Recently, in the UK, there has been considerable interest in the variant of the activated sludge process known as the sequencing batch reactor (SBR). SBR systems offer potential advantages to conventional processes in terms of area requirement and performance. In conventional plant the operations are carried out sequentially in different tanks arranged in series. The SBR process involves performing a series of different operations in the same tank as illustrated in Figure 2.4. There is no separate settling tank in an SBR system. Consequently all SBR systems include parallel tanks to ensure that there is always a tank available to receive the continuous inflow of wastewater. Many sub-variants of the basic system have been developed commercially.

Interestingly, SBR systems are not new but are, in fact, based on the original concept of activated sludge. During the 1920's several 'fill-and-draw' activated sludge plants based on the same principles as SBR systems were in existence. In the 1920's these plants were soon replaced by continuous processes since they required heavy inputs of manpower for successful operation. Modern SBR systems operate automatically and their relative simplicity and smaller area requirements are claimed to result in capital cost advantages compared with conventional plant.

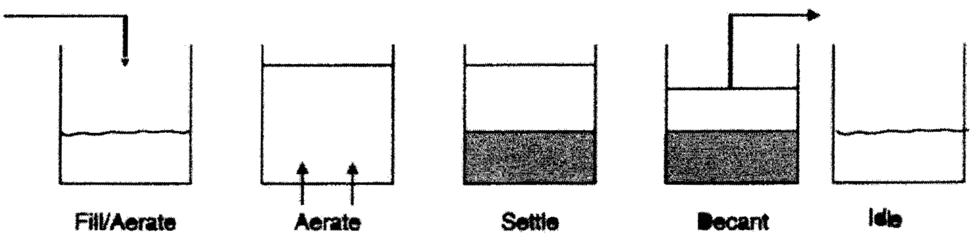



**Figure 2.4 Sequence of operations in an SBR process**

SBR processes are capable of producing very high quality effluents if designed and operated effectively. However, several installations in the UK have not achieved the performance standards required. It has become apparent that:

- The sludge produced in an SBR does not always settle as readily as plant suppliers claim. (Good sludge settleability is usually cited as one of the main advantages of SBR processes). When this happens, excessive concentrations of suspended solids are removed during the decant stage and effluent quality deteriorates. It is important to ensure that the process design of the SBR includes those features which are known to promote good sludge settling properties.

- Problems have been encountered with control system stability. The performance of SBR processes is much more dependent on the automatic control system than a conventional plant. It is extremely difficult to operate a modern SBR process manually and maintain effluent quality.

- The 'small footprint' of an SBR process is largely the result of the need to use deep tanks, (often 6 to 7 m in depth), in order to establish an effective relationship between important design variables. A conventional plant with similarly deep aeration tanks has a footprint which compares favourably with the equivalent SBR process.

- An SBR process is one of the few examples in wastewater treatment where a smaller system performs more effectively than a large plant. This effect is due to the relative ease with which features which promote good sludge settleability can be incorporated into the design of small SBR processes. An SBR process for Guernsey (75000 PE) would be classified as a large plant.

Many plants serve very large populations. In the UK about 15 large SBR processes are in operation.

The small 'footprint' of SBR processes has led to several plants being installed in the UK at sites where space is restricted. However, only a small number of these installations are in environmentally sensitive areas and none have been enclosed in buildings. Very large SBR plants (population 500,000) have been constructed at Bristol (Avonmouth) and Hull. Other plants are in operation at large/medium-sized sites in Yorkshire Water, Southern Water, Northumbrian Water, Scotland and Northern Ireland.

**Membrane Bioreactors (MBR)**

There is considerable interest world-wide in the development and installation of treatment processes based on the use of membranes for solid/liquid separation. In these processes a membrane separation device is installed in an aeration tank containing a high concentration of suspended biomass. Treated effluent passes through the membrane for discharge and the biomass is retained. Thus there is no need for a conventional settling tank and this factor, together with the ability to operate at high biomass concentrations, results in a substantial reduction in the area requirement of the overall process. MBR processes are capable of producing effluent of extremely high quality which can easily meet the requirements of current and proposed legislation

The pore size of the membranes is also small enough to retain bacteria and viruses. Thus, MBR systems can also achieve effluent disinfection, in addition to a high standard of treatment, in a single process stage. Consequently MBRs are usually installed as a 'stand alone' treatment system, without primary treatment. An MBR process has a 'footprint' which is about 20-25% of that of a conventional activated sludge process.

The main disadvantage of early membrane-based treatment systems was the high capital and operating costs. The first MBR installations in the UK were only installed because other constraints, such as land area availability, prevented the use of other systems. However, membrane processes are being actively developed and manufacturers claim that capital costs have been halved, and operating costs reduced by 90%, in the past 10 years. Thus, commercially available processes are now becoming capable of competing with conventional plant on economic terms. The number of MBR installations in the UK is rapidly increasing and

MBRs are now being used for industrial effluent treatment and the treatment of sludge liquors in addition to domestic sewage treatment.

Two proprietary membrane systems are commercially available under licence in the UK (Kubota and Zeno Gem). The Kubota membranes are in the form of 'flat' sheets which are installed vertically in modules. The Zeno Gem system uses membranes in the form of hollow fibres.

The overall economics of MBR processes appears to be strongly dependent on the operational lifetime of the membranes. The oldest units in the UK have been in operation for about 6 to 7 years with few reported problems.

The first full-scale MBR installation in the UK was at Porlock in North Somerset. The treatment site is overlooked by a village and surrounded by hills and the effluent discharges near a bathing beach. The requirement was therefore for a high quality effluent and a compact treatment plant which blended into the landscape. Planning regulations dictated that the plant was housed in a local stone building disguised as a farm property.

A larger MBR plant has recently been constructed at Swanage in Dorset. The plant has been constructed between a marina, a bathing beach and holiday homes. The treatment processes are enclosed and the site is landscaped.

### 2.4.3 Biological Filtration Processes

#### Conventional Biological Filters

Conventional biological filtration processes have been used for wastewater treatment for over 100 years. They can be classified as fixed-film reactors, containing a medium to which the micro-organisms providing the treatment are attached. The use of the term 'filtration' can cause confusion since the treatment process is biological in nature and no physical separation by filtration is involved. Wastewater trickles down through the filter over the surface of the medium in intimate contact with the micro-organisms. Natural or forced ventilation of air between the elements of medium provides the oxygen which is consumed during treatment. As in other biological processes used for wastewater treatment, micro-organism growth is the natural result, and in a biological filter excess microbial mass eventually becomes detached from the surface of the filter medium and is carried away with the treated effluent. The material produced in this way is known as humus sludge and it is removed, before effluent discharge, by settling under gravity in a humus tank.

The principles of design and operation of humus tanks are very similar to those established for activated sludge final settling tanks. A major difference is that settled humus sludge is not recycled back to the filter but instead all of it is removed periodically from the bottom of the tank and transferred to sludge treatment processes.

The quantity of humus sludge produced by a biological filter is only about half that produced by an activated sludge process under the same operating conditions. At many sites it is convenient and economical to recycle humus sludge to primary sedimentation tanks, where it is allowed to undergo co-settlement with primary sludge as a first stage of treatment. Co-settlement of humus sludge is more commonly used than co-settlement of SAS.

The majority of biological filters are constructed using a mineral medium, though the use of random plastic media or modules of ordered, corrugated plastic packing is becoming more common. Plastic media are more widely used for high-rate and tertiary nitrifying filters. Biological filters rely on the effective distribution of settled sewage over the bed of medium which must be 'wetted' at an appropriate rate by the action of a distributor mechanism. Failure of the distributor mechanism can result in consent failure but most problems of this type are rectified by reactive maintenance before effluent quality is placed at risk. Failure of preliminary screening processes often results in the blockage of distributors with non-biodegradable plastic material.

Biological filters are comparatively expensive in terms of capital cost and they also occupy a large land area. Operational costs are attractive, however, since energy use is minimal. Although biological filters can be designed to produce high-quality nitrified effluents, the process in general is not as flexible as activated sludge and at large sites (over 50,000 PE) there is a tendency to replace existing biological filters with activated sludge plants. Biological filters are now only commonly installed at small sites where sufficient land is available.

**Biological Aerated Filters (BAF)**

BAF systems (Biological Aerated Filters, sometimes called Biological Aerated Flooded Filters (BAFF)) are fixed-film processes where biomass is attached to a well-defined support medium through which wastewater is passed so that the process operates with the medium in a flooded condition. The direction of liquid flow through a filter can be either up or down. Process air is introduced into the system to satisfy the requirements of the micro-organisms. Several commercial variants of the basic process are in existence and the design can be altered to achieve a nitrified effluent standard if required. As treatment proceeds the biomass increases and accumulates on the support medium. Eventually excess biomass must be removed by periodic backwashing with treated effluent and while this process is taking place the unit is out of service. All BAF installations, therefore, consist of a number of parallel units which are sufficient to maintain treatment while backwashing is in progress. Even so, the performance of an individual BAF unit will deteriorate in the period immediately following backwashing.

A wide range of different medium types has been used in BAFs. Typically a suitable medium has a smaller and more uniform particle size than that used in a conventional biological filter. The high surface area supports the growth of a high concentration of micro-organisms and promotes a high rate of treatment. The medium must also possess adequate strength and abrasion resistance to withstand the turbulent flow conditions arising during backwashing.

A conventional settlement tank is not required in a BAF process but a storage tank must be installed for removal of SS from backwash waters. These tanks can occupy a significant land area. However, the high specific surface areas of the media used in BAF processes enables them to operate at high volumetric loading rates. Consequently BAF systems occupy a much smaller land area than the equivalent conventional biological filtration process and, typically, only about 20% - 50% of the area required by an equivalent conventional activated sludge process. The process is fairly expensive in terms of operating cost and the biomass support media is usually installed in deep tanks which could be visually obtrusive if constructed at ground level. However, the small 'footprint' of a BAF process facilitates complete enclosure of the plant within a suitable building and they have found wide application at sites where space is restricted.

The process is fairly expensive in terms of operating cost, largely because of the process air requirements, which are similar to activated sludge. BAF processes are not suitable for the treatment of crude sewage and they must be installed following a primary treatment process. BAF processes were originally developed in France, often by the same companies which developed lamella separation technology. As a result the combination of a lamella primary treatment process followed by a BAF plant for secondary treatment is quite common. A number of installations of this type are in operation in the UK.

- Central Plymouth (population 100,000) is served by a treatment plant which includes a 'Densadeg' primary lamella settlement process followed by 'Biofor' BAF units and UV disinfection. The treatment plant is completely enclosed within a building and a 3-stage chemical odour control system prevents odour nuisance within the building and externally.

- Ilfracombe, a popular holiday resort on the North Devon coast, is served by a 26,000-population treatment plant based on the Biostyr BAF process. The entire plant, which is constructed close to the centre of the town, is enclosed and the roof of the building is used as a public car park.

- The City of Aberdeen is served by lamella separator and 2-stage Kvaerner BAF treatment process.

Several other BAF installations (not all of which follow lamella settlers) have been constructed at sites where space is restricted around the UK coastline. Examples include Criccieth, (Welsh Water), Lyme Regis, (Wessex Water), Poole, (Wessex Water – this is a Densadeg/Biofor combination for a population of 150,000), Eastbourne, (Southern Water), Milford Haven, (Welsh Water – population 20,000), Salcombe, (South West Water – population 10,000), St. Austell, (South West Water – population 40,000), Hayle, (South West Water – serves the St. Ives, Penzance and Hayle catchment, population 140,000), Exmouth, (South West Water), Combe Martin, (South West Water). Many of the installations described above include UV systems for effluent disinfection and all include preliminary processes for screening and grit removal

Many BAF processes are proprietary and there is a lack of performance data in the technical literature. Certain design features are commercially protected and have not been made available in the public domain

## 2.5 Tertiary Treatment Processes

### 2.5.1 Sand Filtration

Until recently the BOD and suspended solids concentration limits for discharges to most receiving waters could be met by secondary treatment processes. In many instances it is now necessary to provide a higher standard of treatment by the provision of various designs of sand filter for enhanced suspended solids and BOD removal. Tertiary filtration processes are designed to operate with influent streams which are already of reasonably high quality. If the influent contains excessive concentrations of SS then the filter will need to be backwashed at frequent intervals. An increase in the number of filter backwash cycles is usually an indication of an operating problem in an upstream treatment process. Tertiary sand filters are commonly installed at sites where the suspended solids or BOD limit is less than about 10 mg/l on a

95%-ile basis. Such processes would not normally be required in order to comply with the UWWTD standards for BOD, suspended solids and COD removal. If the receiving water quality objectives for Guernsey can be met by achieving wastewater treatment standards similar to those required by the UWWTD then tertiary sand filtration processes would not be needed for installation on Guernsey.

### 2.5.2 Disinfection Processes

**Introduction**

Marine treatment systems of the 1980's relied on dispersion from long outfalls and disinfection was not otherwise practised. In recent years a major investment in tertiary treatment has occurred in the provision of disinfection processes at coastal treatment sites to meet the requirements of the Bathing Water and Shellfisheries Directives. Disinfection is required at most coastal discharge sites in the vicinity of bathing beaches in the UK but is not normally practised for discharges to inland watercourses.

Properly designed and operated disinfection processes can reliably achieve performance levels of less than 10 indicator bacteria per 100 ml when treating good quality secondary effluents. This value compares with values of $10^9$, $10^7$ and $10^5$ indicator bacteria per 100 ml for crude sewage, primary effluent and good secondary effluent respectively.

A variety of alternative disinfection processes have been investigated. Chlorination is widely used for disinfection of effluents from wastewater treatment plants in many countries in Europe and is appropriate for all works sizes. Chlorination has been found to be cost-effective in the inactivation and destruction of pathogens and indicator micro-organisms such as faecal coliforms and *E. coli*. However, chlorination is relatively ineffective for virus inactivation.

Recently there have been well-founded environmental concerns about the effect of chlorination by-products on receiving waters. In general recognition of the possible adverse environmental effects the UK Environment Agency has prohibited the use of chlorination for disinfection. Disinfection processes which use ultra-violet radiation are competitive with chlorination in terms of capital and operating cost, have been proven to be effective and are now widely installed throughout the UK. Thus, chlorination is not considered further in this report.

**UV Radiation**

UV disinfection is essentially an enhancement of a natural process which occurs when bacteria are exposed to sunlight. Unlike chemical methods of disinfection, UV radiation produces no known toxic residuals and there is no requirement for the storage of potentially hazardous materials. UV disinfection systems are compact, effective, and economic, providing the effluent is already treated to a fairly high standard, and they have rapidly become established as a preferred method of wastewater disinfection.

Ultraviolet (UV) radiation for wastewater disinfection is generated from mercury vapour lamps which are contained within individual quartz or PTFE sleeves to prevent contact with the wastewater being treated. The lamps are usually installed as pre-fabricated modules in effluent channels. The effluent depth is controlled by weirs, or some other arrangement, to keep the lamps submerged and maintain uniform flow conditions.

The effectiveness of UV radiation as a disinfectant depends on transmission of the light through the wastewater. The protective sleeves which contain the lamps adsorb only a small amount of UV light but the transmission through wastewater is a function of turbidity and distance travelled. Typically the transmission of UV light through 1 cm of good quality final effluent is about 45-65%. During use the UV lamp tubes become fouled with organic and inorganic deposits and light transmission is reduced. Automatic cleaning equipment is often installed and this usually involves the use of flexible plastic rings which are moved periodically along the length of the tubes to remove fouling.

Ultraviolet radiation is a physical disinfectant which penetrates the cell walls of micro-organisms and causes photochemical changes to the nucleic acids. This action either prevents cell replication or results in the production of mutant daughter cells. Some micro-organisms are able to 'repair' cell damage after exposure to UV light and the recovery in bacterial numbers needs to be allowed for in system design.

## 2.6 Stormwater Treatment

The vast majority of wastewater treatment plants in the UK and elsewhere are designed to provide full treatment to a defined maximum flow. When the wastewater flowrate is above this maximum value, it is conventional practice to divert the excess flow away from the main treatment processes, upstream of primary treatment, and pass it to large 'storm tanks', where it is retained for a specified time. If the flow of wastewater remains high for a sufficient period then the storm tanks eventually overflow and discharge to the receiving water. Fine screens are required at storm tank outlets to prevent aesthetic pollution.

The maximum flow which receives full treatment is usually '3 DWF', where DWF is the dry weather flow. This flowrate should only occur in wet weather but the frequency with which it occurs is catchment dependent. Storm tanks are normally specified to provide capacity to retain flows between 3 DWF and 6 DWF- usually described as 2 hours retention at 3 DWF, (or 1 hours retention at 6 DWF). Flows in excess of 6 DWF are usually diverted from further upstream of the primary tanks and allowed to by-pass the treatment plant after passing through fine screens. Wastewater held in storm tanks is pumped back for full treatment when the influent flowrate falls below 3 DWF.

Thus, at a typical treatment plant, influent flows up to 3 DWF receive primary and secondary treatment (and any further stages, if installed), flows between 3 DWF and 6 DWF receive treatment in storm tanks and fine screening; and flows in excess of 6 DWF receive fine screening only. However, many variations of this arrangement are in existence.

The construction of storm tanks is virtually identical to conventional primary tanks and at many sites the storm tanks and primary tanks have the same dimensions.

The provision of adequate storm tank capacity at coastal sites often gives rise to major difficulties:

- The problem of providing retention time cannot be solved by compact plant since the basic requirement is one of volumetric capacity. Storm tanks have similar or identical areas to primary tanks at a given site.

- Coastal discharges which occur in the vicinity of bathing beaches and shellfisheries are regulated in the UK by limits on the frequency of storm overflow discharge.

Compliance with the Bathing Water Directive means that no more than 3 discharges per bathing season are allowed. Similarly, the limit for compliance with the Shell Fisheries Directive is no more than 10 discharges per year.

- Stormwater discharges are usually not amenable to effective disinfection by UV since UV transmission is seriously reduced by the residual suspended solids in the stormwater. The bacterial numbers in stormwater discharges would typically be similar to those in the effluent from primary sedimentation tanks.

At some sites in the UK the problem of preventing excessive stormwater discharges has been addressed by using the sewer network to provide the retention capacity. This solution is catchment dependent and, if practical, is expensive to implement.

On Guernsey, the existing long sea outfall is an obvious asset which could be used to minimise the impact of stormwater discharges. It is not possible, without a detailed study, to decide if the outfall needs to be used in conjunction with storm tanks, or if the available dispersion at the end of the outfall means that storm tanks are not required.

# 3. SLUDGE TREATMENT PROCESSES

## 3.1 Introduction

There are three options for the ultimate disposal of the sludges produced in wastewater treatment. These are landfill, agricultural recycling and incineration. Sludge treatment processes are used to bring the sludge to a condition where it is suitable for the chosen disposal route. Sludge disposal is subject to EU Directives and Guidelines and the Regulations have gradually been made more stringent. The costs of sludge treatment and disposal are significant and depend not only on the volume of sludge produced but also on characteristics such as the ease of dewatering. In the UK there has been a steady investment in improved sludge treatment processes in order to secure a particular disposal route at the optimum cost

In general, sludge treatment processes are installed to reduce the water content of the sludges produced in wastewater treatment and to achieve a degree of stabilisation and pathogenic micro-organism reduction commensurate with the available disposal route. Sludge treatment processes, like wastewater treatment processes, are arranged in a logical sequence. Several successive stages of treatment are usually required and the number of possible process combinations is quite large. Primary and secondary wastewater treatment processes produce sludges with different characteristics and it is possible to either treat the sludges together or in separate process streams. Secondary sludges are usually more difficult to dewater than primary sludges. It is recognised that the presence of SAS in a sludge mixture adversely affects thickening and dewatering characteristics and that digested sludges are difficult to dewater. At the present time there is, in some UK Water Companies, a trend away from the initial co-settling option towards separate thickening of primary and secondary sludges. At small sites it is common to install only preliminary dewatering processes prior to transport of partially treated sludge to a large regional centre for further treatment and disposal. It is widely recognised that imported sludges will vary considerably in solids content and dewatering characteristics.

Sludge treatment often presents difficulties at coastal sites and strategies might need to be developed which take account of the characteristics of sludge produced by compact treatment processes and the environmentally sensitive nature of the areas in which such plants are usually located. Thus:

- The treatment processes used for sludge stabilisation at large sites cannot easily be constructed as compact plant. It is therefore sometimes necessary for even a large wastewater treatment plant in an environmentally sensitive area to rely on off-site sludge treatment.

- The number of vehicle movements required to remove sludge from an environmentally sensitive site needs to be considered carefully. Sludge pumping, tanker filling and transport are operations with a high potential for odour emission.

- Some compact treatment schemes do not include primary treatment processes. The sludge produced in such installations will have characteristics which are similar to a typical secondary sludge. Secondary sludges alone are more difficult to dewater than mixtures of primary and secondary sludge. In addition, secondary sludge is not so amenable to anaerobic digestion, a commonly used sludge stabilisation process.

Despite these complications it is possible to establish a typical sequences of sludge treatment processes for a site of medium size (such as Guernsey) by reference to the processes which have been installed at several similarly sized sites in the UK. A treatment sequence, which is suitable for disposal by recycling and which would not involve co-settling of primary and secondary sludges, is described below:

- Gravity Thickening – the solids concentration of the primary sludge is increased by sedimentation. This process is useful for primary sludges but is not so effective for secondary sludges.

- Mechanical Thickening – the solids concentration of secondary sludge is increased by various proprietary designs of equipment, which normally enhance dewatering characteristics by the addition of suitable polymer materials. Such processes are particularly useful for SAS and can also be expected to be suitable for imported sludges and the sludge from BAF plants.

- Anaerobic Digestion of mixed, pre-thickened primary and secondary sludges – a properly designed process reduces the pathogen content of the sludge to the levels required for recycling. A significant proportion of the sludge solids is also converted into gaseous products such as methane and carbon dioxide. The amount of sludge which passes to subsequent treatment processes is therefore reduced. Anaerobic digestion is normally used for mixtures of primary and secondary sludge. Secondary sludges alone are not very amenable to separate anaerobic digestion.

- Mechanical Dewatering – the solids concentration is further increased. Three types of equipment are in common use. These are filter plate/membrane presses, belt presses and centrifuges and all require the addition of polymers for effective performance. The first type is gradually being replaced by the last two, and new installations are infrequent.

The end product of this sludge treatment sequence would be a stabilised sludge of about 20 – 25% solids concentration, which would be easily handled and readily transportable.

If the available sludge disposal route were incineration, then it would not be necessary to include anaerobic digestion in the treatment sequence and both capital and operating costs would be reduced considerably. The end product would again be a sludge cake of 20-25% solids concentration.

More advanced sludge treatment processes, such as thermal drying, have been installed at a number of sites in the UK where the security of the sludge disposal route cannot be guaranteed by the installation of treatment sequences such as those described above. The available information does not suggest that thermal drying, or other similar processes, would be required as part of the sludge treatment sequence for Guernsey, for sludge disposal either by recycling or incineration.

The removal of water from sludge results in the production of liquid streams which are contaminated with high concentrations of pollutants and which must be treated before discharge. It is standard practice at most sites to recycle these liquid streams to the primary sedimentation tanks for further treatment. The contribution of recycle liquors to the total pollutant concentrations must be taken into account in the design of the wastewater treatment processes.

The following sections provide brief descriptions of some commonly used sludge treatment processes.

## 3.2 Sludge Thickening Processes

### 3.2.1 Gravity Thickening

Sludge thickening by gravity is a cost-effective process for reducing the volume of sludge for subsequent treatment and disposal. It relies on the ability of wastewater solids to combine together to form flocs, which can then undergo gravity settlement, followed by compression, as the floc particles come into contact with each other.

Gravity thickening is performed in circular tanks which are similar to circular primary sedimentation tanks. The extent to which a sludge can be thickened depends upon physical properties such as density and particle size and also on upon the process from which it was derived. Secondary sludges from high-rate processes and digested sludges are particularly difficult to thicken. The scraper mechanism associated with a gravity thickener is important in ensuring good performance. The scrapers should incorporate a 'picket fence' mechanism, which not only helps consolidation by promoting upward flow of supernatant but also allows trapped gases to escape Failure will result in inadequate thickening and the production of a dilute sludge and a more concentrated supernatant liquor. The performance of both downstream and upstream processes can be adversely affected. Table 3.1 indicates the range of thickened sludge concentrations which can be expected in practice for various types of sludge. The poor thickening characteristics of SAS and digested sludges, and mixtures containing these sludges, have resulted in gravity thickening being used almost exclusively for primary sludge.

**Table 3.1 Typical Performance of Continuously Operated Gravity Sludge Thickeners**

| Sludge Type | Thickened Sludge Concentration ($kg/m^3$) |
|---|---|
| Primary | 70-90 |
| Primary + Humus | 50-80 |
| Primary + SAS | 30-40 |
| Humus | 20-40 |
| Activated (SAS) | 25-35 |
| Digested | 40-60 |

Gravity sludge thickeners are usually constructed as circular tanks of up to 20 m diameter with sidewall depths of about 4 m. It is important to operate thickeners at the design solids load, and to allow for future increases by constructing spare capacity as separate tanks.

### 3.2.2 Mechanical Thickening

Gravity thickening is not usually very effective for SAS or co-settled primary sludge plus SAS. Experience has shown that it is often better to thicken SAS separately using mechanical thickening processes. A variety of mechanical thickening equipment is commercially available and all types rely on flocculation of sludge solids by the addition of a controlled dose of a suitable polyelectrolyte. The flocculated solids form large clumps from which water can drain more readily. The two most common types of equipment are:

- Belt thickeners, where the feed sludge is allowed to drain through a porous belt on a continuous basis. Performance depends on polymer dosing at a pre-determined rate. Most types of mechanical thickener employ some means of repeatedly breaking up and redistributing the flocculated sludge to enhance removal of water by gravity drainage through the belt.

- Drum thickeners, where the flocculated sludge is gently rotated on the inner surface of a slightly inclined perforated drum. Internal blades or similar devices continually break up the sludge and promote drainage without damaging the floc structure

The equipment is sized so that the loading rate of sludge results in an adequate retention time for thickening. Mechanical thickening is usually capable of achieving solids concentrations of about 5 – 6% dry solids with SAS.

## 3.3 Anaerobic Digestion

Anaerobic digestion is a well-established and widely used sludge treatment process which is known to be capable of producing sludge suitable for disposal by recycling to agriculture or horticulture. The digested sludge is reduced in both volume and pathogen content in comparison with the raw feed sludge. The digestion process results in the generation of considerable amounts of methane gas, which, at large sites, can be utilised as an energy source.

The process involves holding the sludge to be treated in a tank, in the absence of air, usually at a temperature in the range 30-37°C for a period between 12 and 35 days. The anaerobic reactions are usually assumed to take place in two reasonably distinct stages. In the first stage organic material is broken down into simpler substances which are acidic in nature. In the second stage, these intermediate products are converted to methane together with smaller amounts of carbon dioxide. Other reactions result in the production of ammonia and hydrogen sulphide.

Anaerobic digestion, in the absence of any inhibition, can usually achieve a reduction in sludge volatile suspended solids of between 35 and 50%. Gas production is usually about 1 $m^3$/kg of solids destroyed and the gas usually contains 60-70% methane and 30-40% carbon dioxide. Other gases such as hydrogen sulphide are usually present in trace amounts by comparison. Typical digester gas has a calorific value of about 22 MJ/$m^3$.

Anaerobic digestion has traditionally been seen as a suitable treatment process for sludges destined for agricultural land disposal. The temperatures reached in the process result in a substantial reduction in pathogenic organisms, but if the operating temperature falls below 25°C then the destruction of pathogens is significantly reduced and the efficiency of the process in terms of gas production and solids reduction also declines.

Digestion tanks are normally constructed of reinforced concrete, and a large part of the structure is often below ground to enhance insulation against heat loss. Smaller digesters have been constructed of insulated steel plate. Recent installations are usually of fixed volume in preference to the older, floating roof designs and separate gasholders are employed to control the digester headspace pressure and accommodate variable gas production rates. Gas re-circulation systems are now widely used for mixing and have reduced maintenance requirements since there are no moving parts in contact with the sludge.

The temperature range of 30 to 37°C is known as the mesophilic range and nearly all anaerobic digesters operate within it. It is possible to design anaerobic digesters to operate at much higher temperatures (the thermophilic range) and achieve rapid destruction of pathogens. Thermophilic anaerobic digestion is being investigated by a number of UK Water Companies.

The destruction of sludge and the production of methane in anaerobic digestion reduce the calorific value of digested sludge to a level which makes subsequent incineration difficult without the use of an external fuel source. Thus, if incineration is the available sludge disposal route then anaerobic digestion is not required as part of the sludge treatment sequence.

## 3.4 Mechanical Dewatering Processes

### 3.4.1 Introduction

Dewatering of wastewater sludges is widely practised to reduce the volume of solids for final disposal and to produce a more easily handled material. Sludge dewatering reduces the transport costs if it is necessary to move the sludge solids off site and is cost-effective for all disposal options.

The three main equipment options for mechanical dewatering are centrifuges, filter belt presses and filter plate/membrane presses. All require the addition of flocculation and conditioning chemicals to achieve optimum performance. Various polyelectrolytes are commercially available and these are now used almost universally for sludge flocculation. It has been found that the initial mixing of the polyelectrolyte and the sludge is important and special in-line mixing devices are now available and widely used. The dose of conditioner must also be carefully controlled to maintain optimum performance. It is normal practice to install standby capacity.

The choice of equipment depends on the solids concentration required in the dewatered sludge, and on cost considerations, which should include the cost of the conditioning chemicals.

### 3.4.2 Filter plate/membrane press

A typical filter press consists of about 50 to 80 separate plates, each of which is recessed and fitted with permeable filter cloths. Sludge is fed into the recesses under pressure while the plates are held together and the filtrate is forced out through the filter cloths. Feed pressures of about 500-700 kPa are required to obtain high solids concentration cakes. Filter pressing is essentially a batch operation and while opening and closing of the plates is usually automatic, cake discharge remains essentially a manual procedure.

More recently developed membrane presses are fitted with a flexible rubber membrane on one side of the dewatering chamber. At the end of a filtration cycle compressed air is forced into the membrane which expands and squeezes the cake. This produces a slightly higher cake solids content. Applying the membrane pressure before each chamber is completely full of solids can also be used to decrease overall filtration time and increase the number of pressings made per day.

Filter plate/membrane presses are not now so widely installed in the UK as belt presses and centrifuges. The batch operation is relatively labour intensive and the equipment needs to be housed in a two-storey building to allow sludge to fall from the presses on discharge.

### 3.4.3 Belt Filter Press

Belt filter presses are quite complex items of equipment, which have found wide application at all sizes of wastewater treatment plant for the dewatering of most combinations of sludge.

Belt presses are available from several manufacturers and design details differ. The equipment is also being continually improved as a result of operational experience. Figure 3.1 illustrates the operating principles of a typical belt press.

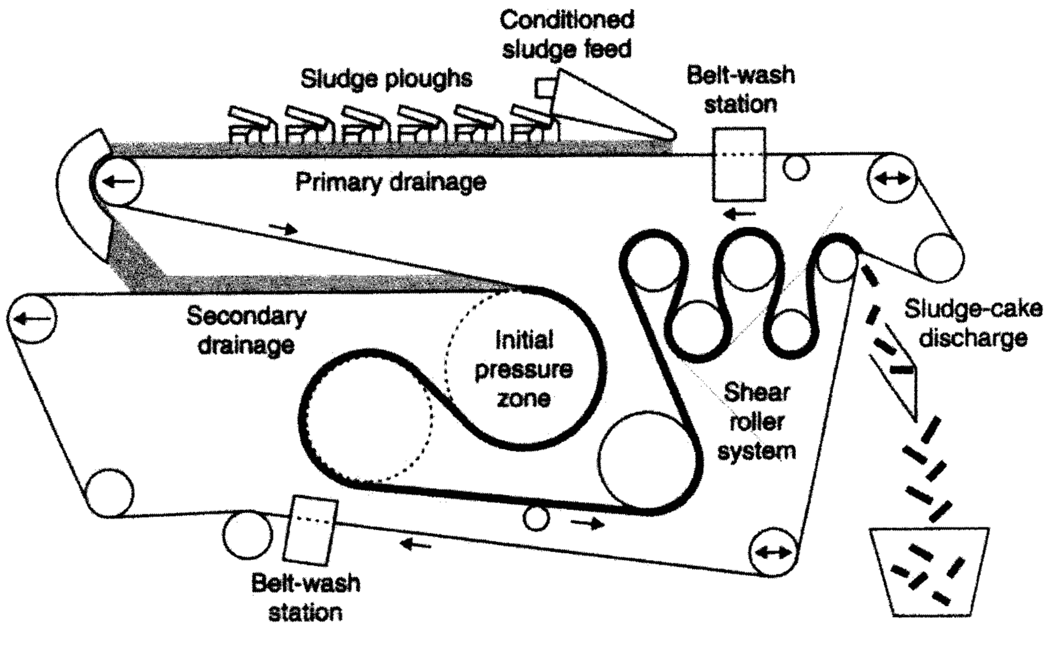



**Figure 3.1 Illustration of Operating Principles of a Typical Belt Filter Press**

A belt press uses two endless porous belts (upper and lower) to apply pressure to a layer of flocculated sludge. The sludge is trapped between the belts as they converge and pass along a tortuous path around successive rollers. The mechanical 'squeeze' applied to the sludge increases as the roller diameter decreases. Dewatered sludge is lifted from the belt and removed at the discharge end of the machine.

Filtrate is produced at several stages of the process and is collected from beneath the moving belts. It is necessary to wash the belts with clean water at high pressure to prevent them becoming 'blinded' by fine sludge particles. Filtrate can be used for this purpose but clean wash water is generally preferred. Inadequate belt washing leads to a loss in dewatering performance.

The capacity of a belt press is largely determined by the width of the belt and the belt speed. It is important to distribute the feed sludge across the entire width of the belt to make use of the area available for filtration. Equipment is normally selected to operate in a range well below the manufacturers rated maximum capacity.

Despite their apparent complexity, belt presses are relatively easy to operate. The optimum type and dose of polyelectrolyte is normally established during commissioning and thereafter only minor adjustments should be necessary.

### 3.4.4 Centrifuges

Centrifuges have been used for dewatering wastewater sludges for several decades but it is only in about the last 10 to 15 years that equipment improvements have led to their widespread use. The type of centrifuge most widely used in sludge dewatering operations is the so-called decanter centrifuge. The principle of operation of this type is illustrated in Figure 3.2.

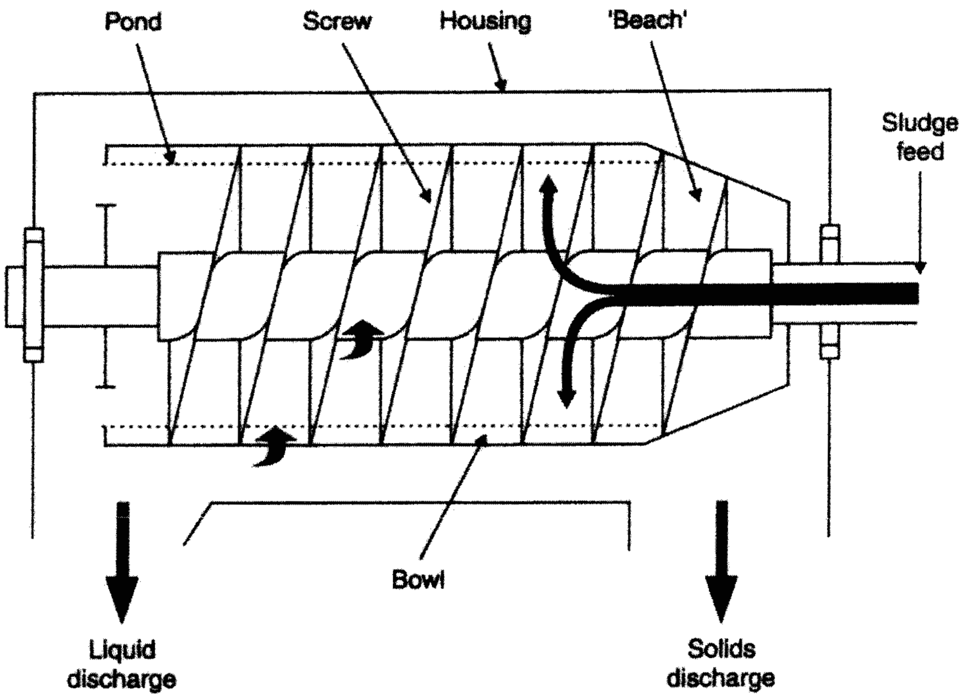



**Figure 3.2 Illustration of Operating Principles of a Typical Decanter Centrifuge**

Sludge, to which polyelectrolyte has been added, is introduced into the central section of a horizontal bowl, which rotates at high speed. The sludge is thrown onto the inner surface of the bowl and liquid/solid separation occurs by the action of 'centrifugal' force. A conveyor, in the form of a helical scroll, moves the separated solids towards the discharge point and further dewatering occurs as the solids are forced up a 'beach' in a tapered section of the bowl. The scroll rotates at a speed which is slightly different to the speed of rotation of the bowl.

The solids content of centrifuge sludge cake depends, like belt press cake, on the origin of the feed sludge and a wide range in performance has been observed with sludges from the same source. Thus, the presence of SAS can be expected to reduce the dewatering performance of centrifuge equipment and belt presses.

There are a number of design and operating variables which affect dewatering performance. The most important are the rotational speed, the relative speed of the helical scroll to bowl, the depth of the 'pond' of separated liquid, the beach angle and the basic dimensions of the machine. In general, increasing the bowl length improves the quality of the centrate (the liquid stream produced by a centrifuge). Increasing the bowl diameter reduces pond depth and improves cake quality but sometimes this is achieved at the expense of centrate solids concentration.

Centrifuges are relatively simple to operate. Many modern designs allow the scroll speed differential, the pond depth and other factors to be adjusted during commissioning. As with a belt press, there should be little need for more than minor adjustments during normal operation.

### 3.4.5 Comparison of Filter Belt Presses and Centrifuges

- Both types of equipment can achieve cake solids concentrations of 20 to 25% dry solids if properly selected and operated. The available operational experience indicates that centrifuges are more often capable of reaching the higher end of this range. This difference can be important if cake stacking and handling characteristics are important.

- Centrifuges are smaller than belt presses for the same duty.

- The capital cost of centrifuges is typically slightly higher than the capital cost of the equivalent belt press.

- The enclosed nature of a centrifuge makes odour control relatively simple in comparison to a belt press, where the free draining stage exposes sludge to the atmosphere.

- The quality of the centrate produced by a centrifuge is generally worse, in terms of SS concentration, than the quality of filtrate from a belt filter treating the same sludge. The optimum polyelectrolyte dose (kg/tonne DS) is usually higher in a centrifuge than a belt press. This increases operating costs.

- The power costs of centrifuges are much higher. Thus, the overall operating costs of centrifuges are considerably higher than belt presses.

- Centrifuges would appear to offer slightly more scope for performance optimisation than belt presses. The operator of a centrifuge has control over the adjustment of more performance-related variables.

## 3.5 Thermal Processes

### 3.5.1 Introduction

Thermal sludge treatment processes are only used at the largest treatment sites where the advantages of economy of scale can be achieved. In general, thermal sludge treatment involves complex M&E equipment which requires careful monitoring and control. The performance of many thermal processes depends strongly on the solids content of the feed sludge. If the feed sludge has a high water content then large amounts of energy will be expended in subsequent thermal processing.

### 3.5.2 Incineration

Incineration is used at about 10 large sites in the UK It is a well-established process which is usually regarded as a disposal route rather than a treatment option. This distinction is unimportant in the context of this report but the need to dispose of the residual ash from sludge incineration must be taken into account. About 30 to 40% of the dry sludge solids is inert ash, which is usually sent to landfill.

Major improvements have been made to sludge incineration equipment since the 1980's and most designs are now based on the use of fluidised bed systems. Sludge incineration is subject to very strict legislation concerning atmospheric pollution but despite this the process is generally not looked upon favourably by local residents. Planning regulations are similarly strict and the process has only been installed at the largest treatment sites.

### 3.5.3 Thermal Drying

Thermal drying of sludge is now quite widespread at large sites and plant exists which can accept raw primary sludges as feedstock. The process requires the input of a considerable amount of energy and operating costs are correspondingly high unless methane generated on site from anaerobic sludge digestion is available as a fuel source. The product from a thermal drier such as the 'Swiss Combi', or similar processes, typically contains about 80 to 90% dry solids and is inoffensive, pathogen free and of potential value for land application. Dried sludge is also much reduced in volume and is usually produced in the form of easily handled pellets which can be easily stored during periods when land access is not possible. These advantages offset the high capital and operating costs of the process to some extent but the process is normally only installed where flexibility is required because permanent access to a disposal route might not be possible. Under normal circumstances, thermal drying is not necessary prior to incineration. Odour and dust production during the drying process can cause nuisance problems. Operating experience has revealed that there is a risk of spontaneous combustion of the dried sludge product and in some cases dust explosions have occurred in the driers.

### 3.5.4 Other Thermal Processes

New thermal processes are being developed and installed to meet the changing requirements of legislation and to safeguard disposal routes. Most of these processes involve the application of various combinations of high temperature and pressure to partially dewatered sludge to produce a stable, completely sterile product suitable for land application. A high level of operator skill is required and such processes have only been installed at a few large sites.

# 4. EFFECTS OF SALINE INTRUSION ON WASTEWATER TREATMENT PROCESSES

## 4.1 Introduction and Background

Operating experience has shown that some types of wastewater treatment process which are suitable for installation at coastal sites can be adversely affected by the increased levels of salinity found in coastal wastewater flows. In addition, saline intrusion has also been observed to result in increased potential for odour generation and to cause problems with sludge treatment and disposal.

In coastal areas saline intrusion into sewer systems usually occurs by infiltration from groundwater in low-lying parts of the catchment. The groundwater salinity is often variable on a daily and seasonal basis as a result of the local tidal range and rainfall events.

The salinity levels in coastal ground water do not usually approach those of undiluted seawater (about 35 g/l). In some instances, seawater enters treatment plant outfalls during high tides but the hydraulic layout of the processes prevents adverse effects on treatment performance. However, some coastal sewer systems include several storm overflows located near the mean high-tide level and there is a possibility of seawater entering the system directly during exceptionally high tides.

## 4.2 Effect of Salinity on Biological Treatment Processes

Saline infiltration is not usually a problem when only preliminary or primary treatment is provided, although there is some evidence that exceptionally high salinity levels can prevent effective settlement in primary tanks and result in reduced removal of suspended solids and BOD. It is thought that salinity inhibits coagulation of solid particles and also causes disruption of bacterial cells which releases soluble BOD. Such effects, where they have been observed, are not usually too detrimental to the overall performance of the process.

High wastewater salinity has a much more serious effect on biological processes and a considerable amount of research has been published on the concentrations which can be tolerated by commonly installed processes before treatment performance is adversely affected. Unfortunately, much of this research has resulted in conclusions which are inconsistent and contradictory and it is evident that little work has been performed on the response of pilot-scale or full-scale plant. However, it is possible to make the following statements with reasonable confidence.

- In general, high salinity levels in wastewater impose a stress on the micro-organisms which perform biological treatment. At low salt concentrations cell respiration is affected and the treatment rate is reduced. At higher concentrations, the differential cell osmotic pressure can result in cell disruption and release of cell contents. Treatment efficiency is then seriously reduced and the released cell material causes increased BOD concentrations and turbidity levels.

- Nitrification is more sensitive to high salinity then the microbial processes involved in BOD removal. The specific micro-organisms which are involved in nitrification are known to be generally intolerant of extreme environments and are much less robust than the large range of heterotrophic bacteria which can achieve BOD removal. Coastal treatment sites where nitrification is required before effluent discharge are likely to present more of a design and operational challenge than those sites where the discharge standard only includes BOD and suspended solids.

- Biological processes are more tolerant of sustained high salinity levels than constant fluctuations in the salt concentration. Adaptation of micro-organisms to gradual increases or decreases in salinity occurs as a result of natural selection from the mixed population of bacteria present in a biological system. Sudden changes in salinity prevent the development of micro-organisms which are tolerant to either extreme. There is evidence that activated sludge micro-organisms which have developed in 'fresh' water are more tolerant to shock loading of salinity than are micro-organisms from saline water which are suddenly exposed to fresh water.

The confined coastal sites available for construction of plants do not usually lend themselves to the processes, or process modifications, which can overcome salinity problems. The high-rate, low-retention time processes which are often installed do not usually have the capacity for flow balancing and load attenuation which could reduce the effect of rapid variations in salinity. Conventional activated sludge plants have been shown to be capable of treating wastewater with chloride concentrations of about 10,000 mg/l without performance being impaired, providing there is no requirement for nitrification. The rate of nitrification has been shown to be reduced to about 20% of its freshwater value by chloride concentrations in the range of 10,000 – 20,000 mg/l. Some studies have shown that long retention time activated sludge systems can successfully treat wastewater containing up to 30,000 mg/l of sodium chloride. This is a concentration approaching that found in typical seawater.

The effect of high salinity on biological filters has been shown to be similar to activated sludge. Sodium chloride concentrations of about 10,000 mg/l will begin to reduce the rate of nitrification and serious deterioration will occur at concentrations of 20,000 mg/l. Low variable concentrations are tolerated less readily than high constant concentrations. BOD removal is less affected than nitrification performance.

Conventionally designed activated sludge systems or biological filters are generally not installed at coastal treatment sites because of the relatively large land area required. This is especially the case with biological filters.

Operating experience with BAF plants in the UK has shown that problems have occurred at those coastal sites where high salinity wastewaters are treated. It has been observed that, under highly saline conditions, the biomass in BAF systems can exude a polysaccharide slime, which adheres strongly to the support medium. This polysaccharide, which appears to be produced in response to microbial stress, protects the micro-organisms from the adverse effects of salinity by providing an external protective layer which also acts as a source of nutrients. Treatment performance is adversely affected and, in addition, the polysaccharide coating is difficult to remove by normal backwashing.

SBR systems have been installed at a few coastal sites in the UK. There is no direct evidence available that they are capable of dealing with high salinity wastewater but the basis of their design involves on inherent degree of flow and load balancing that is not found in conventional activated sludge plants. It is therefore reasonable to assume that an SBR system of appropriate design could be suitable for treating saline wastewaters.

There is no information available on the ability of MBR systems to deal with highly saline wastewaters but, again, it is reasonable to assume that they should be capable of at least the same performance as a conventional activated sludge process.

## 4.3 Effect of Saline Intrusion on the Potential for Odour Production

Saline infiltration into coastal sewer systems is known to result in an increased potential for odour production. Under anaerobic conditions the sulphate in seawater is reduced to sulphide and this can be released into the atmosphere as hydrogen sulphide gas. Hydrogen sulphide is not only dangerously toxic at low concentrations but is also detectable as an objectionable odour at the parts per billion level. The potential for hydrogen sulphide generation is greatest when aerobic sewer systems become anaerobic, such as in pumped rising mains and in outfalls which become flooded with seawater at high tide.

## 4.4 Effect of Saline Intrusion on Sludge Treatment and Disposal

The processes involved in wastewater treatment produce sludges which must be disposed of in an environmentally acceptable manner. The sequence of sludge treatment operations depends on the quality of sludge product required for final disposal and usually consists of processes which increase the solids concentration of the sludge. At coastal sites it is often important to reduce the volume of sludge by dewatering since ultimate disposal can involve transportation of the sludge to another site. It is therefore important to produce a reasonably dry product to minimise traffic movements and transport costs.

High salt concentrations are known to adversely affect anaerobic digestion processes but the physical processes involved in sludge dewatering are unlikely to be affected.

## 4.5 Recommendations for Controlling Salinity-Induced Treatment Problems

There is evidence that some of the problems experienced in the UK as a result of saline intrusion at coastal treatment sites could have been alleviated if the degree of salinity had been included in plant design specifications. Thus, in some instances, the high salt concentrations in wastewater were only identified after treatment problems were encountered.

It is therefore possible to make the following recommendations for control of salinity-induced treatment problems:

- Determine the levels of salinity in the sewer system by sampling and analysis. Establish the degree of variability and the effect of local tides and rainfall events.
- If the salinity levels are high, and no information is available from the research literature, then perform bench-scale and pilot-scale tests to determine the effect on biological treatment. Establish the degree of flow and load balancing required to overcome any treatment problems identified.
- Identify sewerage and sewage treatment strategies which will maintain the salinity variations with an acceptable range for treatment. Determine the extent of the sewer system which is subject to saline infiltration and examine the possibility and cost of sewer lining the affected sections.

- Identify the sludge disposal route which will be used for the sludge produced at the site and include the sludge treatment processes in the overall treatment strategy.

# 5. TREATMENT PROCESS SELECTION

## 5.1 Introduction

The selection of an appropriate sequence of wastewater treatment process is quite a complex procedure and involves the consideration of a large number of variables, especially if a number of competing systems are capable of meeting the effluent quality requirements. The factors which must be taken into account are inter-related and there is nearly always some degree of site dependency in the outcome of such a procedure. It is often necessary to establish fairly detailed process design information before cost data and area requirements can be calculated with reasonable accuracy.

Initial process selection is dependent on the size of the site, as some processes do not scale down satisfactorily from the largest to the smallest installations. There are about 8000 treatment plants in the UK which serve populations from 50 persons upward. Only about 500 of these serve populations in excess of 10000 people. It is not usually cost-effective to install complete sludge treatment schemes at small treatment plants. The usual practice is to transport partially treated and dewatered sludge to a larger regional centre for ultimate treatment. Sewage treatment process selection therefore needs to take account of the prevailing policy for sludge disposal, which is, in turn, influenced by an ever more stringent regulatory framework.

On Guernsey, the procedure is simplified by the objective of selecting an appropriate treatment process for a single site to serve a population equivalent of 75000. Thus, no descriptions of processes which are unsuitable for such a plant size, such as reed beds and lagoons, are included in this report. (Reed beds and lagoons are completely impractical in terms of area requirements). In addition, the transport of sludge from such a relatively large site to another site would present difficulties in terms of traffic movements etc. and is probably not a feasible option.

The three main general factors in process selection are regulation, cost and environmental impact and these largely determine the ultimate selection of a suitable process. They are also the driving force which has led, in recent years, to the development of new processes to complement those already established. In general terms, regulation, which translates into more stringent effluent quality and sludge disposal requirements, demands that treatment processes achieve better performance. This will generally cost more in either capital or operating expenditure. It should not be assumed that the availability of new processes means that they are invariably chosen for installation when the opportunity arises. However, in certain situations the environmental impact of an installation will exert a very important influence and perhaps force a decision to construct a new type of process with further cost implications.

## 5.2 Regulation

The introduction of new legislation derived from EU Directives has resulted in more stringent effluent quality standards being imposed at most of the treatment plants in Europe. The ability of a treatment process to produce effluent of the required quality is the most important factor in process selection. Discharge consents are usually set as concentration limits on a few easily measurable parameters. Considerable improvements in process design techniques have been made in recent years but it is still not possible to derive exact relationships between plant design parameters and effluent quality. Safety factors are a necessary part of design procedures and their magnitude has a strong influence on overall costs.

The effluent quality achieved by treatment plants in the UK is monitored by the Environment Agency. Samples of effluent are taken at a frequency which depends on the population equivalent served by the plant and are analysed for various quality parameters, usually BOD, COD, suspended solids, (SS), ammonia and perhaps, total nitrogen and phosphorus. The results of the analyses are compared with the concentration limits set by the EA in the discharge consent conditions. There are two types of limit and both might not apply to all of the quality parameters monitored. Firstly, there is the 95% -ile, or 'look-up table' limit, which can only be exceeded by a stated number of samples per year. The permitted failure frequency varies with sampling frequency and hence, with plant size, e.g. no more than 5 failures when 40 samples per year are taken; no more than one failure when 4 samples per year are taken. A consent failure is recorded if the annual total of sample failures exceeds the permitted number. Secondly, there is the upper-tier or absolute limit, which is a value which can never be exceeded. Samples which do exceed the absolute limits are immediately recorded as consent failures.

At coastal sites which discharge into the marine environment in the vicinity of bathing beaches or shellfisheries there are additional standards which must be met to safeguard water quality. These standards are based on bacterial and viral numbers and they usually result in the need to disinfect the plant effluent before discharge and to limit the frequency of stormwater overflows.

The standards imposed on sludge destined for agricultural recycling are based on destruction of pathogenic micro-organisms and the production of a stabilised, inoffensive material. The standards for sludge incineration are expressed in terms of air pollution parameters and are not directly related to sludge quality. However, it should be noted that air pollution parameters include specification of incinerator temperatures which ensure the destruction of harmful materials. It can be difficult to maintain these temperatures if attempts are made to incinerate a sludge that has too high a water content. In addition, the ash from sludge incineration needs to be disposed of, probably by landfill. The presence of residual heavy metals in the ash could present difficulties in locating a suitable landfill site.

For Guernsey, compliance with discharge standards similar to those which derive from the EU Urban Wastewater Treatment Directive would mean that a treatment plant would have to meet a BOD concentration limit of 25 mg/l and a COD concentration limit of 125 mg/l, both determined from composite samples of effluent and both determined on an annual 95%-ile basis. Compliance with upper tier limits is imposed in the UK by the EA but is not a requirement of the UWWTD.

The mandatory bacterial standards derived from the EU Bathing Water and Shellfisheries Directives would include concentrations of less than 10,000 total coliforms per 100 ml and less than 2000 faecal coliforms per 100 ml. (Viral standards would be assumed to be met by compliance with a given reduction in a surrogate indicator bacterial species which is easier to enumerate than viruses). Disinfection of treated effluent from the Guernsey plant would probably be required to comply with these bacterial standards but there is scope for a risk versus cost assessment to be made regarding the use of the existing outfall for stormwater discharge.

The standards for sludge disposal by agricultural recycling or incineration can be met by appropriate designs of the sludge treatment processes described in this report. Extra costs might be incurred if a wastewater treatment process is selected which produces only secondary sludge and is therefore difficult to digest or dewater. The important factor is to select a sludge disposal option which offers long-term security.

## 5.3 Cost

In cases when effluent quality requirements are particularly stringent it is usually necessary to provide extra stages of treatment in order to minimise the risks of effluent quality failure. In general there is quite a severe capital cost penalty associated with apparently small improvements in effluent quality.

Effluent quality requirements are site specific and if an entirely new plant is being considered then there might be the possibility of choosing a site where a relaxed consent would be imposed. Any cost reduction would have to be compared with the cost of extending any existing sewer network.

At coastal sites the provision of disinfection represents significant capital and operating costs. Compliance with the BOD and COD limits can be achieved by conventional processes but problems usually arise in the form of construction area availability and environmental impact. Compact wastewater treatment processes are not necessarily more expensive than conventional plant but the cost of enclosing such processes to prevent odour emissions and to minimise visual impact can be considerable. At some confined sites in coastal areas it has been found that even the most compact processes cannot be constructed in the space available at the end of the existing sewer system. In such cases it has been necessary to pump the wastewater to a site with adequate construction area.

## 5.4 Environmental Impact

In certain situations the environmental impact of an installation will exert a very important influence and perhaps force a decision to construct a different type of process with further cost implications. Environmental impact includes such aspects as odour and noise emissions, traffic movements to and from the site, energy use and sludge disposal. The visual appearance of the plant is also very important if construction is planned in the vicinity of residential areas. At coastal treatment sites, which are often located in the centre of resort areas because of the layout of the existing sewer systems, it is often necessary to completely enclose the treatment plant. Compact plant and processes are the obvious choice for installation and much ingenuity has been employed in concealing plant beneath car parks and other municipal features, or by installing processes in buildings which mimic the local architectural style.

Complaints about the odour traditionally associated with sewage treatment operations were relatively uncommon in the UK about 15 years ago but have gradually increased in frequency over the past 10 years. This increase in complaints is partly due to the encroachment of residential developments on wastewater treatment sites. At the present time it is difficult to negotiate the planning stage of a new installation or modification without producing environmental impact assessments of odour emission and control. It is now possible to make accurate predictions of odour impact at the planning stage and these must usually show that no adverse effects will occur at specified distances from the odour source. Odour control technologies are well developed but implementation can be costly, especially if covering tanks of large surface area is involved. The installation of compact treatment processes in enclosed structures greatly facilitates odour control.

## 5.5 Selection of Suitable Treatment Processes for Guernsey

This section establishes a list of process sequences which appear to be suitable for more detailed consideration in relation to wastewater treatment on Guernsey. The list takes account of the characteristics of the treatment processes described previously in this report but is based on the limited information available at the present time. In summary, the listed processes are potentially appropriate for compliance with standards similar to the EU Directives for marine discharge at a site serving a population of 75000 and would therefore achieve the water quality objectives approved by the States of Guernsey. For simplicity it has been assumed that:

- Salinity levels in the influent wastewater can be controlled to a degree which does not significantly affect the performance of the treatment processes
- Preliminary treatment by screening and grit removal is included in all options.
- The site hydraulic design is such that processes which are normally constructed with most of the tank volume below ground level can be constructed in this way.

**Wastewater Treatment**

The following wastewater treatment process sequences are all capable of producing effluent of the required quality.

1. Primary sedimentation plus activated sludge plus UV disinfection.
2. Primary sedimentation plus biological filtration plus UV disinfection.
3. Oxidation ditch plus UV disinfection.
4. SBR process plus UV disinfection.
5. Lamella separator plus BAF process plus UV disinfection.
6. MBR process.

Notes

- Options 3 and 4 do not require primary sedimentation.
- Option 6 does not require a separate disinfection process.

**Stormwater Treatment**

It has been assumed that the wastewater treatment processes listed previously are all designed, according to the conventional approach, to treat maximum influent flowrates of three times the dry weather flow (3DWF). Flows in excess of 3DWF would therefore need to be diverted to some type of stormwater treatment process. The requirement for a separate system of stormwater treatment is therefore common to all the wastewater treatment sequences listed above.

**Sludge Treatment**

The options for sludge treatment sequences depend largely on the availability of routes for ultimate sludge disposal and also, to a lesser extent, on the selected processes for wastewater treatment. The main effect of the different wastewater treatment options is related to the presence or absence of primary sludge.

Incineration of sludge would appear to be a preferred option for Guernsey especially if the same incineration plant is to be used for disposal of municipal wastes. The only residual material would be an inert ash which is suitable for landfill. A suitable sequence of sludge treatment processes would be gravity and/or mechanical thickening, followed by dewatering to produce an easily handled sludge cake with a solids content of 20-25%.

Recycling of treated sludge for use as a fertiliser, or soil conditioner, in agriculture or horticulture, is only a viable disposal option if secure and sustainable outlets are available. Attempts to generate revenue by selling treated sludge have had very limited success in the UK and such products normally have to supplied free of charge to consumers. It is therefore possible that no market exists for recycling of sludge in Guernsey. In addition, land application of sludge cannot be carried out at all times of year and the space required for sludge stockpiles can be considerable. A suitable sequence of sludge treatment processes would be gravity and/or mechanical thickening, anaerobic digestion and finally dewatering to 20-25% solids content.

Thus, the sludge treatment sequence for recycling includes anaerobic digestion in addition to the processes of gravity thickening, mechanical thickening and mechanical dewatering which are required for incineration. In summary, the sludge treatment process sequences are:

1. Incineration - Gravity thickening, (if primary sludge is present), mechanical thickening of secondary sludge, mechanical dewatering of mixed sludges.

2. Recycling – Gravity thickening, (if primary sludge is present), mechanical thickening of secondary sludge, anaerobic digestion of mixed sludges, mechanical dewatering of digested sludge.

**Area Requirements**

Wastewater Treatment

The surface areas of the individual processes in the wastewater treatment options are summarised in Table 5.1. The areas of storm tanks, preliminary treatment processes, UV disinfection, odour control and sludge treatment processes are not included. Details of the area calculations are provided in the Appendix.

It is emphasised that the areas given in Table 5.1 are the net areas or 'footprints' of the individual processes and the arithmetic total of these footprints. The actual area required for construction will depend on site details such as ground conditions, hydraulic considerations and the shape and number of the process tanks. Thus, options 4, 5 and 6, described above, are based on tanks which are normally rectangular in plan. Such tanks can usually be constructed with common sidewalls and the area required for construction is less than that required for the circular settling tanks which are included in the other treatment options. It is not possible to be precise about the relationship between net area and actual area but, in general, the total area required for construction will be greater than the sum total areas of the individual processes by a factor of between 50% and 100%.

**Table 5.1 Surface Areas of Wastewater Treatment Process Options**

| | Net Process Area Required ($m^2$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Prim. Sed.** | **Lamella** | **BAF** | **SBR** | **MBR** | **Biol. Filt.** | **Aeration Tanks** | **Final Tanks** | **Total** |
| **Option 1** | 1500 | - | - | - | - | - | 780* | 1500 | 3780 |
| **Option 2** | 1500 | - | - | - | - | 1500 | - | 1500 | 4500 |
| **Option 3** | - | - | - | - | - | - | 1560* | 1500 | 3060 |
| **Option 4** | - | - | - | 2080 | - | - | - | - | 2080 |
| **Option 5** | - | 225 | 275 | - | - | - | - | - | 500 |
| **Option 6** | - | - | - | - | 400 | - | - | - | 400 |

The aeration tanks in options 1 and 3 are assumed to be 4 m deep. The areas of tanks 6 m in depth are given in the Appendix.

The preliminary treatment processes of screening and grit removal would normally be enclosed within a building for odour control purposes. A suitable building of the size required for Guernsey would occupy a land area of about 200 $m^2$.

The low surface area of the compact options means that there is less potential for odour emission. The compact options are obviously easier and cheaper to enclose within buildings than the conventional plants. Odour control equipment does not usually require a large area for construction. A net area of 100 $m^2$ per option is reasonable.

UV disinfection plant is normally installed in the channels used to convey final effluent to the discharge point. The net area requirement is small and an allowance of 50 $m^2$ per option is reasonable.

SBR and BAF processes often need to be constructed so that a large part of the tank walls are above ground. This is necessary for hydraulic reasons but can give rise to increased visual impact in some circumstances. MBR processes can be constructed so that most of the structures are close to ground level.

Stormwater Treatment

Conventionally designed stormwater tanks for Guernsey require a net area of 1500 $m^2$.

Sludge Treatment

It is standard practice to enclose the equipment used for mechanical sludge thickening and dewatering in a building. This facilitates odour control and, in any event, the mechanical plant is unsuitable for operation in the open air. The net areas of the sludge treatment processes which are involved in each disposal option are:

1. Incineration

Gravity thickener – 40 $m^2$.

Building for mechanical thickener and dewatering plant – 400 $m^2$.

Total net process area = 440 $m^2$.

2. Recycling

Gravity thickener – 40 $m^2$.

Building for mechanical thickener and dewatering plant – 400 $m^2$.

Anaerobic digestion – 140 $m^2$.

Total net process area = 580 $m^2$.

It is apparent that the presence or absence of gravity thickening (required if primary sludge is produced by the wastewater treatment option) has very little effect on the area requirements. The net area of the anaerobic digestion plant is also relatively small in comparison with the sludge treatment total and also in comparison with most of the wastewater treatment process option net areas. For simplicity, it is therefore reasonable to assume that the net area required for sludge treatment processes, for either disposal option, is, say, 500 $m^2$.

The total net areas for each process option, including preliminary treatment, stormwater treatment, sludge treatment. UV disinfection and odour control plant, are given in Table 5.2. The 'Option ' values are the total net areas from Table 5.1. UV disinfection is not required for option 6.

**Table 5.2 Total Net Areas for each Wastewater Treatment Process Option**

| | Net Area Required ($m^2$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Option** | **Preliminary** | **Stormwater** | **UV** | **Odour** | **Sludge** | **Total** |
| **Option 1** | 3780 | 200 | 1500 | 50 | 100 | 500 | 6130 |
| **Option 2** | 4500 | 200 | 1500 | 50 | 100 | 500 | 6850 |
| **Option 3** | 3060 | 200 | 1500 | 50 | 100 | 500 | 5410 |
| **Option 4** | 2080 | 200 | 1500 | 50 | 100 | 500 | 4430 |
| **Option 5** | 500 | 200 | 1500 | 50 | 100 | 500 | 2850 |
| **Option 6** | 400 | 200 | 1500 | - | 100 | 500 | 2700 |

Table 5.2 shows that:

- Option 2 (biological filtration) has the largest net area.
- Options 5 and 6 (lamella + BAF and MBR) have the lowest net areas. These areas can be considered to be identical within the accuracy of the available data.
- The net area required for conventional stormwater treatment is significant.

## Capital Costs

Wastewater Treatment

The capital costs of the six wastewater treatment options have been estimated using cost functions held by WRc on behalf of most of the UK Water Service Companies. The actual cost functions are confidential but the cost descriptors are simple process variables such as flowrates, tank volumes and surface areas. Thus, for example, the cost of activated sludge aeration tanks is a function of the tank volume and the cost of final settling tanks is a function of their surface area.

It is emphasised that the capital cost estimates do not take account of several factors which must be included to arrive at more accurate values of total project costs. Thus:

- The costs assume construction in 'average' ground conditions with adequate space and reasonable topography. No allowance has been made for construction in difficult ground or rock, or for construction at sites with severely restricted access or space constraints.
- The costs do not include design, project management, planning inquiries and any pre-contract work such as Environmental Impact Assessments. No allowance has been made for contingencies.
- No allowance has been made for the costs of site acquisition, site preparatory work and demolition, temporary works, restricted hours working due to tides etc.
- The costs do not include sewage transfer to site, sewage pumping stations, telemetry, special design features or finishes, inter-process pipework, site roads, fencing, lighting, offices or utility connections. No allowance has been made for any costs associated with modifying the existing outfall or for the construction of a new outfall for treated effluent.

It is also important to allow for differences in construction costs in Guernsey and average construction costs in the UK. In addition to the differences due to the location of Guernsey there are also differences arising from the economies of scale which result from procurement in the UK by means of competitive 'framework agreements'. Thus:

- The large and continuing volume of construction work in the UK Water Industry has resulted in most of the Water Service Companies negotiating framework agreements with a few preferred Contractors. These agreements usually provide a guaranteed amount of work for a Contractor over a given period. In return the Contractor agrees to work at relatively low charge rates. The attraction of a framework agreement depends, from the Contractor's standpoint, on the volume of work which is available. Such arrangements have been in place in the UK for several years and it is apparent that construction costs have been controlled to levels which are probably much less than those which would apply for a 'one off' project on Guernsey.
- Construction costs in the UK depend on location and are highest in London and the South East. It is known that construction costs in Guernsey are about 20% higher than Central London costs. The cost estimates given in this report are based on average UK values.

The capital costs of the wastewater treatment options are given in Table 5.3. If the additional cost factors discussed previously are taken into account then it is apparent that these costs, and other costs calculated subsequently, need to be increased significantly to provide accurate predictions of total project costs. However, it is valid to assume that the relative cost differences between the treatment options are reasonable estimates.

**Table 5.3 Capital Costs of Wastewater Treatment Process Options**

| | Total Installed Cost (£'000) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Prim. Sed. | Lamella | BAF | SBR | MBR | Biol. Filt. | Aeration Tanks | Final Tanks | Total |
| **Option 1** | 3000 | - | - | - | - | - | 1590 | 2950 | 7540 |
| **Option 2** | 3000 | - | - | - | - | 3070 | - | 3090 | 9160 |
| **Option 3** | - | - | - | - | - | - | 2510 | 2950 | 5460 |
| **Option 4** | - | - | - | 5580 | - | - | - | - | 5580 |
| **Option 5** | - | 1970 | 4550 | - | - | - | - | - | 6520 |
| **Option 6** | - | - | - | - | 6630 | - | - | - | 6630 |

The costs of storm tanks, preliminary treatment processes, UV disinfection, odour control and sludge treatment processes are not included in Table 5.3 but have been estimated in the same way as the wastewater treatment process costs by using cost functions developed by the UK Water Industry.

Preliminary Treatment

The capital cost of screening and grit removal plant, including the building in which the equipment is housed is estimated to be £2,960,000.

UV Disinfection Process

Estimated capital cost is £650,000.

Odour Control Plant

An accurate capital cost is very difficult to establish until quite detailed process design of the treatment plant has been carried out. Significant cost variations can result from the need to enclose processes which have a large plan area. A capital cost for odour control plant of £3,000,000 is a reasonable maximum value. The installation of compact plant could reduce the cost of odour control considerably.

Stormwater Treatment

The capital cost of conventionally designed stormwater treatment tanks is £2,140,000.

Sludge Treatment

The capital costs of the sludge treatment processes which are involved in each disposal option are:

1 Incineration

Gravity thickener – £240,000.

Building for mechanical thickener and dewatering plant – £780,000

Mechanical thickener - £440,000

Dewatering plant - £1,560,000

Total capital costs - £3,020,000

2 Recycling

Gravity thickener – £240,000.

Building for mechanical thickener and dewatering plant – £780,000

Mechanical thickener - £440,000

Dewatering plant - £1,480,000

Anaerobic digestion – £2,450,000

Total capital costs - £5,390,000

No allowance has been made for the treatment of imported sludges from septic tanks and for simplicity it has been assumed that the capital costs of sludge treatment processes are not affected by the use of wastewater treatment processes which do not result in the production of a primary sludge. (This assumption would not be valid in a more detailed study since secondary sludges are more difficult to thicken, digest and dewater than mixtures of primary and secondary sludge). In any event, the cost of a gravity thickener for primary sludge is a small fraction of the total for each sludge disposal option.

The amount of sludge produced by Option 2 (biological filter), would probably be less than the amounts produced by the other options and might be easier to dewater. No allowance has been made for how such differences might be reflected in the capital costs of individual processes. It is expected that any cost difference would be small in relation to total sludge treatment costs.

It has also been assumed that sludge dewatering is carried out by centrifuges for both options. Centrifuges are usually more expensive than belt presses but are generally capable of better performance. The available cost functions do not allow accurate prediction of belt press costs. The use of digestion reduces the amount of solids that must be dewatered, (the relevant assumptions are given in the Appendix). Thus, the solids load on the centrifuge required for the recycling option is less than the solids load on the centrifuge for the incineration option. This difference represents a small capital cost variation which is taken into account in the estimated values.

The total capital costs for each process option, including preliminary treatment, stormwater treatment, sludge treatment, UV disinfection and odour control plant, are given in Table 5.4. The 'Option ' values are the total capital costs from Table 5.3. The costs of sludge treatment for both disposal options are included since the difference between the two is too large to ignore. UV disinfection is not required for option 6.

**Table 5.4 Total Capital Costs for each Wastewater Treatment Option**

| | Total Installed Cost (£'000) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Option | Prelim. | Storm. | UV | Odour | Sludge | | Total | |
| **Option 1** | 7540 | 2960 | 2140 | 650 | 3000 | 3020 | 5390 | 19310 | 21680 |
| **Option 2** | 9160 | 2960 | 2140 | 650 | 3000 | 3020 | 5390 | 20930 | 23300 |
| **Option 3** | 5460 | 2960 | 2140 | 650 | 3000 | 3020 | 5390 | 17230 | 19600 |
| **Option 4** | 5580 | 2960 | 2140 | 650 | 3000 | 3020 | 5390 | 17350 | 19720 |
| **Option 5** | 6520 | 2960 | 2140 | 650 | 3000 | 3020 | 5390 | 18290 | 20660 |
| **Option 6** | 6630 | 2960 | 2140 | - | 3000 | 3020 | 5390 | 17750 | 20120 |

Table 5.4 shows that:

- The capital cost of the anaerobic digestion plant required for the recycling option is very significant.
- Option 2 (biological filtration) has the highest capital cost.
- Options 3 and 4 (Oxidation ditch and SBR) have the lowest capital costs. These costs can be considered to be identical within the accuracy of the available data.
- The capital costs of preliminary treatment, conventional stormwater treatment, odour control and sludge treatment are significant fractions of the total cost of each option.

# 6. CONCLUSIONS AND RECOMMENDATIONS

- The Water Quality Objectives approved by the States of Guernsey can be met by a number of options for wastewater treatment. Some of these options are based on the use of conventional process sequences while others rely on compact plant, which can be installed at sites where construction area is limited.

- A treatment process based on primary sedimentation followed by conventional biological filtration would require the greatest land area. The same standard of treatment could be achieved by compact plant (MBR and BAF processes), which only occupies about 10-12% of the area required for primary sedimentation and biological filtration.

- Primary sedimentation followed by biological filtration is the most expensive wastewater treatment option. The oxidation ditch and SBR variants of the activated sludge process have the lowest capital cost but have area requirements which are greater than both MBR and BAF processes.

- Preliminary treatment processes and stormwater treatment would be required as an addition to all options. The provision of stormwater treatment by conventionally designed settling tanks requires a large land area and could be a problem at a confined site. The cost of preliminary and stormwater treatment is a significant fraction of the total capital costs of wastewater treatment.

- A disinfection process would be required as a final stage of treatment unless an MBR process option is selected. A system based on the use of UV irradiation would be cost-effective.

- Sludge disposal by incineration would appear to be a viable option. Disposal by recycling depends on the availability of a sustainable market for the sludge product. The capital cost of sludge treatment prior to disposal by incineration is considerably less than the cost of sludge treatment prior to recycling. This is because anaerobic digestion is not required if the sludge is to be incinerated.

- An effective system for odour control is likely to be necessary to minimise environmental impact. The capital cost of an appropriate system depends on the choice of wastewater and sludge treatment processes but could be significant.

- The estimated capital costs of the entire treatment process sequences are in the range £17.2 M to £23.3 M, depending on the selected options for wastewater and sludge treatment. These estimates are likely to be reasonably accurate predictions of relative cost differences but are unlikely to be reliable indicators of total project costs, since several factors which affect construction costs have not been taken into account.

- The levels of salinity in the existing sewer system on Guernsey should be determined and any measures required to control salinity to acceptable levels should be implemented.

# APPENDIX

## DESIGN OF TREATMENT OPTIONS AND CALCULATION OF AREA REQUIREMENTS

### Assumptions

It is possible to estimate the plan areas and capital costs of wastewater and sludge treatment processes by performing simplified design calculations. It has been necessary, for the purposes of this report, to derive the values of some design variables by making reasonable assumptions. The wastewater characteristics given below are used as the basis for these process design calculations. Thus, it has been assumed that:

- The projected total PE (domestic plus industrial) for the wastewater treatment plant is 75000. If it is assumed that the wastewater production rate is 200 l/d per PE, then the design dry weather flow (DWF) of wastewater is 15000 $m^3$/d. This is a typical daily per capita value and similar values are widely used for design purposes throughout the Water Industry. It has also been assumed that design average flow is 1.25 DWF (18750 $m^3$/d).

- The proposed treatment plant is to be designed to provide full treatment for flows up to 3 DWF, (45000 $m^3$/d), retention in storm tanks for flows between 3 DWF and 6 DWF and no treatment (works by-pass) for flows in excess of 6 DWF. It is often convenient to express flowrates in terms of volumes per second, per hour or per day, for use in various aspects of process design. The appropriate values for Guernsey are given in Table A1.

**Table A1 Values of DWF, Average Flow and 3 DWF for the Guernsey Wastewater Treatment Plant**

| | Wastewater Flowrate | | |
|---|---|---|---|
| | (l/s) | ($m^3$/h) | ($m^3$/d) |
| DWF | 174 | 625 | 15000 |
| Average Flow | 217 | 781 | 18750 |
| 3 DWF | 521 | 1875 | 45000 |

- The per capita BOD production rate is 60g/d. This BOD production rate is also a typical value, which is widely used for design purposes.

The average daily BOD load is therefore:

BOD load = Total PE x Daily BOD contribution per PE

= 75000 x 60 g/d

= <u>4500 kg/d</u>

The BOD concentration in the influent wastewater at average flow can be calculated from the BOD load and the average flow value. Thus:

BOD concentration (mg/l) x average flow ($m^3$/d) x $10^{-3}$ = BOD load (kg/d) = 4500 kg/d

Hence, BOD concentration = 4500 x 1000 / 18750

= <u>240 mg/l</u>

In order to design a secondary treatment process (e.g. a BAF system), it is necessary to make assumptions about the performance of the primary treatment process. The gravity sedimentation processes typically used for primary treatment can usually remove about 25-40% of the BOD in the influent wastewater. If a removal efficiency of 33% is considered to represent reasonable performance then this value can be used to calculate the concentration of BOD in the wastewater leaving the primary treatment stage (i.e. in the settled sewage). Thus:

BOD concentration in wastewater entering primary treatment = 240 mg/l

BOD removal efficiency = 33%

BOD concentration in settled sewage = 240 – (0.33 x 240) mg/l

= <u>160 mg/l</u>

- In order to simplify the outline design of sludge treatment processes it has been assumed that the sludge production rates of various processes can be expresses on a per capita basis. Table A2 gives the per capita rates for primary treatment, activated sludge (SAS) and biological filters (humus). Sludge production rates for a PE of 75000 are also given in kg/d and tonne/y.

**Table A2 Values of Sludge Production Rates for the Guernsey Wastewater Treatment Plant**

| | Sludge Production Rates | | |
|---|---|---|---|
| | g/h per day | kg/d | tonne/y |
| **Primary** | 50 | 3750 | 1369 |
| **SAS** | 30 | 2250 | 821 |
| **Humus** | 15 | 1125 | 410 |

**Outline Design of Treatment Process Options**

<u>Primary sedimentation</u>

The important design variable is the upward flow velocity. This is calculated by dividing the value of 3 DWF by the surface area (A) of the tanks. Values in the range 1.0 to 1.5 m/h are typical of established practice. The value of 3 DWF is 1875 $m^3$/h. Thus, if the upward flow velocity is assumed to be 1.25 m/h:

Upward flow velocity = 1875 / A (m/h)

= <u>1.25 m/h</u>

Therefore, total surface area, A = 1875 / 1.25

= $\underline{1500\ m^2}$

This area corresponds to 4 circular tanks, each 22 m in diameter.

Stormwater Treatment

The design basis is a total tank volume which provides a retention time of 2 hours at 3 DWF (1875 $m^3$/h). Thus:

Total volume of storm tanks = 2 x 1875 $m^3$

= $\underline{3750\ m^3}$

Assume storm tanks are 2.5 m deep. Thus,

Total surface area = 3750 / 2.5

= $\underline{1500\ m^2}$

This area is identical to that required by the primary tanks and corresponds to 2 circular tanks, each 31 m in diameter.

Activated sludge process (non-nitrifying)

*Aeration tanks*

The aeration tank hydraulic retention time (HRT) at average flow is the appropriate design variable. HRT is calculated by dividing the aeration tank volume (V) by the value of average flow and is usually expressed in hours. An HRT of 4 h at average flow is suitable for production of effluent of the required quality from a settled sewage influent. Thus;

HRT = V / 781 = $\underline{4.0\ h}$

Hence, V = 781 x 4

= $\underline{3124\ m^3}$

If the aeration tanks are 4 m deep then the surface area is $\underline{781\ m^2}$. The surface area of tanks 6 m in depth is $\underline{520\ m^2}$.

*Final settling tanks*

The upward flow velocity is also the important design variable for final settling tanks and the calculation is identical to that for primary sedimentation tanks. An upward flow velocity of 1.25 m/h at 3 DWF is a reasonable value for a non-nitrifying process. Thus:

Upward flow velocity = 1875 / A (m/h)

= $\underline{1.25\ m/h}$

Therefore, total surface area, A = 1875 / 1.25

= <u>1500 m²</u>

This area corresponds to 4 circular tanks, each 22 m in diameter. Thus, the final settling tanks are identical in area to the primary sedimentation tanks.

<u>Oxidation Ditch</u>

*Aeration Tanks*

As with a conventional activated sludge process, the aeration tank hydraulic retention time is an important variable for initial design. Oxidation ditches normally treat crude (unsettled sewage) and longer retention times are needed to provide the required degree of treatment. An HRT value of 8 h is appropriate. Thus:

HRT = V / 781 = <u>8.0 h</u>

Hence, V = 781 x 8

= <u>6248 $m^3$</u>

If the aeration tanks are 4 m deep then the surface area is <u>1560 $m^2$</u>. The surface area of tanks 6 m in depth is <u>1040 $m^2$.</u>

*Final settling tanks*

Identical to those for the conventional activated sludge plant.

<u>Primary Treatment by Lamella Separators</u>

The total plan area of a lamella separator can be conveniently estimated as a fraction of the equivalent area of conventional primary tanks. If the area required is assumed to be 15% of the area of conventional tanks, (a reasonable conservative value), then:

Total area of lamella separators = 0.15 x 1500 $m^2$

= <u>225 $m^2$</u>

<u>Biological filter</u>

The design variable which determines the filter volume and hence, the filter plan area is the nominal BOD loading rate per $m^3$ of filter medium per day. A typical settled sewage BOD loading rate for production of a non-nitrified effluent is 0.15 kg BOD/$m^3$ of filter medium per day.

BOD load in settled sewage (kg/d) = BOD conc. (mg/l) (settled) x average flow ($m^3$/d) x $10^{-3}$

= 160 x 18750 x $10^{-3}$

= <u>3000 kg/d</u>

Hence volume of filter medium = 3000 / 0.15

= <u>6000 $m^3$</u>

The depth of mineral media in biological filters is invariably about 2 m. Thus,

Total surface area = $\underline{3000\ m^2}$

This area corresponds to 4 filters each 31 m in diameter.

(Plastic media biological filters usually have media depths of about 3 m. The use of plastic media would therefore reduce the filter plan area to 2000 $m^2$).

Humus tanks

It is standard practice to design humus tanks on the same basis as primary settlement tanks. The plan area of the humus tanks is therefore identical to that of the primary tanks. Thus:

Total surface area = $\underline{1500\ m^2}$

This area corresponds to 4 circular tanks, each 22 m in diameter.

Biological Aerated Filter (BAF)

As with a conventional biological filter, the outline process design of BAF processes for BOD removal involves the selection of an appropriate value of the daily BOD load applied per unit volume of the filter medium. BAF processes for BOD removal from settled wastewater are usually designed with nominal loading rates in the range 2-5 kg BOD/$m^3$ of filter medium per day.

Assume nominal loading rate is 3 kg BOD/$m^3$ per day.

BOD load in settled sewage (kg/d) = BOD conc. (mg/l) (settled) x average flow ($m^3$/d) x $10^{-3}$

= 160 x 18750 x $10^{-3}$

= <u>3000 kg/d</u>

Hence volume of filter medium = 3000 / 3

= $\underline{1000\ m^3}$

If the depth of the filter medium is assumed to be 4 m, then,

Total surface area = $\underline{250\ m^2}$

This area can be conveniently divided into 5 units each 50 $m^2$ in area.

Removing one unit for periodic backwashing of the medium temporarily increases the loading rate to 3.75 kg BOD/$m^3$ per day, which is still within the normal range of values.

BAF processes do not require final settling tanks but some provision must be made for separation of solids from the backwash water. The area required for this process is estimated to be 10% of the BAF area. The total area required for secondary treatment by a BAF process is therefore 275 $m^2$.

Sequencing Batch Reactor (SBR)

The process design of an SBR system involves calculation of the total volume of the system, establishing the duration of the components of the cycle time and determination of the number of tanks and the volume decanted per cycle. This procedure is quite complicated but it is possible to calculate the total tank volume, and hence, the plan area by making appropriate simplifying assumptions.

Dividing the total tank volume (V) of an SBR by the sewage DWF produces a value of nominal retention time. Unlike a conventional activated sludge process, this variable has no real physical significance because of the operating characteristics of SBR system. However, experience has shown that a value of nominal retention time of about 20 h at DWF is adequate for production of a non-nitrified effluent. Thus:

Nominal retention time = Total volume (V) / DWF

= V / 625 (h)

= 20 h

Thus, V = 20 x 625

= $\underline{12500\ m^3}$

SBR tanks are usually 6 to 7 m deep. If it is assumed that the tank depth is 6 m, then:

Surface area of SBR system =12500 / 6 $m^2$

= $\underline{2083\ m^2}$

No separate final settling tanks are required.

Membrane Bioreactor Process (MBR)

The outline design of an MBR process is based on the calculation of the tank volume from the standard expression for sludge loading rate (or F/M ratio). No separate final settling tanks are required. The use of membranes for solids operation allows operation at very high MLSS concentrations. A value of about 15000 mg/l (15 kg/$m^3$) is typical. MBR processes usually treat crude sewage and an F/M ratio of 0.25 $d^{-1}$ is appropriate for the production of a non-nitrified effluent. Thus:

BOD load in crude wastewater = 4500 kg/d

F/M ratio = 0.25 $d^{-1}$ = 4500 / V x 15, where V is the volume of the MBR tank. Thus:

V = 4500 / 15 x 0.25 ($m^3$)

= $\underline{1200\ m^3}$

MBR process tanks are typically about 3m in depth. Thus:

Surface area of MBR process = 1200 / 3 $m^2$

= 400 $m^2$

MBR processes are usually rectangular in plan to allow the membrane units to be installed at one end of the tank.

Sludge Treatment Processes

The sequence of processes for each disposal option is:

Incineration - Gravity thickening, (if primary sludge is present), mechanical thickening of secondary sludge, mechanical dewatering of mixed sludges.

Recycling – Gravity thickening, (if primary sludge is present), mechanical thickening of secondary sludge, anaerobic digestion of mixed sludges, mechanical dewatering of digested sludge.

The following assumptions have been made concerning process performance:

Gravity thickener – primary sludge feed of 125 $m^3$/d at 30 kg/$m^3$, thickened sludge production of 47 $m^3$/d at 80 kg/$m^3$.

- Net plan area calculated assuming a specific surface area of 10 $m^2$ per tonne of sludge solids per day. Hence net area is approximately 40 $m^2$.

Mechanical thickener – SAS feed of 320 $m^3$/d at 7 kg/$m^3$, thickened sludge production of 45 $m^3$/d at 50 kg/$m^3$.

Anaerobic digestion – mixed primary and SAS feed of 95 $m^3$/d at 63 kg/$m^3$, digested sludge production of 95 $m^3$/d at 45 kg/$m^3$.

- Solids reduction calculated assuming 40% destruction of volatile solids, where volatile solids are 70% of total solids in digester feed.

- Digester retention time assumed to be 14 days based on 95 $m^3$/d. Digester volume is therefore 14 x 95 = 1330 $m^3$.

- Two equal-sized digesters assumed, each 9.5 m in diameter, 70 $m^2$ in plan net area. Total net area 140 $m^2$.

Dewatering plant – incineration – mixed primary and SAS feed of 95 $m^3$/d at 63 kg/$m^3$, sludge cake product at 250 kg/$m^3$.

Dewatering plant – recycling - digested sludge feed of 95 $m^3$/d at 45 kg/$m^3$, sludge cake product at 250 kg/$m^3$.

**APPENDIX: N**

# EXECUTIVE SUMMARY OF THE WASTE STRATEGY ASSESSMENT REPORT NO 1 LIQUID WASTE

# WASTE STRATEGY ASSESSMENT

REPORT NO. 1

LIQUID WASTE - CURRENT STATUS AND FUTURE STRATEGY OPTIONS

## EXECUTIVE SUMMARY

STATES OF GUERNSEY
DEPARTMENT OF ENGINEERING

MARCH 1997

# EXECUTIVE SUMMARY

This Executive Summary is a précis of the main report which itself is based on 17 consultants' reports as well as reports from within the service and extensive reference material. The Executive Summary can only therefore be selective and cover the major issues.

This report is concerned with liquid wastes, principally agricultural slurries, horticultural discharges and sewage and the effects these wastes have on surface and ground waters and the marine environment.

The report establishes the primary sources of liquid pollution which pose a risk to human health. They are:

- Intensively farmed dairy herds produce substantial quantities of liquid effluent containing nutrients and faecal bacteria. Surplus manure and excess fertilisers leach into the streams and aquifers particularly during the winter months;

- Intensive horticultural practices that require excess feeding of plants grown in rockwool and other artificial substrates produce nutrient rich effluents that percolate into ground waters and can be discharged directly to surface waters;

- Leaking sewerage network and cesspits. Leaking sewerage introduces bacterial contamination to the aquifers and to a lesser extent to the Island streams. Overflowing sewage pumping stations within the Water Board Catchment Area occasionally cause a severe risk of pollution.

  The above three primary sources of pollution create the situation that 70% of the water available for collection by the Water Board is of poor quality. Further the Water Board has to release between 5% and 30% of collectable water every year as a result of poor quality or pollution.

  The above three primary sources of pollution do not present as great a risk to health when they are situated outside the Water Catchment Area unless they affect a private well or borehole. However, they do continue to pollute streams which in turn discharge their acquired bacterial and nutrient pollutants into the marine environment thus affecting bathing waters and shellfisheries. Other sources of liquid pollution which pose less risk to human health are:

- Leachate from old uncontrolled rubbish tips can contain toxic substances. Old tips which are adjacent to Water Board Storage Reservoirs (*e.g.* Dysons close to Longue Hougue and Les Coutures adjacent to Jamblin) are of particular concern;

- Controlled discharge of sewage after preliminary treatment through sea outfall pipes;

- Controlled discharge of aluminium sludge from water treatment works into streams results in the sludge entering the sea.

**<u>Contents</u>:**

## 1.0 INTRODUCTION

In June 1994, the States of Deliberation resolved to conduct an assessment of the Island's long term strategy for waste. The scope of the work was agreed by all the relevant States Committees and is detailed in the Waste Strategy Assessment (WSa) Brief produced in May 1995.

The purpose of the WSa is to establish the most appropriate Waste Management Strategy for the disposal of all island wastes in the long term.

It is important that the Waste Management Strategy adopted is a long term strategy as little will be gained if proposals are only short term solutions to satisfy the current problems. Greater benefit will accrue from integrated complementary long term solutions that are sustainable and reconcile society's objectives of achieving economic development to secure higher standards of living, and the protection and enhancement of the environment, both now and for future generations.

Sustainable solutions for waste management require that today's wastes have to be managed so that they do not create environmental problems for future generations and yet at the same time operate at a cost and in a manner that is acceptable to the community.

The key components for sustainable solutions and the criteria used to evaluate options are:

- Human Health and Safety
- Economic Sustainability
- Environmental Sustainability
- Public and Visitor Perceptions

**The WSa will submit reports to the States of Deliberation in three stages:**

| | | |
|---|---|---|
| **WSa 1** | **Liquid Waste -** | **Current Status and Future Strategy Options.** |
| **WSa 2** | **Solid Waste -** | **Current Status and Proposals for a Solid Waste Management Plan.** |
| **WSa 3** | **Liquid Waste -** | **Improvements and Proposals for a Liquid Waste Management Plan.** |

This report is WSa 1 and its objectives are:

- Establish the types and quantities of liquid waste generated
- Establish the effects of the current disposal practices
- Consider acceptable standards
- Consider (if necessary) the most appropriate options for improvement

This report is mainly concerned with strategy options and the strategic policies to be adopted for liquid wastes. The report makes recommendations where policy decisions are required and where environmental standards need to be adopted. It does not advocate specific environmental improvement schemes (such as a type of treatment plant) as it is unable to do so until the policy decisions have been taken. However, to illustrate the implications of policy decisions the report will give examples of treatment processes and their associated costs, size *etc*.

Many of the questions raised by the report are political requiring decisions to be made on future policy. For these "political questions" the report attempts to be "option neutral" whilst at the same time providing adequate technical information so that the required decisions can be made and the required standards for the future established. The report evaluates technical scenarios on a factual basis but where political factors are involved (such as public perception) it makes no recommendation.

**Essentially the principal purpose of this report is to provide the necessary scientific and technical background to promote informed debate and decision making in the political arena so that a long term liquid waste policy is established.**

Once a liquid waste policy is determined it will provide the Island Government with the framework to develop and implement a suitable infrastructure to manage liquid wastes.

The Island's current practices, their effects and the environmental standards adopted by comparable societies and competing tourist areas raise a number of issues. This report has established the facts, discussed the issues and requires strategic decisions to be made on the following topics:

- Surface and Ground Water Quality
- Sea Water Quality
- Wastewater Treatment Options
- The Sewerage Infrastructure
- The Marketing of Tourism
- Environment Data Management
- Educational Measures

However, because the topic of greatest interest is wastewater treatment this Executive Summary will elaborate more on this issue than any of the others. For more extensive information on other topics the reader is advised to refer to the main report.

## 2.0 SURFACE AND GROUND WATER QUALITY

Surface and groundwaters are either collected by the Water Board or drain to sea.

The greatest health concern is the contamination of surface and ground waters which sooner or later are abstracted into the Island water supply system.

The States Water Board relies on rainwater that enters the surface water networks either by directly discharging to them or after percolating through the ground. Approximately 65-70% of the Island's land area is used by the Water Board to collect water for human consumption (see Figure 1 below). The planned extensions to the water catchment will add 5-10% more area.

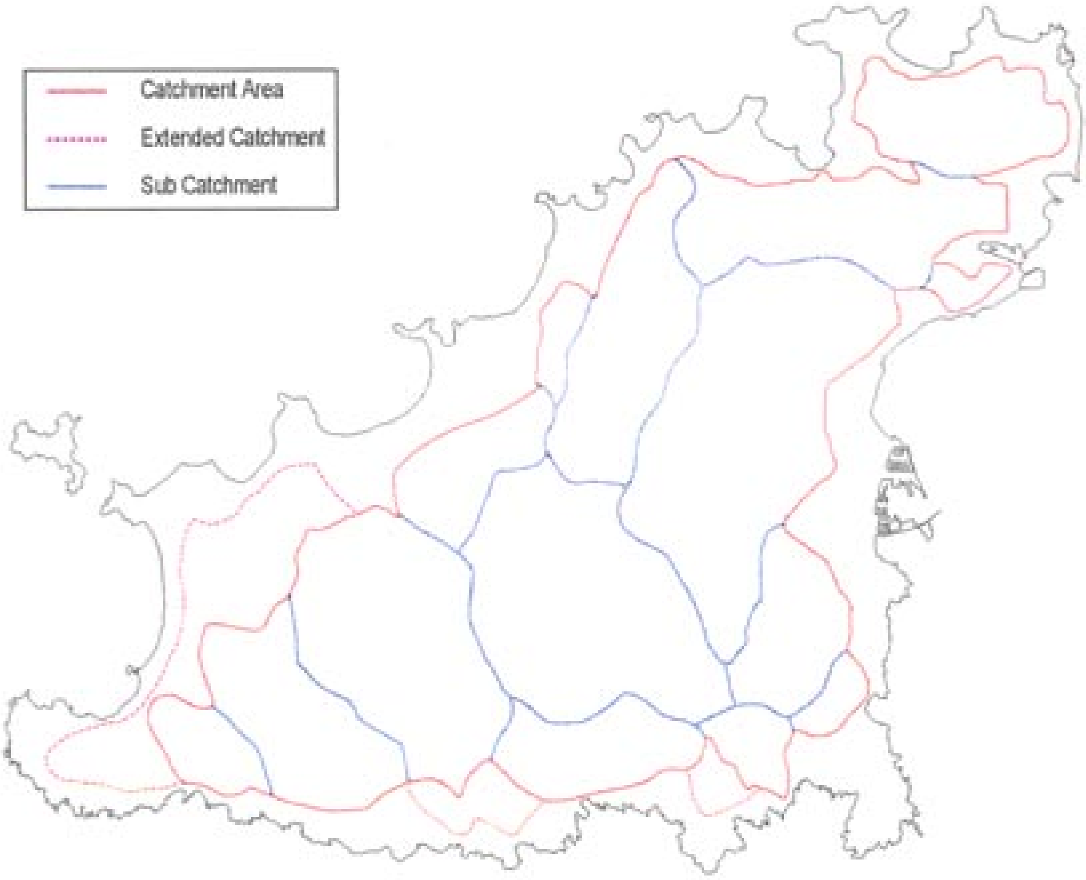



**Figure 1 The Water Catchment Area**

### 2.1 STANDARDS FOR FRESH WATERS

The two major EC Directives concerning water resources are the Directive concerning quality required of surface water intended for abstraction of drinking water in Member States (75/440/EEC), and the Directive relating to quality of water intended for human consumption (80/778/EEC). Mandatory (I) and guideline (G) levels for some of the parameters are given in Table 1 overleaf.

| | | Directive Concerning Quality Required of Surface Water Intended for Abstraction of Drinking Water in Member States | | Directive Relating to Quality of Water Intended for Human Consumption | |
|---|---|---|---|---|---|
| Parameter | Units | 75/440/EEC | | 80/778/EEC | |
| | | Guideline (G) | Mandatory (I) | Guideline (G) | Mandatory (I) |
| Nitrates | $NO_3$ mg/l | | 50 | 25 | 50 |
| Phosphorus | $P_2O_5$ mg/l | - | - | 0.4 | 5 |
| Phosphates | $P_2O_5$ mg/l | 0.7 | | - | - |
| Potassium | K mg/l | - | - | 10 | 12 |
| Total Coliforms | per 100 ml | 5000 | - | - | 0 |
| Faecal Coliforms | per 100 ml | 2000 | - | - | 0 |
| Faecal *Streptococci* | per 100 ml | 1000 | - | - | 0 |

**Table 1: Mandatory and Guideline levels for Directives 75/440/EEC and 80/778/EEC.**

## 2.2 POLLUTION OF SURFACE AND GROUND WATERS

The quality of surface and ground waters is dependent upon a number of human activities illustrated in Figure 2 opposite.

Research indicates that many surface water sources, and ground water abstracted from some private wells and boreholes are subject to pollution. Considering the risk to public health, the ranking of pollution hazards are as follows:

- Nutrient contamination (high nitrate levels) of surface water, affecting the Island's main water supply. The sources are agriculture and horticulture;

- Nutrient contamination (high nitrate levels) of ground water, affecting private domestic water supplies. The sources are agriculture and horticulture;

- Bacterial contamination of ground and surface water extracted for human consumption. The sources are leaking cesspits, leaking sewers, septic tanks and agriculture;

- Point source and diffuse (both intentional and accidental) discharges of nutrients, chemicals, pesticides, oil and oil products;

- Leachate migration from landfill sites.

**The Water Board advise that 70% of the water available for collection is of poor quality and that in any year between 5% and 30% of available water is discarded as a result of pollution.**

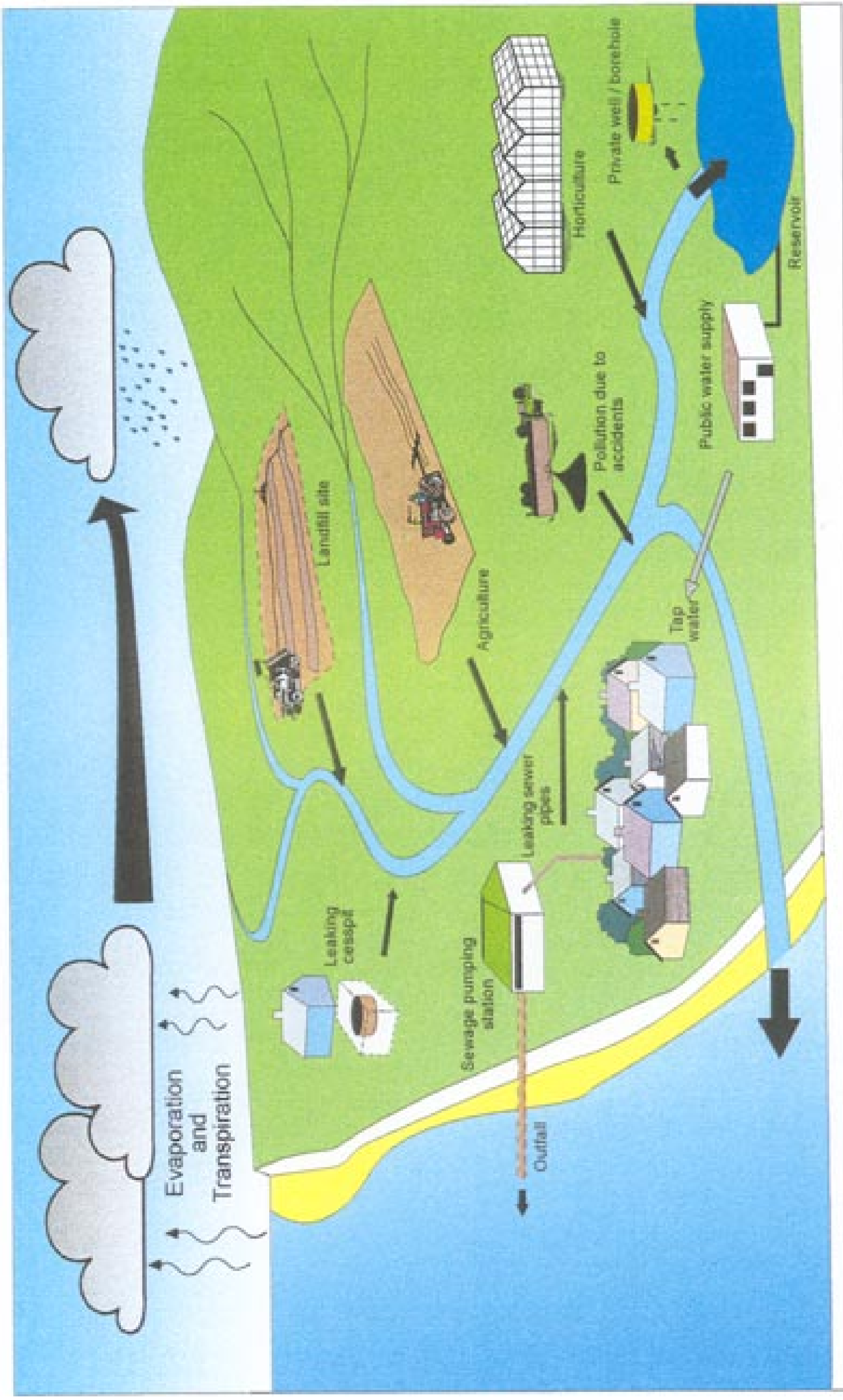



Figure 2. - Pollution of the water cycle.

### 2.2.1 Nutrient Contamination

High nutrient levels, particularly nitrates and potassium are directly attributable to the intensive nature of modern cultivation methods adopted by the horticultural industry and also the agricultural practices of spreading manure onto fields and the grazing of cows on land receiving high application rates of inorganic nitrogen fertiliser. A Code for Good Agricultural Practice for the Prevention of Pollution by Nitrates was circulated to farmers in 1995. However the final publication has been delayed to incorporate findings from this Waste Strategy Assessment Liquid Waste Report No. 1.

Horticultural pollution arises from vineries growing crops in rockwool. They produce excess irrigation water known as run-off which contains dissolved fertilisers. Pollution from vineries growing crops in soil is not considered a major risk.

Pollution is most apparent during the summer growing season when several streams show nutrient levels far in excess of the European Community (EC) mandatory value for potable water of 50 mg/l for nitrate and 12 mg/l for potassium. The guideline limit recommended by the EC for nitrate is 25 mg/l. In comparison Les Nicolles reached concentrations of 350 mg/l nitrate and 140 mg/l potassium in July 1994.

In the winter months because of the reduced grass growth, nitrate pollution arising from agricultural run-off is more apparent. This pollution from the land is caused when excess nitrate cannot be used for crop growth and is flushed from the soil by rainfall or run-off.

There are two main health risks associated with nitrates in drinking water: "blue baby syndrome" (infantile methaemoglobinaemia) and gastric cancer, but these should not be overstated. The "blue baby syndrome" is extremely rare and has been virtually eliminated from the UK with the last reported and confirmed case in 1972. There may be several contributing factors to the incidence of gastric cancer. High nitrate levels in public drinking water have shown a positive relation to gastric cancer in a number of research studies. However, other studies have failed to encounter any such association.

Large inputs of nutrients to the fresh water and marine environments can induce the excessive growth of algae; an ecological state known as eutrophication. Algal blooms cause environmental damage because they can deprive other organisms of oxygen and sunlight. Some varieties secrete toxins. These latter varieties present a risk to human health if they occur in reservoirs or if edible marine shellfish are exposed to the bloom. Blue-green algae have been detected in St Saviour's reservoir (although no degradation of water quality occurred) and there have been incidents of paralytic shellfish poisoning in Morlaix, France.

**As the water supply of the Island is almost wholly dependent upon surface waters (there are a number of private boreholes), available drinking water quantity will increase and quality will improve if preventative measures against nutrient pollution are taken.**

### 2.2.2 Bacterial Contamination

Bacterial contamination of surface and ground waters is attributable to agriculture and the condition of the sewerage assets, in particular private cesspits.

The Island's dairy herd population of 2000 produces as much waste as 60,000 people. All animal wastes (45,000 tonnes) are currently spread onto the land. There are over 6,000 cesspits on the Island of which approximately 22% are suspected of leaking. Half the wells and boreholes voluntarily offered for testing contain water unfit for human consumption due to the high levels of bacteria.

Modelling studies have found that bacterial contamination of surface water systems, which ultimately discharge to sea, is the root cause of inadequate bathing water quality at some of the Island's bathing beaches (see Figure 6 on page 33).

**Alternative management of farm slurry disposal and rectification of faulty cesspits will reduce pollution of water resources.**

### 2.2.3 Accidental Discharges

Accidental discharges and spillages can cause gross pollution. There is a risk that production plants, storage areas and transportation of liquids can cause unacceptable pollution. **Without adequate safety plans, these facilities constitute an unacceptable risk to water resources.**

### 2.2.4 Leachate Migration from Landfill Sites

Leachate migration and consequential pollution of ground waters has occurred. However this reduces over time as the waste decays. Many of the older sites are now producing leachate which has become so dilute that the effects are undetectable. Where necessary, retrospective measures to contain migration of leachate are being provided. Since 1992, new sites have incorporated designed leachate management systems.

With respect to future policy, the main concern is that new sites are not operated until leachate control systems are in place. The Board of Administration's policy is to implement leachate control systems prior to operation.

## 2.3 ACHIEVEMENT OF STANDARDS FOR DISCHARGING POLLUTANTS INTO FRESH WATERS

This section revisits each of the primary sources of liquid pollution and details the means by which improved standards for receiving fresh waters could be achieved.

### 2.3.1 Action by Agriculture

*Reduce Stocking Density on the Intensive Farms*

The most successful method of reducing nitrate and bacterial pollution will be to reduce the stock densities on intensive farms. This will reduce the effect of grazing cows, reduce overall organic nitrogen production and allow farmers to reduce inorganic nitrogen applications.

However, the above will require new thinking about the management of the agricultural industry on the Island. The incentive (*i.e.* high milk price) for farmers to produce more will need to be removed. At first sight, the obvious solution would be to develop a mechanism that links payment to stocking density. However, this must be related to the amount of land farmed. Given that land tenure is very insecure and 70% of land is rented it is difficult to predict the consequence of payment related to land farmed.

This concept will require considerable development if a bureaucratic, unfair, or unmanageable system is to be avoided.

*Encourage Appropriate Management of Farm Slurries*

The over-application of slurry contributes substantially to the nitrate problem. A mandatory maximum organic nitrogen application should be considered, backed up by manure use registers similar to those in either The Netherlands or Denmark.

Additional storage on-farm should be encouraged, **but only if odour can be controlled**. Slurry storage simply to avoid winter application will have a limited effect on nitrate pollution.

If waste storage on-farm (particularly slurry) is increased substantially, odour is likely to become a major issue and treatment will be necessary. **The States should not rely on farmers installing or managing treatment systems effectively**. Depending on the solution to the Island's other waste problems, **centralised treatment, possibly anaerobic digestion** could have a role to play. If promoted and used correctly it could also reduce the amount of inorganic fertilisers used.

For effective reduction of nitrate leaching, a "whole system" approach is needed in which every effort is made to match timing and quantity of nitrogen inputs (especially manures) to crop uptake capacity.

*Shorten the Grazing Season on Intensive Farms*

As the majority of the nitrate leachate problem is related to grazing livestock, shortening the grazing period will reduce leaching. This will increase the need for slurry storage. Implementation of this recommendation will need to be undertaken carefully as increased housing of cows, resulting in greater use of 'sacrificial' spreading areas, will have no net effect on nitrate leaching.

*Continued Farmer Education*

Continued farmer education is vital in reducing nitrate leaching. Explaining the problems and helping farmers adopt more suitable inorganic/organic fertiliser policies will contribute to a reduction in pollution.

*Review of Cropping Practices*

Cropping practices can have a large impact on nitrate pollution. For instance when grass land is ploughed up it will release considerable amounts of nitrogen into the soil, particularly if the sward has been previously grazed. Alternative grassland management systems should be investigated to encourage the use of older leys which should have a lower nitrate polluting potential.

The maize crop, if used as a dumping ground for manures as well as a ley break, is very vulnerable to nitrate leaching. Providing slurry is not applied before ploughing, nitrate leaching should be reduced.

*Place more Focus on Silage Effluent Control*

If damage to the stream ecology is to be avoided, control of silage effluent is essential.

*Regulations*

Strengthen the Island's Code of Good Agricultural Practice to ensure greater compliance in the most important areas, *e.g.* organic nitrogen application rate.

**2.3.2 Action by Horticulture**

*Run-off Management Plans (RMPs)*

Rapid implementation of RMPs is essential to solving the water pollution problem caused by run-off from rockwool vineries. On-going monitoring will be necessary to ensure the plans are successful. All nurseries with RMPs should be inspected regularly to check whether the system is being maintained, operated and monitored correctly.

Generally, growers should be encouraged to collect run-off and rainwater separately wherever possible. **Those vineries which are within reach of a Public Thoroughfares Committee sewer should be encouraged to connect** so that there is a safe option for planned disposal of run-off. Further consideration should be given to transporting horticultural effluent by tanker and discharging into PTC sewers.

Growers must be encouraged to build storage facilities before installing troughs or drains to collect run-off. Channelling all the run-off to one point without a safe means of disposal is more polluting than allowing the run-off to seep into the soil profile.

A loan scheme with variable repayments geared to crop return might encourage growers to speed up implementation of RMPs.

***Minimise % Run-off***

Growers should be encouraged to achieve 30% run-off. This will require properly specified irrigation systems, correctly installed with regular maintenance and monitoring. It also requires that a source of water is available which is relatively low in sodium, chloride and sulphate. This may mean using expensive mains water or building a rainwater reservoir.

***Reducing Nitrate (N), Phosphate (P) and Potassium (K)***

It is now standard practice on the mainland to use reduced nitrate levels for rockwool tomatoes. It is not known how far potassium concentration can be reduced before fruit quality is impaired. Potassium has been shown to have a major influence on both the taste and appearance of tomatoes.

It is suggested that the recommended nutrient requirements for tomatoes are modified for nitrogen as follows:

| Suggested revised nitrate levels for rockwool tomatoes | | | |
|---|---|---|---|
| | Input | Nitrate-N Slab mg/litre | Run-off |
| January-March | 200 | 300-400 | 250-350 |
| April-October | 150 | 120-180 | 100 (minimum) |

However, because of generally high sodium, chloride and sulphate levels in borehole and well water on Guernsey, these lower nitrate inputs could not be used without more collection and use of rainwater by vineries. This precludes replacement of a proportion of the potassium nitrate used in the liquid feed with potassium chloride.

### 2.3.3 Leaking Sewerage Network; Cesspits and Overflowing Pumping Stations

***Public Sewers***

The public sewers are currently the subject of a study commenced by the PTC in 1990 which will result in the preparation of a Drainage Area Plan (DAP) early in 1997. This study includes a structural and condition survey of the public sewers and the construction of a hydraulic model to check the adequacy of the system. Subject to the findings of these surveys and the implementation of the recommendations contained in the DAP, the public sewers are unlikely to be a significant cause of pollution of the ground waters in the catchment area. The condition and operation of overflows on the sewerage system are also covered by this study, and the recommendations in the DAP will take account of the contribution of these overflows to the pollution of ground or surface water in the catchment area. The defects highlighted in the DAP, together with improvements to the operation of overflows, will all be addressed as part of the PTC's on-going rehabilitation programme.

*Private Sewers*

There are a large number of private sewers on the Island about which very little is known. They will all have been constructed to the approval of Building Control, who hold records showing the locations of all private sewers on the Island. In view of the potential for pollution from private sewers, it is suggested that the PTC carries out a survey of all private sewers and use their powers under Section 11 of the Sewerage Law to have them repaired or maintained as necessary. Following this, consideration should be given to their adoption or the institution of regular inspections to ensure that they remain in a good condition.

*Cesspits*

Leakage from cesspits is difficult to detect and to quantify. However, it is believed to be greater than previously accepted with approximately 22% of cesspits suspected of leaking. Leakage from cesspits is, therefore, considered to be a significant contributor to the pollution of groundwater within the catchment area. It is recommended that measures should be taken to extend the sewerage system as far as practicable to reduce the numbers of cesspits and thus the risk of pollution of water sources. It is also suggested that following an Island wide survey of cesspits and domestic drainage, their owners are required to carry out any necessary repairs at their own cost. This should be supported by a media campaign to increase public awareness of the consequences of having leaking or overflowing cesspits and drainage systems.

*Septic Tanks*

The number of septic tanks on the Island is not very significant in terms of pollution, but measures to reduce the number would be a wise precaution in view of the pollution risk.

***Wells and Boreholes***

It is recommended that a pollution survey is carried out to determine the immediate effects of leaking cesspits and septic tanks on boreholes used for public water supplies and the many uncontrolled private wells and boreholes on the Island. This should be in conjunction with any proposed States Geographical Information System, so that the numbers, locations and other details of all private boreholes are properly recorded.

**2.3.4 Landfill Leachate Pollution**

The recommendations below are based on an assessment of the potential risks of pollution to groundwater, surface waters and bathing waters associated with landfill leachate. In many instances, the Board of Administration were aware of problems prior to the commissioning of the WSa and steps are already under way to address those problems. Under these circumstances, some recommendations simply emphasise the necessity for action, whilst for the remainder new action may be required.

- There is a need for increased regulation of all existing sites **including private sites** and new legislation to be applied to all new sites. For existing private sites, this should relate to the definition of wastes which a site may accept and the detailed monitoring of waste types and quantities which actually enter the site as already occurs for public sites. For new sites (*e.g.* Mont Cuet), the new legislation should apply to the design, construction and operation of the site, the monitoring and treatment of leachate and gas, and the monitoring of ground, surface and coastal waters;

- A full assessment of the existing Water Board, Environmental Health and Department of Engineering ground and surface water data should be undertaken. At present there is a great deal of data being generated within separate departments but limited integrated analysis of what it shows. The importance of the resources is such that a better understanding of the available data and point source polluters is required, and this would also be best achieved by establishing a single data base possibly using the proposed Geographical Information System. Such an assessment would also facilitate the establishment of an Island-wide ground and surface water monitoring programme, which is currently being considered by the Environmental Health Officers;

- Analysis of leachate for Red List substances is very limited at present and should be increased. Whilst specific sites (*e.g.* Mont Cuet) should be analysed monthly (as at present), perimeter boreholes of sites such as Bordeaux and Creve Coeur should be sampled and analysed on a six-monthly basis. Random analyses in the vicinity of other sites should also be increased, and the integration of the Environmental Health, Department of Engineering and States Water Board data would help in the process of designing the most appropriate programme of Red List sampling and analysis.

### 2.3.5 Legal Framework

The Prevention of Pollution (Guernsey) Law provides a framework for protecting the groundwaters within the catchment area. Under this Law, an ordinance can be issued which could confer powers upon the States Water Board. It is recommended that the existing powers of the States Water Board are strengthened and expanded by the issue of such Ordinances, in order to limit existing sources of pollution, potential sources of pollution (see 2.2.3 accidental discharges) and control future development which may cause pollution within the Water Board's catchment area.

### 2.3.6 Water Quality Monitoring

*Biological Monitoring*

A programme of biological monitoring should be considered for both freshwater streams and, where appropriate, reservoirs. The need for biological monitoring in coastal waters is linked to the requirement to maintain uncontaminated shellfisheries and is already under consideration. Costs of implementation may be high initially if full scale tests are undertaken and so selective testing is recommended initially.

Rapid screening tests may be useful as they allow an early warning of a water quality problem that can be investigated in more detail by further toxicity tests or *in-situ* bioassays.

***Stream Flow Monitoring***

In order to have some idea of the actual volumes of pesticides and nutrients discharged to coastal waters - in particular from the streams that are not used to top up reservoirs due to high nitrate levels - a programme of stream flow monitoring may be considered. Without this information it is difficult to assess potential effects on marine organisms.

### 2.3.7 Land Zoning

Cesspits, septic tanks and small sewage treatment plants are the options for premises which are not connected to a public sewer.

Watertight cesspits which are regularly emptied do not cause a problem. However discharges from septic tanks and small sewage treatment plants and also the lack of maintenance these often receive can cause pollution of ground and surface waters.

Problems of groundwater pollution have led the Environment Agency in the UK to develop a policy for the protection of groundwaters. The policy establishes protection zones for all sources of groundwater, wells and boreholes. Within these zones certain activities which affect groundwater are prohibited.

For Guernsey, the water catchment area as well as areas outside the water catchment would be classified as protection Zone 1 and only cesspits would be permitted in these areas.

It is recommended that until suitable criteria are established for the provision of septic tanks and small sewage treatment plants, for planning purposes the whole Island should be considered the equivalent of a Zone 1 source protection area and effectively the whole Island should be considered the water catchment.

## 2.4 OPTIONS TO IMPROVE THE QUALITY OF SURFACE AND GROUND WATERS

- Implement farm management practices and appropriate legislation to store and treat (on farm or centralised States facility) farm slurries and limit the application of slurries to land in proportion to crop requirements and/or,

  Reduce the cow population and the intensification of farming practices;

- Provide education to the farming community to reduce and limit the application of inorganic and organic fertiliser;

- Implement horticultural practices that treat nutrient rich irrigation water prior to discharge and/or, Provide facilities that enable nutrient rich waters to be discharged to the sewerage network;

- Implement a programme to identify inadequate cesspits, septic tanks and private drains and enable cesspit repairs and septic tank replacement where required and/or,

  Ensure connection to the sewerage network wherever practicable;

- Implement a programme to identify and contact the industries most likely to cause environmental pollution, to establish the risks and provide adequate containment facilities;

- Increased regulation and monitoring of all existing landfill sites;

- For planning purposes only permit cesspits in unsewered areas of the island until suitable planning guidelines are drawn up for the provision of septic tanks and small sewage treatment plants.

## 2.5 STRATEGIC DECISION REQUIRED ON SURFACE AND GROUND WATERS

To assist the reader in deciding on the standard required for surface and ground waters a decision flow diagram (Figure 3) is provided. The diagram has questions (in diamonds) which, when answered, will conclude on the requirements (in rectangles).

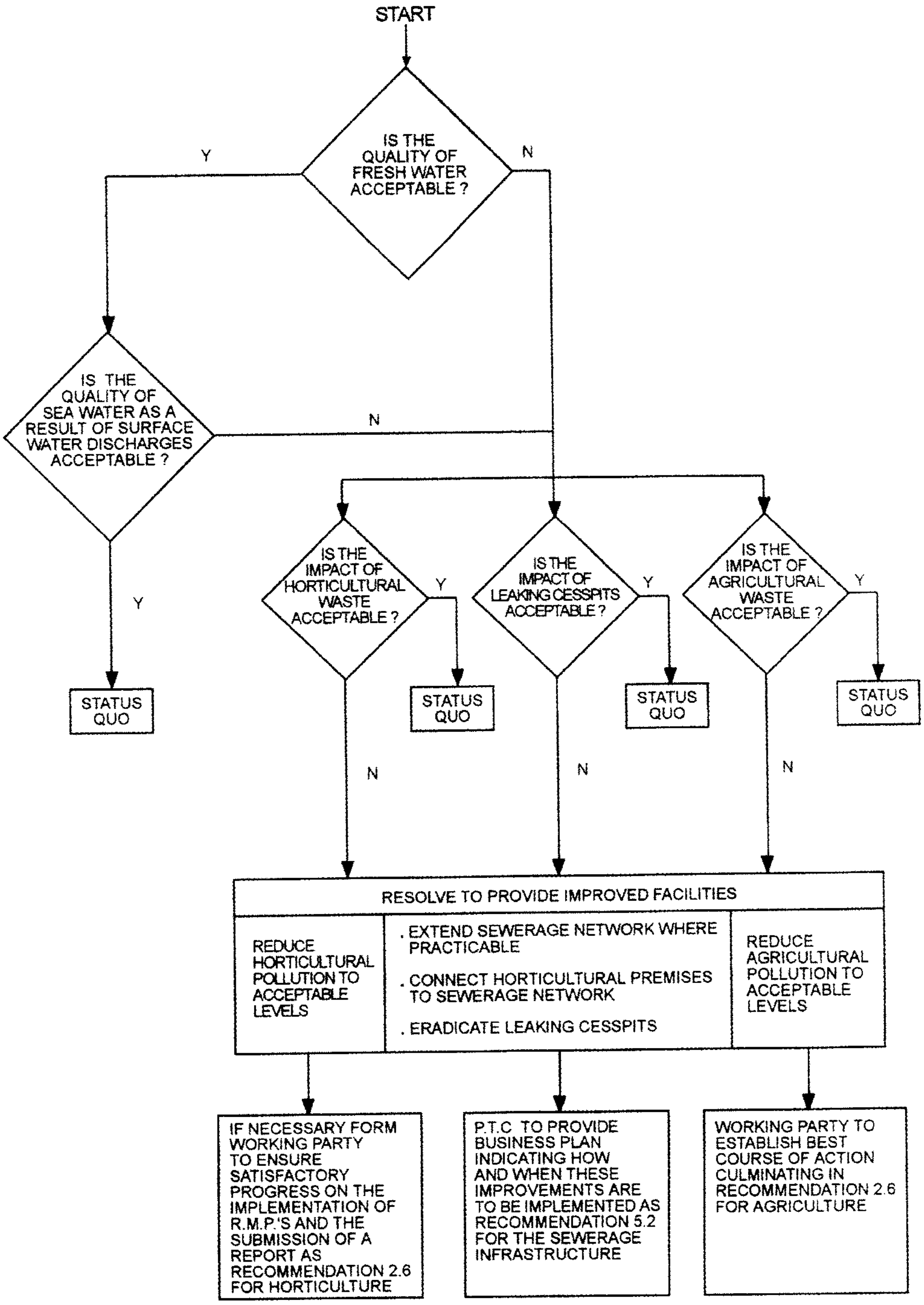



**Figure 3 - Decision Flow Diagram for Surface and Ground Waters**

## 2.6 RECOMMENDATIONS

***For Agriculture:***

| |
|---|
| **The Agricultural and Milk Marketing Board, in consultation with the States Water Board, Public Thoroughfares Committee and Advisory and Finance Committee to prepare and present a report on the introduction of legislative, administrative and other measures with the aim of preventing the pollution of ground and surface waters by the application of fertilisers and slurry along the lines discussed in Section 2.3.1.** |

**Note:** If centralised treatment facilities of agricultural wastes are required this will need to be taken into account for WSa 3 (Liquid Waste - Improvements and Proposals for a Liquid Waste Management Plan).

***For Horticulture:***

| |
|---|
| **The Horticulture Committee, in consultation with the States Water Board, Public Thoroughfares Committee and the Advisory and Finance Committee to prepare and present a report on the introduction of legislative, administrative and other measures with the aim of preventing the pollution of ground and surface waters by nutrient run-off along the lines discussed in Section 2.3.2.** |

***For the PTC:***
Refer to Section 5.0 (The Sewerage Infrastructure).

***For improved monitoring and data management:***
Refer to Section 7.0 (Environmental Data Management).

***For Planning:***
Refer to Section 5.0 (The Sewage Infrastructure)

***For improved protection of surface and ground waters:***

| |
|---|
| **The Water Board to strengthen and expand their existing powers by the issue of Ordinances under the Prevention of Pollution (Guernsey) Law in order to limit existing and potential sources of pollution and control future development which may cause pollution within the Water Board's Catchment Area.** |

| |
|---|
| **Consideration is given to the implementation of a programme to identify and contact the industries most likely to cause environmental pollution, to establish the risks and ensure adequate contingency plans are in place.** |

## 3.0 SEA WATER QUALITY

If the reader is unfamiliar with the make up and the concepts of wastewater treatment referred to in this section, a short summary is given opposite.

There are three discharges to sea that affect the quality of sea water. They are:

- Surface waters;
- Sewage or community wastewaters;
- Aluminium sludges, a bi-product of water treatment carried out by the Water Board.

As the Water Board is currently examining other disposal options for their sludges this topic is not considered further.

Before considering the effects of surface water and wastewater discharges to sea it is worth reviewing the principal standards that apply to wastewater discharges and the quality of sea water.

### 3.1 WASTEWATER DISCHARGE STANDARDS

Over the next decade competing tourist areas in the UK and the continent will be providing sewage treatment facilities to conform to the requirements of EC environmental legislation, in particular the Urban Waste Water Treatment Directive (UWWTD).

#### 3.1.1 The Urban Wastewater Treatment Directive

The UWWTD, issued in 1991, sets minimum standards for sewage treatment. It states that the level of treatment required is dependent upon the size of the population and the type of industrial wastewater that the sewerage system and treatment works have to accommodate. Some of the UK Water Authorities are planning to implement facilities that will provide an effluent quality in excess of that required by the UWWTD.

With reference to Table 2 it can be seen that compliance with the UWWTD would require primary treatment at Belle Greve as the Little Russel is considered to be a high natural dispersion area (HNDA) and appropriate treatment at Creux Mahie, Fort George and Herm.

We tend to think of sewage as just human excreta. Human excreta is less than 1% of sewage. The other ingredients are domestic wastewaters from baths, washing machines, sinks, basins *etc.*; surface water from roofs, road gullies and streams; ground and sea water infiltration; industrial and trade effluents, engine oils and cleaning agents; litter and other debris such as plastic, wood, bricks *etc*. Sewage also contains bacteria and viruses of which some can cause illness and disease to humans. The volume and nature of the sewage varies throughout the day

Sewage (or wastewater) is therefore complex and variable in nature and this is reflected in the different stages of treatment that are required. There are four stages of wastewater treatment:

***Preliminary*** - the sewage is screened by a coarse filtering process that aims to remove all the larger solids. This can be followed by maceration and discharge by outfall, this is the current arrangement at Belle Greve. Storm storage tanks will be required if further treatment stages are to be provided.
***Primary*** - in which the suspended solids are allowed to settle out before the resulting liquid effluent is passed on. This process removes 50-60% of the solids in the form of a sludge, and up to 50% of bacteria and viruses.
***Secondary*** - whereby a biological or chemical process further reduces the oxygen depleting potential of the effluent and further decreases the bacterial and viral concentration of the effluent. This also produces sludge.
***Tertiary*** - a final 'polishing' stage which can be tailored to attain very high standards of effluent. This polishing stage can include the removal of nutrients and the disinfection of the effluent to reduce bacterial and viral concentrations by 99%. There are two types of disinfection, chemical and physical. Chemicals may be applied to raw or treated sewage when it is discharged into the sea. These chemicals may or may not harm marine life, since the relevant tests are believed by some experts to be inadequate. For physical disinfection the wastewater is passed under banks of ultraviolet (UV) lamps.

These four stages are normally used sequentially, *e.g.* secondary treatment is preceded by preliminary and primary processes.

Further plant is required to treat the resultant sludges created by the primary and secondary treatment stages.

Any treatment process will generate a final effluent, as more extensive treatment is implemented the quality of the effluent will improve. The level of treatment provided should take into account the receiving waters to which the final effluent will be discharged.

It is possible, in theory, to treat any effluent to almost any standard, **at a cost**. In selecting the type of treatment process it is critical to decide upon the standard that is required. This decision will be taken on legislative, financial, public health and environmental grounds.

| Population Equivalent | Receiving Water | | |
|---|---|---|---|
| | Fresh | Estuarine | Coastal |
| > 150,000 | Secondary | Secondary | Secondary |
| 10,000-150,000 | "" | "" | Primary for HNDA Secondary for sensitive waters |
| 2,000-10,000 | "" | "" | Appropriate |
| < 2000 | Appropriate | Appropriate | Appropriate |

**Table 2 Urban Wastewater Treatment Directive Requirements**

The principal aim of the Directive is to ban the disposal of sewage sludge to sea. This prevents industrial pollutants, such as heavy metals, being discharged to sea *via* the sewerage network. There is no requirement in the Directive to reduce the quantity of pathogens (bacteria and viruses) in the final effluent.

The consequence of banning sludge disposal to sea is that treatment processes have to be provided which remove sludge from the wastewater. The resultant sludge has in turn to be treated and disposed of, often to land. For Guernsey, if primary treatment was provided, wet sludge quantities are expected to be in excess of 20,000 tonnes per annum, after dewatering this would amount to 1,300 tonnes per annum (about 4% of the total putrescible solid waste stream).

**Sludge disposal is a significant problem for an island of limited land availability.**

### 3.1.2 Considerations Regarding the Adoption of the UWWTD

Because they cover the whole community, the EC Directives are general in nature and are unable to take account of local situations. The Island does comply with some Directives, for instance, those regarding agricultural produce because of trade links with the EU.

The Island has no significant industrial wastes that warrant the banning of sludge disposal to sea.

If Guernsey were to comply with the UWWTD then the resultant on-land sludge disposal would create, for a small island, greater environmental problems than the disposal of sludge to sea.

Guernsey, as well as Jersey and the Isle of Man, does not have to comply with EC Directives however Jersey and the Isle of Man do comply or intend to comply with the UWWTD.

If compliance with the Directive is not an objective in itself then a range of other treatment options are possible and are presented in Section 4.3.

## 3.2 SEA WATER QUALITY STANDARDS

The coastal waters of the Island support a number of activities such as bathing, sailing, fishing and the farming of shellfish. Figure 4 indicates bathing beaches where sea water quality is monitored and farmed shellfish locations.

In addition to the UWWTD the main EC Directives which specify quality of sea water are:

- Bathing Waters Directive (76/60/EEC);
- Shellfish Waters Directive (79/923/EEC).

These two Directives are mainly concerned with pathogen (bacteria and virus) concentrations in sea water.

### 3.2.1 Bathing Waters Directive

The Bathing Waters Directive sets values for designated bathing and recreational waters. There are two levels; a minimum acceptable (mandatory) level of 2000 faecal coliforms/100 ml and a more stringent (guideline) value of 100 faecal coliforms/100 ml.

The Board of Administration wishes bathing waters to conform to the guideline values. Beach awards are based on many different criteria, including the quality of water that is consistently attained during the bathing season.

Many of the Island's beaches are monitored in order to qualify for beach awards. However, some beaches used for bathing are not currently monitored.

Cobo, Havelet, Fermain and Petit Bot have all failed the guideline standard in 2 out of 4 years. Ladies Bay has failed in 2 out of 2 years, Saints has failed in 1 out of 2 years, and L'Eree has failed in 1 out of 4 years. All beaches tested in the last 4 years have met the mandatory standard.

The 1996 Guernsey bathing water test results are indicated below in Table 3 and beach locations are indicated on Figure 4 opposite.

| Beach | Meets Mandatory Standard | Meets Guideline Standard |
|---|---|---|
| Vazon | Yes | Yes |
| Pembroke | Yes | Yes |
| L'Eree | Yes | Yes |
| Port Soif | Yes | Yes |
| Portelet | Yes | Yes |
| Cobo | Yes | Yes |
| Ladies' Bay | Yes | No |
| Havelet | Yes | Yes |
| Fermain | Yes | Yes |
| Saints | Yes | Yes |
| Petit Bot | Yes | Yes |

**Table 3 1996 Guernsey Bathing Water Test Results**

### 3.2.2 Shellfish Waters Directive

The Shellfish Waters Directive recommends guidelines on bacterial concentrations. As filter feeders, shellfish may ingest and retain bacteria and viruses which can be passed on to humans when eaten.

Guernsey shellfish are graded for purity in accordance with the local Food Safety (Live Bivalve Molluscs and Other Shellfish) Ordinance, 1996 which is based on the Shellfish Waters Directive. Table 4 below shows that the gradings are determined by the bacterial content of the shellfish flesh.

| Grade | Bacterial Content | Action |
|---|---|---|
| A | Less than 300 faecal coliforms or 230 *E.coli* per 100g of mollusc flesh | Suitable for immediate consumption |
| B | Less than 6000 faecal coliforms or 4600 *E.coli* per 100g of flesh | Purification/relaying in high quality water until the bacterial content of the flesh is the same as grade A |
| C | Less than 60,000 faecal coliforms per 100g of flesh | As B but purified for longer (at least two months) |
| D | More than 60,000 faecal coliforms per 100g of flesh | Closure of bed |

**Table 4 Shellfish Water Classification**

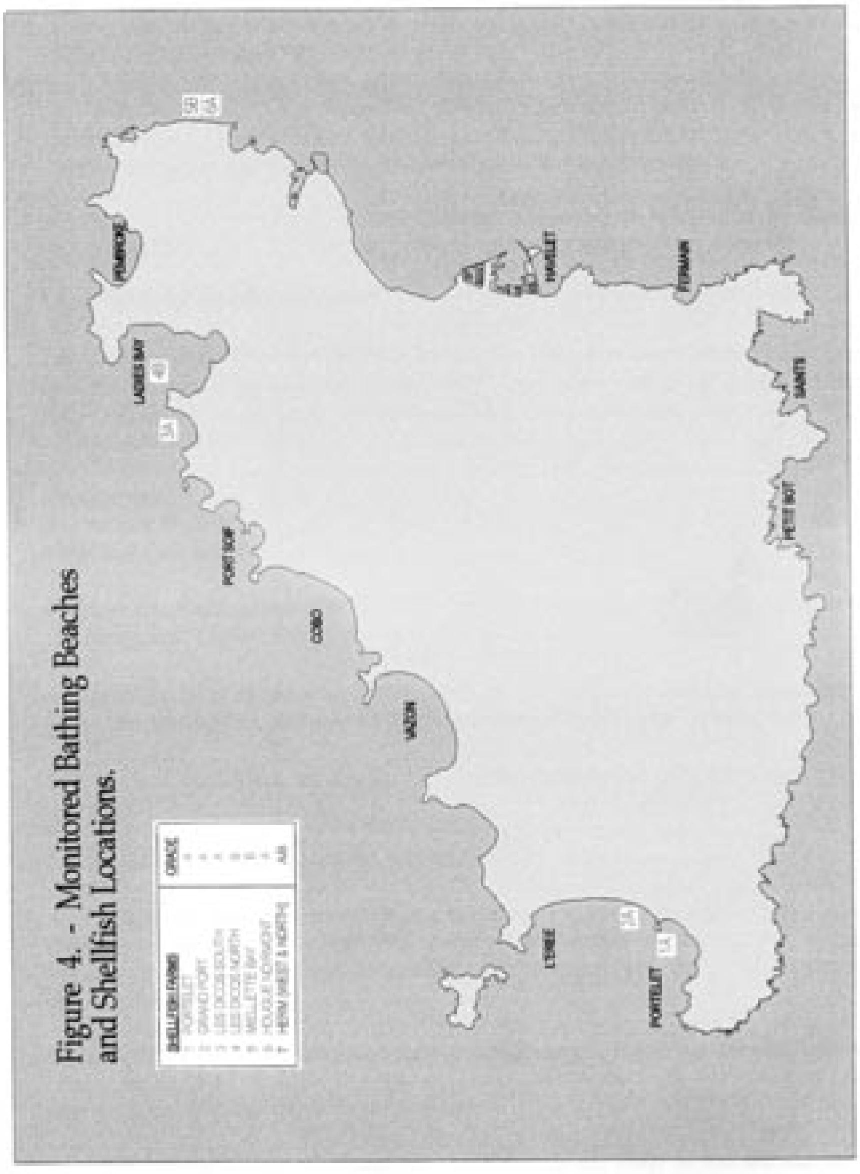



Figure 4. - Monitored Bathing Beaches and Shellfish Locations.

In order to ensure that the bacterial content of the shellfish flesh is to Grade A standard, it is necessary for the marine environment in which the shellfish are developing to be of the same or better bacterial quality. Therefore for the purpose of relating dispersion model results to shellfish quality, we will assume in considering these example treatment schemes that the sea water needed to achieve grade A shellfish must have a bacterial concentration of less than 300 coliforms per 100ml.

Note that, according to the legislation, shellfish which attain grade B or C may be transferred to a location of higher quality water, during which time the bacterial content of the flesh reduces and the shellfish are then eligible for live consumption.

In 1995, five out of the Island's eight shellfish farms received the top grading for quality. The remaining three are situated near potential sources of bacterial contamination.

### 3.2.3 Toxicity Based Consents

The Environment Agency in the UK is introducing new environmental standards based upon the toxic response of aquatic organisms. This is in contrast to the Directives cited above which are based upon the concentration of various substances present within effluent (*e.g.* bacteria).

Development of these so-called toxicity based consents is still underway and therefore they cannot be included in this document. However, local decision makers should be aware that their introduction in Guernsey could offer a number of advantages.

- More direct assessment of environmental damage, which is important locally with the existence of shellfish farms which are especially sensitive to pollutants.

- The WSa Brief requires an investigation of the scope for charging producers of problematic wastes, toxicity may be used as part of the charging scale.

- Improved confidence in identifying non-toxic wastes that may be discharged to sewer.

## 3.3 ANALYSIS OF MARINE DISPERSION

A computerised dispersion model of the Island waters has been created. The model incorporates the state of the tide, the strength and direction of tidal streams, sunlight intensity and wind conditions to predict the movement and decay of wastewater discharges to sea.

Figure 5 shows dispersion model output simulating sewage discharges from Belle Greve, Creux Mahie, Fort George and Herm. The figure depicts the maximum possible concentration of faecal coliforms and indicates:

- No bathing waters monitored for beach awards are likely to fail the mandatory standard of 2000 faecal coliforms per 100 ml of sea water;

- Havelet Bay, Fermain Bay, Bordeaux and the west coast of Herm are likely to fail the guideline standard of 100 faecal coliforms per 100 ml of sea water. In the case of Fermain Bay failure is only expected to occur at night;

- The Little Russel fails the shellfish guideline standard.

**Note that the discharge from Belle Greve outfall has no influence upon the quality of water at the south, west and north coast beaches.**

**The failure of water quality at other bathing beaches (Ladies Bay - see Table 3) is not attributable to sewage discharge, rather the bacterial concentrations that arise from polluted surface water streams discharging to sea as discussed in 2.2 and reflected in Figure 6.**

## 3.4 OPTIONS TO IMPROVE SEA WATER QUALITY

Should the current sewage disposal policy be considered unacceptable, the following course of action may be followed:

- Implement a programme of inshore sampling to confirm that the dispersion model predictions are correct and if so provide treatment to reduce pathogens at Belle Greve outfall.

  This would improve the quality of sea water on the east coast of Guernsey (see Section 4.0 for options).

- For bathing beaches on the other coasts of Guernsey to obtain superior water quality, contamination by polluted surface waters would have to be eradicated, as described in Section 2.0.

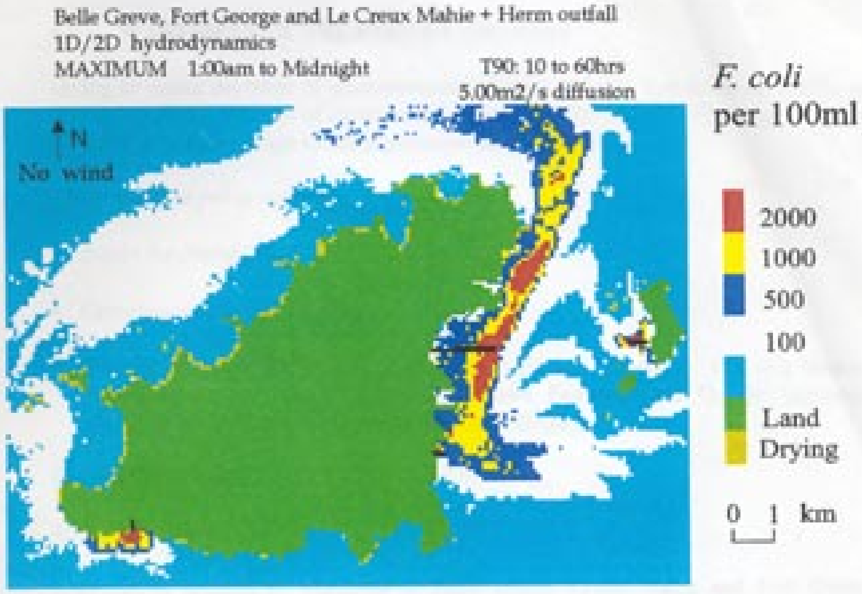



FIGURE 5 - Sewage Discharges from Belle Greve, Creux Mahie, Fort George and Herm. Maximum Bacterial Concentration for Spring Tide.

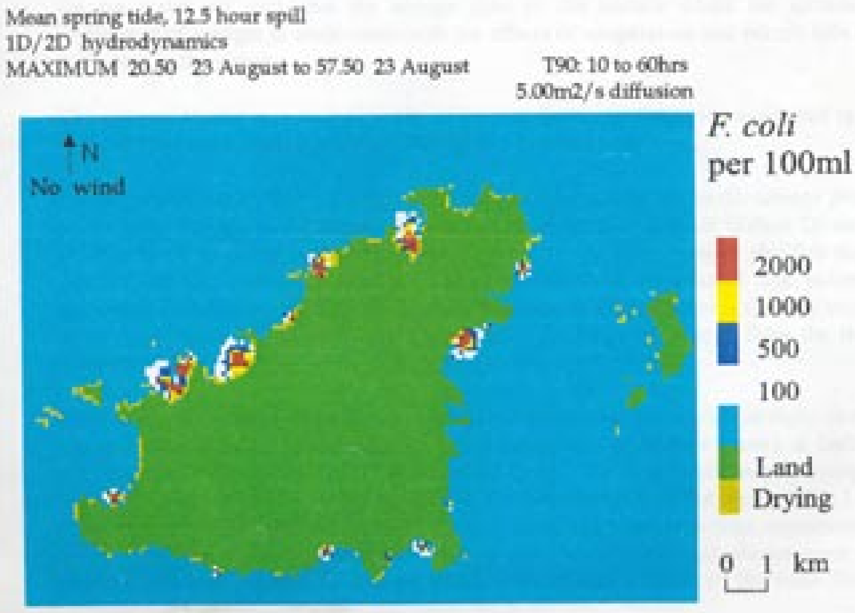



FIGURE 6 - Discharges from Bacterial Polluted Streams. Maximum Bacterial Concentration.

## 4.0 WASTEWATER TREATMENT OPTIONS

Owing to media coverage of environmental incidents and new legislation the public are now generally more aware of environmental issues than in the past. To many, the policy of discharging raw sewage to sea is perceived as unacceptable.

There are three policy options:

- Retain the *Status Quo*;
- Compliance with the UWWTD;
- Provide treatment that reduces pathogens to the level required. This is a bespoke option where the Island establishes its own Environmental Quality Objectives (EQOs) and Environmental Quality Standards (EQSs).

### 4.1 *STATUS QUO* (DO NOTHING OPTION)

#### 4.1.1 Overview

The existing systems of treatment at Belle Greve; Creux Mahie and Fort George incorporate only preliminary treatment (no sludge removal).

The existing system at Belle Greve reduces the solids in the sewage to a size less than 6 mm (1/4") diameter prior to pumping 2 km to sea. The sewage is discharged at the sea bed into a minimum depth of 10 metres of sea water through 5 diffusers which disperse the sewage into the tidal currents. The density and temperature of the sewage relative to the sea water are such that the sewage rises to the surface where the ultraviolet component of sunlight in conjunction with the effects of temperature and salinity kills the pathogens in the plume.

**The present abundance and diversity of marine flora and fauna is considered to be indicative of good overall water quality in the local waters.**

The dispersion model, however, indicates that the water quality within the sewage plume in the Little Russel would contribute to a failure of the EC Shellfish Waters Directive (79/923/EEC) as stated earlier. In 1995, five out of the Island's eight shellfish farms received the top grading for quality. The remaining three are situated near potential sources of bacterial contamination. The shellfish farm at Mielette Bay is the only one of these three which would possibly be affected by discharge of sewage from the Belle Greve outfall.

With respect to sewage, dispersion modelling has shown that the outfalls at Belle Greve, Creux Mahie and Fort George do not affect the quality of inshore waters at bathing beaches (with the exception of some east coast bays). The sewage plume originating at Belle Greve can extend to the western side of the island but it does not come within 1 km of the west coast (see Figures 5 and 7 for mean spring and mean neap tides respectively). Water quality at Bordeaux, Belle Greve Bay and Havelet does not always meet the guideline standard of the EC Bathing Waters Directive as a result of the Belle Greve outfall. However, note that Havelet Bay met the guideline standard during 1996 (Table 3). Failure to meet the guideline standard at any other bathing location is a result of agricultural waste or leaking sewerage contaminating stream discharges.

Owing to the tidal characteristics around the shores as described above, introduction of sewage treatment is therefore only likely to improve sea water quality along the east coast of Guernsey and in the body of offshore water which is currently affected by the sewage plume.

***Disadvantages/Advantages***

The disadvantages of the *status quo* option are:

- Not complying with EC guideline standards for shellfish waters;
- Not complying with EC guideline standards for certain east coast bathing waters;
- Public and visitor perception is generally negative towards this option;
- Not complying with UWWTD to install primary treatment.

The advantages of the *status quo* option are:

- No capital expenditure;
- No land requirement for treatment works;
- No residual sludge to treat and dispose;
- No requirement for additional operational (including staff) and maintenance costs;
- Simple disposal method which does not rely upon expertise from outside the Island;
- All north, south and west coast bays meet required standards (if pollution from agriculture and leaking sewers/cesspits is ignored).

#### 4.1.2 Extend Belle Greve Outfall

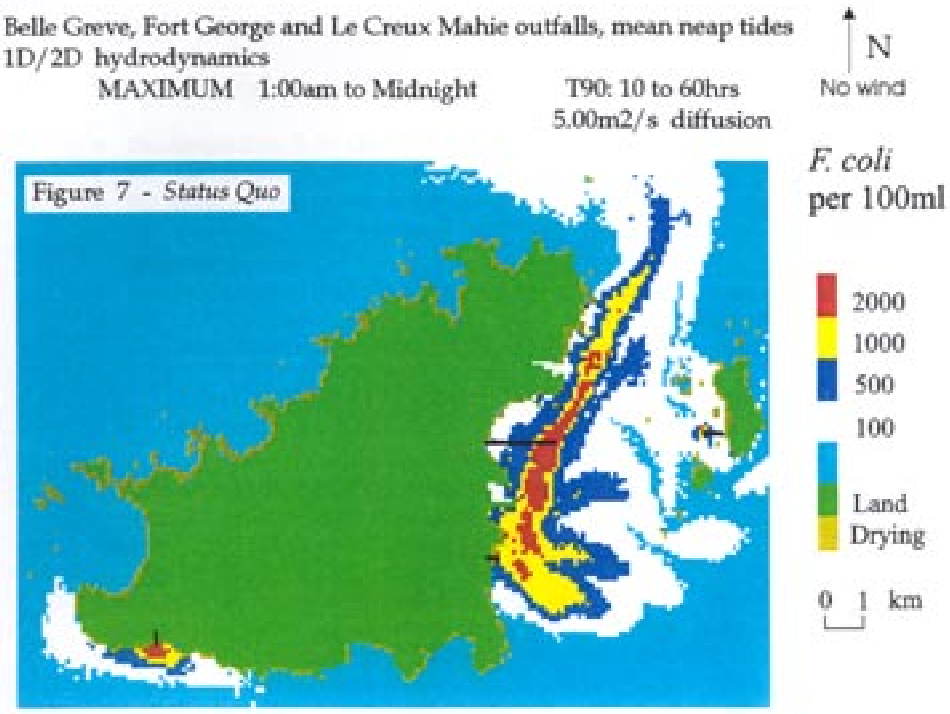
A variation on retaining *status quo* treatment is to extend the long sea outfall by 500 m effectively pushing the sewage plume further out into the Little Russel. As Figure 8 shows this relieves the east coast of the Island of bacterial pollution at the expense of Herm's west coast. The cost of this option is approximately £4,000,000. This figure would increase if underwater rock excavation was required to satisfactorily bed the outfall.

***Disadvantages/Advantages***

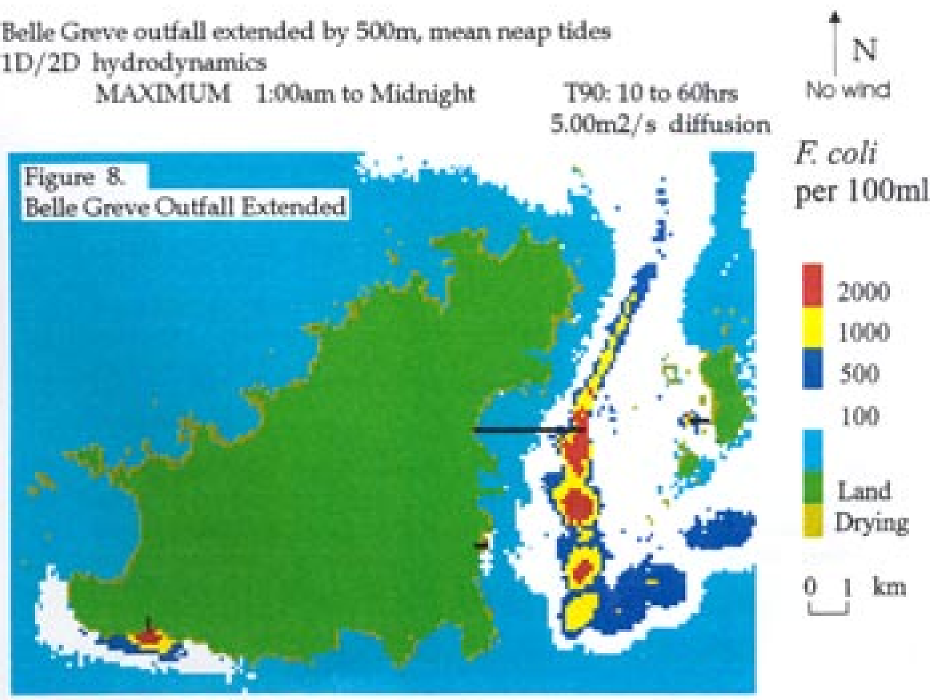
The disadvantages of the *extended outfall* option are:

- Not complying with EC guideline standards for shellfish waters;
- Not complying with guideline standards for Herm's west coast bathing waters;
- Public and visitor perception still likely to be negative towards this option;
- Not complying with UWWTD to install primary treatment.

Belle Greve, Fort George and Le Creux Mahie outfalls, mean neap tides
1D/2D hydrodynamics
MAXIMUM 1:00am to Midnight T90: 10 to 60hrs
5.00m2/s diffusion




Belle Greve outfall extended by 500m, mean neap tides
1D/2D hydrodynamics
MAXIMUM 1:00am to Midnight T90: 10 to 60hrs
5.00m2/s diffusion



The advantages of the *extended outfall* option are:

- Discharges from Belle Greve do not affect Guernsey's coastline;
- No land required for treatment works;
- No residual sludge to treat and dispose;
- No requirement for additional staff and limited additional operational and maintenance costs;
- Simple disposal method which does not rely on expertise from outside the Island;
- All of Guernsey's beaches would meet guideline standard of Bathing Waters Directive (if pollution from agriculture and leaking sewers/cesspits is ignored).

## 4.2 WASTEWATER TREATMENT REQUIRED TO COMPLY WITH THE UWWTD

Compliance with the UWWTD would place Guernsey on a comparable basis with other communities which is likely to enhance the 'image' of the Island and assist the tourism industry.

This option will ban the disposal of sewage sludge to sea. This option will require enhanced preliminary works incorporating storm overflow tanks as well as primary treatment (settlement tanks) and a strategy developed to deal with the resultant sludge.

This option would produce in excess of 20,000 tonnes of wet sludge annually requiring treatment and disposal, whilst reducing bacterial concentrations by up to 20%-50%. Examination of the Marine Dispersion Model (see Figure 9) shows that this option would satisfy all the mandatory requirements of relevant EC Directives. The option does not, however, satisfy the EC guideline values for bacterial concentrations, which both the Board of Administration and Sea Fisheries would wish to achieve. In summary, this option gives little improvement in water quality and creates a greater environmental problem of sludge treatment and disposal than is posed by the *'Status Quo'*.

To illustrate the resource implications of adopting the UWWTD two examples are considered, a classical treatment system and a small footprint works. Both examples include a sludge treatment option and disposal to landfill.

***Classical Treatment Works Example***

A classical treatment system that would comply with the UWWTD would include headworks, conventional settlement (primary treatment), and appropriate sludge treatment (anaerobic digestion and drying) and disposal to landfill. This treatment system would remove 50-70% of the total solids, and 20-50% of the coliforms and 50% of viruses.

The capital costs and footprints are given in Table 5. The total footprint (Site A) is shown on the plan contained in the Appendix, and Plates 1, 2, 3 and 4 (see Appendix) show the visual appearance of headworks, conventional settlement, anaerobic digestion and sludge drying respectively, which are currently operational for similarly sized populations.

| Treatment Process | Capital Cost ± 15% (£) | Footprint ± 15% | |
|---|---|---|---|
| | | ($m^2$) | (vergees) |
| Headworks | 3,100,000 | 300 | 0.2 |
| Conventional Settlement | 1,800,000 | 3600 | 2.2 |
| Sludge Treatment/Disposal | 5,600,000 | 2500 | 1.5 |
| Total | 10,500,000 | 6400 | 3.9 |

**Table 5 Classical treatment works - capital costs and footprints.**

It is estimated that an additional 7 technical and operational staff will be required, and that the operational and maintenance costs will be £450,000 per annum.

An advantage of this treatment system is that it is proven technology with widespread use throughout the world. The main disadvantage, particularly for Guernsey, is the large area of land required, and that it would be extremely expensive to cover the works if it was sited near to housing.

***Small Footprint Works Example***

A small footprint treatment system that would comply with the UWWTD would include headworks, lamella settlement (primary treatment), and appropriate sludge treatment (thermophilic digestion and drying) and disposal to landfill. As with the conventional treatment system, this would remove 50%-70% of the total solids, and 20%-50% of the coliforms and 50% of the viruses.

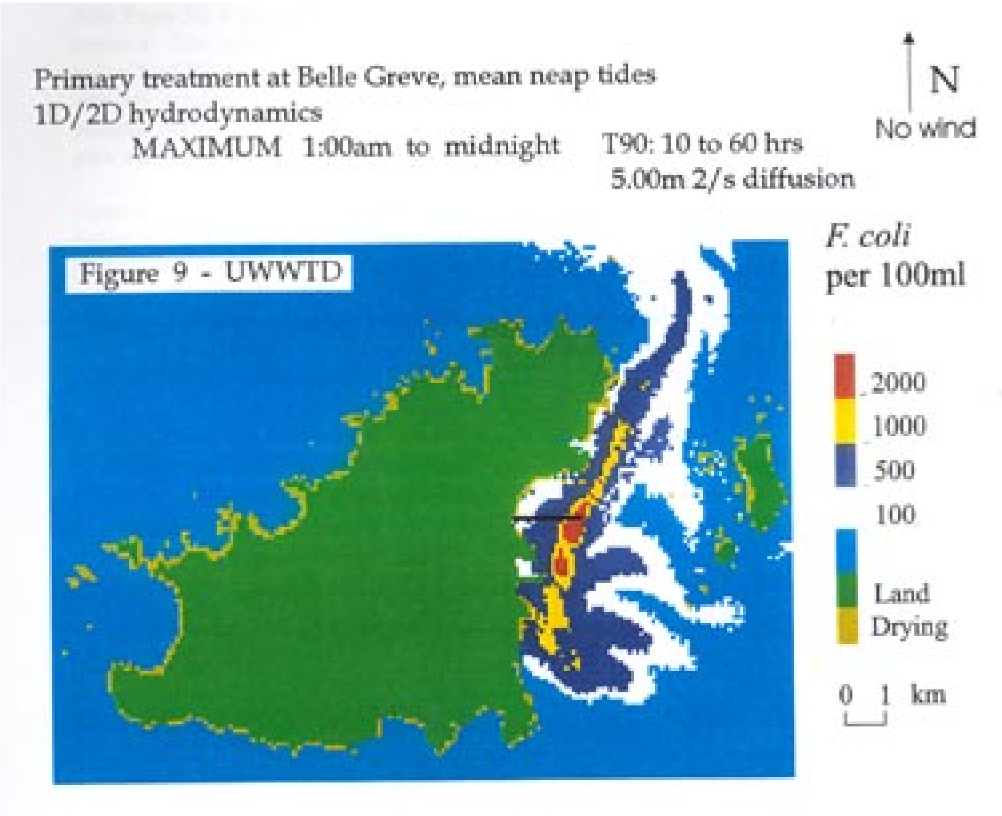
The capital costs and footprints inclusive of sludge treatment are given in Table 6. The total footprint is shown on the plan contained in the Appendix (Site B).

| Treatment Process | Capital Cost ± 15% (£) | Footprint ± 15% | |
|---|---|---|---|
| | | ($m^2$) | (vergees) |
| Headworks | 3,100,000 | 300 | 0.2 |
| Lamella Settlement | 800,000 | 300 | 0.2 |
| Sludge Treatment/Disposal | 6,100,000 | 2200 | 1.3 |
| Total | 10,000,000 | 2800 | 1.7 |

**Table 6 Small footprint works - capital costs and footprints.**

Similarly to the classical treatment works, it is estimated that an additional 7 technical and operational staff will be required, and that the operational and maintenance costs will be £475,000 per annum.

An advantage of this treatment system is the small footprint and the possibility of covering the works. The main disadvantage is that compared to conventional treatment, there is a lack of operational experience with these processes. Another potential problem is that thermophilic aerobic digestion would produce an offgas stream which is a potential source of odour.


Primary treatment at Belle Greve, mean neap tides
1D/2D hydrodynamics
MAXIMUM 1:00am to midnight
T90: 10 to 60 hrs
5.00m 2/s diffusion
N
No wind
Figure 9 - UWWTD
F. coli
per 100ml
2000
1000
500
100
Land
Drying
0 1 km

4.3 PROVIDE TREATMENT THAT SATISFIES ESTABLISHED EQOs/EQSs

This option requires decisions to be made that will determine the quality of coastal waters around the Island. This approach is the establishment of Environmental Quality Objectives (EQOs) and Environmental Quality Standards (EQSs) as detailed in WSa Paper No 4 (Volume 2 of the main report).

WSa Paper No 4 suggests the creation of a working party involving groups with vested interests. The opinions from each of these groups would then be taken into account before final EQOs and EQSs are determined. At this stage it is not possible to assess, with any certainty, the conclusions of such a working party. There is a wide range of potential outcomes; anything from the *status quo* to extensive treatment resulting in near pure water effluent.

However, for the purposes of this report, as the Board of Administration and Sea Fisheries preferences regarding bacteria levels in coastal waters are already known, these preferences have been used to establish likely EQO options.

There are a number of treatment options which can be provided to satisfy the likely EQO based upon the above Committees' requirements of meeting the EC Bathing Waters and EC Shellfish Waters guideline standards:

- Disinfection and continued sludge disposal to sea;
- Primary treatment and disinfection with or without sludge disposal to sea;
- Primary and secondary treatment with or without sludge disposal to sea;
- Primary, secondary and tertiary treatment with or without sludge disposal to sea.

Wastewaters are complicated liquors and differ from one location to another. No two wastewaters are the same. In consequence there is a bewildering number of treatment processes that have been developed. The options that follow are examples only of what may be applicable.

Three EQO examples are considered:

- Maintain High Quality Shellfish Beds in All Waters;
- Comply with Mandatory Standards of the Bathing Waters Directive in All Receiving Waters;
- Comply with Guideline Standards of the Bathing Waters Directive in All Coastal Waters including the Little Russel

#### 4.3.1 EQO: Example 1: Maintain High Quality Shellfish Beds in All Waters

Preliminary, primary and secondary treatment can be provided to reduce coliform levels to below 300 faecal colilforms per 100 ml (the concentration likely to result in shellfish of grade A quality) with the exception of a small mixing zone at the end of the outfall (see Figure 10).

*Classical Treatment Works Example*

A classical treatment system that would comply with this EQO would include storm tanks, headworks, conventional settlement (primary treatment), activated sludge process (secondary treatment), and appropriate sludge treatment (anaerobic digestion and drying) and disposal to landfill. This treatment system would remove 90 to 95% of the total solids, and approximately 95% of the bacteria and viruses.

The capital costs and footprints are given in Table 7. The total footprint is shown on the plan contained in the Appendix (Site C), and plates 5 and 6 show the visual appearance of storm tanks and the activated sludge process respectively, which are operational for similarly sized populations.

| Treatment Process | Capital Cost ± 15% (£) | Footprint ± 15% ($m^2$) | (vergees) |
|---|---|---|---|
| Storm Tanks | 4,900,000 | 4500 | 2.7 |
| Headworks | 3,100,000 | 300 | 0.2 |
| Conventional Settlement | 1,800,000 | 3600 | 2.2 |
| Activated Sludge Process | 3,000,000 | 7200 | 4.4 |
| Sludge Treatment/Disposal | 5,600,000 | 2500 | 1.5 |
| Total | 18,400,000 | 18100 | 11.0 |

**Table 7 Classical treatment works - capital costs and footprints.**

It is estimated that an additional 12 technical and operational staff will be required, and that the operational and maintenance costs will be £780,000 per annum.

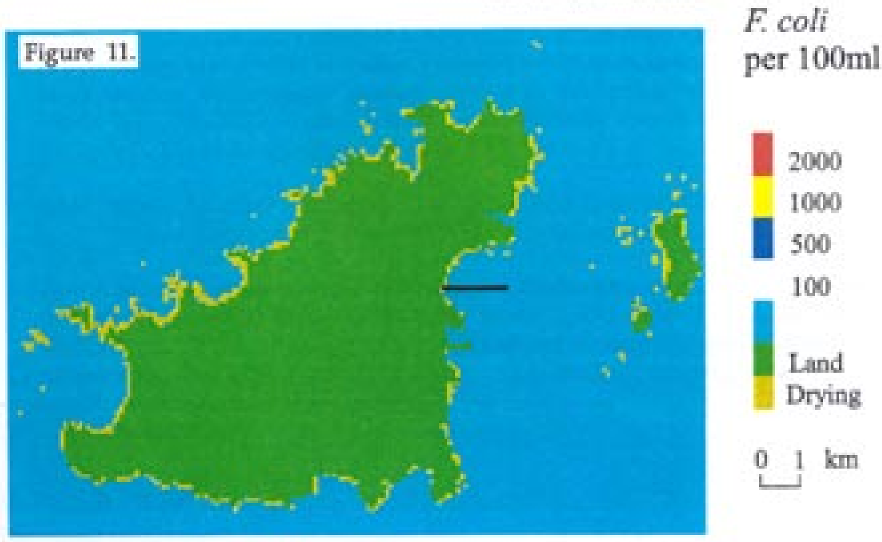
An advantage of this treatment system is that it is proven technology with widespread use throughout the world. The main disadvantage, particularly for Guernsey, is the large area of land required, and that it would be extremely expensive to cover the works if it was sited near to housing.

*Small Footprint Works Example*

A small footprint treatment system that would comply with this EQO would include storm tanks, headworks, lamella settlement (primary treatment), deep shaft (secondary treatment), and appropriate sludge treatment (thermophilic digestion) and sea disposal.

Secondary treatment at Belle Greve, neap tides
1D/2D hydrodynamics
MAXIMUM 1:00am to Midnight T90: 10 to 60hrs
5.00m2/s diffusion


Tertiary treatment at Belle Greve, neap tides
1D/2D hydrodynamics
MAXIMUM 1:00am to Midnight T90: 10 to 60hrs
5.00m2/s diffusion



As with the conventional treatment system, this would remove 90 to 95% of the total solids, and approximately 95% of the coliforms. The estimated capital cost of a deep shaft secondary treatment system assumes that no deep shaft is available although the shaft to the outfall tunnel at Belle Greve may be suitable for conversion.

The capital costs and footprints are given in Table 8. The total footprint is shown on the plan in the Appendix (Site D).

| Treatment Process | Capital Cost ± 15% (£) | Footprint ± 15% ($m^2$) | (vergees) |
|---|---|---|---|
| Storm Tanks | 4,900,000 | 4500 | 2.7 |
| Headworks | 3,100,000 | 300 | 0.2 |
| Lamella Settlement | 800,000 | 300 | 0.2 |
| Deep Shaft | 8,200,000 | 900 | 0.5 |
| Sludge Treatment/Disposal | 2,700,000 | 1500 | 0.9 |
| Total | 19,700,000 | 7500 | 4.6 |

**Table 8 Small footprint works - capital costs and footprints.**

Similarly to the classical treatment works, it is estimated that an additional 12 technical and operational staff will be required, and that the operational and maintenance costs will be £910,000 per annum.

An advantage of this treatment system is the small footprint and the possibility of covering the works. The main disadvantage is that compared to conventional treatment, there is a lack of operational experience with these processes.

### 4.3.2 EQO: Example 2: Comply With Mandatory Standards of the Bathing Waters Directive in All Receiving Waters

The present preliminary treatment systems at Belle Greve; Creux Mahie and Fort George are sufficient to reduce coliform levels to below the Bathing Water Mandatory Standard of 2000 coliforms per 100 ml in all nominated bathing waters.

However for the mandatory standard to be applied to all receiving waters, the equivalent of preliminary, primary and secondary treatment would be required to reduce coliform levels to below the mandatory standard required by the Bathing Waters Directive (see Figure 10). This EQO is satisfied by the same treatment options given by the EQO: Example 1: Maintain High Quality Shellfish Beds - see 4.3.1.

### 4.3.3 EQO: Example 3: Comply with Guideline Standards of the Bathing Waters Directive in All Coastal Waters including the Little Russel

For the purposes of this study, an Environmental Quality Objective is set which assumes that all coastal waters including the Little Russel are to meet the standard of 100 coliforms per 100 ml (*ie* the guideline bathing waters standard). The dispersion model indicates that this EQO would be attained with preliminary, primary, secondary, and tertiary (disinfection) treatment (see Figure 11).

This EQO is satisfied by the treatment options given in the EQO: Example 1: Maintain high quality shellfish beds plus the addition of ultraviolet (UV) disinfection. UV treatment does not remove solids, but it would kill up to 99.99% of the bacteria and viruses. The UV process is estimated to have capital costs of £600,000, a footprint of 150 $m^2$ (0.1 vergees) and additional operational and maintenance costs of £20,000 per annum.

***Classical Treatment Works Example***

The total costs and footprint are given below:

| | |
|---|---|
| Capital Cost: | £19,000,000 |
| Operational Cost: | £800,000 per annum |
| Staff: | 12 |
| Footprint | 18250 $m^2$ (11.1 vergees) |

The footprint is shown on the plan in the Appendix (Site E).

***Small Footprint Works Example***

The total costs and footprint are given below:

| | |
|---|---|
| Capital Cost: | £20,300,000 |
| Operational Cost: | £930,000 per annum |
| Staff: | 12 |
| Footprint | 7650 $m^2$ (4.7 vergees) |

The footprint is shown on the plan in the Appendix (Site F).

4.4 SUMMARY OF OPTIONS

The options described in sections 4.1 to 4.3 are summarised in the following table:

| Option (Report reference) | | Capital Cost (£million) | Footprint (vergees) | Staff | Annual Costs (£1000) | Site (see plan in appendix) |
|---|---|---|---|---|---|---|
| Do Nothing (4.1.1) | | 0 | 0 | 0 | 0 | - |
| Extend Outfall(4.1.2) | | 4 | 0 | 0 | 0 | - |
| UWWTD (4.2) | Classical | 10.5 | 3.9 | 7 | 450 | A |
| | Small | 10.0 | 1.7 | 7 | 450 | B |
| EQO Eg 1 & 2 (4.3) | Classical | 18.4 | 11.0 | 12 | 780 | C |
| | Small | 19.7 | 4.6 | 12 | 910 | D |
| EQO Eg 3 (4.3) | Classical | 19.0 | 11.1 | 12 | 800 | E |
| | Small | 20.3 | 4.7 | 12 | 930 | F |

## 4.5 ADDITIONAL REQUIREMENTS

There could be a number of additional requirements that will have a bearing on the overall costs of the chosen options. These are discussed individually.

### 4.5.1 Upgrading of the Existing Outfalls

In the short and the long term improvements will need to be made to the existing outfalls. After examining several different outfall improvements schemes, the Best Practical Environmental Option (BPEO) for the Belle Greve outfall was to 'continue using the existing tunnel section of the Belle Greve outfall in conjunction with a new diffuser'. The estimated capital cost of this option is £750,000.

### 4.5.2 Horticultural Wastewaters

In the event that horticultural wastes are introduced into the sewerage network, it is estimated that the wastewater flow rates and the resultant treatment costs and footprints would increase by 10%.

### 4.5.3 Agricultural Wastewaters

It is possible that some collected liquid slurries, parlour washings and foul yard run-offs could in certain circumstances and with appropriate pre-treatment be discharged directly to sewer. It is more likely that liquid slurries as well as semi-solid and solid wastes would have to be transported to a central facility.

If a centralised option to deal with agricultural liquid wastes in conjunction with human wastewaters is chosen, the costs and footprints could increase by between 100% to 200%.

### 4.5.4 Enclosed Works

If the proposed site for a treatment works is in a sensitive area and close to housing, there may be a requirement to cover the works. Enclosing the works and providing necessary ventilation and odour control systems increases the cost of the treatment facilities by 50% to 100%.

### 4.5.5 SCADA (Supervisory Control And Data Acquisition system)

SCADA is a computer based system for the control and monitoring of plant. The extent and nature of a new SCADA system is dependent upon the complexity of the infrastructure. It is estimated, that the capital cost would be between £500,000 to £1,000,000.

### 4.5.6 Extraordinary Civil Costs

There may be a need for treatment facilities to be provided at a separate location to the present headworks at Belle Greve. This could require a number of additional civil engineering works such as pumping stations, reclaimed land from the sea *etc*. These costs are so variable that they have not been evaluated at this stage.

### 4.5.7 Sludge Incineration

All the above treatment examples assume that either the sewage sludge will be transported to a putrescible land fill site after appropriate treatment or pasteurised and returned to the sea.

In the event that a sludge incinerator is used as an alternative disposal route, the capital cost would be in the range of £7,000,000 to £14,000,000, with a footprint of 1500 to 6000 $m^2$ (0.9 to 3.7 vergees). The capital cost and footprint will vary significantly depending upon design parameters *i.e.* the nature of the wastes to be incinerated and emission standards. Incineration may remove the requirement for other sludge treatment processes such as digestion.

## 4.6 STRATEGIC DECISION REQUIRED ON WASTEWATER TREATMENT AND DISPOSAL

To assist the reader in deciding on the standard of treatment required, a decision flow diagram (Figure 12) is provided opposite. The diagram has questions (in diamonds) which, when answered, will conclude on the treatment requirements (in rectangles). These conclusions will affect subsequent WSa reports (ovals).

## 4.7 HERM ISLAND

The model indicates (Figure 5) that the west coast of Herm is affected by its own sewage discharge and that the quality of sea water is Grade B at the northern shellfish bed and Grade A at the western shellfishery - refer to Figure 4.

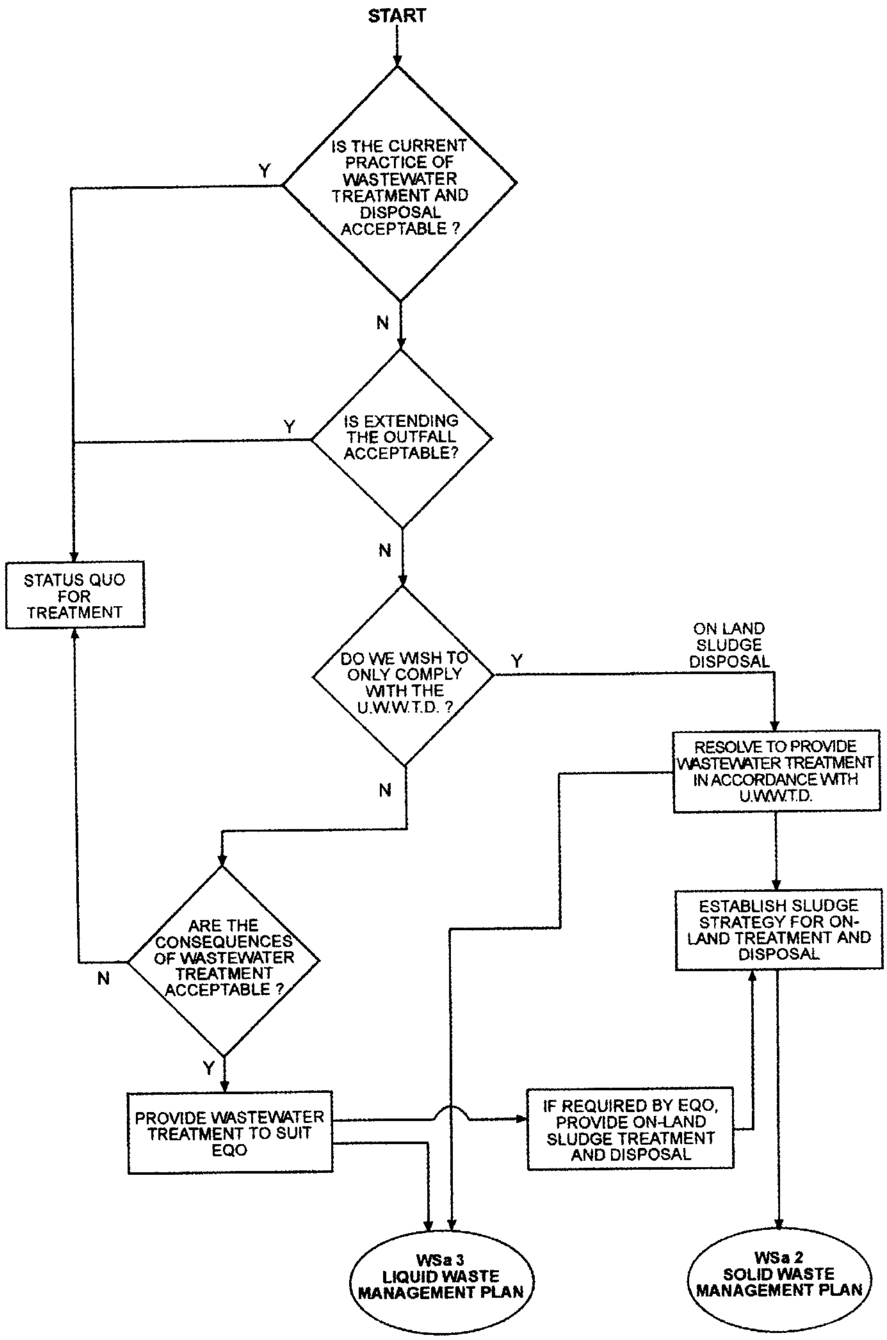



**Figure 12 - Decision Flow Diagram for Wastewater Treatment and Disposal**

4.8 RECOMMENDATIONS

For Guernsey it is recommended that one of the following four options is selected:

| | |
|---|---|
| **(a)** | **The Island should continue to utilise its existing method of sewage disposal by way of preliminary treatment incorporating maceration and discharge to sea through a long sea outfall into Belle Greve bay.** |
| **or (b)** | **The Island should continue to utilise its existing method of sewage disposal by way of preliminary treatment incorporating maceration and discharge to sea through an extended long sea outfall into the Little Russel.** |
| **or (c)** | **The existing method of sewage disposal should be improved to comply with the requirements of the European Communities Urban Wastewater Treatment Directive.** |
| **or (d)** | **The existing method of sewage disposal should be improved to comply with the requirements of established Environmental Quality Standards.** |

**AND if option (d) is chosen then**

**a working party be established to determine the Environmental Quality Objectives and Standards to be adopted.**

**OR to choose one or more of the following Environmental Quality Objectives**

| | |
|---|---|
| **(a)** | **Maintain high quality shellfish beds in <u>all</u> waters** |
| **(b)** | **Comply with mandatory standards of the Bathing Waters Directive in <u>all</u> receiving waters** |
| **(c)** | **Comply with guideline standards of the Bathing Waters Directive in <u>all</u> coastal waters including the Little Russel** |

For Herm it is recommended:

**That the standard of treatment decided for Guernsey should be considered in Herm.**

## 5.0 THE SEWERAGE INFRASTRUCTURE

Two thirds of the Island's population are directly connected to the sewerage network. A plan of the network is indicated in Figure 13. The majority of the remaining properties utilise cesspits. To provide conventional main drain facilities for the majority of these properties would cost £80 million.

Parts of the network show advanced signs of deterioration and permit significant volumes of sea and ground water infiltration. The current assets, valued at £75 million (replacement value) appear to be depreciating at 7% per annum. The effect of rain and tide can increase the flow through Belle Greve pumping station by approximately 5 times the dry weather flow.

A £10 million, 5-year sewerage network rehabilitation programme commenced by the PTC in 1995 will reduce the volumes of infiltration. Removal of infiltration by sea water, surface and ground waters from the sewage flow is an essential precursor to the installation of a sewage treatment works on the basis of reducing the input volumes to the plant and because of their potential to disable biological treatment processes.

***Finances***

The PTC is unable to apply the Polluter Pays principle; income based upon the rateable value of all properties only amounts to 45% of the operational costs of the sewerage network. Similarly, the cesspit emptying service, in the last five years, has been subsidised by 35%-48%. The predetermined revenue budget is not necessarily adjusted to the actual needs of operating and maintaining the PTC's assets. This controlled revenue budget should take into account the needs of a long term business plan to be prepared by PTC.

***Maintenance***

PTC have a planned programme of maintenance to minimise deterioration of their sewerage assets. Private sewers and pumping stations tend not to receive the same attention and have the potential to cause nuisance, pollution and infiltration. Consideration could be given to adopting these sewers or instigating a regular inspection service.

It is suspected that 22% of cesspits are faulty, these place an unnecessary demand upon the emptying service and may also cause groundwater pollution. A range of improvements are possible:

- survey all cesspits and enforce rectification of defects;
- extend sewerage network, giving priority to high risk areas such as the water catchment;
- increase public awareness;
- apply legislative controls.

Figure 13 - Sewerage Network

Lack of cesspit maintenance is as a result of ignorance or negligence. There appear to be two options to improve the standard of maintenance. The first to provide guidance to owners so that they are aware of maintenance requirements and the second is to make maintenance compulsory.

***Unsuitable Liquids***

Intentional or accidental discharges of certain substances can result in damage to the sewer fabric, hazardous conditions to workers and potentially interfere with sewage treatment processes. Provision of services to deal with such liquids and education about the consequences of illegal discharges will improve the current situation.

***Surface Water Disposal***

Inputs of surface water to the sewerage network incur additional costs of pumping and would also increase the costs of any wastewater treatment process. There are two sources of surface water entering the network; drainage from properties and the Mill stream. Investigation of the options to remove both of these should be pursued.

***Network Extension***

In addition to the criteria normally applied by the PTC for sewer extension, the decision process should also take account of areas with a large number of leaking cesspits and vineries which may require disposal of run-off.

Vacuum sewers (a cheaper capital option than conventional sewering) offer an economic means to continue extension of the network into the rural central and south western areas of the Island that are problematic for conventional sewering techniques.

***Wastewater Collection and Disposal Strategy***

If wastewater treatment is adopted it may be installed at a single location, serving the whole Island, or it may be distributed as several smaller plants; centralisation or localisation. A Best Practicable Environmental Option (BPEO) study examined the issue.

It was found that **centralisation of a treatment works and outfall is the best practicable environmental option.** However, localisation may have an economic advantage in certain coastal locations such as Fort George.

Having identified centralisation as the appropriate strategy, a suitable outfall location was investigated by dispersion modelling. The **present location of the Belle Greve outfall was found to be the most efficient** unless there is a requirement to attain higher water quality standards along the east coast. In this case, repositioning the outfall will have limited overall benefit and wastewater treatment will be required. The outfall could then actually be shortened so that effluent emerges from the rock tunnel (discarding the sea bed pipeline) whilst still attaining a higher water quality.

In order to protect surface and ground waters, neither septic tanks nor sewage treatment plants should be permitted in the Water Board's catchment area.

Guernsey legislation gives the States Water Board control on what installations are permitted within the water catchment whereas the Island Development Committee decide on what is acceptable both inside and outside the water catchment.

Outside the catchment, there are areas which, because of their sensitivity, should not have septic tanks or small sewage treatment plants. Either the Island Authorities should permit only cesspits in all unsewered parts of the Island or guidelines should be drawn up for the provision of sewage treatment plants outside the catchment.

Planning Officers and Building Control Inspectors would benefit from guidance (a clear policy needs to be developed) on how to deal with proposed septic tanks or package plants particularly in areas outside the water catchment, especially with regard to arrangements for ensuring regular maintenance and sludge removal.

***Business Plan***

In 1986 the PTC submitted its foul water drainage plan to the States indicating their intentions on extending the network. Since then rehabilitation, rather than extension has been identified as a priority. Furthermore, decisions on this report may require improved standards of treatment. Given these developments, the PTC is presently considering drawing up a business plan for foul water sewerage that reviews/considers and makes recommendations on:

- Current charging and funding arrangements;
- Unnecessary surface water discharges to sewer;
- Commercial and hazardous waste discharges to sewer;
- The cesspit emptying service;
- The maintenance requirements to ensure the public sewerage network is at an acceptable standard of repair;
- Surveillance practices of private sewerage assets, including cesspits;
- Adoption of private sewerage systems;
- Planned extension of the foul sewer network;
- Educational programmes to be adopted to assist in preventing pollution from private facilities and providing a suitable wastewater service for the Island;
- Options of providing improved maintenance for private sewerage assets, particularly cesspits;
- Implementation of any treatment facilities that are required by the States as a consequence of the WSa.

## 5.1 OPTIONS TO IMPROVE THE SEWERAGE INFRASTRUCTURE

- Continued commitment to rehabilitation of the sewerage infrastructure to an adequate standard of repair;

- Upgrade and improve both the public and private sewerage infrastructure to cope with demand and so that all potential pollution sources are eradicated;

- Comprehensive survey and rectification of cesspits;

- For the PTC to draw up its long term business plan for foul water sewerage that incorporates the items listed in Business Plan and taking into consideration:

    - Extension of the sewerage network to accommodate areas with faulty cesspits and vineries. Consider the use of alternative sewerage systems to reach new areas;

    - Promote awareness of the consequences of discharging unsuitable liquids to sewer, consider the provision of a collection service for these liquids. If more extensive sewage treatment is adopted consider the application of charges or compulsory pre-treatment for problematic wastes;

    - Endeavour to continue to remove surface water and sea water discharges from the sewerage network by rehabilitation of sewers and replacement of combined sewers;

    - If more extensive sewage treatment facilities are required, continued use of the Belle Greve outfall and centralisation of treatment plant in this vicinity is the best practicable environmental option.

- A public guidance document is prepared which details the submission procedures relating to drainage matters, in more detail than at present.

## 5.2 RECOMMENDATIONS

***For the Sewerage Infrastructure:***

**The Public Thoroughfares Committee to give top priority to its programme to prevent pollution, particularly within the Water Board Catchment Area, by way of leakage from the Island's sewers and to prepare a report (business plan) on the introduction of legislative, administrative and other measures outlined in 5.1.**

***For Planning:***

**A public guidance document which details the required drainage facilities, the standards required and the submission procedures relating to drainage matters and associated requirements for road closures and road opening notices, be drawn up under the auspices of the Public Thoroughfares Committee.**

**Until such time a guidance document is produced the whole Island should effectively be considered the water catchment.**

## 6.0 MARKETING OF TOURISM

The feedback from visitors to the Island is positive regarding the quality of the environment, and the Guernsey Tourist Board are anxious to maintain this reputation. With the development of markets in Europe the Tourist Board believe it is essential to improve the quality of wastewater treatment to support their "Green" marketing strategy. The Tourist Board consider that the current sewage treatment facilities form a potential constraint to achieving the visitor targets set out in their business plan.

The Tourist Board perceive the provision of sewage treatment (which includes Ultra Violet Tertiary Treatment) on Jersey as a positive marketing tool for Jersey's Tourist Board. The Tourist Board have stated that at shows and exhibitions held in conjunction with the Island of Jersey, it is common for Guernsey to receive adverse comments about its treatment facilities when compared to those of Jersey. Tourist authorities in Jersey, Wales and in the West Country are all adopting a specific 'green' strategy to attract visitors to their area based on pending improvements in the quality of bathing water at certain resorts. The ability to demonstrate a sound physical environment is used as a powerful weapon in their advertising.

The Tourist Board is targeting the ABC1 socio-economic group (*i.e.* the wealthy, the wealthy-retired and families with young children) on the European mainland.

Continental tourists are generally more affluent than visitors from the UK and are also more environmentally aware. Germany has the highest level of spending on tourism - about a third of the European Union total - and its growth is three times above average. To encourage more visitors from Germany, Holland and other continental nations, a holiday resort's environmental standards must, unless it has a specific attraction, be equal to or surpass the standards of the visitors' home country. For Germany, Switzerland and Holland, and to a lesser extent, France, these standards are very high.

In the UK tourist industry, the largest growth in tourist numbers are from young families and recreational water users. In surveys conducted by the Department of the Environment and the West Country Tourist Board, both of these groups were found to be highly aware of bathing water quality issues.

Currently the Island has a number of beaches that have Rural Seaside Awards from the Tidy Britain Group in the UK. However, the standard recognised in Europe is the Blue Flag Award. Guernsey has not, in the past, applied for Blue Flag Awards because practice in the UK has been for such awards to be granted to resort beaches only, whereas Guernsey's beaches have been classified as rural.

## 6.1 OPTIONS TO IMPROVE MARKETING OF TOURISM

- Receipt of beach awards will enhance the Island's image as a tourist destination. The Blue Flag is the most influential beach standard in Europe and therefore should appeal to a wide range of potential visitors.

- Implementation of measures to reduce bathing water pollution via surface waters. A dispersion model (Figure 6) of Guernsey's marine waters has shown that the majority of bathing water failures are caused by surface water pollution.

- Implementation of sewage treatment to conform with the Urban Wastewater Treatment Directive. This would be a useful marketing tool for the Tourist Board and prevent adverse comparisons from being made with other competing resorts such as Jersey.

## 6.2 RECOMMENDATIONS

The following courses of action are recommended:

- **For the Board of Administration to pursue the provision of Blue Flag beach awards.**

- **Implement measures to reduce surface water pollution of bathing waters from stream outfalls along the lines outlined in Section 2.6.**

## 7.0 ENVIRONMENTAL DATA MANAGEMENT

Several of the consultant reports have remarked on the lack of available environmental data and more importantly the lack of management of the data that is available. Separate States bodies collect data that is relevant for their purposes. Some of this data may be useful for other Committees.

**A review of all data collection activities may identify common objectives and highlight priority concerns.**

Provision of a centralised environmental monitoring service should allow more efficient resource usage and solution of problems that have influence beyond one committee. This may be an application suitable for the future States Mapping Information Project or Geographical Information system (GIS).

**It is recommended that the collection and management of environmental data is reviewed, with particular emphasis given to:-**

- Collection and archiving of, as determined by operational and legislative requirements;
- Interpretation of data, including tracking of environmental indicators;
- Distribution of data by provision of reports describing status of environment and trends;
- Sampling of all wells and boreholes which may be used for drinking water;
- Re-evaluation of coastal water monitoring;
- Comprehensive study of nutrient impacts upon water systems;
- Biological monitoring;
- Stream flow monitoring;
- Application of GIS to co-ordination and presentation of data.

It is recommended that:

**Early consideration is given to establish an independent environmental monitoring service to address the above functions and deficiencies.**

## 8.0 EDUCATIONAL MEASURES

Raising the environmental awareness of the community so that behaviours and habits change will facilitate the successful implementation of future waste strategies.

Where different elements of the community work together to resolve problems, education can result in long term changes in attitudes and practices. This can accomplish real financial and environmental benefits, namely:

- Reduction in the costs of waste management;
- Improvements to the environment;
- Minimisation of wastewaters;
- Preservation of valuable resources (*e.g.* potable water).

**Educational measures will be most effective if they are complementary and co-ordinated.** For example, by the provision of educational forums involving in particular the Education Council, and other States Departments, non-governmental organisations and the media.

Carefully structured programmes for information provision and communication are considered to be a necessity if the States are to successfully implement a sustainable waste management strategy making optimum use of the available limited finite resources.

It is recommended that:

**Early consideration is given to the preparation of a report on the introduction of co-ordinated complementary educational measures to improve the environment, support waste management strategies and implement awareness campaigns to use resources efficiently.**

## 9.0 ACTION COMMENCED BY STATES BOARDS AND COMMITTEES

Whilst conducting the WSa, the project team have involved and consulted the staff of a number of States Departments. Relevant consultants' reports have been issued and there has been active involvement in the production of this report.

As a consequence of their decisions in 1990 and their report in 1994 the PTC have actioned a number of initiatives prior to, and in conjunction with, the WSa.

It is pleasing to note that appropriate action has been taken by other Committees namely:

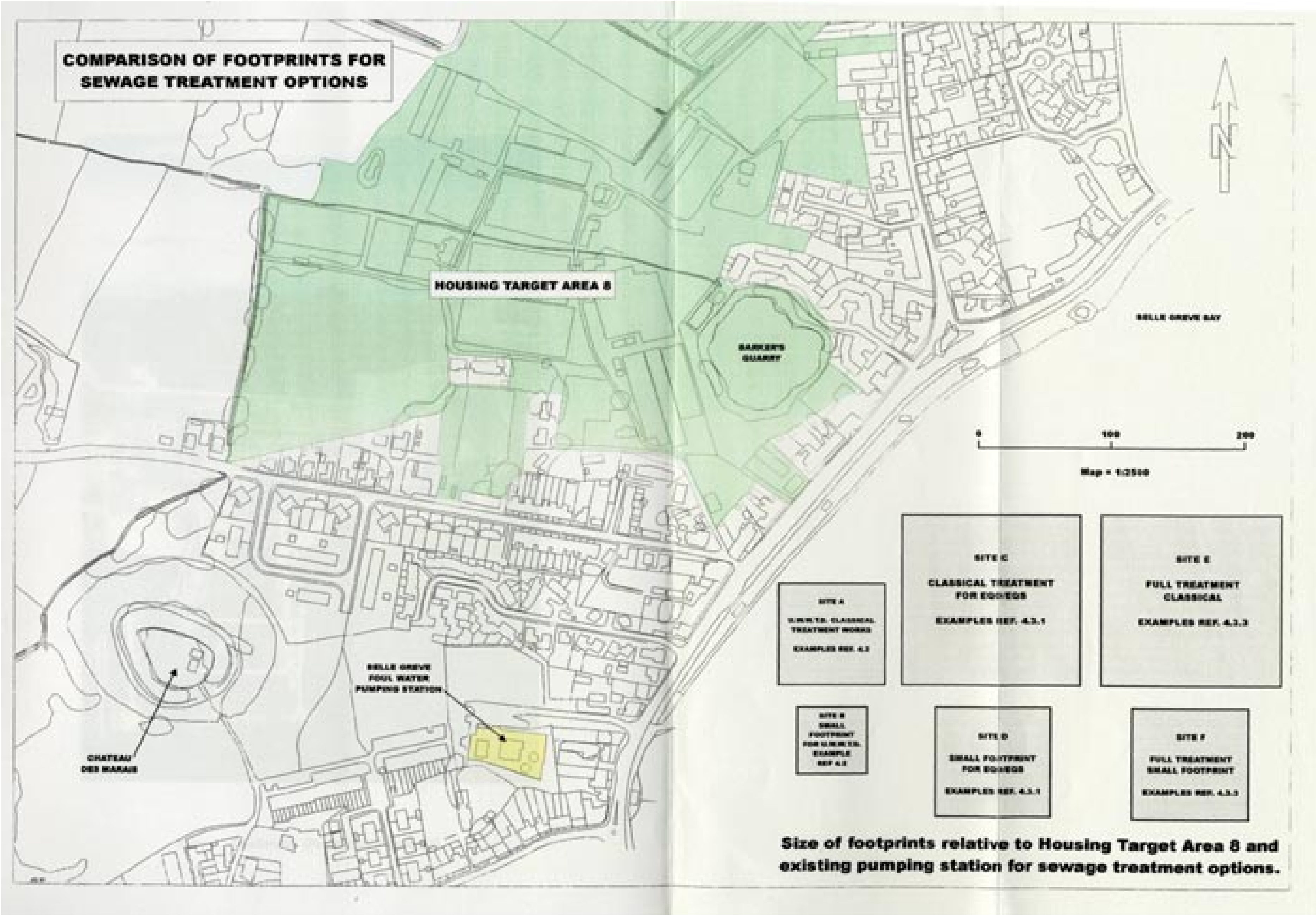
- The Horticulture Committee is implementing increased monitoring of the operation and condition of Run-off Management Plans, revising the laboratory practices which determine fertiliser application and seeking to increase awareness amongst growers of the pollution potential from vineries;

- The Agricultural and Milk Marketing Board has established a working party to begin to examine the agricultural issues;

- The Board of Administration is investigating the provision of Blue Flag Awards.

Also the recent Control of Environmental Pollution legislation which enables the enactment of an ordinance to regulate waste disposal has been accepted by the States of Deliberation.

# APPENDIX




Size of footprints relative to Housing Target Area 8 and existing pumping station for sewage treatment options.

Plate 1. Headworks (Preliminary Treatment)

Plate 2. Settlement Tanks (Primary Treatment)

Plate 3. Anaerobic Digesters (Sludge Treatment)

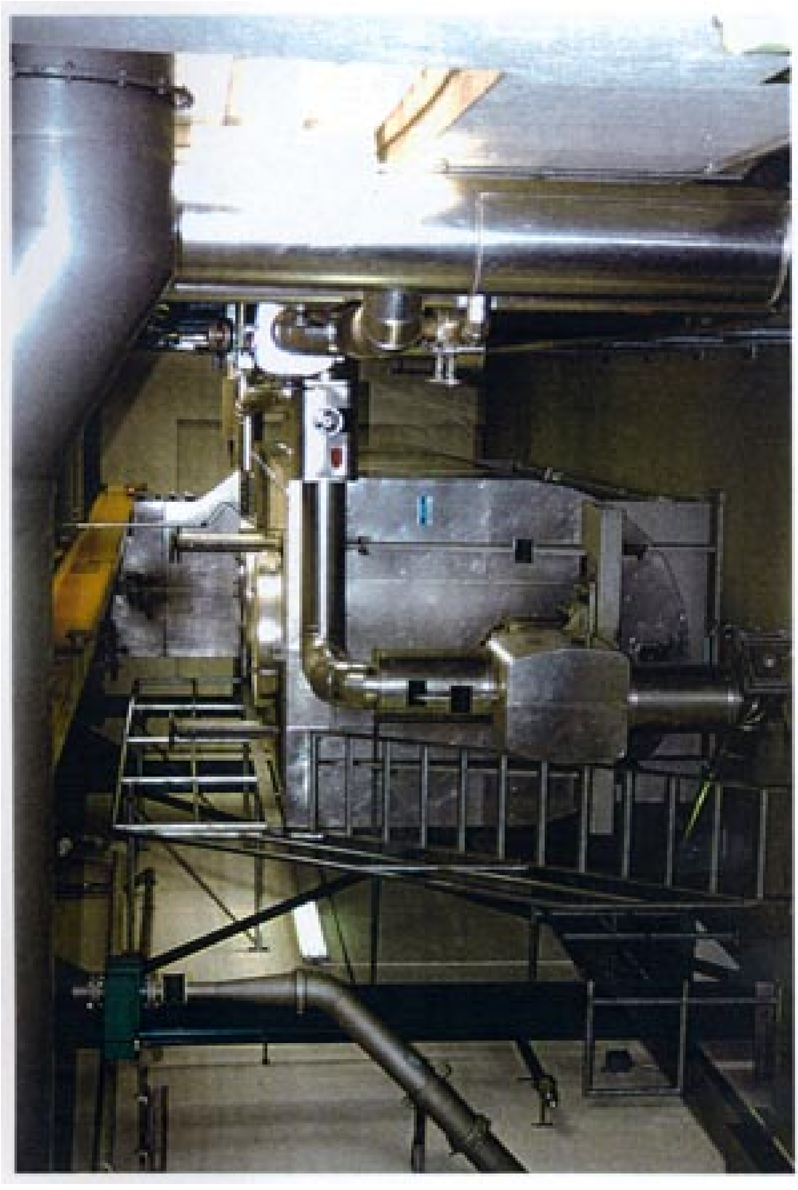


Plate 4. Drying (Sludge Treatment)

Plate 5. Storm Tank

Plate 6. Activated Sludge Process (Secondary Treatment)

**(NB The Policy Council**

- **welcomes the Public Services and Environment Departments' report as a mechanism for consultation on an important and emotive issue**
- **supports the proposal to note the report**
- **endorses the stance of the Treasury and Resource Department that any sewage treatment expenditure would have to be funded in line with the user-pays principle.)**

**(NB The comments of the Treasury and Resources Department are set out below)**

The Chief Minister
Policy Council
Sir Charles Frossard House
La Charroterie
St Peter Port

1st November 2005

Dear Sir

**SEWERAGE AND WASTEWATER TREATMENT**

The Treasury and Resources Department welcomes the Public Services and Environment Departments' intention to "listen very carefully to all discussions and reflect upon the various issues and concerns that are raised," in respect of this important issue.

If full sewage treatment were to be adopted the capital and ongoing costs would be very substantial, estimated at £50m and £1m annually respectively.

The Treasury and Resources Department believes that any sewage treatment expenditure would have to be funded in line with the user-pays principle.

**The Treasury and Resources Department supports the proposal that the Report is noted. However, in doing so it makes no commitment that it will support either the £300,000 for the preliminary environmental impact study, the £1.5m for the full study or any subsequent work.**

Yours faithfully

L S Trott
Minister

The States are asked to decide:-

Whether, after consideration of the Report dated 27th September, 2005, of the Public Services and Environment Departments, they are of the opinion:-

To note that Report

# IN THE STATES OF THE ISLAND OF GUERNSEY

## ON THE 25th DAY OF JANUARY 2006

The States resolved as follows concerning Billet d'État No I
dated 16th December, 2005

## PUBLIC SERVICES AND ENVIRONMENT DEPARTMENTS

SEWERAGE AND WASTEWATER TREATMENT

After consideration of the Report dated 27th September, 2005, of the Public Services and Environment Departments:-

To note that Report

K. H. TOUGH
HER MAJESTY'S GREFFIER