ONSITE WASTEWATER TREATMENT: HERE TO STAY; HOW TO MANAGE?
DEVELOPING AN ONSITE WASTEWATER MANAGEMENT PROGRAMME FOR THE CAYMAN ISLANDS

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ABSTRACT
The performance of onsite wastewater treatment systems is a concern in many regions. Poorly designed, operated or maintained systems can be a major source of water contamination. Utilization of onsite wastewater treatment systems is widespread in the Caribbean region. In Grand Cayman, onsite systems serve approximately eighty percent of the population. The cost and feasibility of providing centralized systems throughout a country or region can be prohibitive, making onsite treatment systems more than just a short-termed solution. This fact has been acknowledged in the United States, where after more than twenty-five years of major funding and efforts to move toward centralized systems, onsite systems serve approximately twenty five percent of the existing population and one-third of new development. In response, the United States Environmental Protection Agency has established Voluntary Guidelines for Management of Onsite Wastewater Treatment Systems (USEPA, 2002). The guidelines provide a flexible framework of management practices needed to develop a programme to raise the level of performance of onsite systems, to improve water quality and protect public health. The Water Authority – Cayman, is developing an Onsite Wastewater Management Programme, using the Guidelines.

KEY WORDS
Grand Cayman, onsite wastewater management, guidelines for management.

INTRODUCTION
The Cayman Islands, a British Overseas Territory, consists of three flat limestone/dolostone islands located in the northwest Caribbean, 480 miles south of Miami, Florida (Figure 1). The total landmass of the three islands is 100 square miles. Grand Cayman is the largest, at 76 square miles, and the most populous, with 95% of the Islands' 40,000 residents (Cayman Islands Census, 1999).

Figure 1: Map of the Cayman Islands, courtesy of www.theodora.com/maps, used with permission.

The Water Authority of the Cayman Islands ("the Authority") was established by law in 1982 to provide public water supply and sewerage to the Cayman Islands, and to protect and manage the water resources of the Country. The Authority serves the dual roles of a utility and a regulatory agency. As those roles relate to wastewater, the Authority owns and operates the central sewerage system and regulates the discharge of all treated sewage effluent, whether from the central system or from onsite systems. Onsite treatment systems are owned and operated by the owner of the property that it serves.

The establishment of the Authority came at a time of rapid development, which has only recently leveled off. In the twenty-year period from 1979 to 1999, the financial and tourism industries flourished: the Islands' resident population more than doubled and annual visitor arrivals increased from 150,000 to 1.4 million (Cayman Islands Census, 1979, 1999; Cayman Islands Tourism Department, 1979, 1999). This paper, and the Onsite Wastewater Management Programme ("Management Programme") being developed by the Authority, is based on conditions in Grand Cayman; however, the Management Programme is applicable to the Sister Islands: Cayman Brac and Little Cayman, where there is less development and no central sewerage system.

The provision of public water supply has kept a closer pace with development than the provision of centralized sewerage. In Grand Cayman, piped water, produced via reverse osmosis, is currently supplied to approximately 90% of the population, while centralized sewerage treats approximately 20% of the wastewater generated. The West Bay Beach Sewerage System (WBBSS), which now consists off twenty-four kilometers (fifteen miles) of collection system, twenty pump stations and four waste stabilization ponds, was installed in 1987 to serve the area with the highest concentration of tourism development.

In September 2002, the Authority broke ground on a new 9,500 cubic meters per day (2.5 million US gallon per day) Sequencing Batch Reactor wastewater treatment plant, to replace the waste stabilization ponds, which are at capacity. The new plant can be expanded to four modules to ultimately treat 38,000 cubic meters per day (10 million US gallons per day) to keep pace with population growth. The Authority is committed to extending the collection system, first to the densely populated areas in close proximity to the WBBSS (districts of West Bay and George Town, to the north and south, respectively), and beyond as population densities warrant it and capital investment is available. Notwithstanding the long-term goal to provide central collection and treatment of wastewater, onsite treatment will continue to serve a significant portion of the Islands' population for the foreseeable future. With this realization comes the challenge of managing onsite systems for the long term.

Many countries – developed and developing – are acknowledging that onsite wastewater treatment will continue to be an integral part of wastewater management. In the past, onsite treatment was often perceived as a stopgap measure, and therefore, management was limited to installation without further intervention barring a complaint or reported failure. For onsite systems to meet their potential as an effective and reliable

wastewater treatment strategy, comprehensive management is required. In the United States, after twenty-five years of significant investment in centralized systems, onsite treatment systems serve twenty-five percent of the existing population and one-third of new development. In response, more resources are being directed at encouraging communities to develop comprehensive management programmes for onsite systems. The United States Environmental Protection Agency ("USEPA") has published a series of documents to guide communities through the process of developing a management programme specific to the needs, resources and capabilities of that community:

- Onsite Wastewater Treatment Systems Manual (USEPA, 2002) ("The Manual"): provides technical information on siting, design, installation, maintenance and replacement of systems,
- Voluntary Guidelines for Management of Onsite Wastewater Treatment Systems (USEPA 2003) ("The Guidelines"): provides a set of recommended practices targeted at improving system performance and reducing risk to human health and water resources, and
- Handbook for Management of Onsite Wastewater Treatment Systems (USEPA 2003) ("The Handbook"): provides a "how to" implement the Guidelines.

The series of USEPA documents provide guidance through a strategic planning process to develop a flexible management programme tailored to a community's needs. The process for developing a programme for any community follows a similar process:

1. Assessing the current status of onsite wastewater management,
2. Selecting appropriate programme elements and objectives to meet the community's wastewater treatment needs,
3. Evaluating the strengths and weaknesses of current activities relative to the programme objectives,
4. Selecting appropriate management activities to meet programme objectives, and
5. Developing a plan for implementation of the management programme.

Variability in programmes arises from a community's approach to each step of the process. Approaches lie on a continuum from basic to intermediate to advanced, depending on the community's particular circumstances, capabilities and resources. The programmes developed following this process are flexible in that as a community's circumstances, capabilities and resources evolve, the approach taken can progress up the scale to a level that adequately addresses public health needs and environmental protection. The resulting programme should reflect the community's best effort to deal with potential public health and water resource risks given their situation. The remainder of this paper discusses how the strategic planning process is being employed by the Authority to develop an Onsite Wastewater Management Programme for the Cayman Islands: seeking a Caribbean – a Caymanian – solution to this Global Challenge.

1) STATUS OF ONSITE WASTEWATER TREATMENT IN GRAND CAYMAN

An assessment of the status of onsite wastewater treatment should consider the number, location, condition and performance of systems to be managed, the value and

vulnerability of water resources, support capabilities and regulatory authority in place. The assessment may range from basic: a review of existing records, estimates of conditions; to intermediate: surveys, site visits; to advanced: inspections of all systems, and scientific evaluation of local water resources. The Authority's approach is intermediate at this stage, taking advantage of available site-specific information and supplementing it with applicable information from published sources.

The Cayman Islands Lands and Survey Department has comprehensive land registry records available on a geographic information system ("GIS"). The Authority subscribes to this information, which is updated monthly. The data set provides a plethora of information including type of development, and proximity to features including water supply, the centralized sewer system (WBBSS), freshwater lenses, surfaces waters and the coast (see Figure 2).

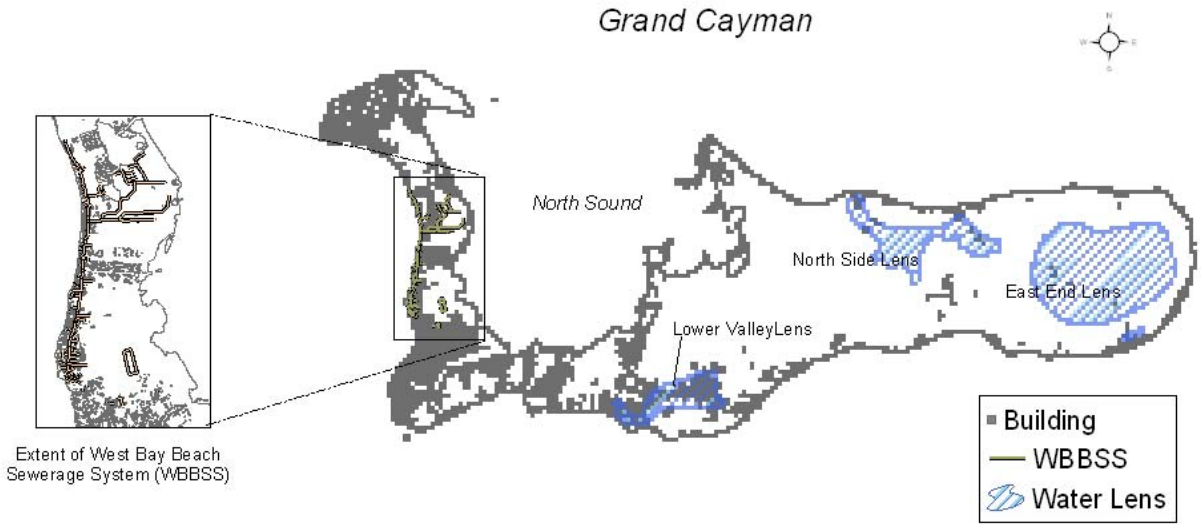

Figure 2: Grand Cayman's Development, Central Sewerage System and Fresh Water Lenses

Based on the number of developments outside the WBBSS service area, there are an estimated 16,000 onsite wastewater treatment systems in Grand Cayman (LIS, 2003). These systems range from cesspits to septic tanks to aerobic treatment units. All treated sewage effluent (with the exception of cesspits, which "soak away") is discharged via disposal wells drilled to a depth of eighteen to twenty four meters (sixty to eighty feet) below water table. The relative volumes of wastewater treated in each type of system are based on census information (Cayman Islands Census, 1999), and estimates of per capita wastewater generation. Table 1 provides a summary.

TABLE 1: Estimated Wastewater Flows by Treatment Type in Grand Cayman.

Wastewater treatment system	Total Flow		Wastewater treated by volume (%)
	m^3/day	gpd	
West Bay Beach Sewer System (WBBSS)	3,800	990,000	19
Aerobic Treatment Unit (ATU)	3,000	800,000	16
Septic Tank	12, 500	3,300,000	65
Outhouse & other, e.g., cesspit	38	10,000	< 1
TOTAL	19,300	5,100,000	100

To date, the management of onsite systems has primarily been limited to the planning stage while operation and maintenance has been left to the owners and operators of the systems. Due to limited resources to conduct inspections of all existing systems, there is little information available on the condition and performance of onsite systems. Product literature and third-party certifications are available for most aerobic treatment units installed on the Island. These indicate the performance capability of a system given proper operation and maintenance. Spot checks of approximately seventy five percent of these installations found twenty percent failing to perform as designed. The large numbers of septic tank installations make inspections of these systems impracticable at this time. There are published performance data on septic tank effluent that indicate a lower removal rate of Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS), than can be achieved with an aerobic treatment unit operating as designed (Table 2).

TABLE 2: Representative Concentrations (mg/l) of Domestic Wastewater Parameters at Different Levels of Treatment.

Parameter	Untreated domestic wastewater	Septic tank effluent	Aerobic treatment unit
Biochemical Oxygen Demand (BOD_5)	155-286	140-200	5-50
Total Suspended Solids (TSS)	155-330	50-100	5-100

Source: USEPA Onsite Wastewater Treatment Systems Manual, 2002.

There is limited site-specific data to assess the vulnerability of water resources in the Cayman Islands. Grand Cayman has three significant freshwater lenses (see Figure 2), primarily utilized for agricultural purposes. Sampling of domestic wells located over the Lower Valley freshwater lens indicates elevated levels of nitrates and bacteria. Table 3 summarizes the mean annual values for the years shown (Mac Aree, 1991).

TABLE 3: Lower Valley Lens Monitoring Results.

Year	% Faecal Coliforms >0	Nitrates (as N) mg/l
1989	22	4.9
1990	21	4.8

Development over the Lower Valley lens consists of residences, served by onsite systems, and agriculture including crop production and livestock; the relative contribution of contaminants from these sources has not been discerned, but it is likely that onsite systems are a contributing factor. These findings do not constitute an immediate health risk as the area is supplied with piped water and domestic wells are primarily used for non-potable uses; however, the findings do suggest contamination from agricultural activities and onsite systems.

There is also limited data on the quality of Grand Cayman's near shore waters. A sampling programme has been established to monitor levels of nutrients and bacteria in George Town Harbour. The Harbour is located in the bustling capital city of George Town, home to Government offices, corporate offices and numerous retail and restaurant outlets. All cruise ship passengers and shipped freight passes through the port. Sampling results in this area should reflect the worst case. Results to date have not identified significant contamination. Table 4 summarizes the mean annual values for data that has been reviewed.

TABLE 4: George Town Harbour Monitoring Results.

YEAR	FAECAL COLIFORM (cfu / 100 ml)	ENTEROCOCCI BACTERIA (cfu / 100 ml)	NITROGEN (μ mol / L)	PHOSPHORUS (μ mol / L)
1996	2.1	0.5	0.42	0.11
1997	0.4	0.2	0.31	0.05
1998	1.0	0.2	0.33	0.07
1999	5.9	1.5	Not available	Not available
2000	3.2	0.5	Not available	Not available

While site-specific data is desirable for monitoring local conditions and determining total maximum daily loads (the amount of a pollutant that a particular water body can assimilate without impairment), the link between the excess discharge of poorly treated wastewater and degradation of water resources is well established in scientific literature. Contact with or consumption of contaminated water sources can have negative health effects and can severely impact reef environments that thrive in warm, clear, nutrient-deficient waters.

The Water Authority Law (1996) and Regulations (1999) provide the necessary legal authority to regulate the discharge of all sewage effluent to protect groundwater resources. Currently, the Authority stipulates onsite wastewater treatment requirements for all developments larger than single-family homes, while the Building Control Unit of the Planning Department specifies septic tanks for all single-family homes. The Water Authority is committed to the development of a comprehensive Onsite Wastewater Management Programme to strengthen public health and water resource protection.

2) SELECTION OF PROGRAMME ELEMENTS & OBJECTIVES

The Guidelines (USEPA, 2003) provide a series of model programmes. The models are progressive, reflecting the need for improved management practices as the complexity of treatment systems and potential risks to public health and water resources increase.

All of the models address the fundamental elements of a comprehensive programme: plan administration, treatment system installation and oversight, and compliance assistance and assurance and provide benchmarks for basic, intermediate and advanced programmes. The Handbook (USEPA, 2003) provides detailed guidance in selecting, evaluating, developing and implementing the right mix from the benchmark models. The elements and objectives in the Authority's Management Programme reflect an appropriate mix relative to current status and goals: Education and Training objectives are at the advanced end of the scale while others are at the basic and intermediate levels. Table 5 summarizes the programme elements and objectives of the Authority's Management Programme.

TABLE 5: Programme Elements and Objectives.

ELEMENT	OBJECTIVES
Permitting / Inventory	• Permit all new onsite systems. • Permit all existing onsite systems. • Maintain register of permitted systems.
Onsite System Requirements	• Develop requirements to address areas of concern in the design, siting, performance and/or maintenance of onsite systems. • Evaluate alternative technologies.
Education & Training	• Increase awareness of risks associated with wastewater. • Inform system owners regarding the care and use of their system. • Facilitate training, certification and licencing of onsite system service providers.
Inspections & Monitoring	• Verify compliance with design and installation requirements. • Verify compliance with operation and maintenance requirements. • Require tracking of hauled septage.
Enforcement	• Respond to violations in a timely, equitable manner consistent with Water Authority Law and Regulations. • Focus on corrective, versus punitive, measures. • Remove any economic advantage of noncompliance.

3) EVALUATION OF CURRENT ACTIVITIES RELATIVE TO OBJECTIVES

The evaluation of current activities is necessary to identify those that are effective, and those that need to be improved or developed. The Authority was aware that, due to the rapid rate of development in the preceding years, and limited staff, regulation of onsite treatment systems had not kept pace. Prior to May 2000, the tasks of reviewing development plans and stipulating wastewater requirements were added to the duties of several staff. This approach made it difficult to see the "big picture". In response, the position of Development Control Technologist was created. The position consolidates development control tasks and all related requirements and records, allowing for comprehensive evaluation of onsite systems and activities. Table 6 summarizes the evaluation of current onsite wastewater management activities, in relation to the programme elements in Table 5.

TABLE 6: Strengths and Weaknesses of Current Activities.

PROGRAMME ELEMENT	STRENGTHS	WEAKNESSES
Permitting / Inventory	o Legal authority exists for permitting; 10% of onsite systems permitted.	o Additional resources required to identify and issue outstanding permits.
Onsite System Requirements	o Several design and siting standards established. o Effluent quality standard established.	o No maintenance requirements. o No siting requirements relative to eventual connection to central sewer.
Education & Training	o Reference materials available. o Several brochures developed. o Operator certification programme under review.	o Low level of public awareness regarding wastewater issues.
Inspections & Monitoring	o New aerobic treatment system installations inspected by Development Control staff. o Legal authority to require manifests of septage loads. o Water Authority has accredited water & wastewater laboratory.	o New septic tank installations inspections by Building Control staff cursory relative to stipulated requirements. o Monitoring of existing installations minimal; i.e., complaint based. o No manifests to track hauled septage. o Onsite monitoring programme will require additional lab resources.
Enforcement	o Legal authority to specify and enforce permit conditions.	o No enforcement response plan in effect.

4) SELECTION OF MANAGEMENT ACTIVITIES TO MEET OBJECTIVES

To ensure continuous improvement, a Programme's activities should be designed to progress along the continuum from basic to intermediate to advanced as system technologies become more complex, and as management capabilities increase. Addressing the weaknesses and building on the strengths identified in Table 6, activities to achieve the Programme's objectives were developed and are summarized in Table 7.

TABLE 7: Activities to Meet Programme Objectives.

OBJECTIVES	ACTIVITIES
PERMITTING / INVENTORY	
• Permit all new onsite systems. • Permit all existing onsite systems. • Maintain register of permitted systems.	o Require as condition for certificate of occupancy o Identify existing systems, inspect and permit. o Continually update the register.
ONSITE SYSTEM REQUIREMENTS	
• Develop requirements to address areas of concern in the design, siting, performance and/or maintenance of onsite systems. • Evaluate alternative technologies.	o Establish requirements to minimize flooding of systems from storm water. o Require approval for any repair or alteration to an existing onsite system. o Explore appropriate technologies to improve the performance of septic tanks. o Require minimum maintenance regimes. o Consider effluent limits for nutrients (N&P).
EDUATION & TRAINING	
• Increase awareness of risks associated with wastewater. • Inform system owners regarding the care and use of their system. • Facilitate training, certification and licencing of onsite system service providers.	o Tailor available reference materials to address risks, responsibilities, care and use of onsite systems. o Select certification training programme for onsite system operators; facilitate training; license certified operators.
INSPECTIONS & MONITORING	
• Verify compliance with design and installation requirements. • Verify compliance with operation and maintenance requirements. • Require tracking of hauled septage.	o Standardize inspections of septic tanks. o Initiate inspections of disposal well installations. o Establish periodic inspections of aerobic treatment systems; phase in effluent sampling of aerobic treatment systems. o Use septage manifests to track maintenance.
ENFORCEMENT	
• Respond to violations in a timely, equitable manner consistent with Water Authority Law and Regulations. • Focus on corrective, versus punitive, measures. • Remove any economic advantage of noncompliance.	o Consider and adopt a version of the proposed Enforcement Response Plan. o Encourage Enforcement Officers from other agencies and the public to report failing onsite systems. o Provide compliance assistance via education and compliance agreements.

5) DEVELOPMENT OF AN IMPLEMENTATION PLAN

An implementation plan is necessary to move a Management Programme from the desk into the field. An implementation plan does not take away from a programme's flexibility. Flexibility can be built in by placing activities into near-term, mid-term and long-term

categories. Definitions of near, mid and long term will depend on available resources, but should not extend so far into the future that conditions are difficult to predict. Placement of an activity into near, mid or long term will depend on priorities, available resources and approaches selected (basic, intermediate or advanced). This phased, categorical approach provides enough flexibility to make adjustments while maintaining focus on achieving milestones. The implementation plan for the Authority's Management Programme is broken down into first year, second year and beyond. This relatively long range is realistic until additional resources can be allocated to the Programme. When that occurs, the plan provides the flexibility of decreasing the length of the terms and/or shifting activities to a nearer term.

The purpose of keeping the period of an implementation plan within the foreseeable future is to allow for routine evaluation of the Management Programme, at least annually. The evaluation should be a structured process, along the lines the programme development process. The status of onsite wastewater management should be evaluated, progress should be gauged based on measurable performance indicators for each programme element, and the need for adjustments to goals, objectives and approaches should be assessed in light of advancements in technology, available resources and management capability. Based on the evaluation, an implementation plan should be developed for the next period.

CONCLUSION

The value of water resources in the Caribbean cannot be overstated. The Caribbean region depends upon a healthy environment to sustain its people and their livelihoods. Fresh water is a scarce resource that must be protected for beneficial uses. Sensitive coral reef environments must be protected as they contribute to the health, beauty and economy of the region, protect shores from heavy wave action, and provide habitat for a variety of marine species. A 1994 study by the Caribbean Environment Programme found that domestic wastewater was the largest point source contributor to marine pollution in the wider Caribbean region (CEP, 1994). The challenge of managing onsite wastewater discharges is both immediate and long-term.

An Onsite Wastewater Management Programme provides a strategic approach to the long-term sustainable use of water resources and ensures that the cumulative and site-specific effects of onsite wastewater are continually assessed and managed. The USEPA guidance documents can provide a valuable resource in the development, improvement, and implementation of Caribbean solutions to the Global Challenge of onsite wastewater management.

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