CHAPTER 5

5.0 WASTEWATER MANAGEMENT

5.1 Overview

The proposed project will result in activities associated with the tourism sector and therefore will incorporate proper wastewater management planning. This section summarizes the estimated effluent production and liquid waste disposal and treatment along with the mitigation measures that are to be adopted. The ecological sensitivity of the surrounding marine and terrestrial environments was accorded the requisite level of priority and this in effect guided the design features and mitigative responses of the treatment and disposal of liquid wastes.

5.2 Composition and Nature of Liquid Waste

It is anticipated that the proposed project will be producing domestic wastewater as a result of its activities. Domestic wastewater is the spent water originating from all aspects of human sanitary water usage. It typically institutes a combination of flows from the kitchen, bathroom and laundry, encompassing lavatories, toilets, baths, kitchen sinks, dishwashers, and washing machines. Domestic wastewater as the name implies, principally originates in residences, commercial and institutional establishments and is also referred to as sanitary sewage.

In order to estimate the projected quantity of sewage waste, it is necessary to look at the nature of the sewage effluent. Data describing the composition of sewage can be found in literature for the region, as there is little or no data in-country that covers this topic. Table 5.1 is a summary of the characteristics of domestic sewage in the Caribbean region. This document also produces a guideline as to the selection of alternatives for sewage treatment.

Table 5.1 Typical Composition of Untreated Domestic Sewage

	Weak	**Medium**	**Strong**
Constituent	**(all mg/l, except for settleable solids)**		
Alkalinity (as CaC03)	50	100	200
BOD	100	200	300
COD	250	500	1000
Total Suspended Solids (TSS)	100	200	350
Settleable Solids	5	10	20
Total Dissolved Solids (TDS)	200	500	1000
Total Kjeldahl Nitrogen (TkN)	20	40	80
Total Organic Carbon (TOC)	75	150	300
Total Phosphorus	5	10	20

The composition and nature of liquid waste described in Table 5.1 reflects that which is to be produced by a typical residential subdivision.

5.3 Wastewater Production

The False Caye Project will produce wastewater as a result of its activities. It is estimated that the entire development will require about 42,480 gallons of water a day at full operation and 100 % occupancy rate. For the purpose of the environmental engineering calculations the wastewater production was calculated as 70 % of the water demand as it is normally the standard.

Table 5.2 Projected Daily Wastewater Production According to Facilities

			Water Demand	
Type	Unit Description	Maximum Occupancy	Units (gals/day)	Wastewater (gallons/day)
1	Typical Hotel Unit	148	50	5,180
2	Type B Hotel Unit	128	50	4,480
3	Villa Type A	114	50	3,990
4	Villa Type B	152	50	5,320
5	Villa Type C-1	48	50	1,680
6	Villa Type C-2	72	50	2,520
7	Special Lot	48	50	1,680
8	Over Water Cabanas	56	50	1,960
9	Special Estate	8	50	280
10	Employees	76	30	1,596
11	Transient Visitors	100	15	1,050
Projected Occupancy		**950**		**29,736**

As can be seen from the table, the total volume of wastewater generated during full operation and occupancy is 29,736 gallons a day. Type 4 will produced most of the wastewater volume, followed by Type 1. These volume percentages can fluctuate according to time of day, occupancy and project activity.

Since these volumes vary and considering the project layout, the wastewater and treatment will be divided into zones or tiers as the developer refers to it. The proposed project will be divided into four wastewater zones with each having its own treatment plant as shown in figure 5.1.

5.4 Environmental Wastewater Load

The following table illustrates the typical domestic wastewater loads that will be encountered by the project at full development. Considering the different buildings and the nature of the business, the typical domestic loads are expected to be strong with TSS and BOD_5 being 300 mg/l, with 80 mg/l for TKN, and 20 mg/l for Phosphorus and 300 mg/l for TOC. This is the typical daily load that any treatment method will have to handle to reduce the concentrations to the acceptable National Effluent Standards. The pH of all these wastes will be in the range of 6.5 to 8.5, with a majority being slightly on the alkaline side of 7.0.

Table 5.3 Project Domestic Wastewater Profile

Constituent	Typical Wastewater (mg/l)	Daily Resort Load (kg/day)
Alkalinity (as CaC03)	200	44.5
BOD	300	66.7
COD	1000	222.4
Total Suspended Solids (TSS)	350	77.8
Total Dissolved Solids (TDS)	1000	222.4
Total Kjeldahl Nitrogen (TKN)	80	17.8
Total Organic Carbon (TOC)	300	66.7
*Total Phosphorus	20	4.4

*Phosphorus may appear in many forms in wastewater. Among the forms found are the orthophosphate, polyphosphates, and organic phosphates. For the purpose of table 5.3 all these are grouped as total phosphorus. Similarly, the TKN is a measure of the total organic and ammonia nitrogen in the wastewater.

5.5 National Environmental Effluent Standards

Presently, the Environmental Protection Effluent Limitation Regulations has a set of wastewater loading parameters that must be abided by any commercial venture. The regulations are intended to control and monitor discharges of effluent into any inland waters or the marine environment of Belize. The standards as per the Second Schedule of the Environmental Protection Effluent Limitation Regulations are shown in table 5.4 below:

Table 5.4 Effluent Limitation Standard for Commercial Activities

Parameter/Pollutant	Maximum Value	Parameter/Pollutant	Maximum Value
Temperature (°C)	30 – 33 °C	Sulphide (as S)	500 mg/l
Ph	6 – 9	Oil and Grease	10 mg/l
Dissolved Oxygen (D.O.)	> 4.0 mg/l	Phosphate(PO_4^-)	5 mg/l
BOD_5 at 20°C	50 mg/l	Nitrates (NO_3)	3 mg/l
Chemical Oxygen Demand (COD)	200 mg/l	Ammonia (NH_4)	1 mg/l
Total Suspended Solids (TSS)	50 mg/l	Total Organic Carbon (TOC)	200 mg/l
Total Dissolved Solids (TDS)	2000 mg/l	Total Coliform	0 – 10 MPN/100 ml
Sulphate(as SO_4)	200 mg/l	Fecal Coliform	0 MPN/100 ml

5.6 Wastewater Collection and Treatment Alternatives

As mentioned previously, the proposed project will be a well planned project thereby utilizing the most applicable and feasible wastewater technology. As a result of these considerations, several options were identified, evaluated and analysed with the preferred option chosen after these deliberations.

The Council for Environmental Protection (CEP) Guide uses a recommended "Decision Tree", which facilitates the decision of identifying a practical and feasible sewage treatment system. The following is a summary of this analysis:

Recommended criteria influencing the decision:

Water availability. If no inexpensive public source of water is available, it is likely that the volume of liquid waste will be minimal; therefore, individual household systems become the recommended option.

Surface Topography. If topography allows for sewers to be laid at downward slope from homes, then gravity systems can be used, reducing cost.

Subsurface Conditions. Unstable soils, rocky soils etc. make conventional gravity sewers more expensive to build and maintain.

Social Considerations. Acceptance of the system is important, as systems requiring regular maintenance such as compost toilets, often break down due to lack of or inadequate maintenance.

Housing or Population Density. "For dispersed rural homes, central sewage collection facilities are not economical due to the high cost of piping wastewater to the central treatment facility" (CEP, 1998). This is further determined by topography, soil type, land acquisition cost, evaporation rate, cost of construction and hydrology.

The various options considered made the following assumptions:

Alternative A "Centralized System with Tertiary Level Treatment". This system would comprise of an advanced "package" type treatment system using aeration as its preferred method of secondary and tertiary treatment.

Alternative B "Individual Treatment Systems". This system assumed that each separate infrastructure unit would consider installing individual units with the same secondary and tertiary treatment capacities. However, these systems would be individually owned instead of owned collectively.

Alternative C "Household Systems". This option considered using Individual Septic Tank Systems, with appropriate leach fields.

The summary discussion on these alternatives is provided in Table 5.5.

Table 5.5 Evaluation of Wastewater Disposal Alternatives

Decision Criteria	Criteria in relation to Project Site	Alt. A (Package System with Secondary Treatment)	Alt. B (Individual Treatment Systems)	Alt. C (Household Systems – Septic System with leach fields)
Water Availability	Low to Medium water needs, Individual systems recommended	Low to medium water needs, would require extensive piping from the different sewer zones	Low water needs (acceptable) for each individual building.	Medium volume water usage
Surface Topography	Unsuitable for gravity feeding. However, installation of pipes is relatively easy.	Gravity feeding is not possible since the area is relatively flat. The system would require the use of pumps.	These systems would generally work well with the individual buildings or sections.	Not fully acceptable since the area is in contact with the marine environment. May be suitable for large buildings.
Subsurface Conditions	Soil is relatively permeable with acceptable infiltration rate	Not suitable for systems using anaerobic ponds due to the low lying topography and cost of land. Ponds would require lining, if used.	Acceptable, but there would be quite a few and this would utilize valuable available land area.	Not fully acceptable, if with well – designed leach fields. In addition, the placement of the tank and leach field would take up too much valuable land area.
Population Density	Low population density	Feasible but may require systems with aeration instead of anaerobic systems	The cost of individual systems is passed on to the project owner (individual buildings etc.)	Household systems are acceptable in sparse areas
Social Considerations	New systems require regular maintenance & training of local personnel	Not a major issue of concern	Would require training and regular maintenance of all the systems that are in place.	Requires guidelines & training on maintenance & inspection of systems
Overall Economic Considerations	Cost is important for both initial investment and long-term maintenance	Cost may be acceptable for commercial sites. Locally available systems have been classified as "expensive" by developers and land owners but very effective in treating wastewater to acceptable DOE levels.	Relatively expensive (due to high cost of system components, maintenance, energy needs etc)	Requires adequate installation & regular inspection and maintenance to ensure maximum efficiency

5.6.1. The Preferred Option

Preferred Option – The proposed project will employ Alternative 1 as the preferred option. The system recommended is a series of prefabricated package treatment plant with secondary treatment. The project will employ the "Purestream ES Model BESST" or approved equivalent treatment plant. BESST is an acronym used for Biologically Engineered Single Sludge Treatment. The BESST system is based on the principals of single sludge treatment for efficient BOD, TSS and nutrient removal, and sludge blanket clarification for efficient solids separation. Also, with its efficient use of the mixed liquor, the BESST system produces less sludge build up. This process places all these components into one vessel thereby reducing the parameters to much less than required by the National Standards.

The collection system associated with the BESST Treatment Plant entails a combination of gravity collection and pumping systems with manholes and cleanouts which would convey the wastewater to a final zone pumping station. The waste would then be pumped from this area to the zone where it is to be handled by the BESST Treatment Plant which is capable of treating liquid wastes to a higher level than those mandated by the National Effluent Standards.

5.6.2 Typical BESST Plant Treatment Effluent and Loading Parameters

The BESST Plant recommended for the proposed project can reduce the Biological Oxygen Demand and Total Suspended Solids to less than 10 mg/L. The treatment plant can also reduce TSS and BOD5 total loading by some 97%, and decrease the daily Organic Nitrogen Total Loading by 67%. Additionally this system could reduce Total Free Ammonia Loading by 97.5% and Total Phosphate Loading by some 80%. The projected performance of the BESST Treatment is summarized in Table 5.6.

Table 5.6 Projected Performance of BESST Treatment Plant.

Constituents	**Typical wastewater post treatment**	**Daily load reduction post treatment**
Total Suspended Solids	10 mg/L	**97%**
Total Organic Nitrogen	5 mg/L	**67%**
Free Ammonia	1 mg/L	**97.5%**
BOD_5 (5 day)	10 mg/L	**97%**
Phosphate	2 mg/L	**80%**

5.7 Wastewater Management

The following sections describe the micro wastewater management that will be required of the proposed development in order to comply with the Effluent Limitation Standards and the Environmental Protection Act. This management is necessary to project a clean and healthy environment to residents, guests and transient visitors. As mentioned previously, the wastewater and treatment will be divided into four treatment wastewater treatment zones or tiers as the as shown in figure 5.1.

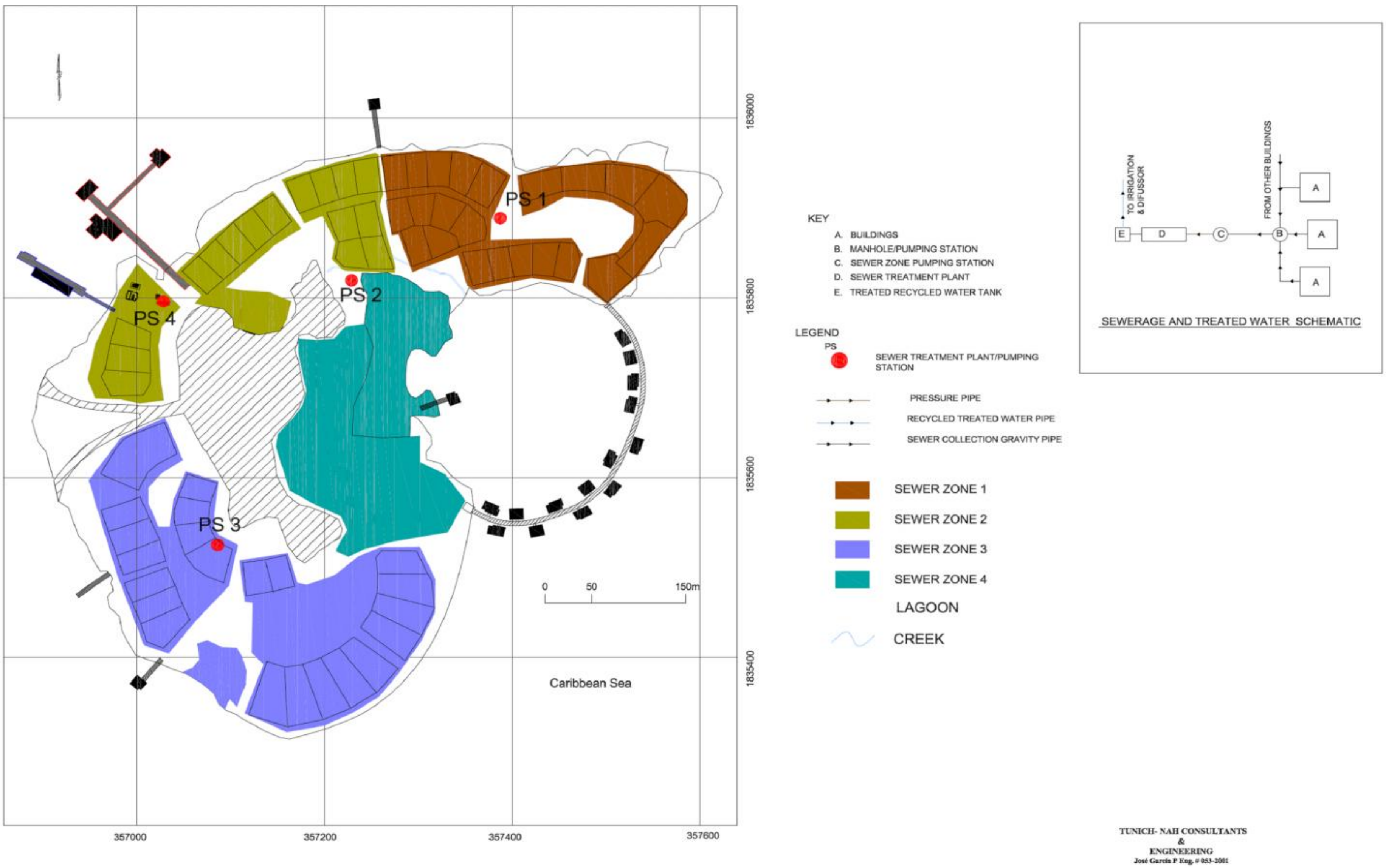

Fig. 5.1 Sewer Zone Plan for False Caye

5.7.1 Wastewater Piping

Just as with potable water, all the wastewater transmission lines will be facilitated with valves and pumps to properly conduct the wastewater to the treatment plants. This will be based on the design and specification of the wastewater system. In addition, each zone will require a pumping station whereby all the wastewater of that zone is sent for preliminary treatment. For the over water cabañas, the wastewater will be piped under the pier to the respective treatment plant.

In all, the wastewater piping network will be required to be pressure tested prior to operation and will entail detailed regular maintenance on the pipelines.

5.7.2 Wastewater Disposal

The project proponent plans to incorporate two disposal alternatives for the wastewater. These include wastewater recycling and disposal into the mangrove lagoon as shown in figure 5.2. Prior to disposal, the wastewater will be post chlorinated and stored before use or disposal. All of these alternatives are considered environmentally friendly and will not pose any long term impacts to the receiving environment. It is important to note that the treated wastewater will be of excellent quality that will meet and exceed the present DoE standards.

Disposal into the lagoon will be facilitated by a small holding tank (to oxidize the chlorine) and diffusers prior to being disposed into the receiving environment. The volume disposed is anticipated to be small considering the normal occupancy rate of 40 % and given the fact that much of the wastewater will be recycled as explained in the following section.

Further polishing of the wastewater is expected to be carried out by the mangrove. The developers will ensure that the discharge wastewater meets and exceeds the environmental guidelines for the discharge of effluent as described in table 5.4.

5.7.3 Wastewater Recycling

The recycling of wastewater is an important factor in reducing the projects water demand. For the purpose of the proposed project, this wastewater will be recycled. The treated wastewater will be post chlorinated by a chlorination system as described in the previous chapter. This process is necessary to remove any harmful pathogens and the treated water will be conveyed to the zone’s holding tank.

As described earlier in the chapter, the development will be divided into four developmental zones which could also be described as four sewer zones with a centralized holding tank. False Caye will recycle about 40 % of its wastewater which will be used for the irrigation of lawns, hedgerows and other related non potable uses and most importantly for fire combating intentions as portrayed in table 5.7.

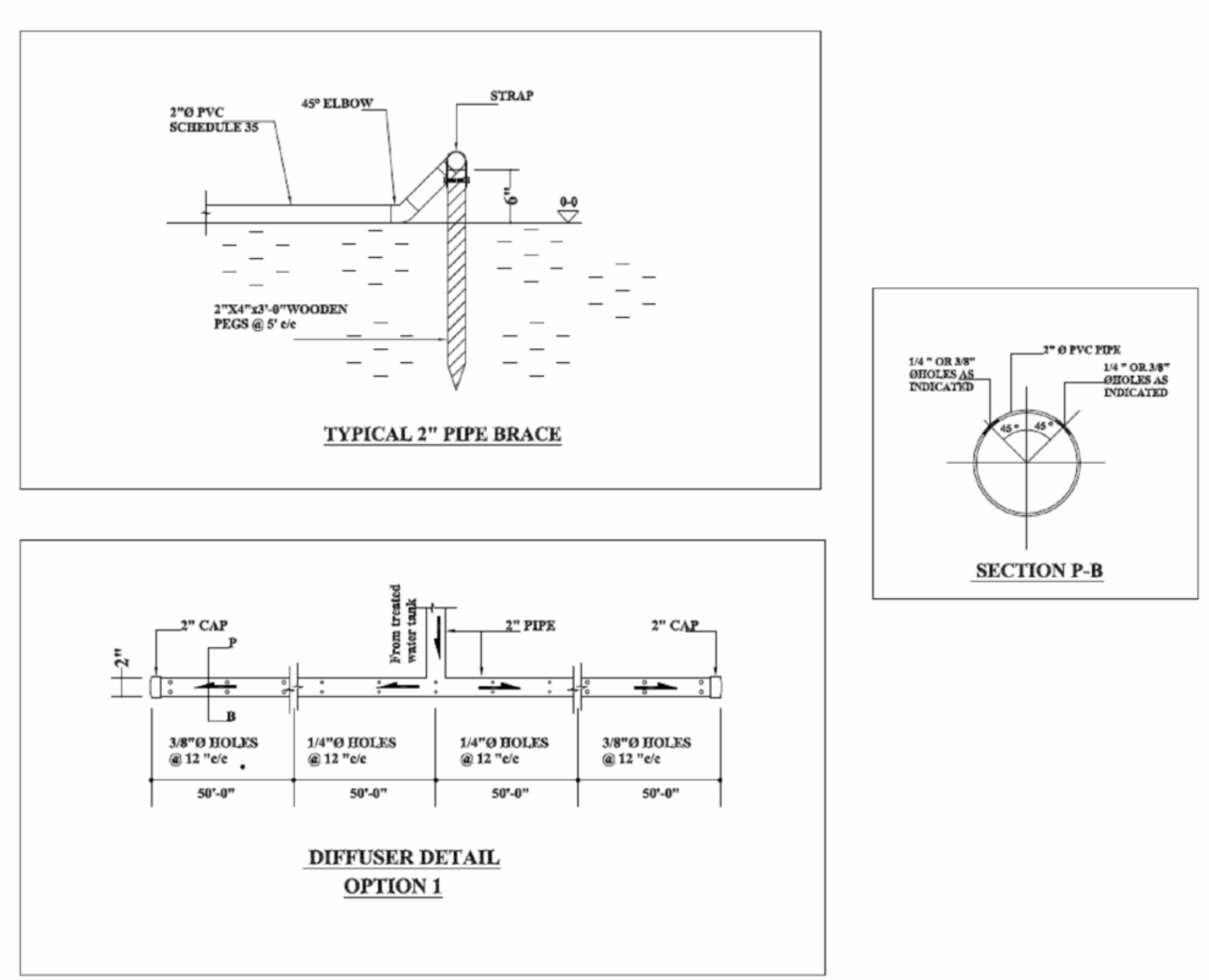

Fig. 5.2 Wastewater Disposal Option

Table 5.7 Wastewater Alternative Uses

	Purpose	Description
Wastewater	Irrigation	Lawns, hedgerows, shrubs ect
	Fire Fighting	Fire combating
	Other	Non potable uses