Engineering Standard

SAES-A-104 10 May 2006

Wastewater Treatment, Reuse and Disposal

Saudi Aramco DeskTop Standards

Table of Contents

1 Scope

1.1 This Standard governs the design of equipment for the collection, treatment, reuse and disposal of wastewater and oily waste sludges in Saudi Aramco controlled facilities (Saudi Aramco housing areas, contractor camps, industrial operations, offshore platforms, etc.).

1.2 This Standard applies to new facilities and to facilities undergoing major modifications or upgrades. In areas where a deficiency is causing non compliance with Saudi Arabian environmental regulations, compliance is required by August of 2007 (Saudi Arabian General Environmental Regulations - GER).

1.3 This Standard applies to oily waste, industrial and sanitary wastewater and sludge produced from the treatment of these wastewaters.

1.4 This Standard does not apply to the disposal of produced water that is injected into any petroleum reservoir from which hydrocarbons are produced.

1.5 This Standard does not apply to drilling fluids evaporation ponds, well site temporary pits or pits utilized for the storage of drilling mud, fresh water, or as emergency liquid and/or flare pits, in support of exploration, development, or production activities related to water, gas, or oil wells; provided that all fluids and hydrocarbon materials are physically removed from the temporary pits, following each distinct well site operation, including drilling & workover programs, and producing field service and well service activities.

NOTE: *This exemption is valid subject to the activities involved complying with the EPD approved Drilling & Workover Environmental Operating Procedure. Activities outside of this approved Procedure shall be evaluated and approved on a case-by-case basis by the General Supervisor of Environmental Engineering Division.*

2 Conflicts and Deviations

2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards and Procedures (SAESs and SAEPs), specific Corporate General Instructions (GIs), Saudi Aramco Sanitary Code (SASC), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Environmental Protection Department (EPD) of Saudi Aramco.

2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, EPD of Saudi Aramco, Dhahran.

2.3 Any conflict between this standard and the most recent government or Saudi government-ratified regional or international standards or regulations, requires compliance with the most stringent requirement.

3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

SAEP-13	*Project Environmental Impact Assessments*
SAEP-14	*Project Proposal*
SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*
SAEP-327	*Disposal of Wastewater from Cleaning, Flushing, and Dewatering Pipelines and Vessels*

Saudi Aramco Engineering Standards

SAES-A-103	*Discharges to the Marine Environment*
SAES-B-067	*Safety Identification and Safety Colors*
SAES-H-002	*Internal and External Coatings for Steel Pipelines and Piping*
SAES-H-101	*Approved Protective Coating System for Industrial Plants & Equipment*
SAES-L-132	*Materials Selection for Piping Systems*
SAES-L-610	*Nonmetallic Piping*
SAES-M-001	*Structural Design Criteria for Non-Building Structures*
SAES-M-006	*Saudi Aramco Security and General Purpose Fencing*
SAES-M-100	*Saudi Aramco Building Code*
SAES-Q-001	*Criteria for Design and Construction of Concrete Structures*
SAES-S-007	*Solid Waste Landfill Standard*

SAES-S-010	*Sanitary Sewers*
SAES-S-020	*Industrial Drainage and Sewers*
SAES-S-030	*Storm Water Drainage Systems*
SAES-S-040	*Saudi Aramco Water Systems*
SAES-S-060	*Saudi Aramco Plumbing Code*
SAES-S-070	*Installation of Utility Piping Systems*
SAES-X-600	*Cathodic Protection of Plant Facilities*

Saudi Aramco General Instructions

GI-0002.716	*Land Use Permit Procedures*
GI-0002.718	*Contractor Site Allotment Procedure*
GI-0006.020	*Personal Flotation Devices (PFDS) for Work On, Over or Near Water*
GI-0430.001	*Waste Management*
GI-0151.006	*Implementing the Saudi Aramco Sanitary Code – SASC-S-02, Sanitary Wastewater and Sewerage Systems*

3.2 Government Documents and Standards

Document No. 1409-01 and revisions, "Environmental Protection Standards", Meteorology and Environmental Protection Administration (MEPA now called Presidency of Meteorology and Environment - PME).

"Royal Commission Environmental Regulations 2004" and revisions, Directorate General for Yanbu Project, Madinat Yanbu Al-Sinaiyah, Royal Commission for Jubail and Yanbu.

"Environmental Design Guidelines", Directorate General for Jubail Project, Royal Commission for Jubail and Yanbu.

Regulation for Treatment Sewage Water and Reuse" Ministry of Municipal and Rural Affairs (MOMRA); M/6; 17 May 2000

General Regulations on the Environment (GER) M/34; 15 October 2001

3.3 Industry Documents and Codes

American Petroleum Institute

API PUB 421	*Design and Operation of Oil Water Separators*

American Public Health Association

Standard Methods for the Examination of Water and Wastewater, 18th or later Edition

American Society for Testing and Materials

2003-2004 Annual Book of ASTM Standards – Section 11, Water and Environmental Technology

ASTM D698	*Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort*

Uniform Plumbing Code

UPC	*Uniform Plumbing Code and revisions, International Association of Plumbing and Mechanical Officials (most recent version)*

3.4 Other References

Wastewater Engineering Treatment and Reuse, Metcalf & Eddy, McGraw Hill, Inc., Fourth Edition.

Water Pollution Control Federation

WPCF FD 13	*Aeration - Manual of Practice*

"Industrial Water Pollution Control", Eckenfelder, Third Edition.

California Title 22 Wastewater Reclamation Criteria, California Department of Health Services (most recent version)

4 General Design Requirements

Since no two treatment needs are alike, this Standard does not dictate a specific treatment train for each application. System components shall be selected on a case-by-case basis as necessary to meet Table 1 requirements (as measured by the methods specified in Table 2) at the point of discharge (immediately after treatment, prior to the addition of any streams that would provide dilution of Table 1 constituents – dilution to meet limitations is not allowed). All individual system components shall meet the relevant design requirements in this Standard.

The proposed treatment system will be evaluated based upon the reports required in Section 4.2 or, if acceptable to the General Supervisor, Environmental Engineering Division (EED), materials supplied during the development of the DBSP, Project Proposal and Detailed Design.

The use of components which are not listed in this standard requires approval of the Manager, EPD on a case-by-case basis. The design of all treatment systems must comply with good engineering practices as specified in the Industry Documents and Codes cited in Sections 3.3 & 3.4. The designs must also be approved by the General Supervisor, EED.

In the case of injection wells, the term "treatment system" includes all pre-injection surface equipment associated with the injection well, but does not include the well itself. A separate approval process for the injection well is outlined in Section 4.2.

4.1 General Requirements

In all onshore areas not subject to Royal Commission requirements, sanitary wastewater generated, treated and disposed of onshore must comply with the most current version of the wastewater reuse regulations (currently MOMRA). Additionally all sanitary and industrial wastewater generated by onshore facilities and treated and discharged to the marine environment must comply with PME requirements. In Royal Commission areas, all wastewater discharges must comply with Royal Commission requirements. Offshore wastewater generation and disposal shall comply with the requirements of SAES-A-103 and those portions of this Standard specifically related to offshore engineering design requirements.

4.1.1 Goals/Standards

4.1.1.1 Safe collection, treatment and disposal / reuse of wastewater from Saudi Aramco housing areas, contractor camps, and industrial operations – both onshore and offshore are necessary for the protection of public health. To accomplish satisfactory results, such wastes must be disposed of so that:

a. They will not give rise to public health hazards by being accessible to insects, rodents, or other possible carriers that may come into contact with food or drinking water;

b. They will not give rise to public health hazards by being accessible to children;

c. They will not pollute or contaminate the waters of any bathing beach, shellfish breeding ground, or stream used for public or domestic water supply purposes or for recreational purposes;

d. They will not contaminate any usable aquifer; and

e. They will not give rise to a nuisance due to odor or unsightly appearance.

4.1.1.2 These criteria can best be met for sanitary wastewater by treatment in an adequate public or community sewage treatment system. Community dumping areas are not acceptable for Saudi Aramco use. When an adequate community sewage treatment system is not available, a wastewater treatment system meeting the design requirements in this Standard shall be installed.

4.1.1.3 Wastewater discharges shall meet the following criteria:

a. Wastewater shall not be discharged onshore to any water bodies (a shoreline discharge, an evaporation pond or a river/wadi) or the land surface unless it meets the quality standards in Table 1.

b. Wastewater being discharged to the marine environment from an onshore or offshore location shall meet the treatment requirements in SAES-A-103.

c. Wastewater that is discharged into an evaporation pond must have been treated in a properly designed treatment system prior to its disposal (some of the quality standards in Table 1 may be waived by the General Supervisor, EED on a case by case basis).

d. Wastewater which is injected shall meet the treatment requirements specified on a case-by-case basis by the Manager, EPD with concurrence of the Chief Hydrologist, Groundwater Division and the General Supervisor, Oil Facilities & Projects Division.

e. All wastewater discharges shall meet the applicable PME, MOMRA, Royal Commission or other government regulations cited in Section 3.2 or any others issued after this Standard goes into effect.

4.1.1.4 Wastewater collection, treatment, reuse and disposal plans for all Projects shall be submitted in the Project Environmental Impact Assessment (EIA) in accordance with SAEP-13. Depending on the impact of the discharge, additional and/or more stringent requirements may be required by the General Supervisor, EED to protect the environment.

4.1.1.5 A Small Flow wastewater disposal system (per Section 12) is an acceptable disposal method where there is a need to treat wastes from a small number of people (less than 30). The discharge limitations in Table 1 are not required to be met for small flow wastewater disposal systems.

4.1.1.6 Small Flow wastewater disposal systems for facilities with greater than 30 personnel require approval by the Manager, EPD. This approval will require a written justification that explains why it is not feasible to discharge the wastes to an existing wastewater treatment system or to install a new treatment system.

4.1.1.7 Holding tanks and off-site disposal of wastewater is not an acceptable disposal method unless prior approval by the Manager, EPD is granted and a permit from the Ministry of Municipal and Rural Affairs (MOMRA) is obtained as required in MOMRA Section 3 requirements. It is the responsibility of the organization requesting the permit to prepare the justification for MOMRA requests. EPD will review the justification and if approved by the Manager, EPD, forward it to MOMRA for their consideration. **Note:** this permit, if granted, will require several months to obtain.

4.1.1.8 EPD will not approve any project documents if the design does not comply with PME and MOMRA or other applicable requirements.

4.1.1.9 Approval of the General Supervisor, EED is required in order to use any areas where soil contamination is present. All remediation requirements cited by EED and all construction requirements mandated by Consulting Services Department for the contaminated site are required to be identified in the Project Proposal.

4.1.2 Treatment System Requirements

4.1.2.1 All wastewater collection (sewer systems), treatment, reuse and disposal systems require approval of the appropriate organizations, as identified in Section 4.2.1.

4.1.2.2 The design of process piping, equipment arrangement, and unit structures in the wastewater treatment plant shall allow for efficiency and convenience in operation and maintenance.

4.1.2.3 The overall design shall accommodate the quantity and quality of existing wastewater as well as anticipated changes. The design shall be based on the results of an adequate number of samples (as defined by the General Supervisor, EED on a case by case basis depending on the wastewater variability) that have been analyzed for all PME requirements.

4.1.2.4 Sanitary wastewater shall not be commingled with industrial wastewater or stormwater collection systems unless approved by the Manager, EPD.

4.1.2.5 All onshore wastewater treatment, disposal and reuse applications shall be enclosed by a Type V fence, per SAES-M-006 unless already inside a facility's perimeter fence.

4.1.2.6 The collection/discharge system shall conform to SAES-S-010, SAES-S-020, SAES-S-030 and SAES-S-060.

4.1.2.7 All wastewater piping shall be labeled and color coded as per the color code in Table 3.

4.1.2.7.1 All piping inside the wastewater treatment facility (potable, chemical lines, wastewater, etc.) and all raw wastewater and effluent/reuse lines inside and outside the wastewater plant shall be color-coded as shown in Table 3.

4.1.2.7.2 The colored stripes required by Table 3 shall run length-wise on wastewater piping.

4.1.2.7.3 The colored stripes required by Table 3 shall be located on the top of the pipe if buried or on the side of the pipe most easily viewed, if located above ground.

4.1.2.7.4 All sides of the pipe must comply with the color-coding requirements. Color coding requirements apply to both above and below ground pipe.

Commentary Note:

HVAC lines and electrical conduits are not color-coded but are painted the same color as *the background construction.*

4.2 Engineering Reports / Design Approval

Wastewater treatment projects need to be developed with the support of EPD.

4.2.1 General

4.2.1.1 Engineering reports shall be prepared to detail plans to meet Saudi Aramco Environmental Standards and regulatory discharge limitations for any new installations or facility expansions that impact the quantity or quality of the facility's wastewater.

4.2.1.2 As part of the project Design Basis Scoping Paper (DBSP), a Preliminary Engineering Report (Section 4.2.2) for a wastewater treatment, reuse or disposal system (including injection wells) shall be prepared and submitted to the General Supervisor, EED for approval. A letter of approval, signed by the General Supervisor, EED, shall be included as an attachment to the Project's DBSP. This Preliminary Engineering Report is in addition to the Project's Environmental Impact Statement & Environmental Impact Assessment as required in SAEP-13.

4.2.1.3 Wastewater injection requires approval of the Manager, EPD, with concurrence of the Chief Hydrologist, Groundwater Division and the General Supervisor, Reserves and Reservoir Development Division.

4.2.2 Preliminary Engineering Report

4.2.2.1 An engineer experienced in the field of wastewater treatment shall prepare the report. It shall contain the conceptual basis for the collection, treatment, and disposal or reuse of the wastewater.

4.2.2.2 The report shall provide justification for the treatment method chosen to meet the effluent limitations in Table 1, if applicable.

4.2.3 Injection Well Proposal

If wastewater injection is proposed as a disposal method, the Preliminary Engineering Report shall contain an Injection Well

Proposal which shall be prepared by an engineer or geologist experienced in the field of subsurface injection.

4.2.3.1 General

The intent of this Proposal is to evaluate whether injection is technically possible and environmentally acceptable. The proposal shall include the information required in Sections 4.2.3.2 through 4.2.3.4.

4.2.3.2 Well Design

A general design of the proposed well completion shall be provided, based on established Company drilling and well construction practices. A general design of the proposed surface completion and pumping equipment shall also be provided.

4.2.3.3 Subsurface Information

The following hydrogeological elements shall be addressed:

a) The nature, thickness, vertical separation distances from target injection zone and all aquifers penetrated by the proposed injection well, and the next aquifer below the target injection zone.

b) The present and potential use of those aquifers penetrated by the proposed injection well, and the next aquifer below the target injection zone.

c) The distribution of aquitards or confining strata in the geologic section penetrated by the proposed injection well, and the next aquitard below the target injection zone (associated confining strata).

d) The hydraulic properties of the target injection zone and associated confining strata together with estimates of their aerial continuity.

e) The compatibility of proposed wastewater and receiving groundwater in the target formation at the anticipated temperatures and pressures.

f) The probable extent of the injected wastewater migration after 1, 10, and 100 years of injecting at maximum anticipated rates, recognizing the existing and future anticipated hydraulic behavior in the receiving zone.

g) The integrity of the confining strata under an exaggerated head differential equivalent to injecting at 150% of well design capacity.

h) The potential for structural deformation to impact the integrity of the confining strata.

i) The potential for existing wells to jeopardize the integrity of the confining strata.

4.2.3.4 The final quality of the wastewater to be injected shall be described. If treatment is needed in order to meet the formation criteria or regulatory requirements, the general design of the proposed treatment system shall be provided.

4.2.4 Engineering Study

4.2.4.1 General

4.2.4.1.1 PMT shall prepare an Engineering Study (or written Request for design approval of the General Supervisor, EED). EED will evaluate the Study/Request to determine the adequacy of the proposed treatment system. A letter of approval from the General Supervisor, EED shall be attached to the Project Proposal.

4.2.4.1.2 The General Supervisor, EED will determine the level of detail required in this document based on the specific Project being evaluated (i.e., which Sections of the Engineering Study are required to be submitted).

4.2.4.1.3 The Engineering Study shall typically consist of the information required in Sections 4.2.4.2 through 4.2.4.10 (except as indicated in Section 4.2.4.1.2).

4.2.4.2 Geotechnical Evaluation

All locations that have had the potential to have been contaminated by previous activities shall have a geotechnical evaluation to determine appropriate construction requirements. The General Supervisor, EED will provide guidance on items to be included in the scope of work for this activity.

4.2.4.3 Site Description

A brief description of the project with maps showing the area to be served, general location of proposed improvements, water and wastewater treatment plant sites, existing and proposed streets, parks, drainage ditches, canals, streams, water supplies, aquifers (with groundwater elevations), water wells and water mains shall be provided. Reference shall be made to the proximity to present and future developments, industrial sites, prevailing winds, public thoroughfares, parks, schools, recreational areas and other areas where people will be present.

4.2.4.4 Collection and Discharge Systems

The following items pertaining to the collection and discharge systems shall be provided:

a. A topographical map with terrain data in sufficient detail to determine drainage patterns of present and future areas to be served;

b. The details of existing and proposed lift stations;

c. The location, of discharge, reuse or location of the injection well;

d. The elevations of high and low water levels for the body of water to which the plant effluent is to be discharged, or groundwater level details for land disposal;

e. A hydrogeologic evaluation of the site to determine if wastewater can be disposed on a long term basis without risk to the groundwater. The evaluation shall include the depth to groundwater and its hardness; and

f. The expected discharge concentrations and daily mass loading for all constituents in Table 1.

4.2.4.5 Equipment Location

The following items pertaining to equipment location shall be provided:

a. A site drawing identifying the size and location of the proposed equipment;

b. A drawing showing the location, dimensions, elevations, and details of all existing and new plant facilities;

c. A process flow diagram showing the flow through the various plant units; and

d. Hydraulic profiles for the wastewater, supernatant liquor and sludge.

4.2.4.6 Waste Loading

The following items pertaining to waste loading shall be provided:

a. An estimate of the quantity of the existing wastewater and the design and peak waste loads (organic, inorganic and hydraulic) anticipated in the future. If records are not available, flow calculations shall be made for existing conditions with an estimate of future flow increases. When available, manufacturer's estimates for new process plants shall be used;

b. An estimate of the existing and anticipated amount of infiltration and inflow, and the method by which it will be addressed in the collection system design; and

c. The domestic population of the area to be served (present and projected), the Project's design population and the maximum population the system can handle.

4.2.4.7 Waste Characterization

The following items pertaining to waste characterization shall be provided:

a. An analysis of a sufficient number of representative wastewater samples to provide a statistically accurate description of the waste to be treated. The analysis shall include all parameters in Table 1 and any other waste constituents that are expected to be present. For new sanitary waste streams, calculated estimates of the constituents are allowed. Calculated estimates are not allowed for wastewater that will be injected into a regulated formation;

b. The name of each facility contributing wastes, the type of facility, the volume of waste, and the characteristics of the waste;

c. If wastes other than those found in normal sanitary or industrial wastewater are to be treated, sufficient data shall be included in order to assess the effect of these wastes on the wastewater treatment process; and

d. The results of any treatability tests;

e. For wastewater injection; the results of injectivity tests, core analyses, wastewater / formation water compatability tests and scale, sediment or plugging tests.

4.2.4.8 Design Specifications

4.2.4.8.1 Descriptions of the type of treatment plant being proposed and its efficiency, capacity, the effluent quality expected, and the basis of the design shall be provided.

4.2.4.8.2 All appropriate design parameters shall be provided.

4.2.4.8.3 This section shall also contain a description of the effect that any proposed system expansion will have on the existing system capacity.

4.2.4.9 Reliability

The following items pertaining to reliability shall be provided:

a. A listing of the equipment that will be used to meet the reliability requirements of Section 4.5;

b. A contingency plan which will detail the systems engineering to prevent untreated or inadequately-treated wastewater from being discharged;

c. Details on the secondary containment measures used to prevent a release of untreated wastewater to the environment; and

d. If emergency storage capacity is chosen as the method of meeting the reliability requirements, the report shall specify the storage capacity provided by the system.

4.2.4.10 Safety and Industrial Hygiene

The plans for meeting safety and industrial hygiene requirements shall be provided for review by the General Supervisor, Environmental Compliance Division.

4.2.5 Operating and Maintenance Manual

Prior to the completion (at the 50% complete stage) of construction of a new wastewater treatment plant or plant expansion, an Operating and Maintenance Manual shall be submitted to the General Supervisor, EED for approval. The Operation and Maintenance Manual shall be prepared by the PMT Design Engineer as part of the project. After it is approved, copies of the manual (as many as requested by the Proponent) shall be furnished to EED and the Operating Department by the Design Engineer. The manual shall cover engineering specifications, recommended operating procedures, preventive maintenance practices, and personnel training, as detailed in Sections 4.2.5.1 and 4.2.5.2.

4.2.5.1 Engineering Specifications

The following items pertaining to engineering specifications shall be provided:

a. Complete technical specifications and drawings for the construction of sewers, wastewater pump stations, wastewater treatment plants, and all junctions between them;

b. Manufacturer's specifications for each piece of equipment, specialized tools and preventive maintenance (p/m) schedules;

c. Installation instructions for all equipment; and

d. Details on all tie-ins to existing equipment.

4.2.5.2 Operating Instructions

The following shall be provided:

a. A complete set of start-up and operating instructions, covering both the mechanical and electrical parts of the treatment plant;

b. Operator training materials;

c. All forms necessary for the operation of the treatment unit; and

d. A program for maintaining existing treatment plant units in operation as much as possible during construction of plant additions.

4.2.5.3 Startup / Training

If the wastewater treatment plant involves sanitary wastewater reuse, the MOMRA requirement for a minimum of 6 months of operation by the manufacturer must be included as part of the startup support package provided by the contractor installing the system.

4.2.6 Revisions

Any deviations (positive or negative) from reviewed plans or specifications which would affect the capacity, flow, or operation of units shall be submitted in writing for approval of the General Supervisor, EED.

4.3 Site Approval Process

4.3.1 Site Inspection

4.3.1.1 The general site shall be inspected by the General Supervisor, EED and/or the General Supervisor, ECD or their representatives to evaluate compliance with the requirements in Section 4.3.2.

4.3.1.2 Approval for the location of a new or modified wastewater treatment facility shall be made through the Land Use Permit process (GI-0002.716) or Contractor Sites Allotment Procedure (GI-0002.718), whichever is applicable.

4.3.2 Siting Requirements

4.3.2.1 Treated wastewater discharges shall be sited in locations where hydrological conditions are such that a long-term discharge will not degrade the quality of groundwater in the area.

4.3.2.2 A wastewater treatment plant site shall be located as far as feasible from any existing facilities, or any areas that are likely to be developed within the foreseeable future.

Unless approval is obtained from the Manager, EPD; a wastewater treatment system shall be constructed a minimum of 150 m from any developed area or area to be developed (defined as where people will be working or residing).

4.3.2.3 The direction of the prevailing winds shall be considered when selecting the plant site. Wherever possible, wastewater treatment plants shall be located downwind (of the prevailing winds) of inhabited areas. Where this is not possible, wastewater treatment plants shall be located as far upwind or cross wind as is possible.

4.3.2.4 Wastewater treatment plants shall be located at an elevation which is not subject to flooding. Swales shall be used to direct surface water runoff away from the wastewater treatment system.

4.3.2.5 The wastewater treatment plant shall be protected against blowing sand. Sand fences, a line of trees, bushes or other diversion devices shall be used to prevent blowing sand from accumulating in the treatment system.

4.3.2.6 The site shall be of ample size to accommodate expansion and for the addition of facilities to increase the degree of treatment. Tie-in points shall be blind flanged.

4.3.2.7 Wastewater treatment equipment or disposal ponds to be located on top of previously contaminated soil require the approval of the Manager, EPD and the Manager, Consulting Services Department as well as the installation of any liners, soil venting systems or other requirements deemed necessary to accommodate the contaminated site.

4.4 Treatment Plant Design

4.4.1 General

4.4.1.1 Wastewater treatment systems shall be designed on the basis of the wastewater characteristics and treatment needs such that the effluent of the treatment system, prior to any dilution (defined as the Point-Of-Discharge), complies with the Table 1 requirements.

4.4.1.1.1 All analytical methods used for determination of compliance with Table 1 requirements shall be according to the Table 2 methods.

4.4.1.1.2 All sanitary wastewater reuse applications shall comply with Section 13 requirements.

4.4.1.1.3 When wastewater influent BOD_5 concentration is less than 100 mg/L, the treatment plant design must include the ability to add supplementary nutrients. Additionally, the wastewater should have approximately 13 g of nitrogen and 2.5 g of phosphorus for every 100 g of cell biomass or the system shall have a means to provide the necessary nutrients.

4.4.1.2 Sanitary wastewater treatment plants shall be designed on the basis of estimated sewer flowrates (as per Section 4.4.2) plus allowances for infiltration, estimated future increases in population, and industrial development.

4.4.1.3 The various treatment units and equipment shall be designed and sized to provide adequate treatment for the worst wastewater that they shall receive. Factors such as high wastewater temperatures; TDS, chlorides, BOD_5, and ammonia concentrations shall be considered.

4.4.1.4 Drains shall be provided so that each process unit may be completely dewatered. Tank bottoms shall be sloped to a drainage point.

4.4.1.5 Construction shall meet the requirements of SAES-M-100, SAES-M-001, and SAES-Q-001. Materials shall be selected that are resistant to corrosion and other forms of deterioration. Consideration shall be given to the possible presence of hydrogen sulfide, other corrosive gases, greases, oils and similar constituents frequently found in wastewater.

4.4.1.6 In order to prevent galvanic corrosion, contact between dissimilar metals, such as steel and copper alloys, shall be avoided in all internally wetted components and on external components that are buried or exposed to moisture.

4.4.1.7 Piping materials shall be selected to comply with SAES-L-132. Buried piping shall be protected from corrosion by the use of an approved nonmetallic material or by the use of metallic piping together with an approved coating as specified in SAES-H-002. Cathodic protection, where indicated desirable by economic analysis, shall be in accordance with SAES-X-600 for plant facilities.

4.4.1.8 Any special tools or accessories needed for the wastewater treatment equipment shall be supplied to the operating department prior to the project completion.

4.4.1.9 Each treatment plant shall be provided with a laboratory area and equipment sufficient to adequately control the treatment system. At a minimum, this capability shall include the ability to measure pH, dissolved oxygen, total suspended solids, settleable solids, temperature and total residual chlorine.

All industrial wastewater treatment systems that require operational field tests (IAFs, DAFs, organic adsorption systems, etc.) require equipment and laboratory space adequate to perform the required operational tests.

4.4.1.10 A PLC based Control System with control indications and supervisory control capability shall be provided for all wastewater treatment systems. The Control System shall also be provided with a Man - Machine Interface and be capable of printing reports for alarms, flow meters and all other measured variables

4.4.2 Hydraulic Capacity

4.4.2.1 The design flowrate of sanitary wastewater treatment systems shall be based on the average monthly wastewater flow with a consideration for any variations in this flow and the possibility for future expansions over the next 10 years. Table 4 wastewater generation rates and the anticipated full capacity headcount shall be used to estimate wastewater quantities.

4.4.2.1.1 Additional capacity shall be provided for truckers, visitors and any others who can be expected to be utilizing the facilities. The wastewater generation rate (used to determine total wastewater treatment requirements) for these individuals shall be 20 liters/person/day – based on an average number of visitors anticipated.

4.4.2.1.2 Other ways of estimating the anticipated wastewater treatment requirements require the approval of the General Supervisor, EED.

4.4.2.2 Equipment design shall take into account peak rates of flow for an hour, week, month and stormwater flows.

The peaking factor for sanitary wastewater treatment systems is 4 unless an alternate factor is approved by the General Supervisor, EED on a case-by-case basis (exceptions will require an automatic diversion to an emergency storage system and/or other requirements mandated by the General Supervisor, EED. The peaking factor shall be achieved by a combination of the system's peak flow capacity and emergency storage capacity).

4.4.2.3 Flow monitoring instruments, connected to a Control System, shall be provided for measuring the treatment system's effluent flow and any internal streams necessary to control the system. The preferred types of flow meters are plastic lined magnetic type flow meters for closed pipes and Parshall Flumes for open channels. Alternative flow meters shall be approved by the General Supervisor, EED on a case-by-case basis.

4.4.2.4 Interconnecting piping between treatment plant processes for new wastewater treatment plants shall be sized for flows a minimum of 50% higher than the peak flow to allow for future expansion.

4.4.3 Organic Capacity

4.4.3.1 The design organic treatment capacity shall be based on the average monthly waste load with a consideration for any variations in this load and the possibility for future expansions.

4.4.3.2 Anticipated loading for sanitary wastewater treatment systems shall be increased to compensate for the percentage of dwellings having garbage grinders. Loading for facilities with variable occupancy (i.e., construction camps) shall be computed for the maximum possible occupancy.

4.4.4 Industrial Wastewater

4.4.4.1 Within a plant area, segregation of wastewater streams (e.g., oily wastewater, high TDS wastewater, non-contact cooling water, and stormwater run-off) shall be practiced to allow the most economically feasible treatment system.

4.4.4.2 A wastewater characterization study shall be performed on existing industrial plants prior to the design of any modifications to the treatment system. This study shall provide for flow measurement, sampling and analysis of the existing wastewater streams during all potential operating situations. Sufficient samples need to be analyzed and sufficient flow measurements to assure a statistically accurate description of the current situation.

4.4.4.3 For new industrial plants and new wastewater flows to existing plants, the expected wastewater characteristics shall be based upon manufacturers' data, anticipated process flows and literature reviews. The flow capacity proposed for the new equipment must be approved by the General Supervisor, EED.

4.4.4.4 The treatment system design shall have sufficient equalization capacity to prevent operational upsets caused by changes in the industrial waste composition or quantity.

4.4.4.4.1 A minimum of one day of surge capacity (at maximum flow) shall be provided for Dissolved Air Flotation (DAF) and Induced Air Flotation (IAF) systems to reduce variations in flow and composition of the wastewater stream to be treated. Other treatment systems shall have surge capacities determined based on standard design practices as cited in Sections 3.3 and 3.4.

4.4.4.4.2 Surge tanks shall be normally operated at 50% capacity with the control philosophy to allow the level to raise or lower as needed to minimize fluctuations in the system.

4.4.4.4.3 Any industrial biological wastewater systems must be designed such that process variations will not cause daily variations of more than 10% in TDS, chlorides or any other contaminant that could negatively affect the biological organisms.

4.5 Reliability Requirements

4.5.1 General

4.5.1.1 Piping within wastewater treatment plants shall be designed with standby unit processes so that when one unit is out of service for repairs the wastewater treatment system may continue to operate.

4.5.1.2 Standby replacement equipment shall be provided for all equipment necessary for the operation of the treatment system, as per Section 4.5.2.

4.5.1.3 Wastewater treatment plant piping shall be sized to allow each unit to be dewatered within a maximum of 12 hours.

4.5.1.4 Wastewater treatment plant power supplies shall be provided with an alarm and either a standby power source or an automatically actuated storage capability (per Section 4.5.4). Two independent power supply sources are required for each lift station, per SAES-S-010.

4.5.1.5 Offshore wastewater treatment systems do not require duplication of tankage if the tanks are constructed of a material that will not require maintenance (i.e., lining inspection & repair). Alternative designs for these systems will be approved on a case-by-case basis by the Manager, EPD.

4.5.2 Component Duplication

4.5.2.1 Wastewater treatment systems shall have standby unit processes, which consist of at least two pieces of equipment for each wastewater treatment function except as specified in Sections 4.5.1.5, 4.5.2.2 & 4.5.2.3. If one unit is needed to meet the process needs, a second unit of equal capacity shall be provided. If multiple units are used, a spare with capacity equal to the largest of them shall be provided.

4.5.2.2 The requirement to provide standby unit processes for aeration tanks, clarifiers and other major tanks and equipment (excluding pumps) shall be determined based on an evaluation of the Preliminary Engineering Report and/or Engineering Study. The General Supervisor, EED will evaluate the project's proposed reliability features and determine the need for equipment duplication and excess capacity. The option of providing two units each having 60 - 80% of the total capacity (rather than two units each having 100% capacity) may be approved by the General Supervisor, EED on a case-by-case basis.

4.5.2.3 All offshore wastewater disinfection systems utilizing electrolic cells to generate chlorine for disinfection do not need to provide a standby cell if an alternate chlorine source is provided (i.e., a sodium or calcium hypochlorite addition system).

4.5.2.4 All flowmeters and other instruments in wastewater service required for PME compliance or Environmental Health requirements shall either be provided with an inline spare or a capital spare shall be provided to allow quick replacement – a common capital spare may be used for more than one installation of identical equipment (exceptions to the duplication of meters and instruments shall be allowed on a case-by-case basis by the General Supervisor, EED).

All flow meters shall be equipped with a by-pass line and valving to allow removal of the meter for maintenance purposes.

4.5.3 Alarms

4.5.3.1 Alarms connected to the Control System shall be provided for all wastewater treatment systems to provide warning of loss of power (from the normal supply) and failure of any portion of the wastewater treatment system.

4.5.3.2 All required alarm devices shall be independent of the normal power supply of the wastewater treatment plant.

4.5.3.3 Individual alarm devices shall be connected to a master alarm in a location where they can be conveniently observed by an attendant or other responsible person designated by the management of the wastewater treatment plant. In cases where the plant is not attended full time, the system shall be connected to an alarm at the security office, utilities office, fire station or other full-time service unit with which arrangements can be made to alert the person in charge of the plant.

4.5.4 Emergency Storage or Disposal

4.5.4.1 An emergency storage capacity (150% of the average daily flow or the 5 year storm capacity, whichever is greater) shall be provided to handle stormwater or other flows that cannot be adequately treated by the system.

4.5.4.2 Automatically actuated retention or disposal provisions shall include the necessary alarms, sensors, instruments, valves and other devices necessary to enable fully automatic diversion of untreated or partially treated wastewater to the emergency storage or disposal system in the event of failure of a treatment process or a flowrate above the treatment capacity. A manual reset to prevent automatic restart until the failure is corrected shall also be incorporated into the design.

4.5.4.3 The emergency storage or disposal facilities shall include diversion devices, provisions for odor and nuisance control, disinfection, and pump-back equipment (for storage facilities). All of the equipment other than the equipment used to pump back the stored wastewater shall be independent of the normal power supply or provided with a standby power source.

4.5.4.4 If the emergency storage is provided in ponds rather than a storage tank, the storage capacity shall be divided into multiple ponds. The ponds should overflow in a series fashion with the overflow lines set at 2 meters.

4.6 Safety and Industrial Hygiene

4.6.1 Safety

4.6.1.1 Lifesaving buoys and other Personal Flotation Devices (PFD's) and rescue poles shall be provided adjacent to facultative ponds, evaporation ponds and any large bodies of wastewater per GI-0006.020.

4.6.1.2 Personal protective equipment specified in Chemical Hazard Bulletins (CHB's) or Material Safety Data Sheets (MSDS's) shall be provided in the areas associated with the storage or use of any hazardous chemical.

4.6.2 Sanitary Facilities

4.6.2.1 Sanitary facilities shall be provided at all manned wastewater treatment plants per GI-0151.006 (Implementing the Saudi Aramco Sanitary Code).

4.6.2.2 The sanitary facilities shall include a separate changing/locker room or enclosure to allow workers to change clothes and clean-up. The room shall have handbasins.

4.6.3 Water Systems

4.6.3.1 Sanitary wastewater treatment plants shall be provided with two separate water systems, which shall not be physically connected in any way (e.g., a plant potable water system and a plant non-potable water system).

4.6.3.2 The piping color code system in Table 3 shall be closely followed and permanent warning signs shall identify all non-potable water fittings or outlets.

For reused sanitary wastewater; signs shall be posted in all areas where the wastewater is being utilized. The signs shall display a pictorial representation of the danger (artist's drawing indicating "no drinking") and a written warning in Arabic and English that the water is recycled wastewater.

5 Sewers and Lift Stations Design

5.1 Sewers

5.1.1 All sewer systems shall be designed and constructed in accordance with SAES-S-010 and SAES-S-020, as applicable.

5.1.2 Requirements for the separation of sewer lines and domestic water lines are given in Table 5.

5.1.3 Bottom corners of the channels must be filleted. Pockets and corners where solids can accumulate shall be avoided.

5.1.4 Suitable gates shall be placed in channels to seal off unused sections which might accumulate solids. The use of shear gates or stop planks is permitted where they can be used in place of gate valves or sluice gates.

5.1.5 There shall be no physical connection between a public or private potable water supply system and a sewer or junction which would permit the passage of wastewater into the potable water supply.

5.1.6 Manholes in both sanitary and industrial wastewater service shall be constructed of a nonmetallic material (such as fiberglass-reinforced plastic, high-density polyethylene, or equivalent).

5.1.7 If the separation distance between a remote wastewater source and a facility sewer system is greater than 150 m, the General Supervisor, EED may allow wastewater to be hauled by vacuum truck to the sewer system of that facility – not to an off-site, remote disposal location. The general site shall be inspected by the General Supervisor, EED and/or the General Supervisor, ECD or their representatives to evaluate compliance with the requirements in this standard and issue the approval for hauling.

5.1.8 Oily wastewater sewers shall have sand separators installed in front of critical wastewater lift stations.

5.2 Wastewater Lift Stations

5.2.1 General

5.2.1.1 All wastewater lift stations shall be designed and constructed in accordance with SAES-S-010 and SAES-S-020, as applicable.

5.2.1.2 Wastewater lift stations shall be constructed such that they will not be subject to stormwater flooding. A suitable superstructure, preferably located off the right-of-way of streets and alleys, shall be provided.

5.2.1.3 Lift stations shall be readily accessible for maintenance and cleaning.

5.2.1.4 There shall be no physical connection between any potable water supply and a wastewater lift station, which under any conditions might cause contamination of the potable water supply.

5.2.1.5 Sanitary wastewater lift stations located in a residential area or within 60 meters of a place of work require an odor control system.

5.2.1.5.1 For small lift stations (capacity less than 150_ m^3/day) this may be achieved by the use of an activated carbon vent system.

5.2.1.5.2 For large lift stations (capacity greater than 150_ m^3/day) a fan forced odor control system is required.

5.2.1.5.3 The amount of hydrogen sulfide produced by the sewer system upstream of the lift station should be calculated during project design to determine the minimum hydrogen sulfide load at the wet well. Odor control systems shall be designed for a minimum of 15 air changes per hour (total wet well volume) and minimum 10 ppm dynamic (fan operating) hydrogen sulfide concentration in the wet well. Water regenerated activated carbon scrubbers are the preferred odor control method. Water regenerated activated carbon systems shall be designed for minimum bed life between regenerations of at least 6 months. Odor control vessels, fans, and duct work shall be constructed of fiberglass or 316 stainless steel or other approved materials resistant to acids and sewer gases. Odor control systems shall be equipped with downstream hydrogen sulfide monitors that will signal when the bed needs regeneration. Odor control systems with fans must have upsteam pre-filters with 316 stainless steel mesh.

5.2.1.6 Lift stations with a capacity greater than 1800 m^3/day, which are part of a community wastewater treatment collection system shall be the wet-well / dry-well type. Smaller lift stations may be wet well if the lift pumps are either submersible or self priming.

5.2.1.7 Wet-well lift stations in both sanitary and industrial wastewater service shall be internally lined with a nonmetallic corrosion-resistant material such as PVC, or coated with APCS-19B (per SAES-H-101 or equivalent). Before coating, concrete shall be sealed with a low molecular weight epoxy sealer.

5.2.2 Pumps

5.2.2.1 Wastewater lift station pumps shall be designed in accordance with SAES-S-010 and SAES-S-020, as applicable.

5.2.2.2 Each lift station must have at least two pumps of the same capacity. The capacity of each lift station must exceed the peak hourly wastewater flow. The lift system must be designed such that it can pump the peak hourly wastewater flow with the largest pump out of service.

5.2.2.3 Pumps handling raw wastewater shall be preceded by readily accessible bar racks with clear openings not exceeding 50 mm unless pneumatic ejectors are used or the pump is fitted with a grinder system at the pump inlet.

5.2.2.4 Pumps in wet well service shall either be submersible or self priming unless approval is obtained from the General Supervisor, EED.

5.2.3 Ventilation

5.2.3.1 A minimum of 12 air changes per hour is required for lift stations with continuous ventilation. A capacity of 30 air changes per hour is required when ventilation is intermittent.

5.2.3.2 Where the pump pit is below the ground surface or within an enclosure, mechanical ventilation is required which shall ventilate the dry well and the wet well independently. There shall be no interconnections between the wet well and the dry well ventilating systems.

5.2.3.3 Dampers shall not be used on exhaust or fresh air ducts.

5.2.4 Alarm Systems

5.2.4.1 Alarm systems shall be designed in accordance with

SAES-S-010 and SAES-S-020, as applicable.

5.2.4.2 Alarm systems, which activate in cases of power failure or pump failure, shall be provided for lift stations.

5.2.4.3 Where a sanitary wastewater facility in a community or construction camp does not have 24-hour shift coverage, lift station alarms shall be telemetered to a manned location. In plant operating areas, pump failure alarms for both sanitary and industrial wastewater shall be connected to the responsible area's Control System. An audiovisual device (a light) shall be installed at the lift station for external observation.

5.2.5 Force Mains

Force mains shall be designed in accordance with SAES-S-010 and SAES-S-020, as applicable.

6 Preliminary Treatment Design

6.1 Bar Screens and Comminutors

6.1.1 General

6.1.1.1 Bar screens, mesh screens, and/or comminutors shall be provided for all sanitary wastewater treatment plants.

6.1.1.2 Bar screens shall be located upstream of the grit chambers and shall be readily accessible at all times to allow inspection and maintenance.

6.1.1.3 In the event that bar screens, mesh screens, or comminutors are located one or more meters below or above ground level, a stairway and/or ladder shall be provided for access. A hoist shall be provided to allow equipment to be easily removed, and equipment shall be provided to transfer the screenings to ground elevation.

6.1.2 Design

6.1.2.1 Manually-cleaned bar screens shall be constructed having a 30 to 60 degrees slope to a horizontal platform in order to provide for drainage of the screenings. Bar spacing for manually cleaned screens shall be from 25 to 40 mm. Mechanically cleaned screens may have spacing as small as

2 mm. Plants using MBRs shall have mechanical screens capable of removing particles as detailed in the manufacturer's requirements.

6.1.2.2 The channel in which the screen is placed shall be of such width as to maintain a minimum velocity (at design flow) of 0.3 to 0.6 m/sec for a manually cleaned bar screen and 0.6 to 1.0 m/sec for a mechanically cleaned bar screen.

6.1.2.3 Where mechanically operated screening devices are used, auxiliary manually-cleaned screens shall be provided. The design shall include provisions for automatic diversion of the entire wastewater flow through the auxiliary screens if the regular units fail.

6.1.2.4 Manually cleaned screening facilities shall include an accessible platform from which the operator may rake screenings easily and safely. Wash water and drainage facilities shall be provided for the platform and for storage areas.

6.1.2.5 The channel in which the comminutor is placed shall be of such width as to maintain a minimum velocity of 0.6 m/sec at design flow.

6.2 Grit/Sand Removal Facilities

6.2.1 General

6.2.1.1 Grit removal equipment shall be provided for all sanitary wastewater treatment plants.

6.2.1.2 Grit removal equipment shall be located upstream of pumps and comminuting devices.

6.2.1.3 Grit washing equipment shall be provided unless the grit is handled in such a manner as to prevent odors and fly nuisance. All grit collecting chambers shall be designed with the capability to be dewatered.

6.2.1.4 Sand separators shall be provided upstream of lift stations in oily wastewater collection systems.

6.2.2 Design

Aerated or vortex grit chambers with mechanical grit removal are required. Typical design criteria as found in Section 5.6 of Wastewater Engineering Treatment and Reuse, Metcalf & Eddy, fourth edition.

6.3 Sand, Screenings and Grit Disposal

6.3.1 Access shall be provided for the removal, handling, storage, and disposal of sand, screenings and grit.

6.3.2 Covered containers shall be provided for sand, screenings and grit that are temporarily stored at the site.

6.3.3 Screenings and grit shall be disposed in a sanitary landfill that is approved by the General Supervisor, EED (per SAES-S-007). This requirement shall be included in the Operating and Maintenance Manual.

6.3.4 Oil contaminated sand shall be disposed of as per Section 7.1.6.

7 Primary Treatment Design

7.1 Industrial Oily Wastewater Treatment

Industrial oily wastewater shall be treated in one or a combination of oil/water separation devices (Tank bottoms settling systems, API separators, CPI separators, settling ponds, IAF, DAF, walnut shell and multi media filters).

7.1.1 Tank Bottoms Water Draining Systems

7.1.1.1 Tank bottoms water drainage systems shall be designed to utilize in-tank sensors that will detect the oil/water interface level and automatically control the draining process such that the oil interface does not enter the drain line. The instrument selected should not have any moving parts or require routine cleaning.

7.1.1.2 All tank bottoms water draining systems must utilize the concept of an air gap to prevent cross contamination between storage tanks (as per API requirements).

7.1.1.3 All tank bottoms water draining systems shall drain into a sump that is contained within the same tank dike that contains the storage tank being drained. This sump shall be provided with a lift pump to transfer it into the oily water sewer – it shall not gravity drain to the oily water sewer – except as in Section 7.1.1.5.

7.1.1.4 All crude and product tank storage shall be enclosed by spill containment devices (berms or other dike walls). The floor of the containment area shall be constructed of 0.3 m of compacted marl or some other liner that will provide greater protection against the migration of the oil into the ground.

7.1.1.5 There shall not be any gravity flow sewer lines leaving a tank dike area – stormwater and tank bottoms water shall be collected in a sump located within the diked area and pumped out to the oily water sewer. An alternative to installing a transfer pump within the diked area is to provide a pipe running from the bottom of the sump to a fitting for a vacuum truck to suck out the contents of the sump. The vacuum truck fitting shall be located outside the diked area – if this is not possible, vacuum truck access must be provided within the diked area.

7.1.2 Preliminary oil removal shall be accomplished with the use of gravity oil/water separators. These separators shall be designed in accordance with the latest edition of the American Petroleum Institute API Pub 421 on the Design and Operation of Oil-Water Separators or other acceptable references.

7.1.2.1 API separators shall be used as primary treatment for oily wastewaters that have the potential to contain oily sludges and solids heavier than water.

7.1.2.1.1 Oily wastewater containing a low quantity of sludge – defined as a concentration such that the sludge collected in a year is less than 20% of API Separator volume, may be designed for batch removal of oily sludge - chain and flight scrappers are not required.

API separators designed for small quantities of sludge may be designed for either surface or below ground installation.

7.1.2.1.2 Oily wastewater containing sludge in concentrations higher than indicated in Section 7.1.2.1.1 shall be elevated above the ground such that it has an elevation sufficient to allow for sludge pumps to be installed below the sludge hoppers.

7.1.2.1.2.1 All elevated API Separators shall locate the sludge pump suctions directly below the sludge hoppers. Sludge piping shall be designed with a minimum of changes in direction, line size, valves and other fittings that could allow sludge to build up and plug lines.

7.1.2.1.2.2 Water jets shall be installed on two opposite sides of each sludge hopper to allow sludge buildups to be broken up without entering the vessel.

7.1.2.1.2.3 Trash pumps shall be used for skimmed oil and oily sludge pumping needs.

7.1.2.1.2.4 All above ground API Separators shall incorporate chain and flight scrappers to move sludge to the collection hoppers.

7.1.2.1.2.5 All chain and flight API Separators shall incorporate alignment sensors on each side of the chain and flight scrappers. The sensors shall be connected to a Control System that will shut off the scrapper drive if the chain is out of alignment by more than 30% of the length of one chain link.

7.1.2.1.2.6 All chain and flight API Separators shall incorporate tension adjustment blocks on each side of the chain and flight scrappers to allow for minor corrections in alignment. The adjustment blocks must have the capacity for an adjustment equal to at least the length of 1.5 chain links.

7.1.2.1.3 API Separators shall be designed with sufficient freeboard such that 0.3 meters is present above the liquid surface at maximum flow conditions.

7.1.2.1.4 API Separators shall be designed as part of a system that includes an emergency gravity overflow at the calculated maximum flow elevation.

7.1.2.1.5 API Separators shall be designed as part of a system that utilizes gravity flow to the maximum possible extent. Pumps utilized in oily water separation shall be minimized to avoid the creation of emulsions.

7.1.2.1.6 API Separators shall normally be designed to operate without covers. If odor concerns are a significant enough issue to require odor control, a combination of floating covers and fixed covers shall be utilized. The fixed covers on the ends shall be designed with explosion rupture vents, nitrogen blanketing, and carbon adsorption systems that incorporate oxygen and temperature sensors to reduce the explosion potential.

7.1.2.2 CPI Separators may be used in applications where the oily wastewater being treated contains very small concentrations of solids and oily sludge.

7.1.2.2.1 CPI Separators shall be designed to accommodate a flow equal to the maximum flow possible with all lift stations pumping.

7.1.2.2.2 CPI Separators shall be preceded by equalization / settling tank with a capacity of 30 minutes at maximum flow conditions. The equalization / settling tank should be designed to gravity overflow into the CPI Separator. The cone bottom of the equalization / settling tank shall have the drain valve located on the tank flange with a chain operating mechanism or automated valve. The drain line shall either drain to a trash pump (which will pump the collected sludge and solids to a transfer truck) or directly to a waste hauling truck. Oily wastes are to be disposed of as per Section7.1.6.

7.1.2.2.3 Water jet nozzles shall be installed on two sides of equalization / settling tank sludge hopper to allow sludge and solid buildups to be broken up.

7.1.2.2.4 CPI Separators shall be constructed with access hatches that will allow the oil overflow weir to be adjusted during operation.

7.1.2.3 Except as otherwise required in this standard, API and CPI separators may be constructed to comply with generally accepted wastewater industry design standards provided that a detailed list of all variances are provided to the Manager, EPD and approved.

7.1.3 Oily wastewater shall be treated to an oil concentration less than 8 mg/L prior to discharge to either a marine environment (as per SAES-A-103) or an evaporation pond.

7.1.3.1 If treatment to this level is not feasible and the discharge is into an evaporation pond, oil skimming equipment (oil spill containment booms and a means to remove collected oil is acceptable) shall be provided for removal of floating oil in the evaporation pond.

7.1.3.2 Offshore oily wastewater discharges must comply with the SAES-A-103 requirements for oil and grease for discharges.

7.1.4 A series of three oil/water separation ponds may be used in lieu of traditional API separators if approval is obtained from the General Supervisor, EED. The ponds shall be equipped with underflow / overflow weirs or discharge pipes with subsurface inlets - a sideways “Tee” fitting as per Figure 1 will allow the surface to collect free floating oil while only allowing clean water to enter the overflow line. The vertical overflow line open to the air on the top will prevent siphoning and allow the pond level to be maintained at the invert of the overflow line. These ponds shall provide a minimum of 2 days of detention time (combined pond volume at average daily flow). Oil skimming for these ponds may either be manual (vacuumed or pumped out whenever an oil layer develops) or by a floating skimmer. The system shall be designed to provide sufficient residence time to meet oil & grease effluent limitations in Table 1.

7.1.5 Where marine discharge of treated oily wastewater is not possible, treated oily wastewater shall be disposed in an evaporation pond. Off-site disposal of oily wastewater is not permitted unless approval is given by the General Supervisor, EED.

7.1.6 Waste oil and oily sludges shall be disposed of in a waste disposal facility (oily waste landfarm, Class 1 or 2 landfill, incinerator, etc.) that is approved by the General Supervisor, EED (**NOTE:** the EPD intranet site contains a listing of the approved waste handling contractors).

7.1.7 Waste oil or wastewater containing oil shall be stored in either an above ground tank with secondary containment or in a lined pit (or sump). The liner for the pit (or sump) is listed in Table 6. The pit shall include, at a minimum, 30-mil High-Density Polyethylene (HDPE). Concrete and/or compacted marl are acceptable materials for maintaining the shape of the pit (or sump). If it is anticipated that entry into the pit will be necessary or if there is the potential for damage to the top of the liner system, a 60-mil HDPE is required. If access for heavy equipment is needed, the HDPE liner shall be covered with reinforced concrete.

7.1.8 All oil concentration in water analyzers shall be designed such that routine maintenance is not required to operate them. Sensors that do not physically contact the oily water stream or those that cannot be affected by solids buildup are required.

7.2 Equalization

7.2.1 Equalization shall be provided for wastewater treatment systems (both sanitary and industrial oily wastewaters) to protect from fluctuations in concentrations of organics, TDS, toxic materials, pH swings and flow surges. Large sanitary treatment plants may apply to the General Supervisor, EED for an exemption to this requirement.

7.2.2 Mixing of sanitary wastewater equalization tanks or basins shall be provided. Mixing requirements shall be between 0.004 and 0.008 kilowatts / m^3 (0.02 - 0.04 horsepower per thousand gallons). Mixing of industrial wastewater equalization tanks shall be determined on a case-by-case basis depending on whether the equalization is required primarily for flow or composition and whether the mixing could cause emulsions to form.

7.2.3 For sanitary wastewater treatment system equalization basins having a detention time of more than two hours, air shall be supplied at a rate of 1.25 to 2.0 $ft^3/10^3$ gal./min. (0.01 to 0.015 m^3/m^3/min.).

7.2.4 Equalization ponds shall be designed in accordance with Section 8.1.

7.2.5 Commonly accepted industrial standards (such as Metcalf & Eddy, Section 5.3) shall be used to determine the volume requirements for sanitary wastewater equalization systems.

7.2.6 Industrial wastewater equalization systems shall be designed to provide adequate equalization to comply with Sections 4.4.4.3.1, 7.1.2.2.2 or as necessary to provide for protection of downstream equipment. A minimum of 24 hours capacity, at maximum flow, is required for oily wastewater equalization unless approval of the General Supervisor, EED is obtained.

7.3 Primary Sedimentation Units

Primary sedimentation is not required. If primary sedimentation is required for a particular wastewater treatment application, the design shall be approved on a case-by-case basis.

7.4 Grease Traps, Interceptors and Separators

7.4.1 General

7.4.1.1 Grease traps shall be designed per SAES-S-060 (specifically Appendix H of the Uniform Plumbing Code) with the modifications/clarifications as detailed in this section.

7.4.1.2 Discharges requiring a trap shall include streams containing oil, sand, kitchen wastes (from communal kitchens catering to 10 or more individuals) and other effluent containing similarly harmful constituents.

7.4.2 Location

7.4.2.1 A grease trap shall be located in an easily accessible place outside the building as near to grade as possible, using the same precautions as for location of the septic tank (Section 12.5.2).

7.4.2.2 Grease traps shall discharge into the building sewer upstream of the septic tank – if present. Grease traps shall be located within 9 m of the plumbing fixtures served.

7.4.2.3 The minimum separation distances for grease traps shall be the same as for septic tanks (Table 7).

7.4.2.4 The minimum separation distances for interceptors and separators shall be the same as for sewers (Table 7).

7.4.2.5 Interceptors and separators shall be located to provide easy access for cleaning, and shall be as close to the source of the sand and/or oil as possible. Sand traps shall be located upstream of lift stations – not downstream.

7.4.3 Design

7.4.3.1 The details shown in Figure 2 shall be used in designing grease traps, and those in Figure 3 shall be used in designing interceptors and separators. Alternate designs may be approved by the General Supervisor, EED.

7.4.3.2 Grease traps shall have tee type inlet and outlet fittings.

7.4.3.3 Interceptors and separators shall have an inlet tee turned clockwise (horizontal) and an outlet elbow that provides a minimum of a 0.15-m water seal.

7.4.3.4 The grease trap inlet, outlet and compartment vertical leg tees shall extend to within 0.3 m of the grease trap floor and extend well above the water level.

7.4.3.5 Grease traps, interceptors and separators shall have fittings that allow the entire system to vent back through building vents.

7.4.3.6 Grease traps, interceptors and separators shall have tight-fitting covers which are light in weight that are located above the inlet and outlet fittings. The minimum dimension of the covers shall be 0.5 m.

7.4.3.7 Grease traps, interceptors and separators shall be water tight and constructed of materials not subject to excessive corrosion or decay. Acceptable materials include concrete, fiberglass, fiberglass-coated metal, or fiberglass-reinforced plastic.

7.4.4 Grease Trap Capacity

7.4.4.1 The capacity of the grease trap shall be equal to the maximum volume of water used in a kitchen during a mealtime period. The design capacity shall be calculated per SAES-S-060 (specifically Appendix H, Paragraph 4 of the Uniform Plumbing Code).

7.4.4.2 The capacity of interceptors and separators shall be equal to 3 times the average hourly flow with a minimum capacity of 3 m^3.

7.5 Offshore Wastewater Treatment

Offshore sanitary wastewater discharges shall be designed to meet the discharge requirements of SAES-A-103.

8 Secondary (Biological) Treatment Design

The type of biological wastewater treatment system will be determined based on the raw wastewater to be treated, the location of the facility, the end use or disposal of the wastewater and the regulations that the discharge must comply with. Process selection shall be proposed in the Preliminary Engineering Report (Section 4.2.2) and approved of by the General Supervisor, EED.

8.1 Facultative Biological Treatment Ponds

Facultative biological wastewater treatment ponds are an acceptable treatment method for sanitary wastewater in remote areas when the volume of raw water consumption at the facility is less than 120 m^3/day (approximately 100 m^3/day of wastewater).

8.1.1 General Requirements

8.1.1.1 General

8.1.1.1.1 Facultative biological wastewater treatment ponds shall normally be designed to discharge into a series of evaporation ponds (2 or more). Discharges to evaporation ponds do not need to meet the Table 1 requirements provided the treatment pond is designed and operated according to Section 8.1.1.2 and approval is granted by the General Supervisor, EED.

8.1.1.1.2 Biological wastewater treatment ponds that discharge to any location other than evaporation ponds require approval of the Manager, EPD.

8.1.1.2 Design

8.1.1.2.1 Ponds shall be of such shape and size that will ensure even distribution of the wastewater flow throughout the entire pond.

8.1.1.2.2 Ponds shall be designed so that sludge can be removed on a routine basis. The ability to by-pass one pond that is part of a series configuration or the ability to divert to another pond that is part of a parallel configuration shall be provided.

8.1.1.2.3 Drainage shall be designed to exclude surface water from all ponds. Access areas and roads shall be provided for removal of weeds around the pond. A minimum of 6 m of open space from the outside edge of the pond embankment walls shall be provided.

8.1.1.2.4 All wastewater ponds shall be enclosed by a Type V fence unless the pond is located within the fenced area of a plant.

8.1.1.2.5 Facultative ponds shall either be preceded by facilities for primary treatment of the raw sewage or shall include a minimum of two facultative ponds in series. The first pond shall be used for solids separation and biological treatment and the second pond shall be for biological treatment only. Additional ponds shall be provided for evaporation.

8.1.1.2.6 Design - Organic Loading

8.1.1.2.6.1 For sanitary wastewater, the basic design for the peak monthly organic loading of the facultative stabilization ponds shall be based on the following:

a. For wastewater with primary treatment, a loading of 10 grams of BOD_5 / m^2 / day (90 pounds per acre per day) and a minimum detention time of 30 days; and

b. For wastewater without primary treatment, a loading of 7 grams of BOD_5 / m² / day and a minimum detention time of 45 days.

8.1.1.2.6.2 The loading of the initial pond in a series operation shall not exceed 25 grams of BOD_5 / m² / day assuming primary treatment. The loading of the initial pond in series operation with no primary treatment shall not exceed 17 grams of BOD_5 / m² / day. The total surface area for all ponds in the series configuration shall equal the area calculated in Section 8.1.1.2.6.1.

8.1.1.2.6.3 Pond design shall be based on a BOD_5 loading of 100 grams per day per person for typical wastewater and increased to 135 grams per person per day for construction camps. Hydraulic loading shall be based on the figures in Table 4.

8.1.1.3 Inlets and Outlets

8.1.1.3.1 Multiple inlets or center-submerged inlets and multiple outlets are required.

8.1.1.3.2 Inlet design shall include a splash pad.

8.1.1.3.3 The inlets and outlets shall be arranged to prevent short-circuiting within the pond so that the flow of wastewater is distributed evenly throughout the pond.

8.1.1.3.4 All outlets shall be baffled to prevent floating material from being discharged. A “Tee” overflow line as described in Section 8.1.1.3.5 may also be used. Outlets shall be constructed so that the level of the pond is maintained at a minimum of 2 meters (except during startup – when the pond should be filled to 50% capacity prior to the introduction of wastewater).

8.1.1.3.5 Overflow pipes with inlets located approximately 0.3 m below the surface shall be provided. A sideways "Tee" fitting with one hole facing down, one up and one sideways (as indicated in Figure 1) shall be used to provide a vacuum breaker - to prevent siphoning between ponds.

8.1.1.4 Embankment Walls and Liner

8.1.1.4.1 The embankment walls shall be constructed of marl and compacted to 95% standard Proctor (per ASTM D698). They shall have a top width of at least 3 meters unless otherwise approved by the General Supervisor, EED. The top surface shall be suitable for use by maintenance vehicles.

8.1.1.4.2 The interior and exterior slopes of the embankment wall shall not be steeper than 1 m vertical to 3 m horizontal.

8.1.1.4.3 The design shall provide for a freeboard of not less than 0.6 m (based on the maximum operating depth).

8.1.1.4.4 Systems to protect embankment walls from wave action shall be provided.

8.1.1.4.5 Wastewater treatment ponds shall be lined with a 30-mil rough-surface HDPE liner over 0.3 m of marl (Table 6) compacted to 95% standard Proctor (per ASTM D698).

8.2 Activated Sludge - Tank Systems

8.2.1 Process Selection – Sanitary Wastewater

8.2.1.1 Membrane Biological Reactors (MBR) are the preferred treatment technology in applications where wastewater reuse is required or where there is a need to provide a simple to operate system.

8.2.1.2 Oxidation ditch or extended aeration are acceptable methods for large community treatment plants.

All oxidation ditch systems shall provide final clarification and return sludge capability equal to that required for the extended aeration system. Provision shall be made to easily vary the immersion depth of the rotor for flexibility of operation.

8.2.1.3 Other systems may be approved on a case-by-case basis by the General Supervisor, EED.

8.2.2 Design

8.2.2.1 The criteria in Table 8 and peak monthly waste loads shall be used for the design of activated sludge biological treatment units.

8.2.2.2 Aeration tank shape shall provide optimum oxygen transfer and sizing for the type aeration device proposed. Liquid depths shall not be less than 2.5 m. All aeration tanks shall have a freeboard of not less than 0.5 m at peak flow.

8.2.2.3 Equipment for measuring return sludge, excess sludge, and air shall be provided in activated sludge plants having a design flow of 1800 m^3 / day or more.

8.2.2.4 Aeration tanks shall be constructed of reinforced concrete or steel unless approved by the Materials Engineering and Corrosion Control Division.

8.2.2.5 Aeration tank equipment in contact with wastewater shall be constructed of 316 stainless steel unless approved by the Materials Engineering and Corrosion Control Division.

8.2.2.6 An access stairway and walkway with handrail shall be provided to all areas that require maintenance.

8.2.2.7 Sanitary wastewater treatment systems must be designed for a peaking factor of 4.

8.2.3 Mixing Requirements

8.2.3.1 A minimum velocity of 0.5 m/sec shall be maintained in all parts of the aeration basin.

8.2.3.2 Sufficient mixing shall be provided to prevent deposition of mixed liquor suspended solids under any flow condition. Minimum mixing requirements are shown in Table 9.

8.2.4 Aeration

8.2.4.1 Aeration Requirements

Commonly accepted industrial standards [such as the Water Pollution Control Federation Manual of Practice (WPCF FD 13)] shall be used to determine aeration requirements. Minimum aeration requirements for extended aeration and plug-flow are given in Table 10.

8.2.4.2 Oxygen Requirements

8.2.4.2.1 The aeration system shall provide for the introduction of air in sufficient volume and in such a manner to maintain at least 2 milligrams per liter of dissolved oxygen under all conditions of loading in all parts of the aeration ponds or tanks except immediately beyond the inlet.

8.2.4.2.2 Oxygen transfer rates in excess of 1.18 kilograms of oxygen per kilowatt-hour (2 pounds of oxygen per horsepower-hour) shall be justified by actual performance data.

8.2.4.3 Surface Mechanical Aerators

8.2.4.3.1 Surface mechanical aerators are the preferred type of aerators for activated sludge systems that treat greater than 3800 m^3 / day.

8.2.4.3.2 Mechanical aeration devices shall be of such capacity to provide oxygen transfer to and mixing of the vessel contents equivalent to that provided by compressed air. Mechanical aerators shall be high energy, efficiency type aerators. Aerators must be rated for minimum

2.1 Kg O_2/kw.h (3.5 lb O_2/hp.h) at standard conditions: tap water 20°C (68°F) at 100 kN/m² (14.7 lbf./in²) and initial dissolved oxygen = 0 mg/l.

8.2.4.4 Subsurface Aerators

8.2.4.4.1 The diffuser systems shall have devices for removing and replacing diffusers without dewatering the tank (exceptions for MBR systems can be granted on a case-by-case basis by the General Supervisor, EED). They shall also have non-clog diffusers for all systems using intermittent aeration.

8.2.4.4.2 The diffuser system shall have an individual diffuser header assembly with air control valves. The diffuser head control valves shall allow for throttling of the airflow. Alternatively, each aeration tank may be provided with individual blowers controlled by a variable speed drive.

8.2.4.4.3 The air diffuser system, including piping, shall be capable of delivering 150% of design air requirements.

8.2.4.4.4 The blower/compressor units shall be equipped with automatic reset and restart mechanisms to place the units back in operation after periods of power outage.

8.2.4.4.5 Air filters shall provide for a flowrate of 120% of the design requirements.

8.2.4.5 Secondary Sedimentation Units

8.2.4.5.1 The basic design criteria in Table 11 shall be used for secondary sedimentation units.

8.2.4.5.2 Secondary sedimentation units shall have dual skimmers or heavy-duty full-length skimmers

8.3 Activated Sludge - Tank Systems, Membrane Biological Reactors

Membrane Biological Reactors (MBRs) are the preferred treatment technology in applications where wastewater reuse is required (raw water consumption greater than 120 m^3/day – approximately 100 m^3/day of wastewater) or where there is a need to provide a simple to operate system.

8.3.1 MBR systems and associated equipment shall be designed to meet the reclaimed wastewater quality for unrestricted irrigation in Table 1 (MOMRA requirements).

8.3.2 A manufacturer's certification of California Title 22 acceptance is required for all MBR systems.

8.3.3 The Manager, EPD, in consultation with other affected organizations, may approve waivers from Saudi Aramco requirements for MBR package systems that are designed to generally accepted wastewater industry standards.

8.3.4 The MBR unit shall be purchased as a package unit unless approved by the General Supervisor, EED.

8.3.5 All upgrades of existing systems in which the current wastewater treatment system is modified to incorporate membranes in place of the clarifiers will require a certification from the manufacturer of the membrane that the complete system will achieve California Title 22 effluent requirements. The General Supervisor, EED will review the design and determine whether the certification is acceptable.

8.3.6 The MBR process configuration shall incorporate the submerged membrane (immersed) design. Cross flow membrane systems are not allowed unless approved by the General Supervisor, EED.

8.3.7 The MBR system shall be designed based on the wastewater average influent flowrate and strength. The system shall be provided with sufficient equalization capacity to buffer anticipated variations in the wastewater influent flowrate or waste composition.

8.3.8 MBR systems shall be designed for a peaking factor of 4. If the MBR system cannot handle this flux rate, this must be provided by a combination of the MBR system peaking factor and emergency storage (i.e., a MBR with a peaking factor of 2 would require 2 days of storage capacity – divided between the balancing tank and the stormwater storage system).

8.3.8.1 Balancing tanks require coarse bubble diffusers for odor control..

8.3.8.2 Stormwater storage ponds need to be segmented and each section sloped to a drain point.

8.3.9 The MBR system shall comply with the design criteria in Table 8.

8.3.10 The MBR system shall be designed with a spare unit that has the capacity equal to the capacity of the largest unit in service. This may be accomplished with two (2) 75% percent units, three (3) fifty percent capacity membrane units, four (4) thirty three percent units, or some other combination that allows for a spare unit to be available.

8.3.11 All critical components shall be provided with an in-line spare. Alternate designs where redundancy requirements are met by multiple units sharing a single spare may be approved on a case-by-case basis by the General Supervisor, EED.

8.3.12 Stand-by equipment (e.g., pumps, blowers) should be designed to start automatically in case of failure of the primary unit. Manual starts of stand-by equipment may be approved by the General Supervisor of Environmental Engineering on a case-by-case basis.

8.3.13 The MBR system shall be designed to maximize reliability and to reduce operator requirements.

8.3.14 The MBR system should be provided with an automated permeate control system to shut down flow should the air flow to the membranes stop. Flow during down-time should by-pass the system to the balancing tank and/or emergency storage system. The by-pass line shall be provided with a tie-in to the chlorination system – with sufficient capacity to provide for emergency disinfection.

8.3.14.1 The MBR system shall be provided with all pretreatment equipment required by the individual feed characteristics and as stipulated by the MBR supplier.

8.3.14.2 The pretreatment equipment shall provide for the removal of free oil and grease. The MBR supplier shall stipulate the oil and grease requirements for their particular system.

8.3.14.3 A fully enclosed pretreatment unit; which comprises duty/standby screening, plus grit removal shall be provided as part of the MBR manufacturer’s package. Screening requirements shall be as needed to meet the selected MBR manufacturer’s requirements.

8.3.14.4 A pH control system shall be provided as part of the MBR supplier's package.

8.3.15 Tanks associated with the MBR shall be made from epoxy-coated carbon steel or fiberglass reinforced plastic (FRP). Concrete tanks and other exceptions shall be approved by the General Supervisor, EED on a case-by-case basis.

8.3.16 The MBR system shall be designed to minimize foaming. A foam control system shall be provided by the manufacturer.

8.3.17 Section 8.2.4.4 requirements for aeration systems are applicable for MBR's.

8.3.18 The aeration system shall provide sufficient air supply (with redundant blowers) to meet the membrane scouring air requirement and aeration requirement for biological activities.

8.3.19 The MBR shall be provided with an automated membrane cleaning system and shall be configured for the membranes to be cleaned in-place (under normal operations).

8.3.20 The MBR system shall be provided with a telemonitoring capability to allow the manufacturer or others to remotely monitor the operation of the system. All critical operating parameters shall be metered and available for monitoring.

8.3.21 Flow rate meters (Magflow) for feed, recycle and permeate, pH meters, dissolved oxygen meters and TransMembrane Pressure (TMP) gauges shall be installed to provide both local readings as well as be connected to the PLC and telemonitoring system.

8.3.22 Effluent from the MBR system shall have a minimum of 3 meters water column head under normal operating conditions.

8.3.23 The MBR system shall be installed such that the surrounding area allows for crane access (to remove the membranes for maintenance).

8.3.24 The effluent storage tank shall be provided with an emergency overflow line to the emergency storage system (the same pond used for raw waste water may be used). The emergency storage pond shall have a minimum of 1.5 days of normal flow capacity – additional capacity may be required to meet the peaking factor requirement (Section 8.3.8).

8.3.25 The MBR manufacturer shall provide 6 months of operation and maintenance service as part of the system.

8.3.26 The disinfection requirements of Section 10 apply to the effluent of an MBR. If required by the MBR system, chlorine requirements for membrane backflushing shall be provided by the effluent disinfection system. Any automated dilution systems required for this system are to be provided by the MBR manufacturer.

8.3.27 Sludge shall be treated to meet USEPA Class B sludge requirements (greater than 550 degree-days – 22 days is typical for this area) prior to discharge. If not adequately treated in the MBR system, it must receive additional treatment (aerated digestor) to achieve these requirements prior to disposal in sludge drying beds.

8.3.28 Except as otherwise required in this standard, a MBR system may be constructed to comply with generally accepted industry design standards provided that a detailed list of all variances are provided to the Manager, EPD and approved.

9 Tertiary Treatment / Chemical Addition Systems

9.1 General

Coagulation, flocculation, sedimentation, filtration and disinfection are the main treatment steps required after secondary biological treatment of sanitary wastewater when the water is to be used for Unrestricted Irrigation (Section 13.2). However, MBR units provide a tertiary quality wastewater without the use of these steps and these systems are exempt from all the Section 9 requirements that are not applicable.

Industrial wastewaters often utilize similar treatment steps (without the biological treatment step) and these requirements also apply to industrial applications using these pieces of equipment.

9.2 Flocculation

9.2.1 The flocculation equipment shall be adjustable in order to obtain optimum floc growth, control deposition of solids, and prevent floc destruction at peak hourly flow.

9.2.2 If polymers are to be used as flocculation aids, they shall be introduced into a flash mix tank upstream of a flocculation tank or into the flocculation zone with several alternate input points.

9.3 Flotation

9.3.1 When used, air flotation of industrial wastewater shall only be located downstream of gravity oil/water separators, equalization equipment and flocculation tanks.

9.3.2 For oily wastewater, the design of either Dissolved Air Flotation (DAF) or Induced Air Flotation (IAF) shall be in accordance with the API or manufacturer's published literature and recommendations. The design basis shall be supported by performance data from bench scale experimental runs or, if approved by the General Supervisor, EED, from systems operating under similar conditions.

9.3.3 A laboratory capable of determining TSS, oil concentration and performing jar tests is required to be provided when a flotation device is used (IAF or DAF).

9.3.4 For industrial wastewater systems requiring flotation, individual flocculation tanks should be dedicated to each flotation device and located immediately upstream of the DAF or IAF. These shall either be incorporated into the design of the flotation device or close coupled to them through a large diameter straight piece of pipe that is as short as possible – the design objective is to minimize shear of the floc.

9.4 Chemical Systems

9.4.1 General

Chemical addition equipment shall be provided in cases where the wastewater needs to be conditioned for downstream treatment equipment, when the pH of the discharge is outside of the pH range of 6 to 9 or in cases where conventional gravity settling or biological treatment is not able to treat the discharge to Table 1 concentrations.

9.4.2 Reliability

9.4.2.1 All chemical treatment systems shall be designed with multiple-unit flexibility to allow for operational adjustments in chemical feed point locations, chemical feed rates, and use of alternative chemicals.

9.4.2.2 Coagulation chemical feed systems shall be provided with the following mandatory features for uninterrupted coagulant feed: standby feeders, adequate chemical storage and conveyance facilities, adequate reserve chemical supply, and automatic dosage control.

9.4.3 Chemical Selection and Dosage

9.4.3.1 The chemical dosage required shall be the minimum necessary to bring about optimum treatment. The design shall compensate for possible inefficiencies of mixing and dispersion.

9.4.3.2 The choice of treatment chemical(s) shall be based upon the characteristics of the influent wastewater, the quality requirement of the final effluent and the economics of the process.

9.4.3.3 In instances where only pH correction is needed, the use of holding tanks and metering pumps (to allow a gradual addition of the high or low pH streams) may be utilized - if feasible. Where unfeasible or when gradual mixing will not provide a sufficient buffering capacity to assure a proper pH in the discharge, a simple pH control system with either acid or base addition shall be utilized – this addition system shall be automated and capable of maintaining the appropriate pH at maximum flow conditions.

9.4.4 Chemical Feed System

9.4.4.1 All liquid chemical mixing and feed installations shall be installed on corrosion-resistant pedestals.

9.4.4.2 Selection of chemical feed points shall be made on the basis of the type of chemicals used, necessary reaction times, the type of wastewater treatment process, and the type of components in use. Flexibility in feed point location shall be provided together with multiple feed points.

9.4.4.3 Liquid chemical feed pumps shall be equipped with variable feed-rate control. Each pump shall be sized to handle the peak hourly flow.

9.4.4.4 An emergency pressure relief line shall be installed as close as possible to the delivery heads of the pumps. Safe disposal shall be provided for any liquid chemicals which may pass through the relief line.

9.4.4.5 Screens and valves shall be provided on the metering pump suction lines.

9.4.4.6 All dry chemical feeders shall be equipped with a mixing tank which is capable of providing a minimum 5-minute retention time at the peak hourly flow rate. Polyelectrolyte feed installations shall be equipped with multiple solution vessels and transfer piping.

9.4.4.7 Make-up tanks shall be provided with an eductor funnel or other appropriate arrangement for wetting the polymer during the preparation of the stock feed solution. Mixing shall be accomplished with a large diameter, low speed mixer.

9.4.4.8 Secondary spill containment shall be provided around all chemical feed system components.

9.4.5 Flash Mixing

9.4.5.1 Flash mixing shall be provided for chemicals such as polymers, metal salts and pH control chemicals.

9.4.5.2 Where separate mixing basins are provided, they shall be equipped with mechanical mixing devices.

9.4.5.3 The flash mixer shall have a mean temporal velocity gradient, G (sec.), of at least 800. The detention period shall be at least 30 seconds at peak hourly flow.

9.4.6 Chemical Storage Facilities

9.4.6.1 Facilities shall be designed to store an adequate supply of treatment chemicals to assure that they are available at all times. The precise storage capacity shall be based upon the size of shipments, delivery times and process requirements.

9.4.6.2 The liquid storage tanks and tank fill connections shall be located within a secondary spill containment structure having a volume of 150% of the total volume of the largest storage vessel. Valves on discharge lines shall be located adjacent to the storage tank and within the secondary containment.

9.4.6.3 Auxiliary facilities, including pumps and controls, not within the containment area shall be located above the highest anticipated liquid level.

9.4.6.4 Bag or drum storage shall be located near the solution make-up point with trolleys provided for convenient drum/bag movement.

9.4.6.5 Platforms, ladders and railings shall be provided as necessary to afford convenient and safe access to all filling connections, storage tank entry locations, and measuring devices.

9.4.7 Other Requirements

9.4.7.1 All materials, chemical feed equipment, and storage facilities shall either be constructed of corrosion-resistant materials or have a protective coating, as approved by the Materials Engineering and Corrosion Control Division.

9.4.7.2 All piping shall be easily accessible. Cleanout connections shall be installed at changes in direction.

9.4.7.3 A bottom draw-off with an elevated inlet shall be provided for chemical storage or feed tanks to avoid withdrawal of settled solids into the feed system. A separate bottom drain shall be installed for removal of accumulated solids.

9.4.7.4 Containment areas shall be sloped to a sump area and shall not contain floor drains that drain into a sewer.

9.4.7.5 Chemical precipitation sludge shall be disposed of separately from other sewage sludge, in a facility approved by the General Supervisor, EED (per GI-0430.001).

9.4.7.6 Eye washes and safety showers shall be provided in areas where chemicals are being handled.

9.5 Filtration

9.5.1 Design

9.5.1.1 Both gravity and pressure filters are acceptable – depending on the application. When grease is present in sanitary wastewater, a gravity filter shall be used.

9.5.1.2 Pressure filters shall be provided with ready and convenient access to the media for treatment or cleaning.

9.5.1.3 Pumping equipment upstream of filter units shall be designed to minimize shearing of the floc particles.

9.5.1.4 Equalization facilities shall be provided when fluctuations in influent quality and quantity can affect filter operations.

9.5.1.5 Intermittent sand filters shall be protected from surface wash and blowing sand.

9.5.2 Filtration Rates

9.5.2.1 Filtration rates shall not exceed 110 liters / minute / m^2 (3 gallons / minute / ft^2) for single media (sand) filters and walnut shell filters (minimum 1.6 meter bed depth); 200 liters / minute / m^2 for continuous backwash (minimum 1.2 meters bed depth), and dual or multi media filters (based on the design flow rate applied to the filter units). Designs proposing alternate filtration rates for any of these pieces of equipment may be approved by the General Supervisor, EED on a case-by-case basis.

9.5.2.2 Total filter area shall be divided between two or more units, and the filtration rate shall be calculated based upon the total available filter area with one unit out of service.

9.5.3 Backwash

9.5.3.1 The overall design of the treatment plant shall accommodate the hydraulic and organic load from the waste backwash water. The rate of return of waste filter backwash water to the treatment units shall not exceed 15% of the design flowrate to the treatment units.

9.5.3.2 The backwash rate shall be adequate to fluidize and expand each media layer a minimum of 20%.

9.5.3.3 Waste filter backwash waters shall be treated in a backwash settling tank and returned to the inlet of the wastewater treatment plant.

9.5.3.4 Filtered water shall be used as the source of backwash water. Surge tanks shall have a minimum backwash capacity sufficient to allow all filters to be backwashed in less than four hours. Walnut shell filters may be backwashed with raw wastewater.

9.5.3.5 Where waste backwash water is returned for treatment by pumping, adequate pumping capacity shall be available with the largest unit out of service.

9.5.3.6 The effluent clear well and backwash settling tank shall have a capacity such that all the filters may be backwashed in less than four hours.

9.5.4 Filter Media

Selection of media size shall depend on the filtration rate selected, the type of treatment provided for the filter influent, the filter configuration and the effluent quality objectives. Local sand shall not be used without approval of the manufacturer.

9.5.5 Filter Appurtenances

9.5.5.1 The filter shall be equipped with a means of measurement and control of the backwash rate, equipment for indicating filter head loss, a positive means of shutting off flow to the filter being backwashed, and filter influent and effluent sampling points. All filtration appurtenances in contact with water shall be PVC, 316 stainless steel, fiberglass, or other corrosion resistant material approved by the General Supervisor EED in consultation with CSD corrosion specialists.

9.5.5.2 If automatic controls are provided, there shall be a manual override for operating equipment and critical valves.

9.5.5.3 The under drain system shall be designed to provide uniform distribution of backwash/air (if appropriate).

9.5.5.4 The system shall have the capability to treat the filter influent and backwash water with chlorine.

9.5.6 Except as otherwise required in this standard, a filter system (including similar equipment specified in Section 9.7), may be constructed to comply with generally accepted industry design standards provided that a detailed list of all variances are provided to the Manager, EPD and approved.

9.6 Direct Filtration

Direct filtration (no flocculation and clarification steps) may be approved on a case-by-case basis by the Manager, EPD for large community sanitary wastewater treatment systems provided that the secondary effluent can be demonstrated to historically be less than 10 NTU. Continuous monitoring of the secondary effluent turbidity (NTU's) is required.

9.7 Chemical Adsorption

Chemical adsorption is a simple to operate system that can be used in place of biological wastewater treatment in cases where the process wastewaters cannot be reliably treated – high TDS, temperature, contaminant concentrations, variability of contaminant concentrations and the presence of refractory contaminants (contaminants that are not biologically degradable).

9.7.1 Carbon or resin adsorption systems require either bench scale or bench scale and field testing to develop an adequate design. Approval of the study is required by the General Supervisor, EED prior to the design development. This study shall be performed prior to the DBSP in order to assure that the proposed project scope is feasible.

9.7.2 If the removal media is to be regenerated rather than disposed of when it can no longer remove the wastes, an appropriate treatment method must be provided to dispose of the concentrated contaminants in the effluent from the regeneration process.

9.8 Wet Air Oxidation

Wet Air Oxidation (WAO) units are capable of oxidizing complex molecules and are an appropriate treatment method for spent caustic and other refractory (difficult to treat) wastes.

9.8.1 WAO units need to be designed to treat the most complex chemicals present in the wastewater stream. Sufficient analysis must be performed in order to fully determine the characteristics of the wastewater to be treated.

9.8.2 The proposed manufacturer shall specify the required analysis and process information needed for the design. After the evaluation, the proposed manufacturer shall issue a certification that their system can adequately treat the wastewater to PME discharge limitations. If the system cannot treat to PME discharge requirements, the manufacturer shall provide a detailed description of the identity and quantity of chemicals expected to be in the discharge of the WAO unit.

9.9 Other Treatment Systems

Should any of the previously described treatment systems not be capable of reliably treating the anticipated wastewater stream, other treatment methods may be required. Other treatment systems are to be evaluated on a case-by-case basis and approved by the Manager, EPD. All analysis and studies requested by EPD shall be performed in order for approval to be granted.

10 Disinfection Design

10.1 General

10.1.1 Sanitary wastewater discharges shall be disinfected to meet the reuse or discharge standards in Sections 13 or 14.

10.1.2 For sanitary wastewater treatment systems handling less than 1900 m^3 / day, Sodium Hypochlorite addition shall be the required disinfection method unless approved by the Manager, EPD. Use of gaseous chlorine is not acceptable for any size of disinfection system.

10.1.3 Any disinfection system (except as prohibited in Section 10.1.2) may be used ahead of a reuse application provided that a minimum of 0.5 mg/L of total chlorine residual is maintained in all parts of the distribution system.

10.2 Chlorination

10.2.1 Design

10.2.1.1 Chlorination equipment shall be capable of providing continuous chlorine residual.

10.2.1.2 Chlorination facilities shall be designed to provide a minimum contact time of 30 minutes at peak hourly flow.

10.2.1.3 Chlorination equipment shall be designed to provide sufficient chlorine that a minimum of 1 mg/L total residual chlorine is present in the wastewater after 30 minutes of contact time as specified in Section 10.2.1.2.

10.2.1.4 The chlorine contact structure may be a tank or a combination of a tank and an outfall sewer. The structure shall be baffled to prevent short-circuiting.

10.2.1.5 Chlorine contact chambers shall have provisions for draining and cleaning in all plants with capacities greater than 3800 cubic meters per day.

10.2.1.6 Means for automatic proportioning of the amount of chlorine compounds to be applied in accordance with the rate of wastewater being treated shall be provided. Manual addition is not acceptable for routine operations.

10.2.1.7 Facilities shall be provided for determining the amount of chlorine compounds used daily, as well as the quantity remaining in the container. This may be achieved through the use of a scale or in the case of Sodium Hypochlorite, a totalizing flowmeter and storage tank level indicator.

10.2.1.8 Materials in contact with chlorine solutions shall be Teflon, Chlorinated Polyvinyl Chloride (CPVC) or Kynar. All glues used in sodium hypochlorite service shall be. All underground piping containing sodium hypochlorite shall be installed in a casing pipe of at least 3 times the outside diameter of the carrier tubing.

10.2.1.9 Provision shall be made for emergency chlorination at points where bypasses have been provided and other means of treatment are not available.

10.2.1.10 Chlorination systems utilizing Sodium Hypochlorite shall include a means to eliminate scaling problems (in piping and the injection nozzles) that are associated with the injection of Sodium Hypochlorite into high TDS wastewater. This may be achieved by dilution of the Sodium Hypochlorite with a low TDS water, open channel addition (an air space between the addition pipe and the wastewater) or an automatic in-line cleaning system that utilizes an acid to eliminate scaling. A stand-by injection nozzle (in-line) is also required.

10.2.1.11 Chlorination systems generating the chlorine from sea water (off-shore platforms or facilities with an available supply of sea water) shall either provide two 100% capacity cells or one cell and a backup chlorination system using one of the alternative sources of chlorine. As sodium hypochlorite rapidly loses its strength, the alternative chlorine source should be calcium hypochlorite or some other dry chlorination compound.

10.2.2 Safety

10.2.2.1 Suitable safety equipment (gas masks, instruments that detect chlorine, alarm systems, and exhaust fans) shall be provided for systems handling more than 1900 m^3/day of wastewater.

10.2.2.2 At least one positive pressure, self-contained breathing apparatus such as a Scot Air Pack shall be provided and hung in a conspicuous place outside the sodium hypochlorite storage room – for facilities handling more than 1900 m^3/day of wastewater.

10.2.2.3 A safety shower with eyewash shall be in close proximity to the disinfection facility. The eyewash shall operate by means of a push bar.

10.2.2.4 A poster providing handling instructions and precautions (as required by HAZCOM) shall be posted in a conspicuous place in the chlorination room. Detailed disinfectant handling manuals supplied by the various manufacturers shall be included in the Operating and Maintenance Manual.

10.2.3 Disinfection Facility

10.2.3.1 A separate enclosure or room at or above ground level must be provided exclusively for disinfection purposes. No other equipment or chemicals shall be installed or stored in the disinfection facility.

10.2.3.2 The door to the disinfection room shall have a 0.3-meter by 0.3-meter window to allow observance of conditions in the room prior to entering. If this space is part of a larger building, the door must open to the outside of the building and must be outward opening.

10.2.3.3 Storage of Calcium Hypochlorite and Sodium Hypochlorite shall be in a cool, dry and dark location to prevent the loss of disinfectant strength.

10.2.4 Ventilation

10.2.4.1 Buildings containing chlorine compounds shall be vented with a minimum of 20 air changes per hour.

10.2.4.2 The exhaust duct shall take in air for exhausting within 0.3 m of the floor level.

10.2.4.3 A louvered fresh air intake shall be provided to serve as a make-up air supply when the exhaust fan is operating. This intake shall be located in the ceiling or near ceiling level.

10.2.4.4 The exhaust fan shall be wired to automatically activate when the room light is turned to the "ON" position. The light switch shall be located outside the room.

10.2.4.5 A pressure-type switch shall be located in the door to the chlorination room, which shall activate the exhaust fan automatically when the door is opened.

10.2.4.6 The exhaust outlet shall be directed away from the fresh air intake and away from other occupied areas. The vent shall be elevated 5 m above the roof of the building.

11 Sludge Management Design

11.1 General

All sanitary wastewater treatment plants shall be provided with sludge treatment (stabilization)/drying facilities. Basic sanitary sludge production equations with standard empirical constants shall be used to predict sludge production for design purposes. As per GI-0430.001, industrial and sanitary wastewater treatment sludges shall be disposed of in a facility approved by the General Supervisor, EED.

11.2 Wastewater Sludge Handling Equipment

11.2.1 Piping

11.2.1.1 The minimum sludge (sanitary or industrial sludges) line size shall be 0.15 m (6-inch pipe).

11.2.1.2 Cleanouts shall be provided such that stoppages can be readily eliminated by rodding with sewer cleaning devices.

11.2.1.3 Sample and control valves shall be provided on the return sludge and supernatant lines.

11.2.2 Sludge Pumps

11.2.2.1 Centrifugal sludge pumps used in secondary or activated sludge systems if they have sufficient net positive suction head or they are self-priming.

11.2.2.2 Return activated sludge pumps shall be capable of providing a variable capacity between 25 and 150% of design flow for conventional (plug-flow) processes and 25 to 200% for extended aeration processes.

11.3 Sanitary Wastewater Aerobic Digesters

11.3.1 General

Aerobic digestors are required for all wastewater treatment systems unless the systems are designed to achieve USEPA Class B sludge requirements (as per Table 14-9 in Metcalf & Eddy, fourth edition) prior to discharge.

11.3.1.1 The design of the air supply, tank configuration and depth shall be the same as that of the aeration tank (Section 8.2.4).

11.3.1.2 A sludge sampling valve (quick-closing type) shall be installed in a location that allows the sludge to be sampled without pumping it to the drying bed. The valve and piping shall be at least 40 mm in diameter (1.5-inch pipe).

11.3.1.3 Aerobic digesters shall be sized to provide a minimum of 0.03 m^3 per capita design load on the plant, assuming that the sludge has a minimum of 15 days detention time.

11.3.2 Aeration

A minimum of 20 m^3 per minute of air per 1000 m^3 of digester volume (2.7 ft^3 per minute of air per 1000 gallons of digester volume) shall be provided for mixing. Oxygen requirements shall be based on peak monthly waste loads with an assumption that 2.3 grams of oxygen are required for every gram of volatile solids reduced.

11.4 Sanitary Wastewater Sludge Drying Beds

11.4.1 General

11.4.1.1 Air drying of sanitary wastewater sludges shall be permitted only for well-digested sludges which will not give rise to odor or other nuisance problems.

11.4.1.2 The sludge drying beds shall be located a minimum of 150 m from residential areas. They shall also be sited downwind of the residential areas, whenever possible.

11.4.2 Sizing of Sanitary Wastewater Sludge Drying Beds

The basic design criteria in Table 12 shall be used to determine the area requirements for sanitary wastewater sludge drying beds. It should be noted that these values have been determined empirically for the areas noted. They represent the drying requirements for the worst month of the year in order to allow year-round use of the drying beds. Exceptions to these values may be granted for large community wastewater treatment systems provided the system has adequate sludge storage capacity to store sludge during the winter months and approval is granted by the Manager, EPD.

Commentary Note:

> *The solids loading assumes the application of a sludge to the drying beds to a depth of 0.3 m with a solids concentration of 1.5% or more. Increased depth or differences in solids concentration will affect these values.*

11.4.3 Design of Sanitary Wastewater Sludge Drying Beds

11.4.3.1 A minimum of two sludge drying beds shall be provided for all applications.

11.4.3.2 The general design criteria in Table 13 shall be used for sludge drying beds. Alternate sludge drying bed designs may be approved by the General Supervisor, EED on a case-by-case basis.

11.4.3.3 A splash block or slab shall be provided at the point where digested sludge is discharged onto each of the beds. The sludge pipe to the beds shall terminate at least 0.3 m above the splash block.

11.4.3.4 The sludge drying bed shall be designed to accommodate a minimum depth of 0.3 m of filtering material, of which 0.10 to 0.15 m is coarse sand. Acceptable sand shall be at least 95% silica.

11.4.3.5 Side walls shall be designed to exclude surface water run-off and eroded earth from entering the drying beds. Walls shall be watertight and extend 0.40 to 0.45 m above and at least 0.15 m below the surface of the sludge.

11.4.3.6 The drainpipes in the sludge drying beds shall be designed to handle the anticipated flow from percolation and rainfall.

Percolated filtrate shall be returned to the influent of the treatment system.

11.4.3.7 Sludge drying beds shall be constructed of concrete unless the General Supervisor, EED approves an alternate design.

11.4.4 Sanitary Wastewater Sludge Removal

The sludge drying beds shall be arranged to facilitate sludge removal. A ramp shall be constructed inside and outside of the drying beds to facilitate sludge removal. The ramps shall not be steeper than 1 m vertical to 3 m horizontal.

11.5 Industrial Oily Sludges

11.5.1 Oily wastes shall be recycled when feasible. If recycling is not economically feasible, oily waste landfarming is typically the most economic and environmentally acceptable treatment and disposal method. Acceptable oily waste landfarm contractors and other acceptable methods of oily waste disposal are listed on the EPD intranet site.

11.5.2 General Oily Waste Handling Requirements

11.5.2.1 A temporary storage pit (constructed of concrete) with a sloped inlet (to provide access for mechanical equipment entering the pit) shall be provided for storage of oily waste.

11.5.2.2 Oily wastes shall not be disposed of or stored in open pits or landfills.

12 Small Flow Wastewater Disposal Systems

Small Flow disposal systems will not provide the same treatment that the biological treatment systems provide; they only dispose of the wastewater. They are designed to dispose wastewater close to people without the removal of pathogenic organisms or dissolved contaminants. As such they are only appropriate for small numbers of people in remote areas where there is no chance of polluting useable groundwater. Because of the increased risk to human health and the environment that these systems represent, they should only be used when there is no other treatment option available. Small Flow wastewater treatment systems may consist of septic tanks with wastewater disposal fields (absorption fields or evapotranspiration fields), holding tanks with an appropriate disposal location (case-by-case approval is required by the General Supervisor, EED for the use of holding tanks) and portable toilets.

12.1 General

12.1.1 When the number of people at a site makes the use of biological wastewater treatment systems unfeasible (i.e., an average of 30 people or less), septic tanks with either seepage pits or wastewater disposal fields may be used for wastewater disposal. Facilities with greater than 30 personnel require approval by the General Supervisor, EED to use a small flow wastewater disposal system.

12.1.2 Approval of the hydraulic profile for the sewer collection system, the septic tank and the wastewater disposal field needs to be obtained from the General Supervisor, EED prior to the design and installation of an Small Flow wastewater disposal system.

12.1.3 Septic tanks and wastewater disposal fields shall be designed according to SAES-S-060 (specifically Appendix I of the Uniform Plumbing Code) with modifications as detailed in this Section.

12.1.4 The maximum seasonal elevation of the groundwater table must be at least 1.5 m below the bottom of the trench or seepage pit. Rock formations or other impervious strata must also be at a depth greater than 1.5 m below the bottom of the trench or seepage pit. Locations not meeting these criteria may be developed into evapotranspiration wastewater disposal fields with the approval of the General Supervisor, EED.

12.1.5 Required clear separation distances for components of septic wastewater disposal systems are shown in Table 7.

12.1.6 Wastewater disposal fields shall be located in areas where an alternate wastewater disposal site of at least the same size is available immediately adjacent to the disposal field. This area shall be reserved for future wastewater disposal should the primary field become unusable. Figure 4 shows a generalized septic tank wastewater disposal field system.

12.1.7 Roof drains, foundation drains and drainage from other sources producing large volumes of water shall not discharge into a septic tank or absorption area.

12.1.8 Suitable collection containers for paper towels, wrapping paper, rags and sticks shall be provided in areas served by septic tanks in order to prevent them from being disposed of in the septic tank.

12.1.9 Abandoned septic tanks and seepage pits shall be filled with sand or rock.

12.1.10 A chart showing the location of the septic tank and disposal system shall be placed at a suitable location in the facility served by the system. The chart shall contain brief instructions as to the inspection and maintenance required by the system.

12.1.11 Underground equipment associated with septic systems and wastewater disposal fields shall be protected from vehicular traffic by posts or highway barricades.

12.1.12 Solids collected in the septic tank and wastewater from holding tanks shall be disposed of in a wastewater treatment facility approved by the General Supervisor, EED.

12.1.13 All piping associated with Small Flow treatment systems shall be constructed of PVC or Reinforced Thermosetting Resin (RTR).

12.1.14 Sewer lines entering the septic tank must enter above the normal operating level for the tank. Gravity sewer lines entering the septic tanks must be able to drain completely empty while the septic tank is full.

12.1.15 Septic tanks may be situated above ground if a gravity drain into a leach field is required. A pressure sewer will be required ahead of the septic tank if this option is selected.

12.2 Area Required For Soil Absorption Systems

12.2.1 Prior to the design of a wastewater disposal leach field, a Robert A. Taft percolation test shall be performed in accordance with the procedure specified in the Saudi Aramco Sanitary Code, Section SASC-S-02 (Subsection 4.10.2). The percolation rate of the soil must be within the range of those specified in Table 14 in order for an absorption field or seepage pit to be acceptable.

12.2.2 Areas that are not appropriate sites for wastewater percolation may be used as evapotranspiration wastewater disposal fields if designed in accordance with Section 12.4.

12.2.3 In areas where the percolation rates and soil characteristics are appropriate for soil absorption systems, the required absorption area and type of absorption system shall be determined using Table 14 and the maximum number of people expected to be served by the system.

12.3 Wastewater Disposal Fields - Absorption Trenches

12.3.1 Location

12.3.1.1 Absorption trenches shall not be used where the percolation time exceeds 60 minutes.

12.3.1.2 On sloping ground, absorption trenches shall be located such that the sides of any of the trenches shall not come horizontally closer than 4.5 m to the ground surface (e.g., a road at a lower elevation than the trench shall be no closer than 4.5 m from a trench).

12.3.1.3 Absorption trenches shall not be used where the bottom of the trench will come within 1.5 m of the highest groundwater elevation at that location.

12.3.2 Design

12.3.2.1 Absorption trenches shall be designed according to SAES-S-060 (specifically Appendix I of the Uniform Plumbing Code) with modifications/clarifications as detailed in this section.

12.3.2.2 The details shown in Figure 5 shall be used in designing absorption trenches.

12.3.2.3 Absorption trench piping shall be 0.1 m in diameter (4-inch pipe).

12.3.2.4 Absorption trench piping shall have two rows of 13- or 16- mm holes drilled 120 degrees apart and spaced approximately 0.13 m on center.

12.3.2.5 Absorption trenches shall be 0.5 to 0.9 m wide and no longer than 30 m long. Individual trenches shall be spaced a minimum of 2 m center-to-center with a minimum of 1.2 m between the trenches.

12.3.2.6 When two or more absorption trenches are used, a distribution box shall be installed at the head of the field.

12.3.2.7 The inverts of all outlets from the distribution box shall be level and the invert of the inlet shall be at least 25 mm above the outlets. The details shown in Figure 6 shall be used in designing distribution boxes.

12.3.2.8 If over 150 m of absorption piping are needed to dispose of the wastewater, a dosing tank system is required.

12.3.2.9 A non-woven polypropylene geotextile with a weight of 90-110 grams / m^2 shall be used to separate the filter material from the earth backfill.

12.3.3 Sizing/Capacity

12.3.3.1 The disposal area shall be a minimum of 14 m^2.

12.3.3.2 The absorption trench area shall be determined by using Table 14 and the maximum number of people expected to be served by the system. The table assumes an average daily usage of 380 liters per person. In cases where the actual wastewater use is different from this assumption, the values in the table shall be adjusted assuming a linear relationship.

12.3.3.3 If the disposal field area is to be covered by black top or other paving, the absorption trench area shall be increased by 30%.

12.4 Wastewater Disposal Fields - Evapotranspiration Trenches

12.4.1 Location

12.4.1.1 In areas where rock or impermeable soil is near the surface or the results of the percolation test are unacceptable, an evapotranspiration wastewater disposal field is an acceptable alternative.

12.4.1.2 The required separation distances for evapotranspiration wastewater disposal fields are the same as for absorption trenches (Table 7).

12.4.2 Design

12.4.2.1 Evapotranspiration wastewater disposal fields shall be designed similar to absorption fields. The details shown in Figure 7 shall be used in designing evapotranspiration wastewater disposal fields.

12.4.2.2 In locations where absorption trenches are not feasible because of marl and the resulting low absorption capability of the soil, an appropriately sized one-meter deep pit shall be excavated for the evapotranspiration wastewater disposal field.

12.4.2.3 The design of the distribution system shall be the same as that used for absorption trenches.

12.4.2.4 A non-woven polypropylene geotextile with a weight of 90-110 grams / m² shall be used to separate the filter material from the earth backfill.

12.4.3 Sizing/Capacity

12.4.3.1 The minimum area for an evapotranspiration field shall be 250 m².

12.4.3.2 The evapotranspiration field shall be sized to provide the area required for open pan evaporation corrected for 40% efficiency.

12.5 Septic Tanks

12.5.1 General

Septic tanks shall be designed per SAES-S-060 (specifically Appendix I of the Uniform Plumbing Code) with modifications/clarifications as detailed in this section.

12.5.2 Location

12.5.2.1 The relative position of a septic tank in a typical subsurface disposal system shall be as shown in Figure 4. Note: a subsurface installation may not be possible if the sewer line entering it and the location of the wastewater disposal field will not allow for proper drainage (Section 12.1.14 & 12.1.15).

12.5.2.2 The minimum distances cited in Table 7 shall be maintained for septic tank installations.

12.5.2.3 Septic tanks shall not be located in swampy areas, inter tidal zones, or areas subject to flooding.

12.5.2.4 Septic tanks shall be located where the largest possible area will be available for the disposal field. Access for cleaning and maintenance shall be provided. Where public sewers may be installed at a future date, provision shall be made in the plumbing system to permit easy connection to such sewer.

12.5.3 Capacity

Minimum septic tank capacities are listed in Table 15.

12.5.4 Tank Proportions

12.5.4.1 The septic tank proportions shall conform to the Saudi Aramco Plumbing Code design standards for septic tanks in SAES-S-060 (specifically Appendix I, Section 5 of the Uniform Plumbing Code).

12.5.4.2 The details shown in Figure 8 shall be used in designing septic tanks.

12.5.5 Materials

12.5.5.1 Septic tanks shall be water tight and constructed of materials not subject to excessive corrosion or decay. Acceptable materials include concrete, fiberglass, fiberglass-coated metal, or fiberglass-reinforced plastic.

12.5.5.2 Precast tanks shall have a minimum wall thickness of 75 mm and shall be adequately reinforced to facilitate handling. When precast slabs are used as covers, they shall be watertight.

12.5.5.3 All reinforced concrete surfaces shall be coated externally with APCS-10 or equivalent, and internally with APCS-3 or equivalent (per SAES-H-101).

12.5.6 Use of Compartments

12.5.6.1 Septic tanks shall consist of two or more compartments, with the first compartment equal to one-half to two-thirds of the total volume. Each compartment shall have a minimum plan dimension of 0.6 m with a liquid depth ranging from 0.7 to 1.5 m.

12.5.6.2 Venting between compartments shall be provided to allow the free passage of gas.

12.5.6.3 The first compartment shall have a minimum capacity of 1.9 m^3 and the second compartment shall have a minimum capacity of 1 m^3.

12.5.7 Adequate Access

12.5.7.1 Adequate access shall be provided to each septic tank compartment for inspection and cleaning. Both the inlet and outlet devices shall be accessible.

12.5.7.2 Access shall be provided to each septic tank compartment by means of a manhole or removable cover of at least 0.5 m in diameter. Where the top of the tank is located more than 0.5 m below the finished grade, manholes and inspection holes shall extend to approximately 0.2 m below the finished grade.

12.5.8 Inlet and Outlet

12.5.8.1 The inlet invert shall enter the tank at least 50 mm above the liquid level in the tank. The location of the septic tank and its inlet must allow any gravity sewer lines entering it to drain empty.

12.5.8.2 Any septic tank installation where the septic tank is located anywhere but immediately next to the wastewater source will likely not have sufficient elevation to allow for the Section 12.5.9.1 requirement and still allow the septic tank to gravity drain into the disposal field.

12.5.8.2.1 If the septic tank can be installed at an elevation low enough that a gravity drain from the facility can comply with the Section 12.5.9.1 invert requirement, the septic tank can overflow into a small effluent tank that contains a sump pump that discharges into the disposal field.

12.5.8.2.2 If conditions make it unfeasible to install the septic tank and sewer line such that Section 12.5.9.1 invert requirements cannot be met, a lift station inside the facility shall be installed to pump the wastewater to the septic tank. The level control system for this lift station shall be designed to maintain the wastewater level below the invert of the sewer lines entering it.

12.5.8.3 A vented inlet tee shall be provided to divert the incoming wastewater downward. It shall penetrate a minimum of 0.3 m below the liquid level, but in no case shall penetration be greater than that allowed for the outlet device.

12.5.8.4 The outlet device shall extend to a distance below the surface equal to 40% of the liquid depth. For horizontal, cylindrical tanks, this shall be reduced to 35%.

12.5.8.5 The inlet device shall extend above the liquid line to approximately 25 mm from the top of the tank to allow gas to escape through the tank into the building vent.

If the septic tank design is as per Section 12.5.8.2.2 (a pressurized feed line rather than a gravity drain line feed), a separate vent system for the septic shall be provided. This vent shall discharge a minimum of 5 meters above the ground. If odor problems are anticipated because of local conditions, a carbon odor control system is required.

12.5.8.6 The outlet invert shall be 50 mm lower than the inlet.

12.5.8.7 The inlet and outlet shall be a minimum of 0.1 m in diameter (4-inch pipe).

12.5.8.8 The outlet of the septic tank must be high enough to allow gravity overflow into the wastewater disposal field. If this cannot be achieved (as per Section 12.5.8.2.2) with a buried tank, the septic tank must be installed above the ground with a pressure feed line.

12.5.9 Storage Above Liquid Level

12.5.9.1 The design shall provide capacity above the liquid line to provide for that portion of the scum that floats above the liquid. The design shall assume that 30% of the total scum will accumulate above the liquid line.

12.5.9.2 For tanks having straight, vertical sides, the distances between the top of the tank and the liquid line shall be equal to approximately 20% of the liquid depth. For horizontal, cylindrical tanks, an area equal to approximately 15% of the total circle shall be provided above the liquid level. This condition is met if the liquid depth (distance from outlet invert to bottom of tank) is equal to 80% of the diameter of the tank.

12.6 Temporary Toilets

12.6.1 Temporary public toilets (temporary hammams) are acceptable for temporary wastewater disposal needs not exceeding 90 days. After that time a water carriage disposal system is required unless a waiver of the time period is authorized in writing by the General Supervisor, Environmental Compliance Division.

12.6.2 The only type of temporary public toilet that will be considered for use is the purpose-built, portable chemical toilet that is provided by a contractor who specializes in the maintenance and servicing of portable chemical toilets.

12.6.3 The waste from temporary toilets shall be disposed of in a wastewater treatment facility approved by the General Supervisor, EED.

12.7 Wastewater Holding Tanks

Wastewater holding tanks without absorption trenches shall only be used when the maximum number of people served by the system is less than 30 and the wastewater is disposed of in a wastewater treatment facility approved by the General Supervisor, EED (this design requires case-by-case approval from the General Supervisor, EED). Municipal dumping areas are not considered acceptable disposal locations for Saudi Aramco wastewater. Facilities wishing to utilize off-site disposal for wastewater require approval from the General Supervisor, EED and MOMRA to be allowed to transport sanitary wastewater to an off-site wastewater treatment facility. All documentation required for the MOMRA approval shall be completed by the facility requesting the waiver. If approved by EED, the documents will be forwarded to MOMRA. Wastewater from holding tanks may be trucked to a wastewater treatment plant located at the same facility - with approval of the General Supervisor, EED.

12.8 Drilling Camps / Remote Area / Temporary Wastewater Disposal

In remote areas where support facilities are limited and where the wastewater disposal need is of a temporary nature, alternative Small Flow disposal methods may be permitted. Approval of the General Supervisor, Environmental Compliance is required in order to use one of these methods.

12.8.1 General Requirements

12.8.1.1 All Section 12.8 wastewater disposal systems will utilize a septic tank to settle out solids from the wastewater. The septic tank should be designed as per Section 12.5.

12.8.1.2 Clear effluent from the septic tank will need to be disposed of by evaporation, percolation or a combination of the two.

12.8.1.3 All wastewater disposal ponds (evaporation or percolation), shall be sited such that there is sufficient space to build another one if it becomes necessary.

12.8.1.4 All wastewater disposal ponds shall be located a minimum of 150 meters from a residence camp, worksite or office.

12.8.1.5 All wastewater disposal ponds must be enclosed by temporary fencing for the entire time that water is present in the pond (even if this lasts beyond the need for the pond).

12.8.1.6 Closure of a wastewater disposal pond will involve the spreading of lime over the bottom surface of the pond and backfilling to a level grade.

12.8.1.7 Closure of a septic tank that will be reused at a new location will require that the contents be transferred in a 2 meter deep pit, lime being spread over the surface and the pit being backfilled to grade. Closure of a septic tank that will be abandoned in place will require the clear liquids to be drained off, lime being spread over the remaining material and the tank being backfilled.

12.8.1.8 Odor problems from any vents associated with these wastewater disposal systems can be moderated by the addition of a carbon vent canister to the vents causing the odor problems.

12.8.2 Evaporation ponds are appropriate for Section 12.8 locations where there is a high water table or where the local topography could result in standing wastewater around the camp.

12.8.2.1 Evaporation ponds shall be designed as per Section 14.2.

12.8.2.2 Evaporation ponds shall be constructed to a depth of 2 meters below the invert of the gravity sewer line feeding the pond (**note:** the bottom of the evaporation pond must be above the water table or the system will need to incorporate a pressure line to transfer wastewater to the pond). If wastewater is pumped to an evaporation pond, it can be constructed above ground – a 2 meter depth.

12.8.2.3 The evaporation pond shall be sized to provide 100 m² of surface area for every individual in a housing camp and 25 m² for every individual at their workplace. These required surface areas can be reduced to 25 and 6 m², respectively if the pond is only going to be used for less than 1 year and if the fence is maintained for the full time that water is present.

12.8.3 Percolation ponds are appropriate for Section 12.8 locations that have a large quantity of wastewater and where percolation is possible without causing standing water to develop in areas outside of the pond itself.

12.8.3.1 Percolation ponds shall be designed the same as an evaporation pond with the exception of the bottom – compacted marl is only required for the side, not the bottom. The bottom of the pond shall have 10 cm thick gravel on top of 20 cm depth of clean stone.

12.8.3.2 The percolation pond shall be sized to provide 10 m² of surface area for every 30 employees that will utilize the pond.

12.8.3.3 The bottom of the percolation pond should be at least 1.5 m above the highest groundwater level.

12.8.3.4 The percolation pond shall be constructed to a depth of 2 meters below the invert of the gravity sewer line feeding the pond (**note:** the bottom of the evaporation pond must be above the water table or the system will need to incorporate a pressure line to transfer wastewater to the pond). If wastewater is pumped to an evaporation pond, it can be constructed above ground – a 2 meter depth.

12.8.3.5 The design of the percolation pond shall conform to Figure 9.

13 Wastewater Reuse Design Requirements

13.1 General

13.1.1 Any reuse of reclaimed wastewater for irrigation requires approval of the Manager, EPD

13.1.2 Any industrial use of reclaimed industrial wastewater requires approval of the General Supervisor, EED with concurrence of the appropriate Operations Manager.

13.1.3 Reclaimed sanitary wastewater shall meet the quality standards in Table 1 and treatment requirements in Table 16.

13.1.4 The reclaimed sanitary wastewater treatment process shall not create odors or slime, or provide a breeding ground for flies, mosquitoes, and other pathogenic vectors.

13.1.5 No connection between the potable water supply and a reclaimed wastewater system shall be permitted. Adequate control measures to prevent inappropriate alterations of the plumbing shall be developed and implemented. These shall be included in the Operating and Maintenance Manual.

13.1.6 An approved reduced pressure backflow preventor assembly shall be provided at all domestic water service connections in reclaimed water use areas.

13.1.7 All reclaimed sanitary wastewater piping, valves, outlets, quick couplers, water controllers, tanks and surface impoundments containing reclaimed water shall be tagged to warn the public that the water is not safe for drinking or bathing.

13.1.8 All reclaimed sanitary wastewater valves, outlets, quick couplers, and sprinkler heads shall be of a type or secured in a manner that only permits operation by personnel authorized by the Proponent Operating Department.

13.1.9 Use of permanently connected hoses on reclaimed sanitary wastewater lines is not permitted.

13.1.10 As-built drawings shall be maintained for all wastewater reuse applications.

13.1.11 Reclaimed sanitary wastewater reuse applications shall be designed to minimize the potential for ponding. The Operating and Maintenance Manual shall identify requirements to prevent ponding.

13.1.12 Reclaimed sanitary wastewater systems shall be designed to provide a minimum chlorine residual of 1.0 mg/L after 30 minutes of contact time and a minimum of 0.5 mg/L at the furthest point in the distribution system.

13.1.13 Reclaimed sanitary wastewater systems shall be designed to prevent direct or windblown water from reaching external drinking water facilities.

13.1.14 Signs shall be posted in areas where reclaimed sanitary wastewater is being used to warn the public that reclaimed wastewater is being used and that they should not drink the water. These signs shall include both a pictorial representation of the danger and a written warning.

13.1.15 Reclaimed wastewater distribution systems that may be supplemented with potable water shall be separated from the potable water system by an air gap.

13.1.16 No irrigation with reclaimed sanitary wastewater, or storage of this water shall be allowed within 150 m of any well used for domestic supply.

13.1.17 Applications for use of wastewater that doesn't meet the unrestricted reuse requirements will be considered on a case-by-case basis by the Manager, EPD to determine whether this wastewater may be used in a "Restricted Reuse" application. Case specific requirements will be included as part of any approval for this type of reuse.

13.2 Unrestricted Irrigation Water

13.2.1 Unrestricted Irrigation reclaimed sanitary wastewater shall be:

a. Oxidized, coagulated, flocculated and clarified, then filtered (or by MBR treatment) and disinfected so that at some location in the treatment process the median number of total Coliform bacteria determined by multiple-tube fermentation does not exceed 2.2 per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of total Coliform bacteria does not exceed 23 per 100 milliliters in more than one sample within any 30-day period;

b. The flocculation and clarification steps are not required if the secondary effluent can be demonstrated to be historically less than 10 NTU for the proposed treatment process and approval is obtained from the Manager, EPD on a case-by-case basis;

c. Treated under process conditions that have been demonstrated to the satisfaction of the Manager, EPD to consistently provide a degree of treatment as defined above and so that the number of detectable enteric animal viruses is expected to be less than one per 40 liters;

d. Treated so that the effluent can be expected to be consistently free of detectable viable oocysts or cysts of Cryptosporidium, Giardia, and Entamoeba in 40 liter samples; and

e. In compliance with the quality standards in Table 1.

f. Continuously monitored by a turbidity meter located at the discharge of the secondary effluent and residual chlorine analyzer located at the discharge of the final effluent. These monitors shall be equipped with continuous recording capability.

13.2.2 Unrestricted Irrigation water shall be used such that:

a. Contact with the public is minimized;

b. Irrigation of any food crops with Unrestricted Irrigation water ceases 30 days prior to harvest; and

c. There shall be no direct contact between the edible portion of any crops and the reclaimed water.

13.2.3 Irrigation systems for the following may be designed to use Unrestricted Irrigation water, provided that the requirements in Section 13.1 and 13.2.1 are followed:

a. Irrigation at parks, playgrounds, schoolyards, street medians and areas of similar access or exposure, provided that adequate precautions are taken to prevent contact with the public;

b. Industrial cooling applications, provided that the system is treated to prevent viability of Legionella and Klebsiella; and

c. Other areas may be approved on a case-by-case basis. Such uses shall be approved by the General Supervisor, Environmental Compliance Division.

13.3 Distribution of Reclaimed Water

13.3.1 Combining with Raw Water

13.3.1.1 Any proposal to combine the raw water supply with reclaimed water (i.e., using raw water as make-up for reclaimed water) requires approval of the General Supervisor, Environmental Compliance Division. In all cases, such reclaimed water shall meet the requirements for Unrestricted Irrigation reclaimed water in Section 13.2.

13.3.1.2 Irrigation systems that combine raw water with reclaimed water shall have approved reduced pressure backflow prevention devices and an air-gap separation of 0.15 m.

13.3.2 Separate Reclaimed Water Distribution

Where there are to be multiple uses served by a single reclaimed water distribution system, all of the reclaimed water supplied shall meet the most stringent quality standard that is applicable.

13.3.3 Piping

13.3.3.1 Requirements for the color-coding of reclaimed water piping are given in Section 4.1.2.7 and Table 3. These color-coding requirements are applicable for all wastewater piping (above and below ground - inside and outside of the wastewater treatment facility).

13.3.3.2 Requirements for the separation of reclaimed wastewater lines from sewer lines are given in Table 7. When protecting domestic water lines from reclaimed water, the reclaimed water line shall be considered a sewer.

13.3.4 Effluent Wastewater Storage

All wastewater reuse systems shall be provided with a minimum effluent storage tank capacity of one and a half days. Additional storage may be required if this capacity will not accommodate the facility's water use requirements.

14 Wastewater Disposal

14.1 General

14.1.1 These standards apply to wastewater disposal systems that discharge to ponds, injection wells and marine waters. Wastewater disposal to absorption trenches, evapotranspiration wastewater disposal fields, percolation ponds and evaporation ponds part of a remote area disposal system are covered in Section 12.

14.1.2 Any discharge of wastewater to ponds or marine waters shall be approved by the General Supervisor, EED. Any discharge of wastewater to injection wells shall be approved by the General Supervisor, EED with concurrence of the Chief Hydrologist, Groundwater Division and the General Supervisor, Oil Facilities & Projects. Details on the approval process can be found in Section 4.2.1.

14.1.3 The discharge of untreated wastewater is prohibited, except for high TDS wastewater meeting Table 1 requirements, and injected wastewater when approved by the appropriate organizations.

14.1.4 Dilution of a wastewater discharge shall not be used to meet effluent discharge limitations (Table 1 requirements). The point of compliance is immediately after the last piece of wastewater treatment equipment.

14.1.5 Wastewater from tank cleaning, maintenance clean-outs and hydrotests may be disposed of in an evaporation pond (without complying with Table 1 requirements) if approved by the General Supervisor, EED.

14.2 Wastewater Disposal to Ponds

14.2.1 A minimum of one upgradient and two downgradient groundwater monitoring wells shall be installed around disposal ponds as required in Table 6, unless otherwise approved by the General Supervisor, EED.

14.2.2 The quality of the effluent discharged from wastewater treatment plants into lined evaporation ponds shall comply with the criteria set in Table 1 and shall at no time contain substances in concentrations toxic to human, animal, plant or fish life. Sanitary wastewater discharges that have been treated in a properly designed and operated facultative stabilization pond may be discharged into an evaporation pond without meeting all of the Table 1 requirements. Exceptions to the Table 1 requirements may be granted on a case-by-case basis by the General Supervisor, EED.

14.2.3 Evaporation ponds shall be sized to maintain a minimum depth of 0.75 m and a minimum freeboard of 0.6 m, based on minimum and maximum operating depths. Multiple ponds in a series configuration may be used to maintain this minimum depth.

14.2.4 The pond embankment walls shall be compacted thoroughly and compaction details shall be included in the construction specifications. The interior and exterior slopes of the embankment wall shall not be steeper than 1 m vertical for every 3 m horizontal.

14.2.5 Systems to protect embankment walls from wave action shall be provided. Splash pads shall be provided to protect the pond bottom from the influent discharge line.

14.2.6 The pond's drainage system shall be designed to exclude surface water from all ponds.

14.2.7 The pond design shall provide access areas for truck traffic and the removal of weeds around the pond. These areas shall be cleared and maintained for a distance of at least 5 m from the outside edge of the pond embankment walls. This requirement shall be included in the Operating and Maintenance Manual.

14.2.8 The use of multiple cells (in series) in pond systems is required (evaporation capacity shall be divided between a minimum of two ponds). The design of the ponds or cells shall allow operational flexibility, permitting parallel or series operation and allowing one or more of the ponds or cells to be taken out of service without affecting the operation of the remaining ponds or cells.

14.2.9 Ponds shall be surrounded with a Type V fence, as specified in SAES-M-006.

14.2.10 As per Table 6, evaporation ponds for the disposal of treated effluent shall have a 30-mil high-density polyethylene liner (over 0.3 m of compacted marl) or, if compatible with the effluent and approved by the General Supervisor, EED, may be lined with 0.5 m of compacted marl (with a permeability of 1x10-5 cm/sec or less). Exemptions to these lining requirements may be made by the General Supervisor, EED. Thicker liners may be required if wastewater discharged into the pond may require solids removal – thicker liners will be prescribed on a case-by-case basis by the General Supervisor, EED after consultation with Consulting Services.

14.2.11 Discharge of wastewater containing H_2S (up to 40 mg/L) into an evaporation pond is prohibited unless the pond is surrounded with a Type V fence that is situated a minimum of 20 meters from the centerline of the containment berm. Discharge of H_2S containing wastewater with concentrations greater than 40 mg/L are not allowed unless the protective systems have been approved by the Managers of EPD and Loss Prevention.

14.3 Wastewater Disposal to a Marine Environment

14.3.1 Land-based wastewater treatment systems with discharges into the marine environment shall be designed to meet the discharge standards in SAES-A-103 and the most recent PME Environmental Protection Standards and/or Royal Commission Standards, whichever are applicable.

14.3.2 The location of a discharge into the marine environment shall be located at a distance from shore such that proper mixing can take place. Approval of the marine wastewater specialists in EED is required for approval of the discharge location. Effluent diffusers shall be used to provide for rapid mixing of the wastewater discharge.

14.3.3 Additional restrictions may be added by the General Supervisor, EED if the discharge will be located in an area of special biological significance.

14.4 Wastewater Disposal into Injection Wells

14.4.1 An Injection Well Proposal (Section 4.2.3) shall be prepared and submitted with the Preliminary Engineering Report (Section 4.2.2) prior to approval of an injection well for wastewater disposal.

14.4.2 After approval of the Preliminary Engineering Report and Injection Well Proposal, an Engineering Study (Section 4.2.4) shall be prepared covering the treatment system details.

14.4.3 Injected wastewater (other than that specified in Sections 14.4.5 and 14.4.6) shall meet the quality requirements specified on a case-by-case basis by the General Supervisor, EED with concurrence of the Chief Hydrologist, Groundwater Division and the General Supervisor, Oil Facilities & Projects Division.

14.4.4 The design of the treatment system shall incorporate the requirements in all applicable Sections of this Standard.

14.4.5 Produced water (and desalter water) may be injected into any reservoir from which hydrocarbons are produced without approval.

14.4.6 Produced water (and desalter water) may be injected into any formation containing groundwater exceeding 30,000 mg/L total dissolved solids (TDS) with the approval of the General Supervisor, EED and concurrence of the Chief Hydrologist, Groundwater Division. PME approval is also required for injection of wastewaters into non-petroleum producing formations.

14.4.7 All engineering reports/studies described in Section 4.2 are required for the injection of produced water (and desalter water) into any formation containing groundwater having less than 30,000 mg/L total dissolved solids (TDS) with the approval of the General Supervisor, EED and the concurrence of the Chief Hydrologist, Hydrology Division.

15 Installation

15.1 General

15.1.1 Manufacturer's installation instructions shall be followed for the installation of all wastewater treatment equipment.

15.1.2 Construction debris shall be disposed of in a landfill approved by the General Supervisor, EED (per SAES-S-007).

15.1.3 The ground shall be graded such that surface water will not drain into any unit.

15.2 Equipment

Project specifications are to be written such that the installation and initial operation of major items of mechanical equipment shall be checked by a representative of the manufacturer after completion of construction but prior to startup of the plant.

15.3 Sewers and Lift Stations

The installation and construction of all collection systems for wastewater treatment facilities shall comply with Installation Section of the following standards:

SAES-S-010	*Sanitary Sewers*
SAES-S-020	*Industrial Drainage and Sewers*
SAES-S-030	*Stormwater Drainage Systems*
SAES-S-040	*Saudi Aramco Water Systems*
SAES-S-060	*Saudi Aramco Plumbing Code*
SAES-S-070	*Installation of Utility Piping System*

15.4 Septic Tanks and Wastewater Disposal Fields

15.4.1 Septic Tanks and Distribution Boxes

15.4.1.1 Backfill around septic tanks shall be made in thin layers and thoroughly tamped between layers. Settlement of backfill may be accomplished with the use of water, provided the material is thoroughly wetted from the bottom upwards and the tank is first filled with water to prevent floating.

15.4.1.2 The connection between the septic tank and the distribution box shall be laid on natural ground or compacted fill.

15.4.1.3 All laterals shall be at least 1.5 m from the distribution box.

15.4.1.4 All piping associated with septic tanks and distribution boxes shall be made of either PVC or RTR, per SAES-L-610.

15.4.2 Absorption Trenches

15.4.2.1 Trenches shall not be excavated when the soil is wet enough to smear or compact easily.

15.4.2.2 Before placing filter material or absorption trench piping into a prepared excavation, all smeared or compacted surfaces shall be removed by raking to a depth of 25-mm and removing the loose material.

15.4.2.3 Clean stone, gravel, slag or similar material varying in size from 20 to 65 mm shall be placed in the trench. The depth of this layer shall be 0.3 m.

15.4.2.4 After the filter material (clean stone, gravel, slag or similar material) is placed into the bottom of the trench, the filter material shall be graded and checked to assure that it is level. A grade board staked in the trench to the intended depth of the filter material shall be used to assure the piping is straight (when a flexible absorption trench pipe is used). It may not be sloped more than 0.1 m vertical to 40 m horizontal.

15.4.2.5 The absorption trench piping shall be placed on top of the filter material with the center-point of the holes facing downward.

15.4.2.6 Pipe joints shall be coupled together and fittings shall be used for changes in direction.

15.4.2.7 Additional filter material shall then be added to cover the piping by a minimum of 50 mm.

15.4.2.8 The non-woven geotextile shall be laid on top of the filter material covering the absorption trench piping.

15.4.2.9 Earth backfill shall be used to fill the trench to slightly above grade (0.1 to 0.15 m) and then hand-tamped. The backfill shall not contain marl.

15.4.2.10 Heavy machinery shall be excluded from the disposal area unless special provision is made to support the weight. All machine grading must be completed before the field is laid.

15.4.2.11 The use of the field area shall be restricted to activities that will not contribute to the compaction of the soil.

15.4.3 Evapotranspiration Wastewater Disposal Fields

15.4.3.1 Clean stone, gravel, slag or similar material varying in size from 20 to 60 mm in diameter shall be placed in the pit. The depth of this layer shall be 0.1 m.

15.4.3.2 The surface of the stone shall be graded to assure that it is level.

15.4.3.3 The distribution piping shall be laid in the pit.

15.4.3.4 The distribution piping shall be checked to assure that it is level. It may not be sloped more than 0.1 m vertical to 40 m horizontal.

15.4.3.5 Additional stone shall be added to cover the distribution piping by 0.1 m.

15.4.3.6 The non-woven geotextile shall be laid on top of the stone.

15.4.3.7 A 0.4-m deep layer of fine sand with an average grain size of 0.1 to 0.2 mm shall be applied above the stone covering. Common desert sand is not acceptable as it contains materials that will cause the bed to plug. Acceptable sand shall be at least 95% silica.

15.4.3.8 A layer of marl-free topsoil shall cover the fine sand. This layer shall extend above the surface 0.1 m and be sloped away from the disposal field.

15.4.3.9 The surface of the evapotranspiration field shall be planted in methyl or other vegetation with deep root structure.

15.4.3.10 Provision to water the vegetation shall be made to assure that the plants have adequate time to develop their root structure.

15.4.3.11 Evapotranspiration wastewater disposal fields shall be constructed with the same installation requirements as in Section 15.4.2.

Exceptions:

a. It is not necessary to protect the bottom of the excavation *from compaction; and*

b. Instead of digging trenches, the disposal pipe shall be laid on the filter material in an appropriately sized excavation.

15.4.4 Seepage Pits

15.4.4.1 Seepage pits shall not be dug in wet soils. The cutting teeth on mechanical equipment shall be kept sharp. Bucket-augured pits shall be reamed to a larger diameter than the bucket. All loose material shall be removed from the excavation.

15.4.4.2 Pits shall be backfilled with clean gravel to a depth of 0.3 m above the pit bottom or 0.3 m above the reamed ledge.

15.4.4.3 If brick and block are used, they shall be laid dry with staggered joints.

15.4.4.4 Excavation voids behind the brick, block, or concrete liner shall have a minimum of 0.15 m of clean 20-mm gravel or rock.

15.4.4.5 All connecting lines shall be laid on a firm bed of undisturbed soil throughout their length.

15.4.4.6 The grade of a connecting line shall be a minimum of 2%. The pit inlet pipe shall extend horizontally at least 0.3 m into the pit with a tee or ell to divert flow downward.

16 Testing and Inspection

16.1 General

PMT shall provide for each new wastewater treatment plant and plant expansion project manufacturer’s training for all rotating equipment, process equipment, and instrumentation including SCADA systems before commissioning the plant. Manufacturer’s trainers must have manufacturer approved training by the manufacturer in the manufacturer’s facilities. Trainers qualifications must be submitted and approved by the project proponent before the construction is 80% complete.

16.1.1 All manufacturer's recommended testing shall be performed prior to the start-up/commissioning of a wastewater treatment plant.

16.1.2 The initial inspection shall assure that:

a. All lines are clear of debris and all valves are free to operate; and

b. All lines and equipment are installed in accordance with the design.

16.1.3 Factory performance testing shall be conducted prior to the startup of aeration processes to verify oxygen transfer rates.

16.2 Sewers and Pump Stations

All sewer systems shall be tested for water tightness per Section 5.3 of SAES-S-010.

16.3 Small Flow Wastewater Disposal Systems

Prior to start-up, septic tanks and holding tanks shall be filled with water and allowed to stand overnight to check for leaks. If leaks occur, they shall be repaired.

17 Definitions

Activated Sludge Process: A biological wastewater treatment process in which a mixture of wastewater and activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated wastewater by sedimentation and wasted or returned to the process as needed.

Aerated Pond: A wastewater treatment pond in which mechanical or diffused-air aeration is used to supplement the oxygen supply.

Aerator: A device that brings air and wastewater into intimate contact.

Aerobic Digestion: A biological wastewater treatment process in which organic matter is degraded in the presence of oxygen.

Aquifer: A formation, group of formations, or part of a formation capable of yielding groundwater to wells or springs in sufficient quantities for its intended use.

Biochemical Oxygen Demand (BOD_5): A measure of the quantity of oxygen utilized in the biochemical oxidation of organic matter in five days. Treatment plant sizing is a function of the BOD_5 of the wastewater.

Biological Treatment: Method of wastewater treatment in which bacterial (biochemical) action is used to oxidize the organic matter present.

Chlorination: The application of chlorine or chlorine compounds to water or wastewater, generally for the purpose of disinfection, but also for chemical oxidation and odor control.

Concentrate (Reject): The MBR stream that contains the concentrated biomass.

Coagulation: The process in which colloidal (less than 0.001 mm) and finely divided (0.001 to 0.1 mm) suspended matter has been destabilized and agglomerated by the addition of a suitable floc-forming chemical or by an equally effective method.

Comminutor: A shredding or grinding device that reduces the size of gross suspended materials in wastewater, without removing them from the wastewater.

Confining Strata: An area immediately above or below the target formation, which is at least 100 times less permeable than that of the target formation.

Direct filtration: The filtration of secondary treated wastewater which has been coagulated, but not flocculated or clarified. It is typically used as part of a tertiary treatment process when the turbidity of the secondary wastewater is less than 10 NTU.

Discharge: The release of wastewater onto or into the ground, or into a body of water.

Disinfection: The destruction of waterborne fecal and pathogenic bacteria and viruses by chemical, physical or biological means.

Disposal: The final deposition of waste or wastewater that is not reused.

Effluent: Wastewater leaving the treatment plant. May also be used to describe wastewater leaving an individual treatment step.

Equalization: Storage capacity that is used to dampen fluctuations in wastewater flowrate and composition.

Evapotranspiration: A disposal method by which wastewater is allowed to evaporate from the soil surface and transpire from the leafy structure of vegetation.

Extended Aeration: A modification of the activated sludge process which provides for aerobic sludge digestion within the aeration system. The process includes the stabilization of organic matter under aerobic conditions and disposal of the gaseous products into the air. The effluent contains finely divided suspended matter and soluble matter.

Facultative Stabilization Pond: A relatively shallow body of wastewater in which biological oxidation of organic matter takes place.

Filtration: The process of passing coagulated, flocculated and clarified wastewater through a filter media for the removal of suspended or colloidal matter. It is typically used as part of a tertiary treatment process.

Flash Mixer: A device for quickly dispersing chemicals uniformly throughout the water or wastewater.

Flocculation: The agglomeration of coagulated particles, which enhances sedimentation and filtration processes.

Flux: The volumetric output per unit membrane area.

Grit Chamber: A detention chamber or sewer enlargement that is designed to separate heavy suspended mineral matter from organic solids by differential sedimentation (i.e., reduction of velocity).

Industrial Wastewater: Wastewater resulting from industrial processes and manufacturing operations such as factories, processing plants, repair and cleaning establishments, and refineries.

Lined Pond: A body of water of limited size which is confined with either marl (with a coefficient of permeability of less than or equal to 10-5 cm/sec) or synthetic membrane.

Membrane Bioreactor (MBR): The pressure driven unit process that couples the biological breakdown of organic and inorganic compounds with a physical (membrane) separation process that produces tertiary quality effluent water.

Multiple Units: Two or more units of a treatment process which operate in parallel and serve the same function.

Nominal Pore Size: The average size of openings in the MBR membrane filter - determines the size of particles that will be removed.

Oily Waste Sludge: Oily sludge that has been generated from industrial operations or sanitary wastewater treatment operations.

Oxidation Ditch: A secondary wastewater treatment facility comprised of an oval channel with a rotor(s) placed across it to provide aeration and circulation.

PME: the Kingdom of Saudi Arabia, Ministry of Defense & Aviation, Presidency of Meteorology and Environment [formerly known as Meteorology and Environmental Protection Administration (MEPA), established under Royal Decree No. 7/M/8903, dated 21/4/1401 H (25 February 1981)].

Percolation: A disposal method by which wastewater is allowed to pass downward through the soil.

Permeate: The clean product water stream that is produced by an MBR after the wastewater crosses the semi-permeable membrane.

Point-of-Discharge: most accessible plant wastewater discharge point where the final effluent of the treatment system can be sampled. This should be after treatment but prior to the addition of any dilution water.

Preliminary Treatment: Unit operations such as screening, grinding, and grit removal that prepare the wastewater for subsequent major treatment.

Primary Treatment: The removal of substantial amounts of suspended matter from wastewater. It is typically the first major process in a wastewater treatment facility and is normally accomplished by sedimentation (not biological oxidation).

Produced Water: Water that is not a primary product of the petroleum production process and is not solely or separately produced by the production process. Produced water is wastewater if it is used in a manner that constitutes disposal. Produced water that is injected for producing hydrocarbon reservoir maintenance is not wastewater.

Raw Water: Water supplied by Saudi Aramco that is intended for non-potable uses, such as irrigation, washing and bathing, but must be, because of the nature of its distribution, of potable water quality (except for the total dissolved solids level).

Reclaimed Water: Treated sanitary wastewater which is beneficially used (reused).

Sanitary Wastewater: Wastewater generated from domestic activities. Sources include toilets, sinks, showers, etc.

Secondary Treatment: The treatment of wastewater by biological methods after primary treatment by sedimentation.

Sedimentation: Gravity settling of suspended matter, which may be enhanced by coagulation and flocculation. Also called clarification.

Septic Tank: An underground vessel for settling solids out of wastewater from an Small Flow disposal system. Effluent from the tank is normally disposed of in a soil absorption system, while settled solids are periodically pumped out and hauled to a treatment facility for disposal.

Sludge Drying Bed: An area comprised of natural or artificial layers of porous material on which digested wastewater sludge is dried by drainage and evaporation.

Small Flow Treatment: Wastewater treatment systems that are designed for small wastewater treatment needs. Examples include septic tanks, leach fields, evapotranspiration fields, portable toilets, and holding tanks.

Standby Chlorinator: A duplicate chlorinator which is sized equal to the largest chlorinator unit in regular use.

Standby Power Source: An automatically actuated self-starting alternate energy source maintained in an immediately operable condition and of sufficient capacity to provide necessary service during failure of the main power supply.

Standby Replacement Equipment: Reserve parts and equipment which can be placed in operation within a 24-hour period.

Standby Unit Process: Duplicate process equipment which is maintained in operable condition and is capable of providing comparable treatment for the entire design flow of the unit for which it is a substitute.

Suspended Solids: Insoluble solids that are in the wastewater.

Target Formation: The area between confining strata, into which wastewater will be injected.

Tertiary Treatment: The treatment of wastewater beyond the secondary or biological stage, typically used to make wastewater suitable for reuse.

Transmembrane Pressure (TMP): The difference between the average feed and permeate pressures in an MBR process.

Treatment: A process in which the physical and/or chemical characteristics of a wastewater are modified to make it acceptable for either further treatment, reuse or disposal.

Unrestricted Irrigation Reclaimed Water (Called "Class A Reclaimed Water" in a previous version of this standard): Tertiary treated wastewater that meets stringent quality standards and can be used in specific applications (see Section 13.2).

Waste: Useless, unwanted or discarded materials (solids or liquids) resulting from domestic or industrial activities. Includes waste heat from process operations and the products generated from wastewater treatment.

Wastewater: Any liquid waste containing water.

	Revision Summary
21 December 2005	Major revision.
10 May 2006	Editorial revision.

Table 1 – Effluent Discharge Limitations [1]

		MOMRA Limits for Wastewater		Yanbu Royal Commission Limit [4]		
	PME[2]	Unrestricted Irrigation	Pretreatment Limitations	Monthly Mean	Maximum	Pretreatment Limitations
Physical -Chemical Pollutants mg/L[3]						
Floatable	None	None	None	None	None	
pH Units	6-9	6-8.4	6-9	6-9	6-9	5-9
Total Suspended Solids (TSS)	15 mg/L	10 mg/L	600 mg/L	25 mg/L	40 mg/L	500 mg/L
TDS		2000				
Temperature(°C)			30-50			50
Turbidity [5]	75 NTU			8 NTU	15 NTU	
Dissolved Oxygen	-			5 mg/L min.	2 mg/L min.	
Salinity	-			+ 1 ppt	+ 2 ppt	
Non-Organic Pollutants	mg/L (30 day mean)			mg/L	mg/L	
Aluminum	-	5		15	25	30
Ammonia (as N)	1.0	5	80	1	3	80
Arsenic	0.1	0.1	0.1	0.1	0.5	
Beryllium		0.1				
Boron		0.75	2.0			
Barium	-	1.0	1.0	1	2	
Cadmium	0.02	0.01	0.02	0.01	0.05	0.5
Total Chlorine (residual) [6]	0.5			<0.2	0.3	400
Free Chlorine		0.2				
Chlorides (Cl-)		100				
Chromium (total)	0.1	0.01	1.2	0.1	1	1.0
Cobalt	-	0.05		0.1	2	2.0
Copper	0.2	0.2	1.2	0.2	0.5	1.0
Cyanide	0.05	0.05	0.05	0.05	0.1	1.0
Fluoride	-			15	25	25
H_2S [7]	40					
Iron	-	5.0		5	10	4.0
Lead	0.1	5.0	1.0	0.1	0.5	1.0
Manganese	-	0.2	5.0	0.2	1.0	1.0
Mercury	0.001	0.001	0.05	0.001	0.005	0.01
Nickel	0.2	0.02	2.0	0.2	0.5	0.25
Nitrates (NO_3-N)		10		1.0	10	
Phosphorus (total as P)				1.0	2.0	2.0
Phosphates (total, as P) [6]	1.0					
Selenium		0.02	0.5			
Sulfide	-			0.05	0.1	10.0
Sulfates (SO_4)		600	1000			150
Vanadium		0.1	1.0			

		MOMRA Limits for Wastewater		Yanbu Royal Commission Limit (4)		
	PME(2)	Unrestricted Irrigation	Pretreatment Limitations	Monthly Mean	Maximum	Pretreatment Limitations
Zinc	1.0	2.0	2.6	2	5	1.5
Organic Pollutants	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Biochemical Oxygen Demand (BOD_5)	25	10	500	15	25	800
Chemical Oxygen Demand (COD)	150	50	1000	75	150	1500
Total Organic Carbon (TOC)	50	40	1000	50	150	400
Total Kjeldahl Nitrogen (TKN)	5			10	5	
Total Chlorinated Hydrocarbons	0.1		0.5	0.1	0.5	
Oil & Grease (8)	8	None	100	8	15	100
Phenols	0.1	0.002	5	0.1	1.0	25
Biological Pollutants	MPN/100 mL (8)			MPN/100 mL	MPN/100 mL	
Total Coliform	1000 (30-day geometric mean)			1000	2400	

Notes:

(1) Royal Commission Standards shall apply to Saudi Aramco facilities within the Royal Commission jurisdictions. See SAES-A-103, Appendices I and II for Royal Commission boundary maps.

(2) All values represent monthly average unless otherwise indicated.

(3) mg/L unless otherwise indicated.

(4) Limits taken from Environmental Protection Manual, Royal Commission for Jubail and Yanbu/Yanbu Project, Madinat Yanbu Al-Sinaiyah, 2004.

(5) Nephelometric Turbidity Units. Also, to be determined on a case-by case basis in areas deemed by EED to be biologically sensitive.

(6) Not applicable for wastewater reuse applications or discharge into evaporation ponds. For Jubail R.C. area, this value should read Phosphorus reported as total P

(7) Based on the assumption of a security fence located a minimum of 20 meters from the centerline of the pond's berm.

(8) Visible oil sheen can be assumed to demonstrate an 8-15 mg/L oil concentration. I.E; Non Compliance

Table 2 – Wastewater Sampling Methods

Parameter	APHA-Standard Methods [(1)] or Other Approved Method [(3)]	ASTM Standards [(2)]
Physical-Chemical Pollutants		
Floatable	Method 2530-B	
pH	Method 4500-H	D1293-84
Total Dissolved Solids (TDS)	Method 2540-C	
Total Suspended Solids (TSS)	Method 2540-D	
Temperature	Method 2550-B	
Turbidity	Method 2130-B	
Dissolved Oxygen	Method 4500-O	
Salinity	Method 2520-C	
Organic Pollutants		
Biochemical Oxygen Demand	Method 5210-B	
Chemical Oxygen Demand	Method 5220-C	
Total Organic Carbon	Method 5310-C	
Total Kjeldahl Nitrogen	Method 4500-N	D3590-89
Total Chlorinated Hydrocarbons	Method 6420-B	
Oil and Grease	Method 5520-C	
Phenols	Method 5530-D / 6420-B	
Insecticides, Pesticides	Method 6610, 6630	
Non Organic Pollutants		
Alkalinity (as $CaCO_3$)	Method 2320-B	
Aluminum	Method 3500-Al-B	
Ammonia (as N)	Method 4500-NH_3	D1426-89
Arsenic	Method 3500-As-B	
Barium	Method 3500-Ba	
Beryllium	Method 3500-Be	
Boron	Method 4500-B-B, 4500-B-C	
Cadmium	Method 3500-Cd-B, 3500-Cd-C	
Chlorides	Method 4500-Cl^-	
Chlorine (Free)	Method 4500-Cl	
Chlorine (Residual)	Method 4500-Cl-B, 4500-Cl-I, 4500-Cl-G	
Chromium (total)	Method 3500-Cr-B, 3500-Cr-C	
Chromium (+6)	Method 3500-Cr-B, 3500-Cr-C, 3500-Cr-D	
Cobalt	Method 3500-Co	
Copper	Method 3500-Cu-B, 3500-Cu-C	
Cyanide (Total)	Method 4500-Cn-E	
Fluoride	Method 4500-F	
H2S	SW 846 – 9030-H	
Iron	Method 3500-Fe-B	
Lead	Method 3500-Pb-B	
Lithium	Method 3500-Li-B	
Manganese	Method 3500-Mn-B	
Mercury	Method 3500-Hg-B	
Molybdenum	Method 3500-Mo-B, 3500-Mo-D, 3500-Mo-E	
Nickel	Method 3500-Ni-B, 3500-Ni-C	
Nitrates (NO_3-N)	Method 4500-NO_3	
Phosphate (Total as P)	Method 4500-P	D515-88
Selenium	Method 3500-Se-B, 3500-Se-C	

Parameter	APHA-Standard Methods [1] or Other Approved Method [3]	ASTM Standards [2]
Silver	Method 3500-Ag	
Sodium	Method 3500-NA-B	
Sulfates (SO4)	Method 4500-SO_4^{2-}	
Sulfides	Method 4500-S^{2-}-E	
Vanadium	Method 3500-V-B	
Zinc	Method 3500-Zn-B, 3500-Zn-C	
Biological Pollutants		
Total Coliform	Method 9221-B, 9221-C	

Notes:

(1) American Public Health Association, Standard Methods for the Examination of Water and Wastewater (18th edition or newer).

(2) American Society for Testing and Materials, Annual Book of ASTM Standards.

(3) The Saudi Aramco Research & Development Center shall approve other analytical procedures for environmental monitoring.

Table 3 – Piping System Color Codes

Piping System	Pipe Color	Legend		Arrow & Legend Color
Aerobic Digester Supernatant	Light Brown w/Pink Bands	ADS		Pink
Aeration Tank Effluent	Light Gray w/Pink Bands	ATE		Pink
Air	Orange w/Black Bands	AIR		Black
Alum	White w/Dark Blue Bands	ALS		Black
Bypass	Light Gray	BPO		Black
Chlorine Gas & Liquid	Yellow w/Red Bands and Arrows	CLG		Red
Chlorine Injection Water	Light Gray w/Red Bands	CIW		Red
Chlorine Residual Sample	Yellow Band	CRS		Black
Chlorine Solution (including sodium hypochlorite)	Yellow	CLS		Black
Chlorine Vacuum	Yellow w/Black Bands	CLY		Black
Unrestricted Irrigation Water *	Brown	CAW		Yellow
Dewatering Line	Black w/Orange Bands	DL		Red
Digested Sludge	Dark Brown w/Red Bands	DSL		Red
Effluent Flushing Water	Dark Green	EFW		Yellow
Leachate	Light Gray w/Dark Blue Bands	LEA		Dark Blue
Plant Irrigation Water	Light Green	PIW		Blue
Polymer	White w/Light Blue Bands	POLY		Black
Potable Drinking Water	Light Blue	PDW		Black
Potable Raw Water	Dark Blue	PRW		White
Raw Sewage	Dark Gray	RS		Orange
Return Sludge	Light Brown	RSL		White
Scum	Light Brown w/Pink Bands	SC		Pink
Secondary Effluent	Dark Green	SE		White
Tertiary Effluent	Light Green w/Blue Bands	FPE		Blue
Waste Sludge	Light Brown	WSL		Yellow

Table 4 – Wastewater Generation Rates

Facility Type	Per Capita Volume Generated (Liters per Capita per day)*
Pump Stations w/housing	700
Communities	600
Offshore Platforms w/housing	400
Marine Drilling Rigs	400
Non-Family Communities	400
Large Facilities	400
Sea Islands	380
Refineries	350
Construction Camps	325
Gas Plants	200
Vela Crude Vessels	200
Training Facilities	175
Inland Drilling Rigs	160
Bulk Plants	150
Maintenance Facilities	125
Small Facilities	125
Airports, Air Bases, AFOs	100
Offices	80

* Based on Facility reported data

Table 5– Separation Distances for Sewer Lines

Minimum Distance Require From:	Meters
Builders	0.6
Water Supply Wells	15.0
On-Site Domestic Water Lines (1)	0.3
Pressurized Domestic Water Lines (1)	3.0
Reclaimed Water Lines	3.0

Note: (1) If the sewer line must cross over the water line, the additional requirements in SAES-S-010, Sections 4.38 and 4.39 apply to the sewer line construction.

Table 6 – Lining & Groundwater Monitoring Wells Requirements for Wastewater Ponds

No.	POND TYPE	LINING REQUIREMENTS	GROUNDWATER MONITORING WELLS REQUIREMENTS*
1.	Facultative Ponds	HDPE	NONE
2.	Evaporation Ponds associated with only Sanitary Wastewater	Compacted Marl	NONE
3.	Industrial Wastewater Ponds	HDPE	YES
4.	Industrial waste disposal / Storage Ponds	HDPE	YES
5.	Stormwater runoff – uncontaminated water	Compacted Marl	NONE
6.	One time disposal of wastewater from cleaning, flushing and dewatering pipelines, tanks, and vessels and hydrostatic tests	Compacted Marl	NONE
7.	Emergency, Surge or Storage Ponds, used less than once per year, and emptied following usage.	Compacted Marl	NONE

* A minimum of one upgradient and two downgradient groundwater monitoring wells shall be installed around the ponds.

Table 7 – Separation Distances for Components of Sewage Disposal System

Minimum Distance (in meters) Required From:	Building Sewer	Septic Tank	Disposal Field	Seepage Pit
Buildings	0.6	1.5	2.4	2.4
Property Lines	-	1.5	1.5	2.4
Water Supply Wells	15	15	30	45
On-site Domestic Water Lines	0.3	1.5	1.5	1.5
Pressurized Domestic Water Lines	3	3	3	3
Distribution Boxes	-	-	1.5	1.5
Seepage Pits	-	1.5	1.5	3.7
Disposal Fields	-	1.5	1.2	1.5

Note: (1) If the sewer line must cross over the water line, the additional requirements in SAES-S-010, Sections 4.38 and 4.39 apply to the sewer line construction.

Table 8 – Design for Activated Sludge Units and MBR

	Plug-Flow	Complete Mix	Extended Aeration	Oxidation Ditch	MBR
Sludge Age (days)	5 - 15	5 - 15	20 - 30	10 - 30	22 - 30
F/M (kg BOD_5/KG MLVSS/day)	0.2 - 0.5	0.2 - 0.5	0.050 - 0.20	0.05 - 0.30	0.07 – 0.30[1]
Volumetric Loading: kg BOD_5/m^3/day lb $BOD_5/10^3 ft^3$/day	 0.32 – 0.64 20 – 40	 0.80 – 1.92 50 – 120	 0.16 – 0.40 10 – 25	 0.08 – 0.30 5 – 30	 0.80 – 2.20 50 – 135
MLSS (mg/L)	1200 – 3000	2500 – 6500	1500 – 5000	1500 – 5000	10,000 – 15,000
Hydraulic Retention Time (hr)	4 – 8	3 – 5	18 – 36	8 – 36	4 - 6
Recycle Ratio	0.25 – 0.75	0.25 – 1.0	0.5 – 1.5	0.75 – 1.50	4 – 8 [2]
BOD Removal (%)	85 – 95	85 – 95	75 – 95	75 – 95	96 - 99
Nominal pore size (μm)	-	-	-	-	0.03 – 0.4 [3]
Normal Flux Rate (m^3/m^2-day) Max. Flux Rate (m^3/m^2-day)	-	-	-	-	0.3 – 0.6 [4] 0.8 [4]
Membrane scouring air (scfm/100 ft^2)	-	-	-	-	3 – 5 [4]

1. May be lower if required for redundancy needs – approval from Gen. Supv. required.
2. For denitrification only.
3. Above 0.1 only if the effective pore size in operation is in the ultra filtration range
4. These are general values – depending on the manufacturer, different values may be allowed by the Gen. Supv., EED on a case-by-case basis.

Table 9 – Mixing Requirements for Activated Sludge Tanks

Aeration System	Mixing Energy Required
Fine bubble floor coverage	10 - 15 m^3/min/1000 m^3
Fine bubble spiral roll	20 - 30 m^3/min/1000 m^3
Surface aeration	19 - 39 kW/1000 m^3

Table 10 – Aeration Requirements for Activated Sludge Tanks

Treatment System	Aeration System	Minimum Aeration Requirements
Activated sludge, plug-flow	Air diffusion	45 m^3/kg BOD_5
Activated sludge, extended aeration	Air diffusion	70 m^3/kg BOD_5
Activated sludge, plug-flow	Surface aeration	1.0 kg 0_2 kg BOD_5
Activated sludge, extended aeration	Surface aeration	2.0 kg 0_2/kg BOD_5

Table 11 – Design for Secondary Sedimentation Units

	Design Flow ($m^3/m^2/d$)	Peak Hourly Flow ($m^3/m^2/d$)	Design Flow (kg BOD/m^2/h)	Peak Hourly Flow (kg BOD/m^2/h)	Depth (m)
Activated sludge (excluding extended aeration)	16.3 - 32.6	40.7 - 48.8	3.9 - 5.9	9.8	3.7 - 6.1
Extended aeration	8.0 - 16.3	24.4 - 32.6	1.0 - 4.9	6.8	3.7 - 6.1

Table 12 – Solids Loading Rate for Sludge Drying Beds

Location	Solids Loading (kg dry solids/m^2/yr
Safaniya	60
Ras Tanura	60
Dhahran	80
Abqaiq	110
Shaybah	120

Table 13 – Design for Sludge Drying Beds

Design Criteria And Operational Depth of Sludge	Design Value (meters)
Typical dimensions of a drying bed: Length Width	 6 - 30 6 - 8
Sludge depth	0.20 - 0.30
Sand layer depth (sand grain size is typically 0.55 mm)	0.15 - 0.30
Gravel layer depth (typically 75 mm layers graded from coarse at bottom to fine at tope)	0.30 - 0.45
Drainage pipe spacing (pipe diameter is typically 0.15 m)	0.20 - 0.50

Table 14 – Absorption Requirements for Septic Systems

Percolation Rate (Time Required for Water to Fall 2.5 cm) minutes	Required Absorption Area Per Person (380 liters) for Standard Trench or Seepage Pits [(a)] m^2
1 or less	3.3
2	3.8
3	4.7
4	5.0
5	5.5
10	7.5
15	8.8
30 [(b)]	11.5
45 [(b)]	14.0
60 [(b,c)]	15.5

Notes:

(a) Absorption area is calculated as trench-bottom area and includes a statistical allowance for vertical side wall area. Absorption area for seepage pits is calculated as effective side wall area beneath the inlet.

(b) Unsuitable for seepage pits if over 30 minutes.

(c) Unsuitable for absorption systems if over 60 minutes.

Table 15 – Septic Tank Capacities

Number of Persons [1]	Minimum Tank Capacity (m^3)
1 to 4	2.9
5 to 6	3.8
7 to 8	4.7
9 to 10	5.7
11 to 13	6.6
14 to 16	7.6
For each additional person in excess of 16, add the following capacity	.04

Table 16 – Wastewater Reuse Treatment Requirements and Permitted Uses

Category	Required Treatment	Permitted Uses
Unrestricted Irrigation	Oxidation Coagulation Flocculation [1] Sedimentation [1] Filtration Disinfection Process approved by Gen. Supv., EED in Section 13.2.1-g Enteric animal viruses less than 1 per 40L Free of detectable viable oocysts or cysts [2]	1. Irrigation at parks, playgrounds, schoolyards, street medians, and areas of similar access or exposure. 2. Industrial cooling applications.

Notes:

(1) Flocculation and sedimentation are not required if the secondary effluent is less than 10 NTU and a monthly demonstration of the absence of all controlled bacteria and viruses is provided by the treatment plant to the General Supervisor, Environmental Compliance Division.

(2) Free of cysts of Cryptosporidium, Giardia, and Entamoeba in 40-liter samples.

Figures

Figure 1 – "Tee" Fitting

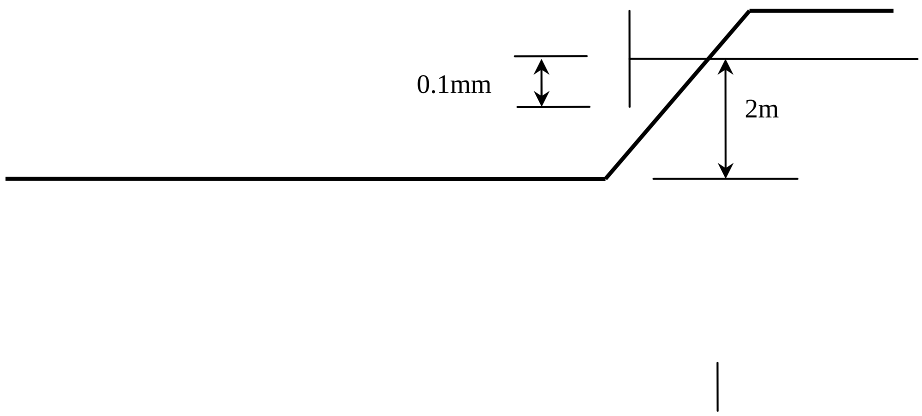

Figure 2 – Design of Grease Traps

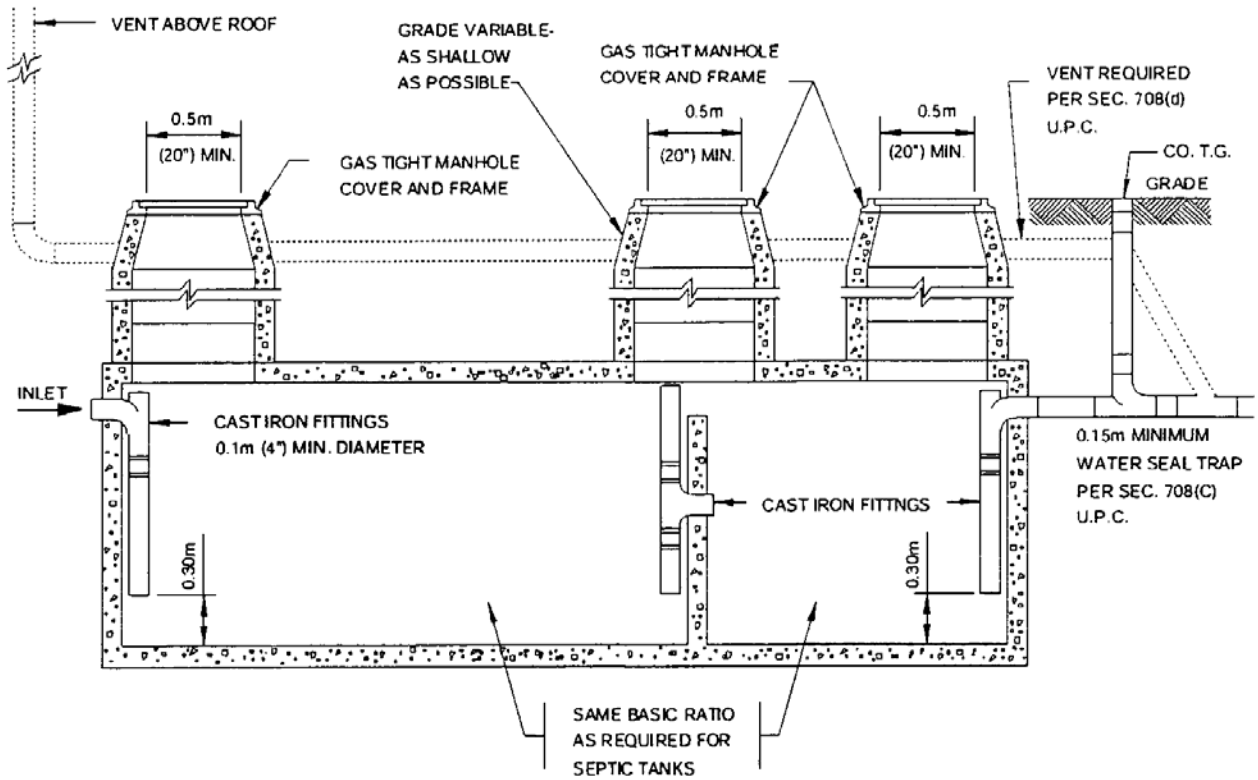

Figure 3 – Design of Interceptors and Separators

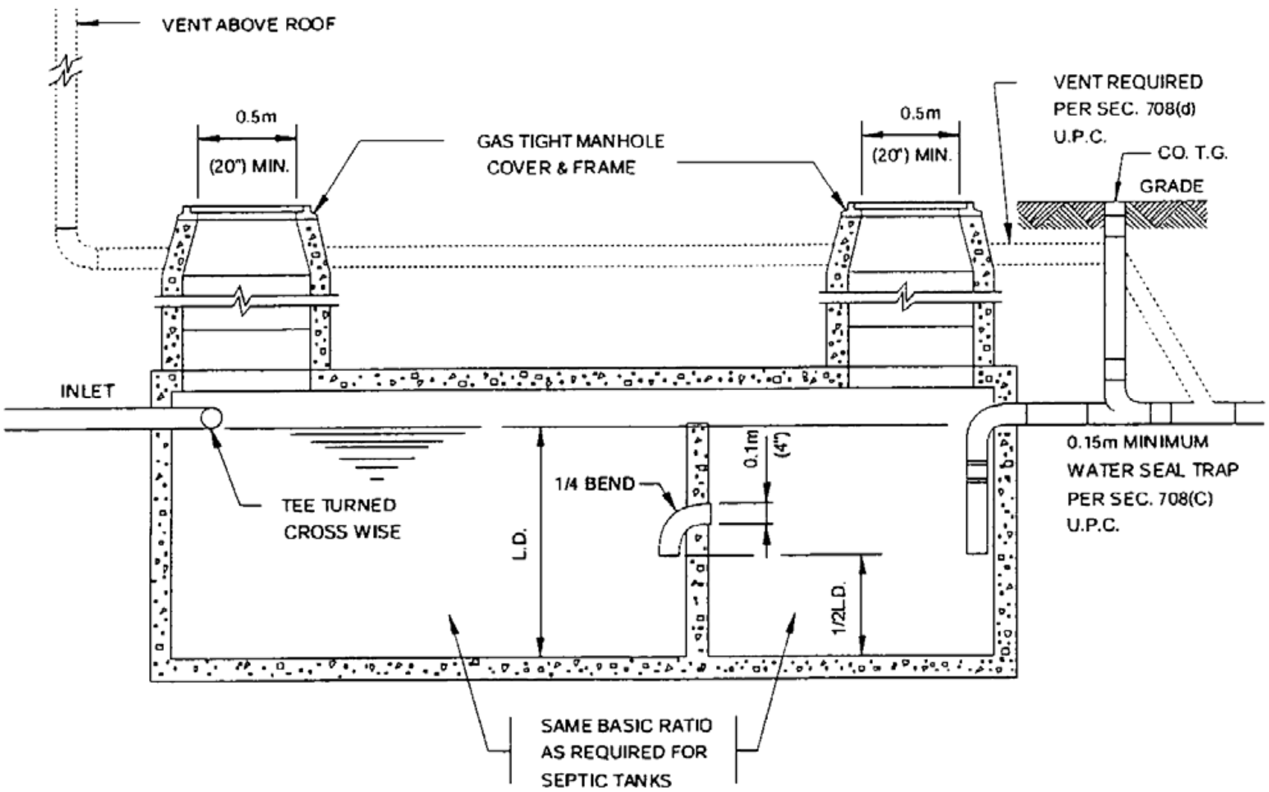

Figure 4 – General Septic Tank Systems

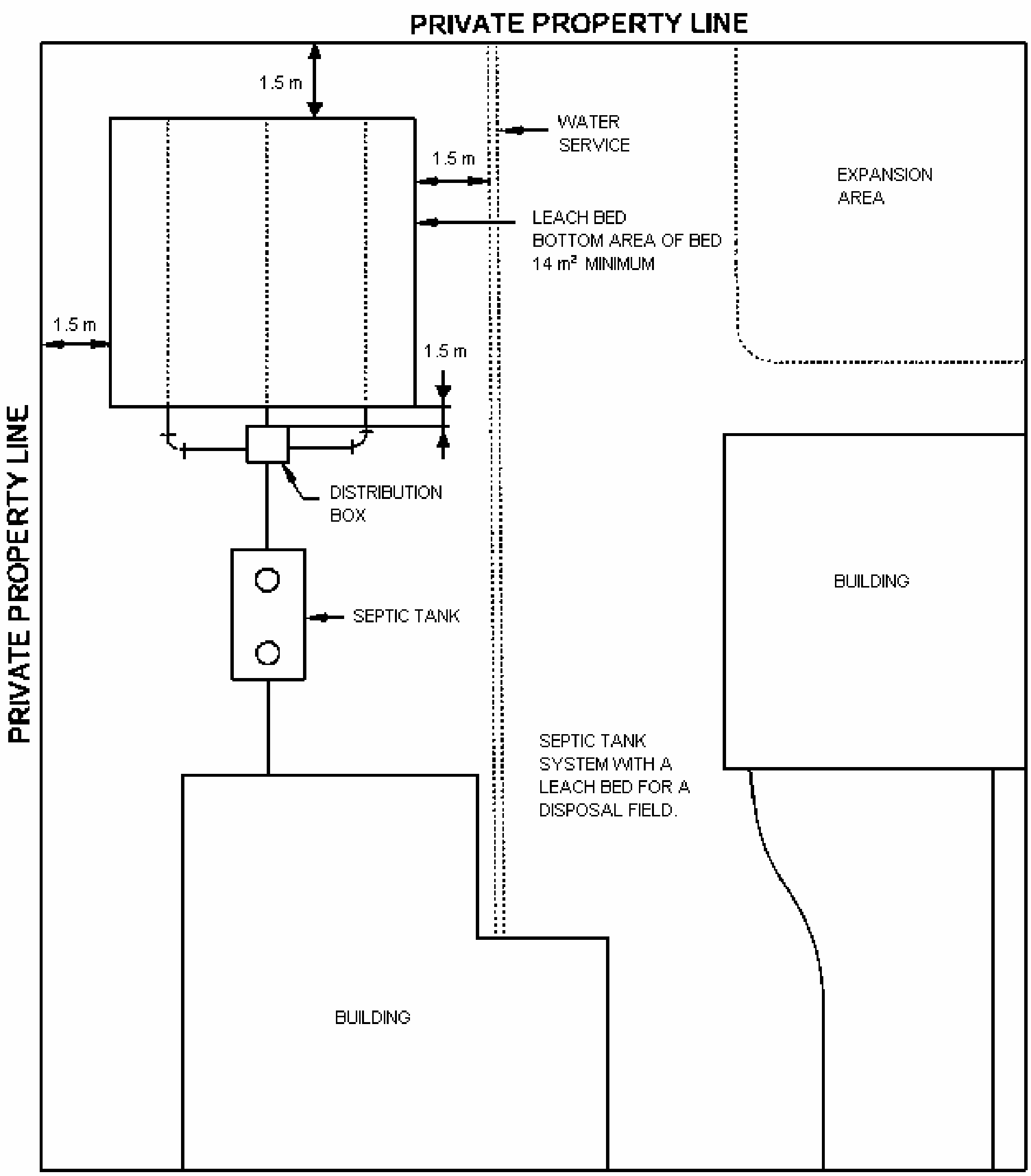

Figure 5 – Design of Absorption Trenches

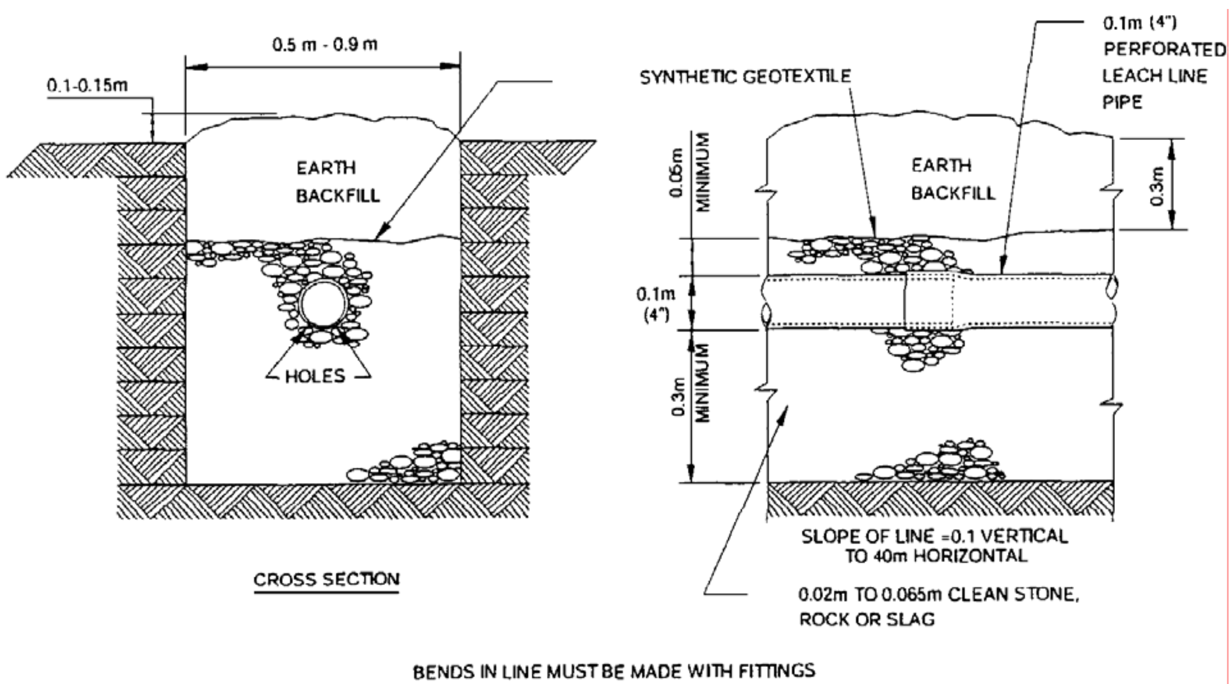

Figure 6 – Design of Distribution Boxes

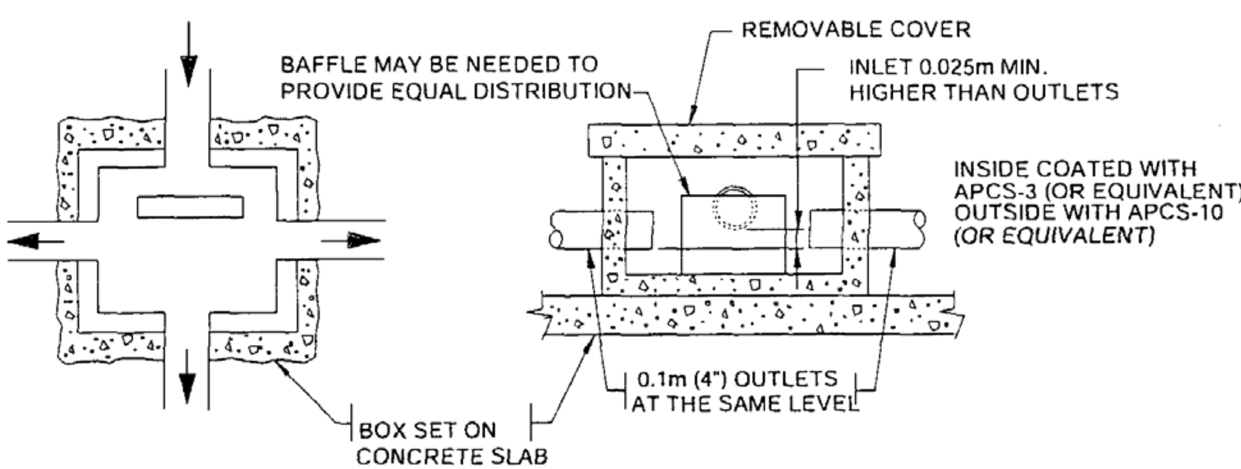

Figure 7 – Design of Evapotranspiration Wastewater Fields

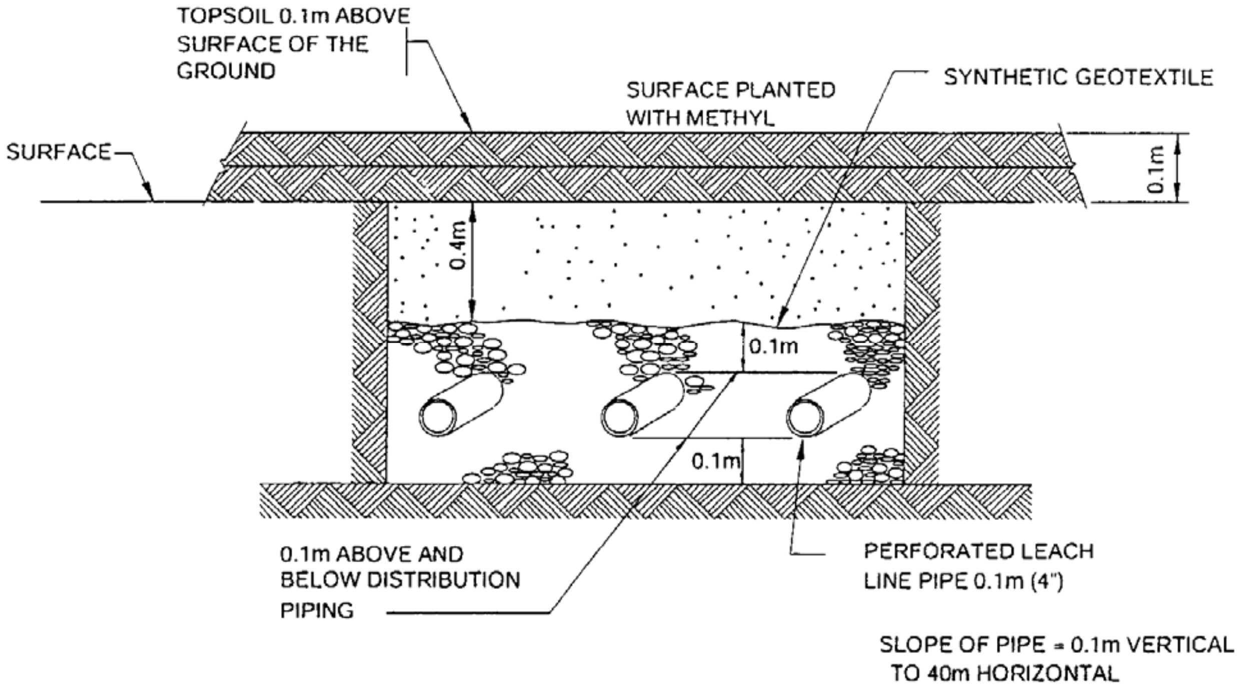

Figure 8 – Design of Septic Tanks

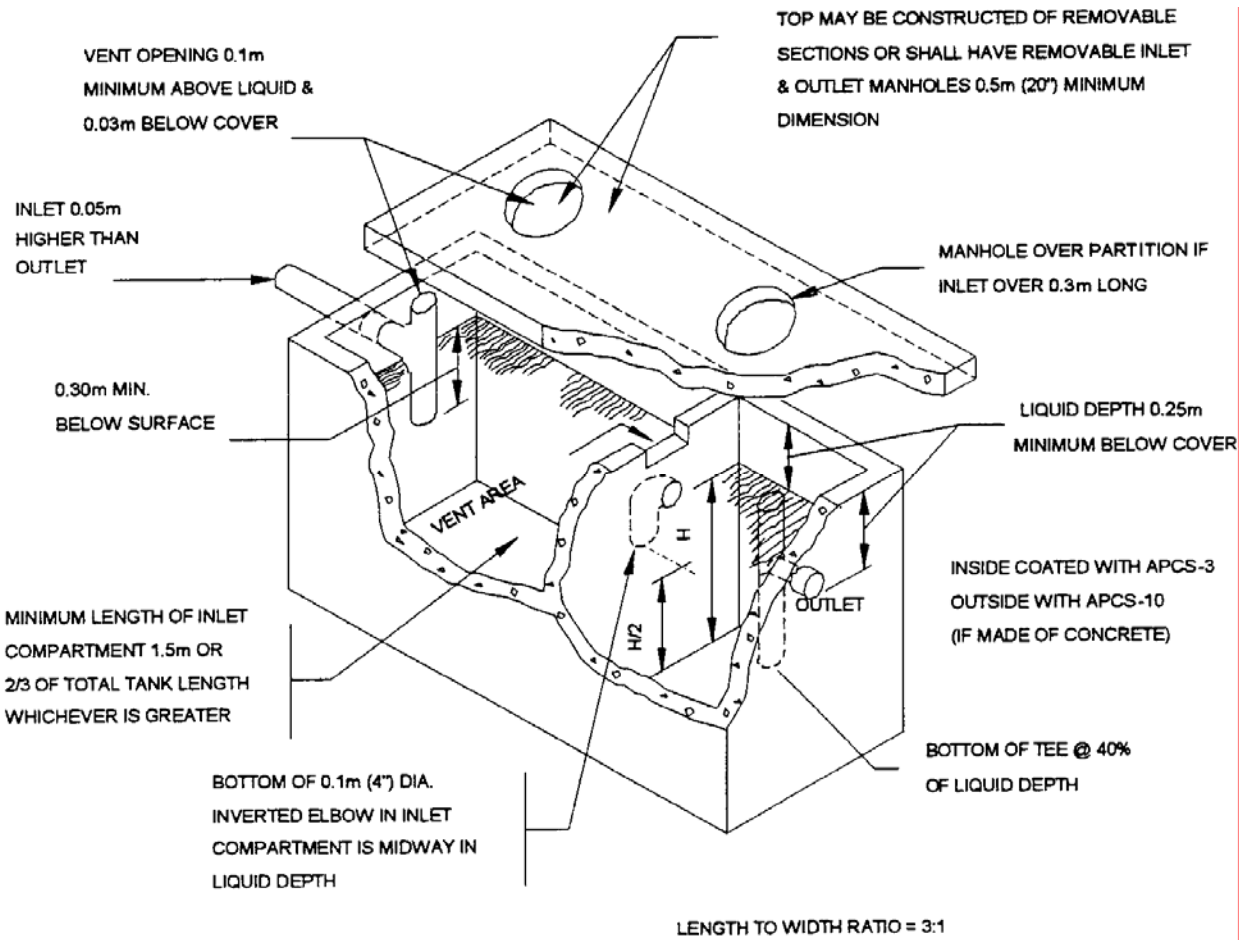

Figure 9 – Remote Area Wastewater Disposal