PDHonline Course C542V (4 PDH)

Introduction to On-Site Wastewater Treatment (Video Course)

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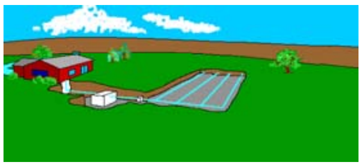
Introduction to Onsite Wastewater Treatment Systems (OWTS)



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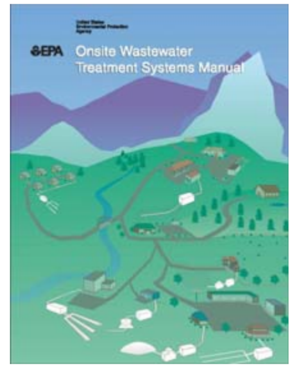

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Agenda

- Background and use of onsite systems
- Management of onsite systems
- Establishing treatment performance standards
- Treatment processes and systems
- Treatment system selection

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Background and use of onsite systems

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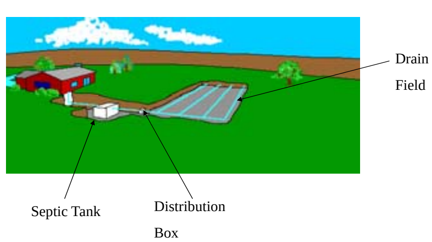
Typical Septic System



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Typical Pollutants of Concern

- Pathogens
- Nitrogen
- Phosphorus

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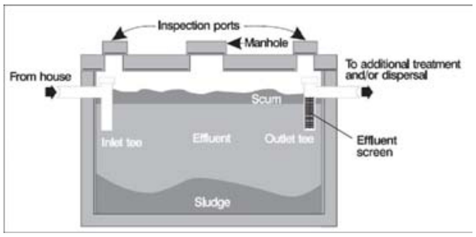
Inside a Septic Tank



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Onsite System Statistics

- 23% of 115 million households use a system (1999)
- About 50% of systems >30 years old
- 10-20% of all systems fail (2000)

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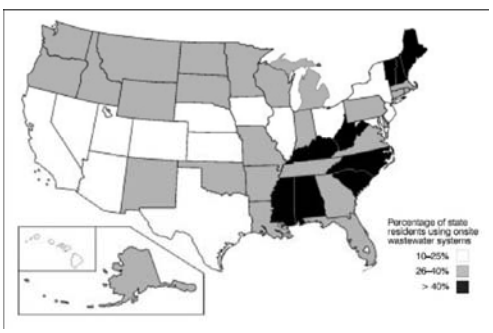
System Distribution in the US, 1990



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Typical Reasons for Failures

- Age
- Hydraulic overload
- Faulty design
- Improper installation
- Inadequate maintenance

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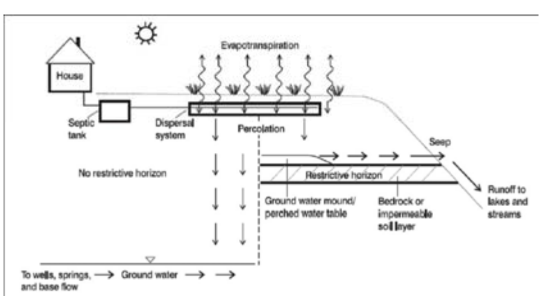
Fate of Water from an Onsite System



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Problems with Existing Management Programs

- Failure to adequately consider site-specific environmental conditions
- Codes that thwart adaptation to difficult local site conditions
- Ineffective or nonexistent public education and training
- Failure to include conservation and potential reuse of water

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Problems, page 2

- Ineffective controls on system operations and maintenance
- Failure to consider the special requirements of commercial, industrial and large residential customers
- Weak compliance and enforcement programs

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Critical Elements of a Successful Management Program

- Public involvement and education
- Adequate financial support
- Support from elected officials

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Public Involvement & Education

- Builds support for funding
- Supports regulatory initiatives
- Supports elements of a comprehensive program
- Increases general awareness of onsite systems
- Improves routine O&M

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Barriers to Effective Management Programs

- Public misperceptions that centralized systems are better
- Legislative and regulatory constraints and prescriptive requirement
- Splitting of regulatory authority
- Liability laws that discourage innovation
- Grant guidelines, loan priorities and other financial or institutional barriers

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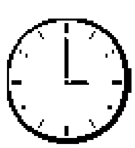
Based on a 1997 survey, about half of all septic systems are what age

A. 20 years old
B. 30 years old
C. 40 years old
D. 50 years old



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Management of Onsite Wastewater Systems

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Elements of a Successful Management Program

- Clear and specific program goals
- Public education and outreach
- Technical guidelines for site evaluation, design, construction and O&M
- Regular system inspections, maintenance and monitoring

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Elements, Part 2

- Licensing or certification of all service providers (designers, installers, inspectors and haulers)
- Adequate legal authority, effective enforcement mechanisms, and compliance incentives
- Funding mechanisms (loans and grants)
- Adequate record management
- Periodic program evaluations and revisions

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Public Education and Outreach

- Public Education
  - Public participation in support of
    - Planning
    - Design
    - Construction
    - O&M Requirement
    - Identifying concerns and priorities
    - Determining management and compliance program elements
  - Public meetings

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Public Outreach

- Educating homeowners
  - About proper O&M
  - How onsite system function
  - How improperly operating systems affect public health and environment
  - What can and cannot go into a system
  - How to control water usage

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Education, contd.

- Materials and courses should target
  - Homeowners
  - Site designers
  - Site evaluators
  - System installers
  - System inspectors
  - O&M personnel

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Technical Guidelines

- Set guidelines for
  - Site evaluation
  - System design
  - System construction
  - System O&M
  - System inspection

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System O&M and Monitoring

- Regular O&M
  - Individual system
  - Sets of systems
- Periodic Monitoring
  - Visual
  - Physical
  - Bacteriological
  - Chemical
  - Remote sensing

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Licensing of Providers

- Licensing can be based on:
  - Examinations
  - Basic knowledge
  - Skills
  - Experience
- Continuing education
- Defined service protocols
- Disciplinary guidelines

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Typical Management Entities

- Government Agencies
  - Federal
  - State
  - Local (counties and municipalities)
  - Tribal
- Special purpose and improvement districts
- Public authorities and utilities
- Public nonprofit corporations
- Private nonprofit corporations
- Private for profit corporations

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Federal and State Agencies

Responsibilities	Financing capabilities	Advantages	Disadvantages
Enforcement of federal and/or state laws and regulations	Usually through appropriations and grants	Authority level and code enforceability high; programs can be standardized; scale efficiencies	Sometimes too remote; not sensitive to local needs and issues; often leaves enforcement up to local entities

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County Govts.

Responsibilities	Financing capabilities	Advantages	Disadvantages
Enforcement of state codes and county ordinances	Able to charge fees, assess property, levy taxes, issue bonds, appropriate general funds	Authority level and code enforceability are high; programs can be tailored to local conditions	Sometimes unwilling to provide service, conduct enforcement, debt limits could be restrictive

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Municipalities

Responsibilities	Financing capabilities	Advantages	Disadvantages
Enforcement of municipal ordinances; might enforce state and county codes	Able to charge fees, assess property, levy taxes, issue bonds, appropriate general funds	Authority level and code enforceability are high; programs can be tailored to local conditions	Might lack administrative, financial, other resources; enforcement might be lax

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Special Districts

Responsibilities	Financing capabilities	Advantages	Disadvantages
Powers defined; might include code enforcement (i.e. sanitation district)	Able to charge fees, assess property, levy taxes, issue bonds	Flexible; renders equitable service (only those receiving services pay); simple and independent approach	Can promote proliferation of local government duplication/ fragmentation of public services

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Improvement Districts

Responsibilities	Financing capabilities	Advantages	Disadvantages
State statutes define the extent of authority	Can apply special property assessments, user charges, other fees; can sell bonds	Can extend public services without major expenditures; service recipients usually supportive	Contribute to fragmentation of government services; can result in administrative delays

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Public Authorities

Responsibilities	Financing capabilities	Advantages	Disadvantages
Fulfilling duties specified in enabling instrument	Can issue revenue bonds, charge user and other fees	Can provide service when government unable to do so; autonomous; flexible	Financing ability limited to revenue bonds; local government must cover debt

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Public Nonprofit Corporations

Responsibilities	Financing capabilities	Advantages	Disadvantages
Role specified in the articles of incorporation (e.g. homeowner association)	Can charge fees, sell stock, issue bonds, accept grants and loans	Can provide service when government unable to do so; autonomous; flexible	Local governments might be reluctant to apply concept

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Private Nonprofit Corporations

Responsibilities	Financing capabilities	Advantages	Disadvantages
Role specified in the articles of incorporation (e.g. homeowner association)	Can charge fees, accept grants and loans	Can provide service when government unable to do so; autonomous; flexible	Services could be of poor quality or could be terminated

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Private For Profit Corporations

Responsibilities	Financing capabilities	Advantages	Disadvantages
Role specified in the articles of incorporation	Can charge fees, accept some grants and loans, sell stock	Can provide service when government unable to do so; autonomous; flexible	No enforcement powers; company might not be fiscally viable; not eligible for grant and loan programs; may not be locally owned

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Responsibilities of a Management Program

- Power to propose legislation and establish and enforce program rules
- Land use planning involvement, review and approval of system designs, permit issuance
- Construction and installation oversight
- Routine inspection and maintenance of all systems
- Management and regulation of septage handling and disposal
- Local water quality monitoring

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Responsibilities, contd.

- Administrative functions
- Grant writing, fund raising, staffing and outreach
- Authority to set rates, collect fees, levy taxes, acquire debts, issue bonds, make purchases
- Authority to obtain easements for access to property, enforce regulations, require repairs
- Education, training, certification and licensing programs for staff and contractors
- Record keeping and database maintenance

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Management Program Components

- Authorities
- Program Goals
- Comprehensive Planning
- Performance requirements
- Implementing performance
- Public education/outreach
- Site evaluation
- System design criteria and approval
- Construction and installation oversight
- Operation and maintenance requirements

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Components, Contd.

- Residential management requirements
- Certification and licensing of service providers and staff
- Education and training programs for service providers and staff
- Inspection/monitoring programs to verify and assess system performance
- Compliance, enforcement and corrective action programs
- Data collection, recordkeeping and reporting
- Program evaluation criteria and procedures
- Financial assistance for management programs and system installation

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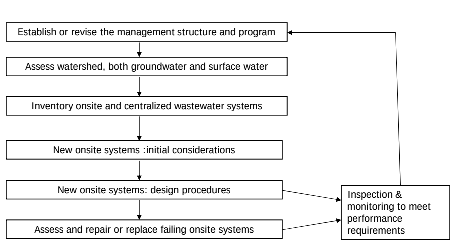
Process for Developing a Management Program



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New OWTS: Design Procedure

- Estimate wastewater flow and composition
- Evaluate potential receiver sites
- Delineate design boundaries
- Establish/revise performance requirements
- Determine design boundary loadings
- Identify feasible treatment train alternatives
- Evaluate alternative treatment trains
- Develop conceptual design
- Develop final design
- Obtain final design approval and construction permit

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Assess and Repair or Replace Failing OWTSs

- Evaluate causes of failures (design, site conditions, maintenance)
- Consider changes in plumbing fixtures, waste generation patterns
- Evaluate cost-effectiveness of repair vs. replace
- Replacement follows sequence describer for new systems

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Public Education Questions to be Answered

- How much will it cost?
- Will the changes mean more development in my neighborhood? How much?
- Will the changes prevent development?
- Will the changes protect our resources?
- How do the proposed management alternatives relate to the above questions?

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Potential Audiences

- Homeowners
- OWTS Manufacturers
- Installers
- System operators and maintenance contractors
- Commercial or industrial property owners
- Public agency planners
- Inspectors
- Site evaluators
- General public
- Students
- Citizens groups
- Homeowner associations
- Civic groups
- Environmental groups

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Outreach Information

- Promoting water conservation
- Preventing household and commercial/industrial hazardous waste discharges
- Benefits of the OWTS management program

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Media That can be Used

- Local newspapers
- Radio and TV
- Speeches and presentations
- Exhibits and demonstrations
- Conferences and workshops
- Public meetings
- School programs
- Local and community newsletters
- Reports
- Direct mailings

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Site Evaluation Program Elements

- Establish administrative processes for permit/site evaluation applications
- Establish processes and policies for evaluating site conditions (i.e. soils, slopes, water resources)
- Develop and implement criteria and protocols for site evaluators
- Determine the level of skill and training required for site evaluators
- Establish licensing and certification programs for site evaluators
- Offer training opportunities as necessary

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System Design Criteria

- Establish parameters
- Determine acceptable technologies

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Typical Design Parameters

- Fecal coliform bacteria
- Biochemical oxygen demand (BOD)
- Nitrogen
- Phosphorous
- Nuisance parameters

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Prescriptive Design Criteria

- Wastewater characterization and expected effluent volumes
- Site conditions
- System capacity
- Location of tanks and appurtenances
- Tank dimensions and construction materials
- Alternative tank effluent treatment units and configuration

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Prescriptive, Page 2

- Required absorption field dimensions and materials
- Requirements for alternative soil absorption field areas
- Sizing and other acceptable features of system piping
- Separation distances from other site features
- O&M requirements
- Accommodations required for monitoring

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Construction Oversight Program Elements

- Establish preconstruction review procedures for site evaluation and system design
- Determine training and qualifications of system designers and installers
- Establish designer and installer licensing and certification programs
- Define and codify construction oversight requirements
- Develop certification process for overseeing and approving system installations
- Arrange training opportunities for service providers

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O&M Elements

- Establish guidelines or permit program for O&M
- Develop reporting system for O&M
- Circulate O&M information and reminders to system owners
- Develop O&M inspection and compliance verification program
- Establish licensing/certification programs for service providers
- Arrange training opportunities
- Establish procedures for follow-up notices
- Establish reporting and reminder system for monitoring system effluent
- Establish septage management requirements

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RA/ME Training, etc. Program

- Identify tasks that require in-house or contractor certified/licensed professionals
- Develop certification and/or licensing program
- Establish process for licensing/certification applications and renewals
- Develop database of service providers
- Establish education, training and experience requirements
- Develop or identify continuing training opportunities
- Circulate information on available training
- Update service provider database to reflect verified training participation/performance

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Inspecting/Monitoring Program Elements

- Develop/maintain inventory of all systems in management area
- Establish schedule, parameters and procedures for system inspectors
- Determine knowledge level required of inspectors and monitoring staff
- Ensure training opportunities for all staff and service providers
- Develop inspection program (owner inspection, staff inspection, contractor inspection)

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Inspection, Part 2

- Establish right of entry provisions to access systems
- Circulate inspection program details and schedules to system owners
- Establish reporting system and database
- Identify existing groundwater and surface water monitoring in the area and determine supplemental monitoring required

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I/M Components

- Specified intervals for inspections
- Legal authority to access system components
- Monitoring of overall O&M
- Monitoring of receiving environment at the point of compliance
- Review of system use or flow records
- Required type and frequency of maintenance for each technology
- Identification, location and analysis of system failures
- Correction schedules for failed systems
- Record keeping on system inspected, results and recommendations

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Corrective Action Program Elements

- Establish process for reporting and responding to problems
- Define conditions that constitute a violation of program requirements
- Establish inspection procedures for reported problems and corrective action schedule
- Develop a clear system for issuing violation notices, compliance schedules, contingencies, fines or other actions to address uncorrected violations

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Enforcement Elements

- Response to complaints
- Performance inspections
- Review of required documentation and reporting
- Issuance of violation notices
- Consent orders and court orders
- Formal and informal hearings
- Civil criminal actions or injunctions
- Condemnation of systems and/or property
- Correcting system failures
- Restriction of real estate transactions
- Issuance of fines and penalties

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Establishing Treatment System Performance Requirements

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Types of Wastewater

- Residential
- Non-residential

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Residential Wastewater Sources

- Single family homes
- Condominiums
- Apartments
- Multi-family homes
- Cottages
- Resorts

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Residential Wastewater Flows

- Average Daily Flow
  - Based on occupancy
  - Often based on no. of bedrooms
    - 1-1.5 persons/bedroom
    - Most codes use 2 people/bedroom
  - Estimated at 50-70 gallons/person/day
  - Newer homes 40-60 gallons/person/day

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Flows Based on Fixture (gallons/person/day)

Toilet	18.5	
Shower	11.6	
Bath	1.20	
Clothes Washer	15.0	
Dishwasher		1.0
Faucets	10.9	
Leaks		9.5
Other Domestic	1.6	
Total	69.3	

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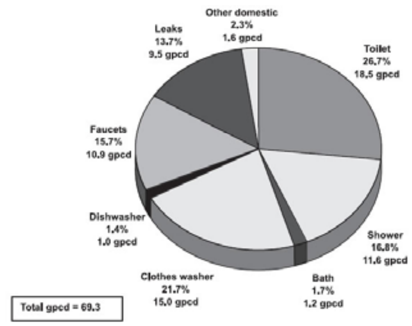
Indoor Water Use (%)



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Non-residential Flows

- Institutional
  - Schools
  - Govt. Buildings
- Commercial
  - Restaurants
  - Car Washes
  - Other
- Industrial
  - Manufacturing facilities
  - Warehouses
  - Other

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Typical Wastewater Flows - Nonresidential

Facility	Units	Gallons/Unit/Day
Airport	Passenger	3
Apartment	Person	50
Automobile Service Station	Vehicle/Employee	12/13
Bar	Customer/Employee	3/13
Boarding House	Person	40
Department Store	Toilet/Employee	500/10
Hotel	Guest/Employee	50/10
Industrial Building	Employee	13
Laundry (self service)	Machine/Wash	550/10
Office	Employee	13
Public Lavatory	User	5
Conventional Restaurant	Customer	9
Short Order Restaurant	Customer	6
Restaurant	Meal	3
Shopping Center	Parking Space/Employee	2/10
Theater	Seat	3

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Typical Wastewater Flows - Institutional

Facility	Units	Gallons/Unit/Day
Assembly Hall	Seat	3
Hospital, medical	Bed/Employee	165/10
Hospital, mental	Bed/Employee	100/10
Prison	Inmate/Employee	120/10
Rest Home	Resident/Employee	90/10
School, w/ cafeteria, gym, showers	Student	25
School, w/cafeteria only	Student	15
School, w/o cafeteria, gym or showers	Student	11
School, Boarding	Student	75

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Typical Wastewater Flows - Recreational

Facility	Units	Gallons/Unit/Day
Apartment, Resort	Person	60
Bowling Alley	Alley	200
Cabin, resort	Person	40
Cafeteria	Customer/Employee	2/10
Campground, developed	Person	30
Cocktail lounge	Seat	20
Coffee Shop	Customer/Employee	6/10
Country club	Guest/Employee	100/13
Dining Hall	Meal served	7
Dormitory	Person	40
Fairgrounds	Visitor	2
Hotel, resort	Person	50
Picnic park, flush toilets	Visitor	8
Store, resort	Customer/Employee	3/10
Swimming Pool	Customer/Employee	10/10
Theater	Seat	3
Visitor Center	Visitor	5

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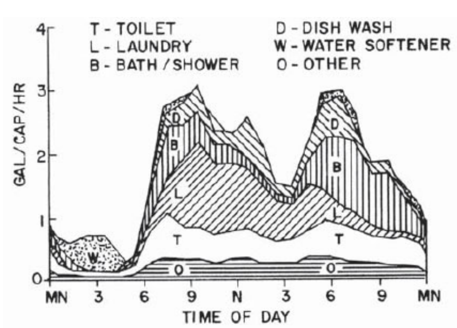
Daily Variation - Residential



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Variation of Flow - Residential

- Varies due to:
  - Fixture and appliance usage characteristics
  - Residential water use demand
  - Plumbing fixture failures
  - Appliance misuse
- Peak flow is a function of:
  - Fixtures present
  - Appliances and their position in the plumbing system

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Variation of Flow - Nonresidential

- Varies due to
  - Characteristics of the water-using fixtures
  - Appliance being used
  - Business characteristics of the establishment
    - Hours of operation
    - Fluctuations in customer traffic
    - Nature of business

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Wastewater Quality - Residential

Parameter	Concentration (mg/l)
Total solids (TS)	500-880
Volatile solids	280-375
Total suspended solids (TSS)	55-330
Volatile suspended solids	110-265
BOD_5	155-286
COD	500-600
Total Nitrogen (TN)	26-75
Ammonia (NH4)	4-13
Nitrites and nitrates	<1
Total phosphorous (TP)	6-12
Fats, oils and greases (FOG)	70-105
Volatile organic compounds (VOC)	0.1-0.3
Surfactants	9-10
Total coliforms (TC)	10^8-10^{10}
Fecal coliforms (FC)	10^6-10^8

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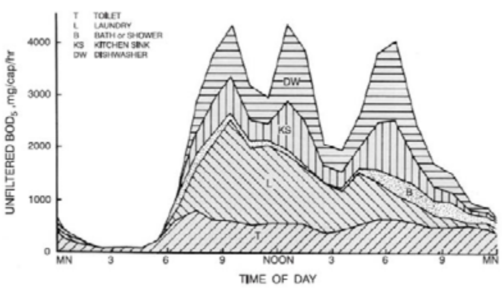
Daily Variation of BOD_5



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Mean Contributions by Source – Residential (grams/capita/day)

	BOD5	TSS	TN	TP
Garbage Disposal	18.0	26.5	0.6	0.1
Toilet	16.7	27.0	8.7	1.6
Bathing, sinks and appliances	28.5	17.2	1.9	2.7
Total	63.2	70.7	11.2	2.7

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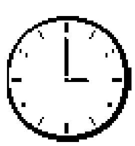
The average daily wastewater flow from a residence is

A. 40-50 gals/person/day

B. 50-60 gals/person/day

C. 50-70 gals/person/day

D. 60-80 gals/person/day



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Minimizing Wastewater Volumes

- Most common failure of OWTS due to hydraulic overload
- Most usage due to
  - Toilet flushing
  - Bathing
  - Clothes washing
- Methods to reduce overload:
  - Elimination of extraneous flows
  - Reduction of existing wastewater flows
  - Wastewater recycle/reuse

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Elimination of Extraneous Flows

- Improved water-use habits (best approach)
- Improved plumbing and appliance maintenance and monitoring (reduce water pressure in system, example: reducing water pressure from 80 psi to 40 psi will save 40%)
- Elimination of excessive water supply issues

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Water Use Habits

- Using toilets to dispose of sanitary waste only
- Reducing time in shower
- Reducing number of showers
- Turning off faucets while brushing teeth or shaving
- Operating clothes washer or dish washer with a full load
- Adjusting clothes washer water level based on load
- Making sure faucets are completely turned off
- Maintaining plumbing system
- Do not connect water softeners

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Reduction of Existing Wastewater Flows

- Toilets
- Bathing devices, fixtures and appliances
- Clothes washing devices, fixtures and appliances
- Miscellaneous

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Toilets

- Toilet tank inserts
- Ultra low flush toilets
- Composting toilets
- Incinerator toilets

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TOILET REBATE PROGRAMS

- Many municipalities offer rebates for converting old toilets to low flow models
- Information:
  - www.homedepot.com go to bath, then toilets

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Bathing Devices

- Shower flow controls
- Reduced flow showerheads
- On/off showerhead valves
- Mixing valves
- Air-assisted, low flow shower systems

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Clothes Washing Devices

- High-efficiency washer (front loaded)
- Adjustable cycle settings
- Washwater recycling feature

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Miscellaneous

- Faucet inserts
- Faucet aerators
- Reduced-flow faucet fixtures
- Mixing valves
- Hot water pipe insulation
- Pressure reducing valves
- Hot water recirculation
- Instant on hot water heaters

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Reducing Pollutant Loads

- Modifying household product selection
- Improving user habits
- Eliminating or modifying fixtures

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Modifying Household Products

- Use low phosphorous detergents (can reduce loadings by 40-50%)
- Use mild cleaners
- Carefully select chemicals
- Read labels for proper disposal methods

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Improve User Habits

- Do not use every flush toilet cleaners
- Reduce the use of drain cleaners by minimizing hair, grease and food particles that go down the drain
- Do more scrubbing with less cleanser
- Use the minimum amount of soap
- Use minimal amounts of mild cleaners
- Do not drain swimming pools into the septic system
- Do not dispose of solvents, paints, prescription drugs, etc. into system
- Save Household hazardous wastes for Amnesty Days

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Eliminating Appliances

- Do not use a garbage disposal
- Segregate toilet flows (blackwater) from sink, shower, washing machine and other waste flows (graywater)
  - More cost-effective for
    - New homes
    - Homes with adequate crawl spaces
    - Mobile or modular homes
  - Use caution due to pathogen exposure
  - Use composting or incinerating toilets

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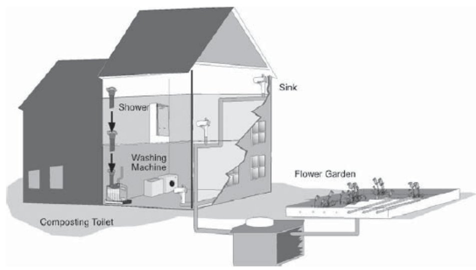
Typical Graywater Reuse System



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Wastewater Reuse/Recycling

- *Wastewater reuse*

  The collection and treatment of wastewater for other uses such as irrigation, ornamental ponds and cooling system.

- *Wastewater recycling*

  The collection and treatment of wastewater and its reuse in the same water use scheme, such as toilet and urinal flushing.

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Wastewater Reuse/Recycling

- Can be used in:
  - Individual homes
  - Clustered communities
  - Larger institutional facilities such as office parks, schools
  - Recreational facilities
- Reduces the use of potable water
- Common concerns
  - Cross connections
  - Difficulties in modifying and integrating potable and nonpotable plumbing
  - Public and public agency acceptance
  - Required maintenance of the treatment systems

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Wastewater Recycling/Reuse

- Sink/bath/laundry wastewater recycling for toilet flushing
- Recycling toilets
- Combined wastewater recycling for toilet flushes
- Combined wastewater recycling for outdoor irrigation

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Safety Factors for Flow

- Incorporated into minimum size of septic tanks
- Estimate flow as 100-150 gallons/bedroom/day
- Estimate flow as 75-100 gallons/person/day
- Use a safety factor of 2 times estimated flow
- Safety factors for an individual home will be higher than for systems of 10 or more homes

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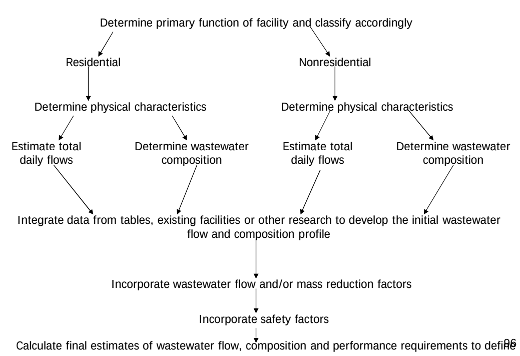
Strategy For Estimating Wastewater Flow



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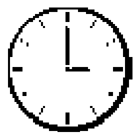
Reducing water pressure from 80 psi to 40 psi can reduce water usage by

A. 30%

B. 40%

C. 50%

D. 60%



97

Transport and Fate of Pollutants

- Pollutants of concern (POC)
- Movement of water through soil
- Movement of POC's through soil

98

POC's

- TSS and turbidity
- BOD
- Pathogens
- Nitrogen
- Phosphorous
- Toxic organics
- Heavy metals
- Dissolved organics

99

Problems with POC's

POC	Reason for concern
TSS/turbidity	Result in sludge deposits that smother benthic macroinvertebrates and fish eggs; sediment oxygen demand, block sunlight and lower plant's ability to increase dissolved oxygen in the water column
BOD	Deplete dissolved oxygen in surface waters, create anoxic zones harmful to aquatic life; taste and odor problems
Pathogens	Cause communicable diseases
Nitrogen	Cause eutrophication and dissolved oxygen loss in surface waters; can affect infants and pregnant women; affects livestock health
Phosphorous	Cause eutrophication of surface waters and reduces dissolved oxygen
Toxic organics	Persist in groundwater and contaminate drinking water sources; damage water ecosystems
Heavy metals	Cause human health problems; accumulate on fish
Dissolved inorganics	Affect taste and odor of drinking water; affect soil structure and SWIS performance

100

Nitrogen

- Primary form is ammonia
- Ammonia is converted by aerobic bacteria in the drain field to nitrite, then to nitrate, finally nitrogen gas
- Nitrogen (primarily as nitrates) contamination beneath drain fields has been documented
- Main treatment methods in soils are:
  - Adsorption
  - Volatilization
  - Mineralization
  - Nitrification
  - Denitrification

101

Phosphorous

- Key plant nutrient that can lead to eutrophication in excess
- Amount that leaches through soil depends on:
  - Characteristics of the soil
  - Thickness of the unsaturated zone
  - Applied loading rate
  - Age of the system
- Retention capacity is finite and depends on:
  - Mineralogy
  - Particle size distribution
  - Oxidation-reduction potential
  - Ph
- Fine textured unstructured soils (clays, silty clays) enhance treatment as opposed to coarse granular soils (sands) and highly structured fine-textured soils (clayey silts)
- Also important is the amount of soil that the wastewater will contact

102

Surfactants

- Can mobilize otherwise insoluble organic pollutants in the soil
- Degree of mobility is affected by:
  - Soil solution chemistry
  - Organic matter content of the soil
  - Rate of degradation by soil microorganisms
- They also may:
  - Change soil structure
  - Alter wastewater infiltration rates
  - Decrease adsorption of other pollutants

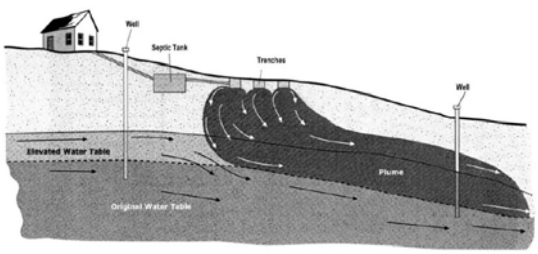
103

Pathogens

- Main methods of bacterial retention in unsaturated soils are:
  - Filtration
  - Sedimentation
  - Adsorption
- Most pathogen die-off occurs in first 2-3 feet of soil
- Failure to properly site, design install or operate and maintain system can result in groundwater and surface water contamination

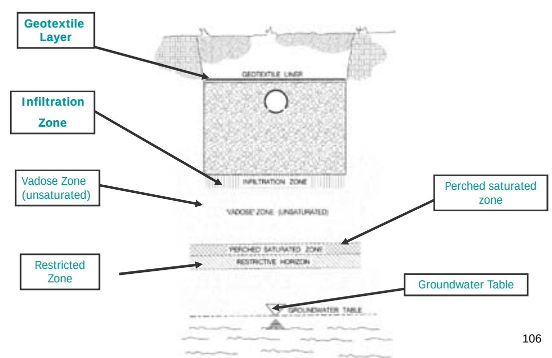
104

Plume Movement Through Soil



105

Soil Treatment Zones



106

Treatment Zones

- Primary treatment in septic tank; removes most of:
  - Settleable solids
  - FOG
  - Anaerobic digestion of sludge
- Secondary treatment occurs at the infiltrative surface of the subsurface wastewater infiltration system (SWIS) in a biomat and provides
  - Physical treatment
  - Chemical treatment
  - Biological treatment
- Effluent polishing occurs in the unsaturated or vadose zone of the groundwater

107

Performance Requirements

- Measured at a specific performance boundary
- Established based on water quality standards
- Assimilative capacity of the environment between the point of wastewater release and the performance boundary
- Based on a risk assessment
- Assess source vulnerability and receiving water capacity
- Establish narrative or numerical performance requirements

108

Risk Assessment

- Should consider
  - The hazards of each pollutant in the wastewater
  - Its transport and fate
  - Potential exposure opportunities
  - Projected effects on humans and the environmental resources

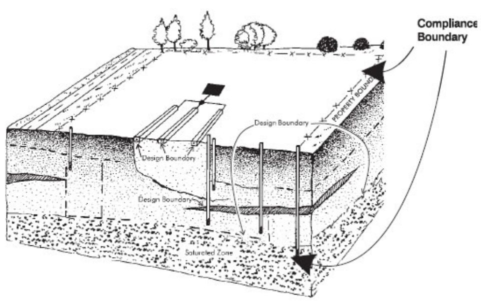
109

Performance Boundaries

- Where conditions abruptly change
  - Intersection of unit processes
  - Between saturated and unsaturated zones
  - Drinking water well
  - Property boundary

110

Example Compliance Boundary



111

Site Suitability Assessments

- Utilize a variety of approaches
  - Multivariate ratings
  - GIS overlay analysis
  - Value analysis
  - Probability of impact
  - Quantitative analysis

112

Monitoring System O&M

- Serves several purposes:
  - Ensure that treatment systems are operated and maintained in compliance with performance requirements
  - Provides performance data useful in making corrective action decisions
  - Assist in evaluating area-wide environmental impacts of land use and wastewater planning
- Historically not been required

113

Monitoring of Systems

- Failure rates can exceed 10% in some areas
  - Aging systems established before 1970
  - Poor maintenance by homeowner indifference or ignorance
  - Regional hydraulic or pollutant overloads
- Strongly recommended in the following circumstances when OWTS are used:
  - In moderate to high density developments
  - Seasonal developments
  - Areas with aging systems
  - Areas that have a likelihood of groundwater or surface water contamination

114

Operating Permits

- Issue renewable or revocable operating permits
- Stipulates conditions that the system must meet before renewal
- Owner is responsible for documenting and certifying that permit conditions have been met
- Permit periods vary based on treatment system complexity
- Can be backed up by fines or penalties

115

Elements of a Monitoring Program

- Clear definition of parameters to be monitored and measurable standards against which the results will be compared
- Strict protocols that identify when, where and how monitoring will be done, how results will be analyzed, the format in which the results will be presented, and how the data will be stored
- Quality assurance and quality control measures that should be followed to ensure credible data.

116

System Inspections

- Mandatory inspections are an effective method for identifying system failures or systems in need of corrective actions
- Inspections should be required:
  - On a regular basis
  - At the time of property sale
  - As a condition for obtaining a building permit for remodeling or expansion

117

Prescribed Maintenance

- In accordance with unit manufacturers instructions in the O&M manual
- May be contracted out to a service provider
- Homeowner may conduct if properly trained
- May require periodic pump outs
  - Based on size of family and number of bedrooms

118

Treatment System Design

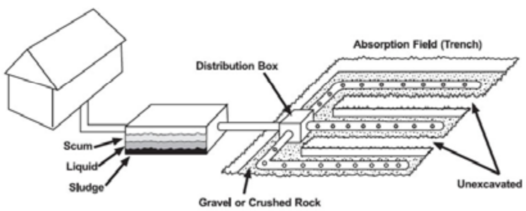
119

Quick Review

- Introduction
- Regulatory Agencies
- Management Entities
- Expected flows and parameters
- Pollutants of concern
- Performance standards
- Performance boundaries
- General O&M and design issues

120

Typical Septic System



121

Conventional Treatment Systems

- The subsurface wastewater infiltration system (SWIS) is the interface between the engineered system and the groundwater
- Performance of the OWTS relies primarily on the SWIS
- Treatment options include physical, chemical and biological processes
- Use of the particular processes is site-specific

122

Typical Treatment Processes

- Sedimentation
- Filtration
- Aerobic biological treatment
- Physical removal
- Chemical reactions
- Predation
- Disinfection
- Floatation
- Adsorption
- Nitrification/Denitrification

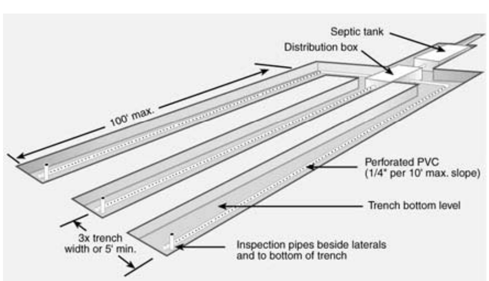
123

Treatment Methods Summary

Treatment method	POC
Septic tank	Suspended solids, FOG
Subsurface Wastewater Infiltration System (SWIS)	Suspended solids, soluble BOD, phosphorous, pathogens,
Wetlands	Suspended solids, soluble BOD, nitrogen
Packed bed reactors (sand, gravel, glass bottom ash, peat)	Suspended solids, soluble BOD, pathogens, phosphorous
Bioreactors (extended air, sequencing batch, fixed film, trickling filters, RBCs, lagoons)	Suspended solids, soluble BOD, nitrogen,
Chemical reactors	Phosphorous, pathogens, nitrogen

124

Typical SWIS Using Trenches



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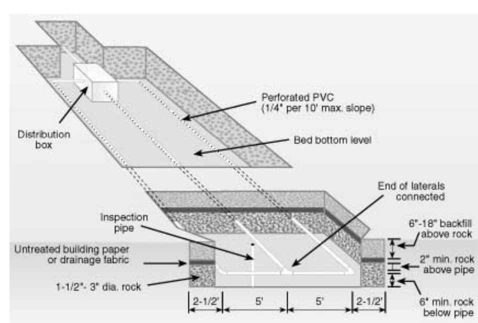
Typical SWIS Bed



126

SWIS Siting Decisions

- Construction considerations
- Hydraulic loading
- Mass loading
- SWIS design and geometry
- Distribution methods

127

SWIS General Information

- Requires permeable, unsaturated soils
- Uses crushed rock, gravel, crushed tires on the bottom with geotextile above this layer
- Perforated pipe distributes wastewater to the bottom of the trench
- Methods include:
  - Trenches
  - Beds
  - Mounds
  - At-grade systems
  - Seepage pits

128

Trenches/Beds

- Trenches have a large length to width ratio
- Beds have a wide, rectangular or square geometry
- Both rely on the bottom interface for water infiltration

129

Seepage Pits

- Seepage pits are deep, circular excavations that rely almost completely on side wall infiltration
- Seepage pits are not recommended because:
  - Depth and relatively small horizontal profile create a greater point source pollutant loading potential to groundwater

130

SWIS Applications

- Type of wastewater: domestic and commercial
- Daily flow: <20 population equivalents
- Minimum pretreatment: septic tank, Imhoff tank
- Lot orientation: Loading along contours must not exceed allowable contour loading rate
- Landscape position: Ridge lines, hilltops, shoulder slide slopes
- Topography: Planar, mildly undulating slopes of <20% grade
- Soil textures: sands to clay loams
- Soil structure: Granular, blocky
- Drainage: Moderately drained or well drained
- Depth to groundwater: > 5 feet

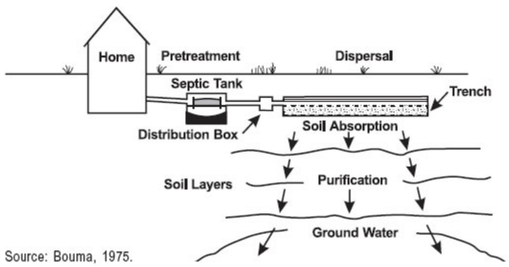
131

SWIS Applications to Avoid

- Type of wastewater: industrial or other high-strength
- Daily flow: >20 population equivalents
- Minimum pretreatment: raw wastewater applied to SWIS
- Lot orientation: Loading along contours will exceed allowable contour loading rate
- Landscape position: Depressions, foot slopes, concave slopes, floodplains
- Topography: Complex slopes of >30% grade
- Soil textures: very fine sands, heavy clays, expandable clays
- Soil structure: Platy, prismatic, or massive soils
- Drainage: extremely well, somewhat poor, or very poorly drained
- Depth to groundwater: < 2 feet

132

Side View of SWIS



Source: Bouma, 1975.

133

SWIS Design Considerations

- Shallow placement of the infiltration surface (<2 feet below final grade)
- Organic loading is comparable to that of septic tank effluent at its recommended hydraulic loading
- Trench orientation parallel to surface contours
- Narrow trenches (<3 feet wide)
- Timed dosing with peak flow storage
- Uniform application of wastewater over the infiltration surface
- Multiple cells to provide periodic resting, standby capacity and space for future repairs or replacement
- May use imported soils
- Bottom may be gravel, rock or tire chunks

134

Separation Distances

- Adequate separation between infiltration surface and any saturated zone or hydraulically restricted horizon must be maintained to
  - Achieve acceptable pollutant removals
  - Sustain aerobic conditions in the subsoil
  - Provide an adequate hydraulic gradient

135

Minimum Separation Distances

- 18 inches between seasonally high water table and infiltration area
- 2-4 feet separation removes most fecal coliforms in septic tank effluent
- Can be reduced by:
  - Reducing the hydraulic loading rate
  - Providing uniform distribution of septic tank effluent
- Can be compensated for by:
  - Raising the infiltration surface in an at-grade system
  - Incorporating a mound system

136

Depth of the Infiltration Surface

- Depth should be sufficient to:
  - Maintain adequate subsoil aeration
  - Protect from frost in cold climates
- Maximum depth should be no more than 3-4 feet below final grade
- Minimum of 1-2 feet below final grade in cold climates to protect against freezing
- Should be less in slowly permeable soils or soils with high ambient moisture content

137

Sizing of the SWIS

- Can include both the bottom and side walls: however, to include the side walls water must pond on the bottom, could result in hydraulic failure
- Function of:
  - Maximum anticipated daily wastewater volume
  - Maximum instantaneous and daily mass loading

138

Design Flow

- Previously discussed
- Include safety factors and therefore often overestimate actual flows
  - Commonly use 150 gallons/day/bedroom
  - Implicit safety factor is 2.3-3.6
  - Use of hydraulic loading rates are recommended primarily for residential properties
  - Safety factor is much less for commercial or industrial operations

139

Suggested Hydraulic and Organic Loading Rates

- Refer to Table on Page 4-12 of manual

140

SWIS Details

- Geometry
- Length
- Width
- Height
- Orientation
- Configuration

141

SWIS Geometry

- Trenches
- Beds
- Seepage pits (provide little treatment, but disperse the water, not recommended)

142

SWIS Width

- Infiltration surface clogging is less where the surface is narrow
- Trenches perform better than beds
- Typical trench width is 1-4 feet
- Narrower trenches are preferred
- Narrow trenches are a necessity on a sloping site
- Wider trenches can work in at-grade and mound systems
- Beds should be no wider than 10-15 feet

143

SWIS Length

- Length is critical for:
  - Downslope linear loadings are critical
  - Groundwater impacts are a concern
  - The potential for groundwater mounding exists
- Lengths have generally been limited to 100 feet
- Long trenches reduce linear loadings on a site by spreading the wastewater loading parallel to and farther along the surface contour

144

SWIS Height

- Height is determined by the type of porous material used in the system
- Height is minimum needed to encase the distribution piping and/or storage for peak flows
- A height of 6 inches is usually sufficient for most porous aggregates

145

SWIS Orientation

- Important consideration on:
  - Sloping sites
  - Sites with shallow soils over a restrictive horizon or saturated soil
  - Small or irregularly shaped lots
- Long axes of trench should be parallel to the ground surface contours
- Extending the depth of the trenches perpendicular to the groundwater gradient reduced mass loadings per unit area

146

SWIS Configuration

- Spacing of trenches is determined by the soil characteristics and the method of construction
- Trenches should be parallel
- Sidewall to sidewall distance should be sufficient to not damage adjacent trenches
- The finer (tighter) the soil, the greater the trench spacing should be

147

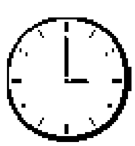
Typical Design Criteria

	Trenches	Beds
Width	Preferably less than 3 feet	Should be as narrow as possible. Beds wider than 10-15 feet should be avoided
Length	Restricted to length parallel to site contour, distribution method and distribution network design	Restricted to length parallel to site contour, distribution method and distribution network design
Sidewall Height	Sidewalls are not an active part. Minimum height needed to encase distribution piping or meet peak flow storage	Sidewalls are not an active part. Minimum height needed to encase distribution piping or meet peak flow storage
Orientation/ Configuration	Parallel to site contours and/or water table or restrictive layer contours; limited by construction method; should not exceed site's maximum linear hydraulic loading rate/unit of length	Parallel to site contours and/or water table or restrictive layer contours; should not exceed site's estimated downslope maximum linear hydraulic loading rate/unit of length

148

SWIS trench lengths are usually limited to

A. 25 feet
B. 50 feet
C. 75 feet
D. 100 feet



149

Wastewater Distribution

- Gravity Flow
- Gravelless wastewater dispersal systems
- Dosed Flow

150

Gravity Flow

- Perforated Pipe
  - Most commonly used is 4-inch pipe
  - Typically PVC, PE, or ABS
  - 1-2 rows of holes spaced 12 inches apart
  - Laid level in gravel with holes or slots on bottom
- Distribution Box
  - Divide flow among multiple distribution lines
  - Shallow, flat bottomed, watertight with 1 inlet and multiple outlets
  - Must be on sound frost-proof footing
  - Can use other distribution methods within the D-box when it fails to evenly distribute flow
    - Adjustable weirs
    - Leveling the box
    - Blocking outlets

151

Gravity Flow, Contd.

- Serial relief lines (diagram on Page 4-19)
  - Distribute water to a series of trenches on a sloping site.
  - Loads the uppermost trench first and water flows down hill via the lines
  - Solid wall pipes that connect the crown of the higher trench with the distribution pipe in the lower trench
  - Normally separated by 5-10 feet to avoid short circuiting
- Drop box (diagram on Page 4-21)
  - Used similar to relief lines
  - Can take individual trenches out of service

152

Gravelless Systems

- Used widely
- Can be:
  - Open bottomed channels
  - Fabric wrapped pipe
  - Expanded polystyrene foam chips
  - Long plastic tubing covered with nylon filter fabric
- Minimum pipe size of 10-12 inches
- Placed in a 12-24 inch trench

153

Gravelless Part 2

- Can be installed in areas with steep slopes
- Requires small equipment
- Can be installed in hand-dug trenches
- Has a reduced infiltration surface (up to 50%)
- Benefits for areas where gravel is expensive or site soils may be damaged during construction

154

Dosed Flow Distribution

- Dosing Method
  - On-demand
  - Timed
- Dosing device
  - Pump
  - Siphon

155

Dosing Methods

- On-demand
  - Occurs when sufficient volume of wastewater has accumulated in the dose tank to activate the pump switch or siphon and continues until the tank reaches a specified low level. There is no control on the daily volume of wastewater
- Timed
  - Dosing is performed by pumps on a timed cycle at equal intervals and for preset dose volumes so that the daily volume does not exceed the system's design flows. Peak flows are stored in the dose tank.

156

Dosing Devices

- Pump
  - Pressure distribution networks are set at elevations that are typically higher than the dose tank. Multiple lines can be dosed from the same tank using dedicated pumps
- Siphon
  - On-demand dosing of gravity or pressure distribution networks is used where the elevation between the siphon invert and the distribution pipe orifices is sufficient for the siphon to operate. Siphons cannot be used for timed systems. Two siphons in the same dosing tank can alternate automatically between two infiltration areas

157

SWIS Contingency for Failures

- Options
  - Reserve area
  - Multiple cells (each cell might include several trenches)
  - Water conservation
  - Pump and haul
- Multiple cells provide the most immediate relief
- Water conservation and pump and haul provide only temporary relief

158

SWIS Construction Considerations

- Keep other, unrelated construction activities away from the site
- Stake the site off before any construction activities
- Establish site access points, traffic lanes, material stockpile areas, and equipment parking areas
- Clearing should be limited to mowing and raking
- Trees should be cut at the base of the trunk and removed without heavy equipment
- Grubbing of the site should be avoided
- Do not remove the organic layer
- Use lightweight backhoes to excavate
- Do not disturb the infiltration surfaces
- Use a backhoe bucket to place gravel
- Grade the site to divert surface runoff
- Mound the infiltration surface backfill to account for surface settling and eliminate depressions
- Seed and mulch the area

159

SWIS O&M

Task	Description	Frequency
Read water meter	Primarily for large, commercial systems	Daily
Dosing tank controls	Check function of pump, switches, and timers	Monthly
Pump Calibration	Check pumping rate and adjust dose timers accordingly	Annually
Infiltration cell rotation	Direct wastewater to standby cells to rest operating cells	Annually in the Spring
Infiltration surface ponding	Record wastewater ponding depths over the infiltration surface and switch to standby cells when ponding persists for more than 1 month	Monthly
Inspect surface and perimeter of SWIS	Walk over SWIS area to observe surface ponding or other signs of stress or damage	Monthly
Tank solids level and integrity	Check for sludge and scum accumulation, condition of baffles and inlet and outlet appurtenances and potential leaks	Varies

160

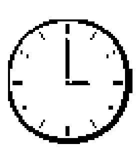
SWIS's achieve high removal rates for all wastewater characteristics, except

A. BOD

B. Pathogens

C. Nitrogen

D. Surfactants



161

Septic Tanks

- Most commonly used pretreatment unit in an OWTS
- Provides primary treatment
- Typically buried, watertight and made of concrete
- Stores and partially digests settled and floating organic solids, which can reduce sludge volume by 40%
- Conditions the wastewater by hydrolyzing organic molecules for subsequent treatment in the SWIS or other units.

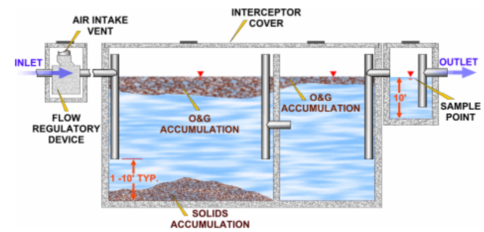
162

Septic Tanks, part 2

- Removes 60-80% of the settleable solids
  - Solids are stored in sludge and scum layers
  - Acid-forming bacteria partially digest the solids
- Removes 30-50% of the BOD
- Gases formed in the tank rise to the wastewater column and can reduce the settling efficiency of the tank

163

Typical Septic Tank



164

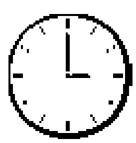
The typical design daily flow per bedroom used to design a SWIS infiltration system is

A. 100 gpd

B. 150 gpd

C. 200 gpd

D. 250 gpd



165

Septic Tank Components

- Inlet structure - designed to limit short circuiting
- Outlet structure – designed to keep sludge and scum layers in the tank and draw effluent only from the clarified zone
- Outlet should have an effluent screen to retain larger solids
- Inspection ports and manways are provided in the tank cover, to allow access for cleaning
- Baffles are sometimes installed in the center to control movement of the water and retain the sludge and scum layers

166

Septic Tank Design Considerations

- Volume
- Geometry
- Compartmentalization
- Inlets and outlets
- Tank access
- Construction materials
- Watertightness

167

Septic Tank Volume

- Typical hydraulic residence time is 6-24 hours
- Times vary depending on tank geometry, depth, and inlet and outlet configuration.
- Sludge and scum buildup can also reduce residence time
- Tank volume often specified by state and national plumbing codes
- Many jurisdictions require a minimum volume of 1,000 gallons

168

International Private Sewage Disposal Code

No. of bedrooms	Tank volume, gallons
1	750
2	750
3	1,000
4	1,200
5	1,425
6	1,650
7	1,875
8	2,100

169

Septic Tank Geometry

- Affects the hydraulic residence time
- Length to width ratios greater than 3:1 reduce short circuiting
- Prefabricated tanks may be rectangular, oval or cylindrical
- Shallower liquid depth tanks better reduce peak outflow rates and velocities; therefore solids are less likely to be carried out
- Reduced depth tanks reduces the depth to be excavated and costs
- A typically specified depth below the outlet invert is 36 inches
- Shallower depths can disturb the sludge blanket and require more frequent pumping

170

Septic Tank Compartmentalization

- Tanks with compartments or placed in series provide better suspended solids removal
- For 2 compartment tanks, better removal occurs if the first tank volume is ½ to 2/3 of the tank volume
- In a 2 compartment system, an air vent must be provided to allow each compartment to vent

171

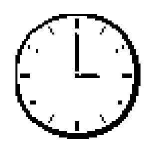
A typical 3 bedroom house should have a septic tank designed for

A. 750 gallons

B. 1,000 gallons

C. 1,250 gallons

D. 1,500 gallons



172

Septic Tank Inlets/Outlets

- The inlet invert should be at least 2-3 inches above the outlet invert
- At least 9 inches of free space should be between the tank top and the liquid level
- Both the inlet and outlet are commonly baffled; baffles are usually made of fiberglass or plastic and bolted in place or concrete and formed in place
- Plastic sanitary tees are often used
- All connections should be watertight

173

Septic Tank Inlets/Outlets, Contd.

- Inlet baffles are designed to prevent short circuiting
- The inlet pipe should extend 6 inches above the liquid level and into the clear water space, but not more than 30-40% of the liquid depth
- The volume of the inlet leg should not be larger than 2-3 gallons
- The outlet baffle should extend 6 inches above the liquid level and into the clear water space, but not more than 30-40% of the liquid depth
- Effluent screens should have opening of from 1/32 to 1/8 inches

174

Septic Tank Access

- Manways should be from 18-24 inches in diameter
- Each compartment should have a manway
- Manways are usually placed over the inlet and outlet baffles and in the center of the tank
- Manways should be raised to ground level or above grade for ease of location
- Inspection ports should be at least 8 inches in diameter
- Inspection ports are located over the inlet and outlet baffles if manways are not located there

175

Septic Tank Construction Materials

- Septic tanks <6,000 gallons are typically premanufactured, while larger tanks are constructed in place
- Materials used include:
  - Concrete
  - Fiberglass reinforced polyester (FRP)
  - Polyethylene
  - Coated steel

176

Septic Tank Construction Materials, Part 2

- FRP tanks usually have a wall thickness of ¼ inches
- Concrete tanks have a wall thickness of 4 inches and are reinforced with no. 5 rods on 8 inch centers
- Sulfuric acid and hydrogen sulfide can corrode the concrete tanks

177

Septic Tank Watertightness

- Critical to performance, leaks are serious
- Infiltration of clean water adds to the hydraulic load
- Exfiltration can threaten groundwater with partially treated wastewater
- Standard that should be applied is ASTM C 1227

178

Construction Considerations

- Location
  - Needs to be easily accessible and away from drainage swales or depressions
- Bedding and backfilling
  - Tank should rest on a uniform bearing surface
  - Soils with high organic content or containing large boulders are not suitable
  - Tank should be leveled and connected, then backfilled
  - Backfill should have no stones larger than 3 inches diameter, debris, ice or snow
  - Imported material should be used in soils containing fine textured silts, silt loams, clay loams, and clay

179

Construction Considerations, Contd.

- Watertightness
  - All joints must be properly sealed
  - Only high quality sealers should be used
  - Backfilling should not occur until the sealer dries
  - A test should be performed following the ASTM standard
- Floatation prevention
  - Required in high water table sites

180

Septic Tank O&M

- Inspections
  - Performed to observe sludge and scum accumulations
  - The top of the sludge layer should be at least 1 foot below the bottom of either the tee or baffle
  - The bottom of the scum layer should not be less than 3 inches above the bottom of the outlet tee
  - Observe the structural integrity and watertightness of the tank after it is pumped
  - Observe the interior of the tank for pitting, spalling, delamination, cracks and holes
  - The baffles and screens should be inspected to confirm they are in the proper position, secured well to the piping or tank wall, clear of debris and not cracked or broken

181

Septic Tank O&M

- Septage Pumping
  - Tanks should be pumped when sludge and scum accumulations exceed 30% of the tank volume.
  - Typical pumping frequency is every 3-5 years depending on tank size, number of occupants water use habits, and household appliances used
- Periodic effluent filter screen cleaned

182

Typical Pump Out Frequency (Years)

Tank Size (Gallons)	Number of people in household					
	1	2	3	4	5	6
500	6	3	2	1	1	
1,000	12	6	4	3	2	2
1,500	19	9	6	4	3	3
2,000	25	12	8	6	5	4

183

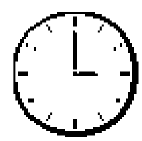
Septic Tanks remove

A. Suspended solids

B. Soluble carbonaceous BOD

C. Nitrogen

D. Phosphorous



184

Advanced Treatment Systems

- Sand and media filters
- Aerobic treatment units (ATU)

185

Sand Filters

- Sand or other media filters consist of a lined excavation (using impervious PVC liner on a sand bed) filled with uniformly sized washed sand placed over an underdrain
- Wastewater is dosed onto the sand surface and allowed to percolate through the sand to the underdrain
- The underdrain collects the filtrate and discharges it to a SWIS or to another treatment unit for further processing
- Some filters have no bottom and the filtered wastewater percolates to the underlying soil

186

Filter Treatment Mechanisms

- Filters act as aerobic, fixed-film bioreactors with most treatment occurring in the first 6 inches
- Straining
- Sedimentation
- Chemical adsorption of dissolved pollutants

187

Filter Considerations

- Wastewater retention time must be sufficiently long to allow for treatment and reaeration
- Residence times can be extended using multiple small dose volumes
- Pore clogging can reduce treatment effectiveness
- Clogging can occur in finer media with excessive organic loadings
- Chemical adsorption can occur throughout the medium bed
- Capacity of the medium depends upon the target constituent, pH and mineralogy of the medium

188

Key Design Considerations

- Media type
- Pore size distribution
- Continuity of the filter medium
- Dose volume
- Dosing frequency

189

Design Considerations

- As the effective size and uniformity of the medium increases, the reaeration rate increases, but the retention time decreases
- May be necessary to recirculate wastewater to meet effluent requirements
- If saturated conditions are avoided, treatment will remain high
- Intervals between doses provide time for reaeration of the medium

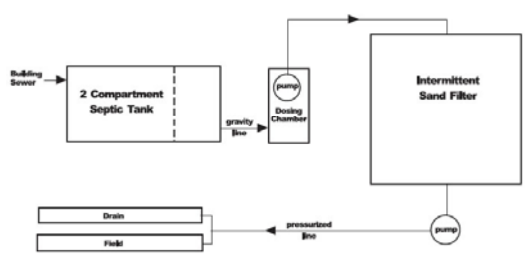
190

Filter Designs

- Single pass filters
- Recirculating Filers

191

Single Pass Filter Diagram



192

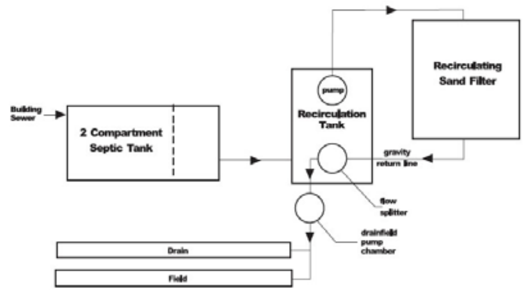
 © 2011 James Newton, PE

Design Considerations

- Wastewater should be intermittently dosed
- Timed dosing is the most common
- Finer media is used in this type of system
- BOD, fecal coliforms, TKN and ammonia removals in excess of 90% are common
- TSS removal can reach 75-90%
- TN removal rates are around 40%
- Daily hydraulic loading rates of 1-2 gpd/ft^2
- Not commonly used to control nitrogen

193

Recirculating Filter Diagram



194

Design Considerations

- Wastewater is dosed 1-3 times per hour
- Returned filtrate mixes with fresh septic tank wastewater
- BOD, fecal coliforms, TKN, removals in excess of 95% are common
- TSS removal can reach 90%
- TN removal rates are around 50%
- Primarily used to control nitrogen
- Nitrogen removal of 70-80% can be achieved when an anoxic reactor is added ahead of the recirculation tank

195

Filter Media Types

- Washed, graded sand (most common)
- Gravel
- Anthracite
- Crushed glass
- Expanded shale
- Bottom ash from coal-fired power plants
- Peat (becoming more common)
- Foam chips
- Non-woven coarse fibers

196

Sand Media Filters

- Can be used for:
  - Single family residences
  - Large commercial establishments
  - Small communities
- Primarily used to treat domestic wastewater

197

Aerobic Treatment Units (ATUs)

- Pre-engineered wastewater devices for both residential and commercial use
- Designed to oxidize both organic material and ammonium nitrogen, decrease suspended solids and reduce pathogens
- Most ATUs are suspended growth devices
- Most ATUs are designed with compressors or aerators to oxygenate and mix wastewater
- Placed before the wastewater enters a SWIS
- An advanced treatment method to reduce nitrogen

198

ATU Design Considerations

- Can treat flows from 400 gpd-1,500 gpd
- Influent total organic concentrations of 100-300 mg/l
- Influent TSS concentrations of 100-350 mg/l
- Should be equipped with audible and visual alarms
- Should be constructed on noncorrosive materials, such as fiberglass, coated steel, reinforced concrete
- Appurtenances should be constructed from PVC, ceramic stone, polyethylene

199

ATU O&M Considerations

- Should have audible and visual alarms
- Cleaning agents, bleach, caustic agents, floating matter and other detritus can damage system
- Owners must maintain service contract with manufacturer
- Should be pumped when the MLSS is above 6,000 mg/l
- Should be inspected every three months

200

ATU Inspections

- Visual check of hoses, wires, leads and contacts
- Alarms should be tested
- Mixed liquor should be examined
- Filters should be cleaned
- All detritus should be removed
- The effluent should be inspected

201

ATU Costs

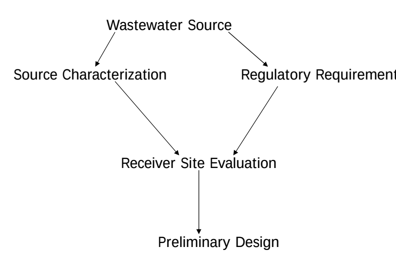
- Installed costs range from $2,500-$9,000
- Pumping costs range from $100-$300
- Aerators/compressor replacement $300-$500, and should occur about every 3-5 years
- Service contracts typically range from $100-$400/yr
- Power requirements generally are around $200/yr

202

TREATMENT SYSTEM SELECTION

203

Preliminary Design Steps



204

Source Characterization

- Current and future use plans
- Wastewater flow projections
  - Daily min., average, max. flows
  - Temporal variations
- Wastewater pollutants
  - Type
  - Concentration
- Owner requirements
  - Location and aesthetics
  - O&M requirements
  - Total and annual costs

205

Additional Considerations

- Owner’s use of the property
  - Footprint and location of existing buildings, paved areas, swimming pools and other structures
- Owner’s concern for the system’s visual impact or odor potential
- Owner’s ability and willingness to perform O&M
- Capital and O&M costs owner willing to pay

206

Regulatory Requirements

- Treatment requirements
  - Effluent limits
  - Unit processes required
- Design requirements
  - Siting requirements
  - Production/material approval
  - Design parameters
  - Submission requirements
- Permit requirements
  - Construction
  - Operation and monitoring

207

Additional Considerations

- State and national codes
  - Public health
  - Plumbing
  - Nuisance
  - Environmental protection
  - Building
- Many counties and other local jurisdictions administer the program

208

Receiver Site Evaluation

- Groundwater Discharge
  - Topography
  - Soils
  - Geology
  - Groundwater
- Surface water discharge
  - Stream flow
  - Outfall locations
- Atmospheric discharge
  - Monthly net evaporation and annul water balance

209

Additional Considerations

- Treatment requirements are based upon a performance boundary and natural design boundaries

- Careful and thorough evaluation is necessary

210

Design Boundaries and Boundary Loadings

- Typical design boundaries
  - Between system components
  - System/soil interface
  - Soil layers
  - Property boundaries
  - Places where design conditions abruptly change
- System failures often occur at design boundaries

211

Boundaries, Contd.

- Site evaluation determines the design boundaries of the physical environment
- Boundaries can be physical planes or points or can be defined by rule
- Typical boundaries for groundwater
  - Water table surface
  - Property line
  - Drinking water well
- Typical boundaries for surface discharge
  - Outfall
  - Location where permit limits are applied

212

Boundaries, Part 3

- Physical boundaries may include:
  - Soil infiltrative surfaces
  - Hydraulically restrictive soil horizons
  - Zones of saturation
- SWIS boundaries
  - Infiltrative surfaces where the wastewater first contacts the soil
  - Secondary infiltration surfaces that cause percolating wastewater to perch above an unsaturated zone
  - Groundwater table surface where the wastewater must enter without mounding or degrading water quality

213

Preliminary Design

- Receiving environment selection
- Design boundary loadings
  - Mass loadings
  - Concentration limits
- Treatment train screening
  - Unit processes
  - Process sequence
- Treatment train selection
- Concept design

214

Site Evaluation

- The evaluation should:
  - Determine feasible receiving environments (groundwater, surface water, atmosphere)
  - Identify suitable receiver sites
  - Identify significant design boundaries associated with the receiver sites
  - Estimate the design boundary mass loading limitations
- Site evaluators must be properly trained and licensed in many states

215

Phases of the Evaluation

- Phase I
  - Preliminary review of documented site information
- Phase II
  - Reconnaissance of potential sites
- Phase III
  - Detailed evaluation of the most promising site or sites

216

Preliminary Review

- Site survey map
- Soil survey, USGS topographic map
- Aerial photos, wetland maps
- Source water protection areas
- Natural resource inventories
- Applicable regulations, codes and setbacks
- Hydraulic loading rates
- Criteria for alternative OWTS
- Size of house/facility
- Loading rates, discharge rates
- Planned location of water well
- Planned construction schedule
- Date and time for meetings

217

Reconnaissance Survey

- Identification of unsuitable areas
  - Water supply separation distances
  - Regulatory buffer zones and setbacks
  - Limiting physiographic features
- Subsurface investigations
  - Groundwater depth from pit/auger
  - Soil profile from backhoe pit
  - Presence of high water table
  - Percolation tests

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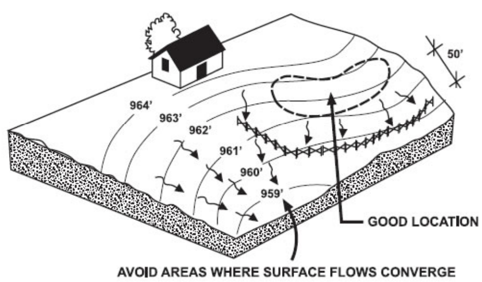
Typical Site Profile



Source: Purdue University, 1990.

219

Soil Characterization

- Use backhoe-excavated test pits to expose soil
- Soil profiles can be described using a hand auger

220

Characterization References

- ASTM D 5921 (latest edition): Standard Practice for Subsurface Site Characterization of Test Pits for On-Site Septic Systems
- ASTM D 2487 (latest edition): Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- USDA Field Book for Describing and Sampling Soils

221

Steps for Characterization

1. Select backhoe test pit
2. Excavate pit
3. Enter test pit
4. Expose natural soil structure
5. Describe soil horizons
6. Determine soil changes
7. Interpret results
8. Issue site report

222

Step 1

- Process steps:
  - Pick site near but not in proposed drain field
  - Orient pit so sunlight illuminates vertical face of pit
  - Typically to 4 feet below the proposed infiltrative surface
- Information to be collected
  - Location of soil adsorption field

223

Step 2

- Process steps:
  - Excavate to depth required by agency regulations
- Information to be collected
  - Required groundwater
  - Seasonally high water table separation
  - Soil profile depth

224

Step 3

- Process steps:
  - Take safety precautions
  - Beware of cave-ins
  - Select area of pit wall to examine
- Information to be collected
  - Safe depths for unbraced pit walls

225

Step 4

- Process steps:
  - Use soil knife, blade, screwdriver to other tool to pick at an area of 0.5 m wide along the full height of pit wall
- Information to be collected
  - Soil structure type (e.g. prismatic, columnar, angular blocky, subangular blocky, platy, granular)

226

Step 5

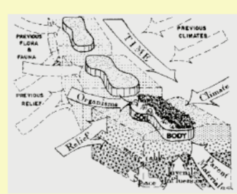
- Process steps:
  - Note master soil horizon layers
  - Describe features of each horizon
- Information to be collected
  - List all horizon features:
    - Depth of horizon, thickness
    - Moisture content
    - Color (hue, value, chroma)
    - Volumetric percentage of rock
    - Size, shape, type of rock
    - Texture of <2 mm fraction of horizon
    - Presence/absence of mottles
    - Soil structure by grade
    - Level of cementation
    - Presence/absence of carbonates
    - Soil penetration resistance
    - Abundance, size, distribution of roots

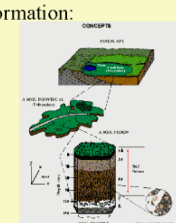
227

Where do soils come from?

Soil Genesis - The study of changes in soil bodies. The science of the evolution of soils which are conceived of as natural units in a dynamic three-dimensional continuum.

5 Factors of Soil Formation:





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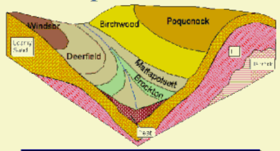
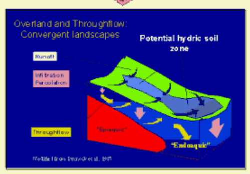
Relief and Landscape Factors

- Position on the landscape (convex/concave).
- Elevation.
- Aspect.
- Slope.
- Water movement.
- Soil drainage.





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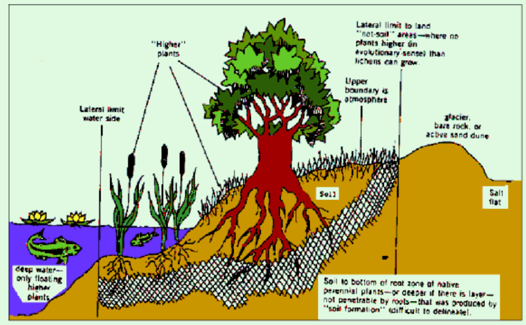

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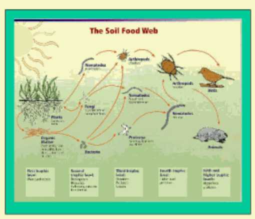
Organisms

- Micro & Macroscopic
- Decomposition of OM
- Redoximorphic formation.
- Animals living in soil
- Vegetation types.
- Humans!



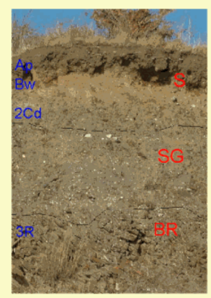
231

Earth Layers

S - Soil - USDA - formation, classification, interpretations.

SG - Surficial Geology - USGS - Soft regolith above bedrock.

BR - Bedrock Geology - USGS - Type of rocks, formation, age.



232

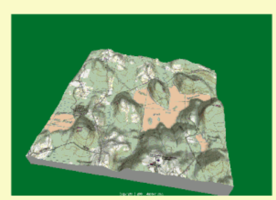
Glacial Till

- Unsorted/stratified material deposited beneath and within glacial ice.
- Heterogeneous mixture of all particle sizes (boulder to clay).
- Oldest surficial deposit.

233

Till Properties

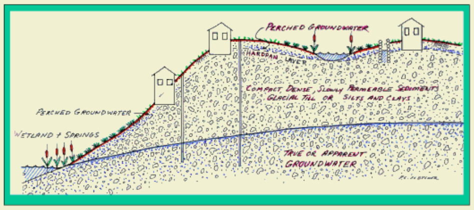
- Major Types: Basal and Ablation.
- Landforms: Drumlins, moraines, ridges.
- Basal till has a dense restrictive layer which impedes downward water movement.
- Large angular Stones/Boulders.



Drumlins in Central Massachusetts

234

Hydrology in Tills

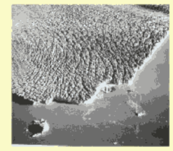


Hardpan layer perches water, causes seasonal high watertables (sketch by Pete Fletcher).

235

Non-soil Areas

- Beaches
- Active pits (gravel/quarries)
- Urban-land
- Deepwater habitats
- Bedrock outcrops
- Glaciers



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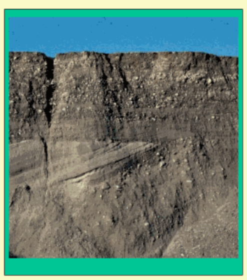
Outwash Properties

- Dominantly sand and gravel sized particles.
- Rapid water movement, associated with aquifers.
- Apparent watertable.
- Few limitations for most uses.



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Post-Glacial Deposits

- Material deposited after glacier left (Holocene-10K BP).
- Eolian - wind deposited sand to silt sized particles.
- Most upland soils in NE have a thin 18-36 inch eolian cap. Deposited rapidly after ice left.

238

Post-Glacial Deposits

- Organic deposits - swamps, bogs, marshes.
- Alluvial deposits - modern day floodplains.
- Anthro-transported material.

239

Soil Information of Interest

- Soil depth
- Horizons
- Texture
- Structure
- Color
- Redoximorphic features
- Soil consistence
- Restrictive horizons
- Organic content
- Phosphorous adsorption potential
- Moisture content
- Porosity
- Penetration resistance
- Rupture resistance
- Roots
- Clay mineralogy
- Boundaries
- Coatings

240

Redoximorphic

- Color patterns represent amount of iron and manganese in soil formed by oxidation or reduction
- Good indicator of the seasonally high water table

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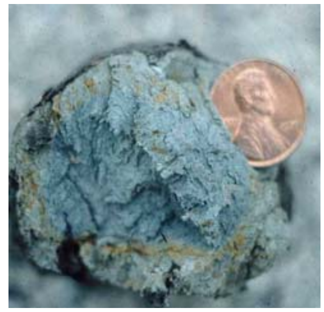
Example Redoximorphic Soils



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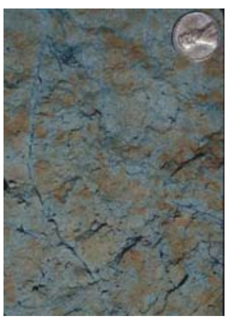
Soil Mottles



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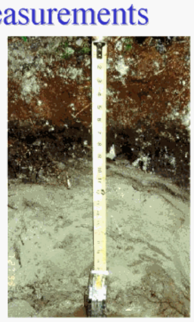
Horizons

- A layer of soil that exhibits similar properties and is generally denoted based upon texture and color
- Designated as master horizons and layers with subordinate distinctions
- Horizons with strong textural contrast, stratified materials and redoximorphic indicators are especially important

244

Horizon Measurements

- Record upper and lower boundary.
- Depends on the use of the description:
- Soil Survey: 0 datum is ground surface.
- NE Indicators: Histosols/histic top of Oe. Mineral soils 0 is top of mineral horizon.



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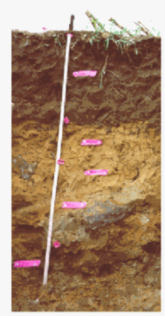
Describing Soil Profiles

- Locate horizon breaks, determine horizonation (learn definitions).
- No set number of horizons in a pedon.
- For each horizon document depth, color, texture, redox, structure, consistency, rocks, etc.
- Note variability.



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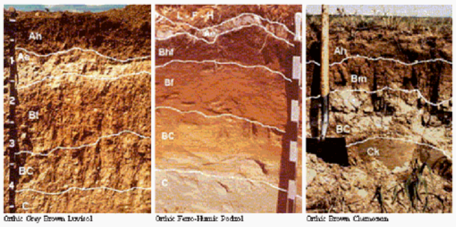
Describing Soil Profiles



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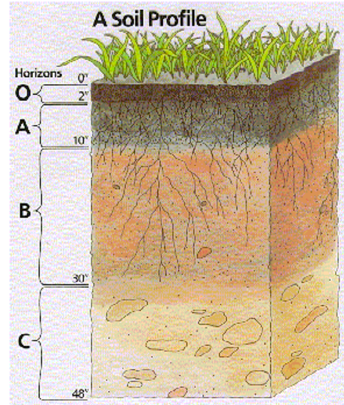


248

O - Horizons

Organic layers of decaying plant and animal tissue (must be greater than 12-18 % organic carbon, excluding live roots).

- Oi - Fibric >=3/4 fibers after rubbing
- Oe - Hemic 1/3-2/3 fibers before rubbing
- Oa - Sapric <1/6 vol. After rubbing, pyro color.

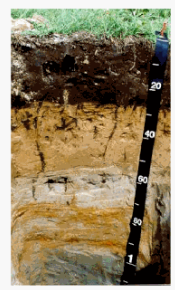
249

A - Horizons (topsoil)

Mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material.

Ap - Plowed A horizon.

Ab - buried horizon.



250

E - Horizons

Eluvial horizons: Mineral horizon which the main feature is loss of silicate clay, iron, aluminum.

Must be underlain by a B (illuvial) horizon.

Eg - use if the eluviation is caused by wetness (photo to right).

251

A horizon

E horizon

Bh horizon

Bs horizon

252

B - Horizons (subsoil)

Mineral horizon with evidence of pedogenesis or Illuviation (movement into the horizon).

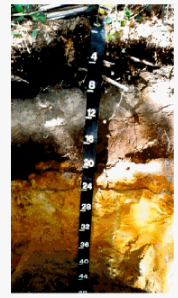
Bw - Weakly color or structure.

Bhs - Accumulation of illuvial organic matter-sesquioxide complexes.

253

B - Horizons (cont.)

- Bhsm - Strong pedogenic cementation of Bhs horizon.
- Bg - Strong gleying - gray colors due to prolong saturation / reduction. Must have other evidence of pedogenesis (usually structure) or it is a Cg!



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C - Horizon/Layers (substratum)

The un-weathered geologic material the soil formed in. Shows little or no sign of soil formation.

Cd - Dense layer (till)

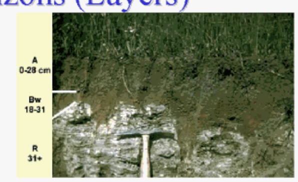
2C - Shows a discontinuity with solum.

Cg - Strong gleying/no pedogenesis.

255

R - Horizons (Layers)

- Hard Bedrock (Ledge).
- Typically requires large machinery or blasting to dig through.
- In NE: Depth ranges from 0-300 feet.
- Saprolite is a Cr horizon.



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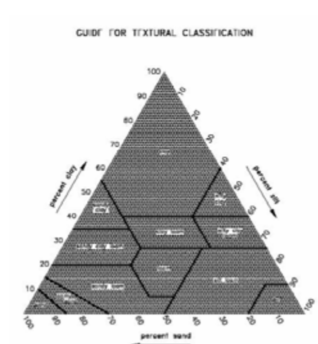
Texture

- Defined as the percentage by weight of separates (sand, silt and clay) that make up the physical composition of a given sample
- One indicator of a soil's ability to transmit water
- Uses the textural triangle
- Usually identified through hand texturing
- ASTM has a field guide to assist

257

Soil Texture Profile



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Structure

- More important than texture for determining water movement
- Common types of structures:
  - Granular
  - Angular blocky
  - Subangular blocky
  - Platy
- Structureless soils include:
  - Massive
  - Single-grain (sand)
- Grade, size, shape and orientation influence water movement

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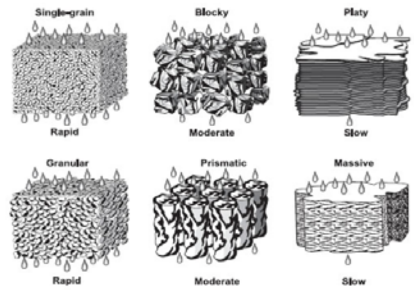
Soil Structure



Source: USDA, 1951.

260

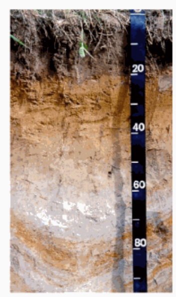
Other Indicators

- Color:
  - Indicates soil's aeration status and moisture regime
- Redoximorphic
  - Can suggest the soil is intermittently saturated
  - Product of biochemical activity

261

Soil Color

- Easily identified property.
- Used to relate chemical/physical properties such as watertable depth, drainage, chemical constituents, formation, horizons.



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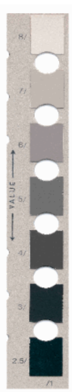
Value

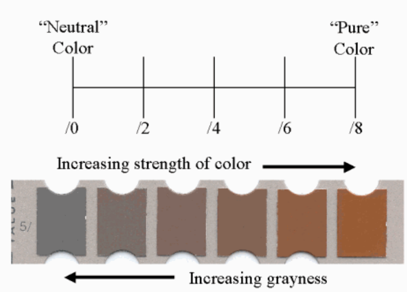
The Lightness or Darkness of Color

- 10/0 - Pure White
- 5/0 - "Gray"
- 0/0 - Pure Black



263

Chroma



264

Soil Color

- The munsell color book is used to document color in a standard notation.
- **Hue:** Dominant spectral color.
- **Value:** The degree of light/dark of a color in relation to a neutral gray scale.
- **Chroma:** Strength of hue.

265

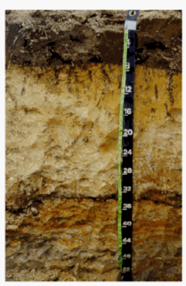
Reading Soil Colors

- Optimum conditions
  - Natural light
  - Clear, sunny day
  - Midday
  - Light at right angles
  - Soil moist
  - NO sunglasses!

266

Describing Soil Color Patterns

- Matrix color - dominant color of horizon.
- Redox colors.
- Redox contrast, abundance, size, shape, location, boundary, etc.
- Other colors (mottles)



267

Redoximorphic Features

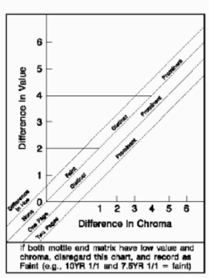
After the matrix color is determined, record the color patterns of the redox features if present.

- Can be very complex.
- Describe color, size, contrast, shape, location.

268

Contrast of Redox

- Contrast refers to the degree of visual distinction between associated colors
  - Faint -- evident only on close examination.
  - Distinct -- readily seen.
  - Prominent -- contrast strongly.

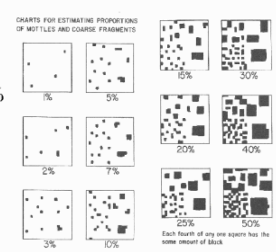


269

Abundance and Size of Redox

- Few -- less than 2%
- Common -- 2 to 20%
- Many -- more than 20%

- Fine -- < 5 mm
- Medium -- 5 to 15 mm
- Coarse -- > 15 mm



270

Step 6

- Process steps:
  - Look for lateral changes in soil profile
  - Use auger and/or compare to profile of second pit
- Information to be collected
  - Determine changes, if any, in soil profile across proposed site

271

Step 7

- Process steps:
  - Identify limiting depths
- Information to be collected
  - Check vertical separation distances
  - Identify mottled layers, concretions
  - Determine depth to saturation
  - Measure depth to confining layer
  - Identify highly permeable layers

272

Estimating Groundwater Flow

- Infiltration rate: rate at which water is accepted by the soil
- Hydraulic conductivity: rate at which water is transmitted through the soil
- Both are determined using site percolation tests

273

Groundwater Table

- Important if present within 5 feet below the small infiltration systems or 10-15 feet below large systems
- Should estimate the following:
  - Depth
  - Seasonal fluctuation
  - Direction of flow
  - Transmissivity
  - Thickness of the water table
- Mounding beneath the infiltration system can decrease its effectiveness

274

Step 8

- Process steps:
  - Log all data onto required survey forms in required format
- Information to be collected
  - Develop system type, size, location and installation recommendations

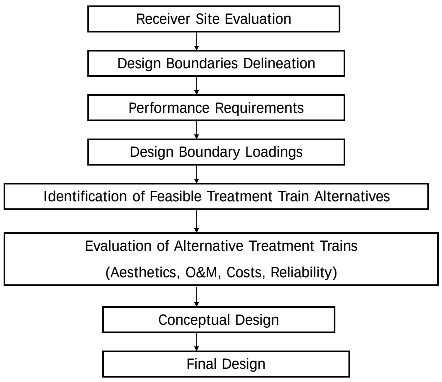
275

Identification of Recommended SWIS Site

- Integration of all collected data
- Identification of preferred areas
- Assessment of gravity-based flow
- Final SWIS site selection

276

OWTS Design Concept Diagram



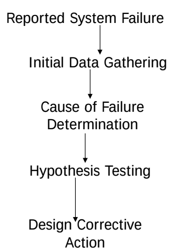
277

System Failure Indicators

Type of Failure	Evidence of Failure
Hydraulic failure	Untreated or partially treated sewage pooling on ground surfaces, sewage backup in plumbing fixtures, sewage breakouts on hill slopes
Pollutant Contamination of groundwater	High nitrate levels in drinking water wells; taste and odor problems in well water; presence of toxic chemicals in well water
Microbial contamination of ground and surface water	Shellfish bed bacterial contamination; recreational beach closure due to high bacterial levels; contamination of drinking water wells with fecal bacteria
Nutrient contamination of surface water	Algae blooms, high aquatic plant productivity, low DO concentrations

278

Failure Diagnosis Procedure



279

Initial Data Gathering

- System layout and boundary loadings
- Soil test reports
- Age of system
- Description of failure symptoms
- Daily flow estimates
- Visual observation

280

Failure Hypothesis

- Cause of Failure
  - Develop failure hypothesis considering:
    - Failure boundary
    - Boundary loadings
- Hypothesis Testing
  - Soils testing
  - Wastewater metering
  - Wastewater sampling
  - Component testing/monitoring

281

Design Corrective Actions

- Change boundary loadings
  - Water conservation
  - Wastewater segregation
  - Additional infiltrative surface area
  - Pretreatment
  - Subsurface drainage diversion
  - Infiltrative surface orientation and geometry
- Change receiver site
- Change receiving environment

282

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EXAMPLE DESIGN INFORMATION from THE STATE OF DELAWARE

283

Site Evaluation Report

- A site drawing and observations of
  - Soil borings, holes and/or pits
  - Parcel size, location map of project site, configuration and approximate dimensions
  - Slope – percent and direction
  - Surface streams, borings or bodies of water and their definition
  - Existing wells within 150 feet of approved soils areas
  - Escarpments
  - Cuts and fills
  - Unstable landforms
  - A representative number of soil profile descriptions in the evaluated area(s) and the soil series or classification to the subgroup level
  - Zones of saturation (as indicated by redoximorphic features)
  - Approved soils area(s)
  - Encumbrances
  - Central wastewater or water systems availability
  - Any other applicable information such as hydric soils
  - Any overhead lines
  - Existing dwellings

284

Percolation Tests

- One test shall consist of at least 3 holes
- The test depth:
  - If the limiting zone is at least 20 inches from the soil surface, the test shall be within the zone, but not more than 60 inches
  - If the limiting zone is less than 20 inches, the site is unsuitable for a conventional system
- The holes shall be a minimum 6 inches in diameter
- The bottom and sides of each hole shall be scarified; loose soil shall be removed; 2 inches of coarse sand or aggregate shall be added to the hole bottom
- The hole shall be filled with 12 inches of water above the aggregate layer; this level shall be maintained for at least 4 hours

285

Percolation Tests, Part 2

- The water level shall be adjusted to 6 inches over the gravel or sand; the hole shall be allowed to stand for 30 minutes; the water level shall again be adjusted to 6 inches and let to stand for 30 minute
- Where the water level drop is 2 inches or more in 30 minutes, the readings shall be 10 minutes apart
- Where the water level drop is less than 2 inches in 30 minutes, the readings shall be 30 minutes apart
- Readings shall continue for a minimum of 4 hours where the interval between readings is 30 minutes
- For intervals of 10 minutes, the readings may be discontinued after 1 hour
- If the water levels have not stabilized after the minimum period, the testing shall continue
- A steady state is established when two consecutive water level drops do not exceed 1/16 inch
- The percolation rate shall be the average of all percolation tests conducted; sites with rates less than 120 mpi are not acceptable

286

Design Information

- Disposal system sizing
  - Trenches: for percolation rates less than 120 minutes/inch, the trench area shall be equal to $0.33*Q*(t)^{0.5}$
  - Seepage beds: For percolation rates less than 120 mpi, the bed area shall be equal to $0.42*Q*(t)^{0.5}$
  - Q is flow in gpd, t is the average percolation rate in mpi, with a minimum of 20 mpi
  - Where percolation rates are faster than 5 mpi, a pressurized distribution system is required and the area shall be equal to 1.2*Q

287

Materials

- Sandy fill materials shall be medium sand, sandy loam, loamy sand/sandy loam mixture and shall have the following maximum percentage passing sieve:
  - For 3/8": 100%
  - For No. 4: 95-100%
  - For No. 50: 5-30%
  - For No. 100: 1-7%
- Filter aggregate shall have the maximum percentage passing sieve:
  - For 2.5": 100% minimum
  - For 2": 100% minimum
  - For 1.5": 100% minimum
  - For 1": 100% minimum
  - For ½": 50% maximum
  - For #4: 10% maximum
  - For #8: 0% maximum

288

Gravity Trenches and Beds

- Filter aggregate:
  - Minimum of 12 inches deep, with 6 inches placed under the distribution laterals, and a minimum depth of 2 inches above the crown of the distribution pipe
  - For trenches and beds with sidewalls of 24 inches
    - Backfill must be at least 12 inches deep above the fabric filter
    - Backfill shall not be tamped
  - For trenches with sidewalls of 12-24 inches
    - A capping fill must be placed over the trench or bed
    - No stones larger than 2 inches
    - The minimum gradient shall be 3:1 with a recommended 5:1

289

Sand Mounds

- Bottom soils shall be plowed to a depth of 6-8 inches
- Sandy fill shall be applied to a specified depth
- A 12 inch layer of filter aggregate shall be added to the sand layer
- 6 inches shall be placed under the distribution lateral, with 6 inches placed around and above the lateral, with at least 2 inches over the crown of the lateral
- A minimum distance of 4 feet and a maximum distance of 6 feet shall separate adjacent laterals
- The slope of the sand fill shall be a minimum of 3:1 with 5:1 recommended
- Mound covering shall be loamy sand or sandy loam
- The mound shall extend 12 inches above the 12 inch filter aggregate layer, plus at least 6 inches of top soil
- The outside cover or berm shall be 3:1 with a recommended 5:1
- Grass or sod shall be used for erosion control

290

Wastewater Flow Rates

- The projected peak flow rate shall be the design flow rate
- If actual flow rates are available, the records over the last 3 years shall be used
- Residential dwelling flow rates shall be 120 gallons per bedroom, with a minimum flow rate of 240 gpd being used

291

Septic Tank Design

- The standard wastewater treatment method shall be a septic tank
- Minimum volume shall be 1,000 gallons
- The capacity of septic tanks shall be:
  - Flow less than or equal to 500 gpd, 1,000 gals
  - Flow >500 gpd and less than or equal to 15,000 gpd, the volume shall be 1.5 times the expected flow rate, with a minimum of 1,500 gals
- All tanks shall be watertight, non-corrosive, durable and structurally sound
- Materials of construction shall be:
  - Cast in place reinforced concrete with a minimum wall thickness of 4 inches
  - Pre-cast reinforced concrete with a minimum wall thickness of 2.5 inches
- All tanks shall be multi-compartmented with a minimum of 2 compartments; the first shall contain at least 2/3 of the volume
- Inlet/outlet baffles shall be constructed of cast in place concrete or PVC and at least 3 inches in diameter; the tees shall extend 12 inches below the liquid level, but no deeper than 40% of the total liquid depth

292

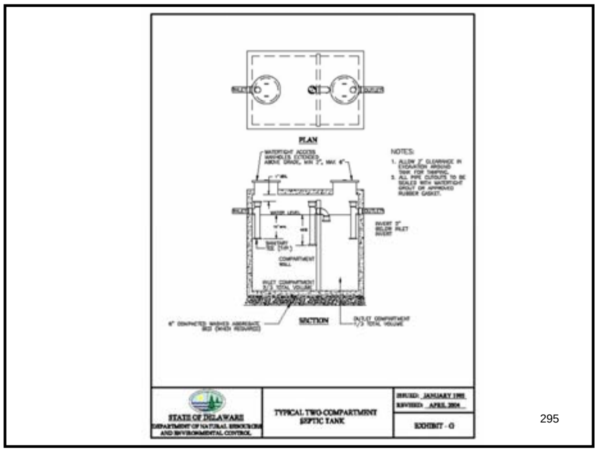
Septic Tank Installation

- Excavation:
  - Shall be large enough to allow safe, unencumbered working conditions, but in no case more than 2 feet outside the tank dimensions and deep enough top allow gravity flow from the source
- Foundation:
  - Be placed on firm, dry, granular, undisturbed soil that has been graded level;
  - A gravel bed foundation shall consist of stone no larger than that which will pass through a ¾" sieve and shall have a minimum thickness of 6 inches and extend 1 foot beyond the tank perimeter
- Backfill:
  - Can use previously excavated material from the site if stones larger than 4" , construction debris, concrete, wood are removed
  - Shall extend a minimum of 2 feet beyond the perimeter of the tank
  - Shall be placed in uniform 8 inch layers and compacted to no less than 85% of the Modified Proctor Test
- Testing:
  - All tanks shall be tested by filling to overflowing with water to observe the operations of all connections and fittings

293

DE ENGINEERING DRAWINGS

294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STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL
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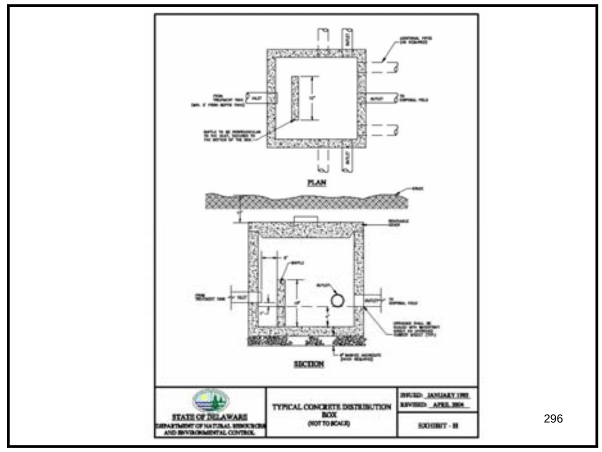
ISSUED: JANUARY 1985
REVISED: APRIL 2004
EXHIBIT - G
295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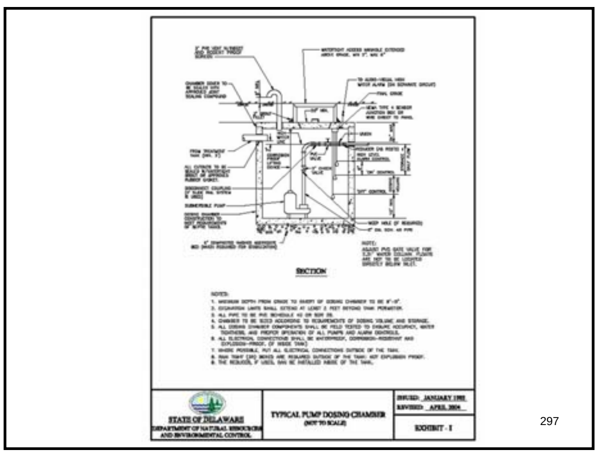
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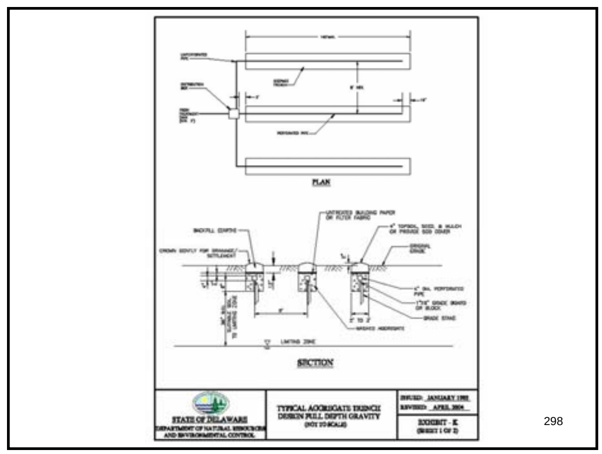
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DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL
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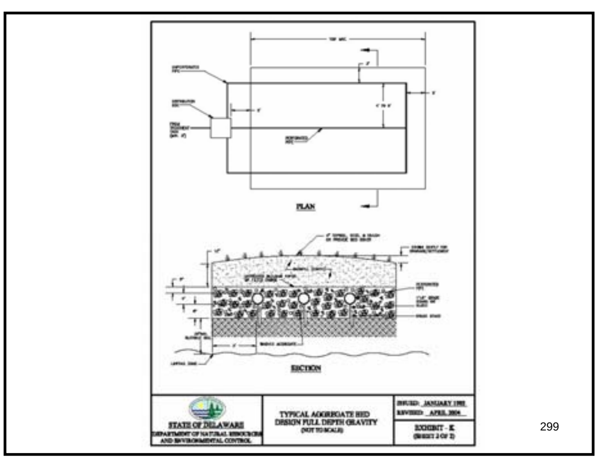
ISSUED: JANUARY 1985
REVISED: APRIL 2004
EXHIBIT - K
(SHEET 1 OF 2)
298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DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL
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ISSUED: JANUARY 1985
REVISED: APRIL 2004
EXHIBIT - K
(SHEET 2 OF 2)
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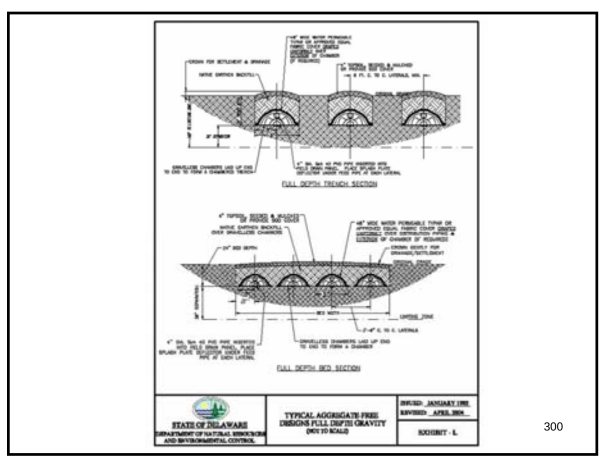
FULL DEPTH TRENCH SECTION
FULL DEPTH BED SECTION
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DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL
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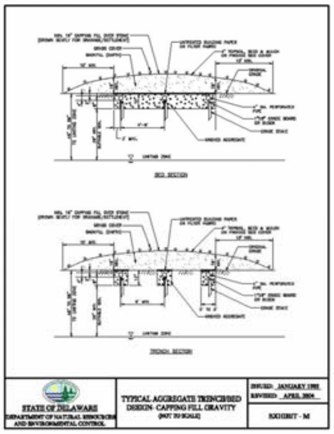

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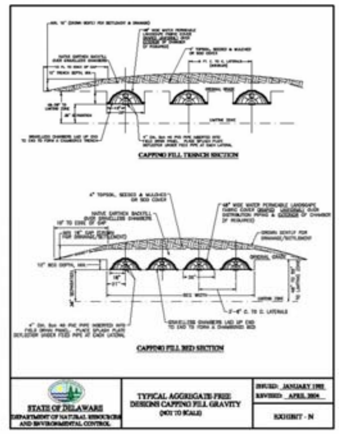

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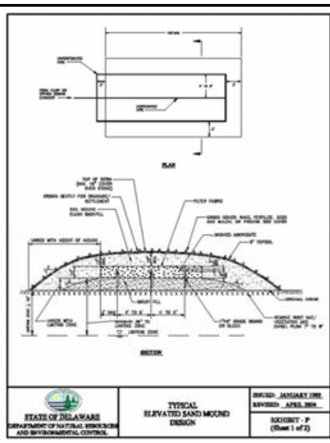

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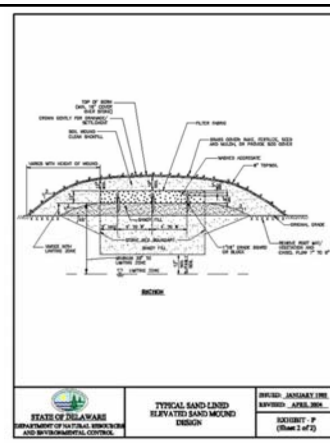

304

New York State Regulations

305

NYS Design Manual

http://store.payloadz.com/str-asp-i.51867-n.NYS_Department_of_Health_Individual_Residential_Wastewater_Treatment_Systems_Design_Handbook_1996_ed__Other_Files_-end-detail.html

Additional reference:

http://www.inspect-ny.com/ashi/inspusa.htm

306

Sections of Regulations

- Introduction (definitions)
- Regulation by other agencies
- Sewage flows
- Soil and site appraisal
- House or building sewer
- Septic tanks
- Distribution devices
- Subsurface treatment
- Alternative systems
- Other systems
- New product/system design interim approval

307

Sewage Flows

(excludes roof drains, garage, cellar and surface water drainage; water softener, water recharge and backwash water must have a separate system, 250 feet from wells or water courses)

Plumbing Fixtures	Design Flows GPD/Bedroom
Old Plumbing Fixtures 3.5+ gals/flush 3.0+ gpm/faucet	150
New Standard fixtures 3.5 gpf max 3.0 gpm/faucet max	130
Water saving toilets 1 gpf or less	90
Waterless toilets	75 (graywater only)

308

Site Separation

System Component	Well/Suction Line	Streams, etc.	Dwelling	Property Line
House sewer	25' if cast iron, 50' otherwise	25'	3'	10'
Septic tank	50'	50'	10'	10'
Effluent line/distribution box	50'	50'	10'	10'
Distribution box	100'	100'	20'	10'
Absorption field	100'	100'	20'	10'
Seepage pit	150'	100'	20'	10'
Dry well	50'	25'	20'	10'
Raised/mound system	100'	100'	20'	10'
Evapotranspiration system	100'	50'	20'	10'
Composter	50'	50'	20'	10'

309

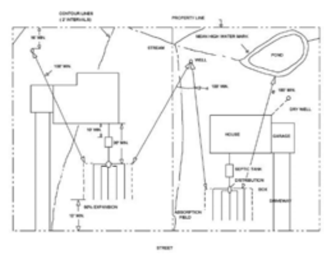

FIGURE 1
ABSORPTION FIELD SEPARATION REQUIREMENTS

310

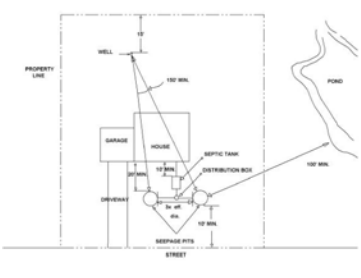

FIGURE 2
SEEPAGE PIT SEPARATION REQUIREMENTS

311

Site Investigation

- Determine highest groundwater level
- Have at least 4' of useable soil over impermeable deposits
- Test holes for seepage pits shall extend to mid-depth and full depth of pit bottom
- Soil tests may be in lieu of percolation tests

312

Soil Percolation Tests

- At least 2 tests/site
- For seepage pits, one test at bottom and one at mid depth
- Test must be consistent with soil classification

313

Septic Tank Capacities

(a garbage disposal shall be considered an additional bedroom)

No. of bedrooms	Min. Tank capacity (gals.)	Min. Liquid surface area (sq. ft.)
1-3	1,000	27
4	1,250	34
5	1,500	40
6	1,750	47
>6	250 for each bedroom	7 for each bedroom

314

Septic Tank Design

- A minimum liquid depth of 30” and a maximum depth of 60”
- Minimum distance between inlet/outlet 6’
- Must be watertight and made of durable material
- Tanks with liquid depth of 48” and greater shall have a top opening of 20” while shallower shall be 12”
- Tanks shall have inlet and outlet baffles that extend a minimum of 12-14” below liquid level for liquid depths of 40” or less and 16-18” for depths greater than 40”
- Min. clearance of 1” between the underside of the top of the tank and the top of all baffles
- Shall be placed on a minimum of 3” bed of sand or pea gravel
- A minimum elevation drop of 2” between the inverts of the inlet and outlet pipes

315

Additional requirements

- Multi compartment tanks
- Tanks in series
- Concrete tanks
- Fiberglass/polyethylene tanks
- Steel tanks
- Aerobic units

316

Distribution devices

- Distribution box
- Serial distribution
- Drop manholes
- Pressure distribution/dosing

317

Absorption Field

- Separated from other facilities
- Minimum of 4’ of useable soil above bedrock
- Minimum separation of 2’ from groundwater
- Not built under driveways, parts of buildings or above ground swimming pools
- Surface waters diverted from the vicinity of the system

318

TABLE 4A
REQUIRED LENGTH OF ABSORPTION TRENCH
(Based Upon Two (2) Feet Wide Trench)

Flow Rate (Gals/Day)										
Percolation Rate	2 Bdrms		3 Bdrms		4 Bdrms		5 Bdrms		6 Bdrms	
(Min./Inch)	260	300	390	450	520	600	650	750	780	900
1 - 5	108	125	162	187	216	250	270	312	325	374
6 - 7	130	150	195	225	260	300	325	375	390	450
8 - 10	145	167	217	250	290	333	360	417	433	500
11 - 15	162	188	244	281	325	375	406	469	488	563
16 - 20	186	214	279	321	372	429	464	536	557	643
21 - 30	217	250	325	375	433	500	542	625	650	750
31 - 45	260	300	390	450	520	600	650	750	780	900
46 - 60	290	333	433	500	578	667	722	833	867	1000*
	Dosing Not Required				Dosing or Alternate Design Required					

*Greater than 1000 ft of trench requires Alternate Dosing

319

PERCOLATION RATE minutes/inch	APPLICATION RATE gal/day/sq ft
1 - 5	1.20
6 - 7	1.00
8 - 10	0.90
11 - 15	0.80
16 -20	0.70
21 - 30	0.60
31 - 45	0.50
46 - 60	0.45
Soil with a percolation of less than 1 min/in is unsuitable for a conventional system	
Required Area (sq ft) = Flow Rate (GPD) / Application Rate (GPD/sq ft)	
Required Absorption Field Length = Required Area (sq ft) / 2 ft (trench width)	

320

Additional requirements

- Materials
- Construction
- Gravelless Absorption Systems
- Deep Absorption Trenches
- Shallow Absorption Trenches
- Cut and fill systems
- Absorption bed systems
- Seepage pits

321

TABLE 5
ABSORPTION BEDS - REQUIRED BOTTOM AREA

Percolation Rate Minutes/Inch	Application Rate Gallons/Day/Sq. ft.
1 - 5	0.95
6 - 7	0.80
8 - 10	0.70
11 - 15	0.60
16 - 20	0.55
21 - 30	0.45
30+	Not Acceptable

322

TABLE 6
SEEPAGE PITS - REQUIRED ABSORPTIVE AREA
(IN SQUARE FEET) FOR HOUSEHOLD SYSTEMS

PERCOLATION RATE MIN/IN	SEWAGE APPLICATION GPD/SQ.FT	300 GPD 2 BR	450 GPD 3 BR	600 GPD 4BR	750 GPD 5BR	900 GPD 6 BR
1 - 5	1.20	250	375	500	625	750
6 - 7	1.00	300	450	600	750	900
8 - 10	0.90	333	500	667	833	1,000
11 - 15	0.80	375	563	750	938	1,125
16 - 20	0.70	429	643	857	1,071	1,286
21 - 30	0.60	500	750	1,000	1,250	1,500
31 - 45	0.50	600	900	1,200	1,500	1,800
46 - 60	0.45	667	1,000	1,333	1,667	2,000
OVER 60	UNSUITABLE.........USE SPECIAL DESIGN					

323

TABLE 7
SEEPAGE PITS (CYLINDRICAL) - DIMENSIONS FOR
REQUIRED ABSORPTIVE AREA (IN SQUARE FEET)

DIAMETER OF SEEPAGE PIT (FEET)	EFFECTIVE STRATA DEPTH BELOW FLOW LINE (BELOW INLET)									
	1 FOOT	2 FEET	3 FEET	4 FEET	5 FEET	6 FEET	7 FEET	8 FEET	9 FEET	10 FEET
3	9.4	19	28	38	47	57	66	75	85	94
4	12.6	25	38	50	63	75	88	101	113	126
5	15.7	31	47	63	79	94	110	126	141	157
6	18.8	38	57	75	94	113	123	151	170	188
7	22.0	44	66	88	110	132	154	176	198	220
8	25.1	50	75	101	126	151	176	201	226	251
9	28.3	57	85	113	141	170	198	226	254	283
10	31.4	63	94	126	157	188	220	251	283	314
11	34.6	69	104	138	173	207	242	276	311	346
12	37.7	75	113	151	188	226	264	302	339	377

324

Alternative Systems

- General
- Raised system
- Mound systems
- Intermittent sand filters
- Evaporation-Transpiration systems
- Evaporation-Transpiration Absorption systems

325

Other systems

- Holding tanks
- Non-waterborne systems (composting toilets)
- Chemical/recirculating toilets
- Engineered systems

326

- END -

327