Cristen

Decentralized Wastewater Systems: From Planning and Design to Operations

Part 1: Planning, Design, and O&M Considerations for Collection, Treatment, and Disposal Systems

September 18, 2024

EFCN environmental finance center network

SOUTHWEST ENVIRONMENTAL FINANCE CENTER

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Meet the Team


Cristen

Cristen Crew
SU-EFC
Facilitator

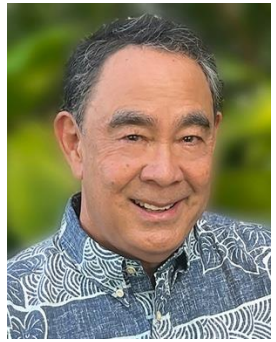
Cari Ishida, PhD, PE, ENV SP, Carollo
Project Manager

Adrienne Fung, PE
Carollo
Background

Jill Kjellsson, PE
Carollo
Collection and Disposal Systems

Andrew Gilmore, PE
Carollo
Wastewater Treatment

Jason Garside, PE
Carollo
Project Delivery



Mike Miyahira, PE, Carollo
Ownership & Permitting

Target Audience


Cari

- Wastewater treatment operators
- Civil/Environmental engineers and planners
- Leaders of organizations that may be able to help with implementation (e.g., agency leadership, owners of existing private wastewater systems, funding agencies, non-governmental organizations, etc.)

Poll of the audience


Cari

- Who's in attendance?:
  - Operator and/or maintenance personnel
  - Consulting engineer
  - Manager or engineer of a utility or agency
  - Manufacturer or vendor
  - Other

Agenda Parts 1 + 2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Part 1: Planning, Design, and O&M Considerations for Collection, Treatment, and Disposal Systems

Part 2: Program Development, Planning, Permitting, and Organizational Considerations

Introduction and background

Individual wastewater systems

Why decentralized systems?

Design, construction, and operation and maintenance considerations

Collection systems

Treatment systems

Effluent management or disposal systems

O&M staffing

Program development, planning, and permitting considerations

Process and timelines

Funding and ownership

Permitting

Case study

Learning objectives


Cari

1. **Understand the components of a decentralized wastewater system and why it makes sense for some individual wastewater system conversions.**
2. Discuss the steps that are involved with planning, design, and construction of a new decentralized system.

Why decentralized systems?


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Approximately **20 percent** of homes in the U.S. are **not** connected to public sewers (Olsen et al., 2022; U.S. Census Bureau, 2021).

Of the homes not connected to sewers, approximately **52 percent** have a household income of less than or equal to **$61,000** (U.S. Census Bureau, 2017).

There is a strong correlation between income and sewer access for Florida, Hawaii, Delaware, and Rhode Island (U.S. EPA, 2021).

Adrienne

02

Decentralized Systems Background

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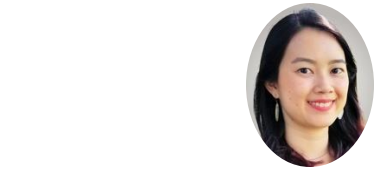
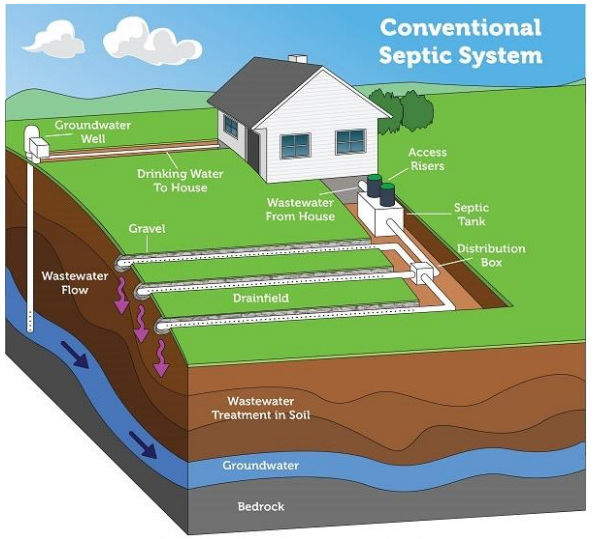
Definitions and key terminologies


Adrienne

- Decentralized, cluster, or satellite wastewater system

- Centralized wastewater system



- Individual wastewater systems

https://gis.hawaiicounty.gov/arcgisportal/apps/webappviewer/index.html?id=9517e052e2464706bfc81165e35b7fcc
https://twri.tamu.edu/publications/txh2o/2022/winter-2022/bigger-is-not-always-better-decentralizing-texas-wastewater-infrastructure/
https://www.epa.gov/septic/types-septic-systems

Poll: Project Experience


Adrienne

- What systems have you had experience with?
  - » Centralized wastewater systems
  - » Decentralized wastewater systems
  - » Individual wastewater systems
  - » More than one of the above
  - » None of the above

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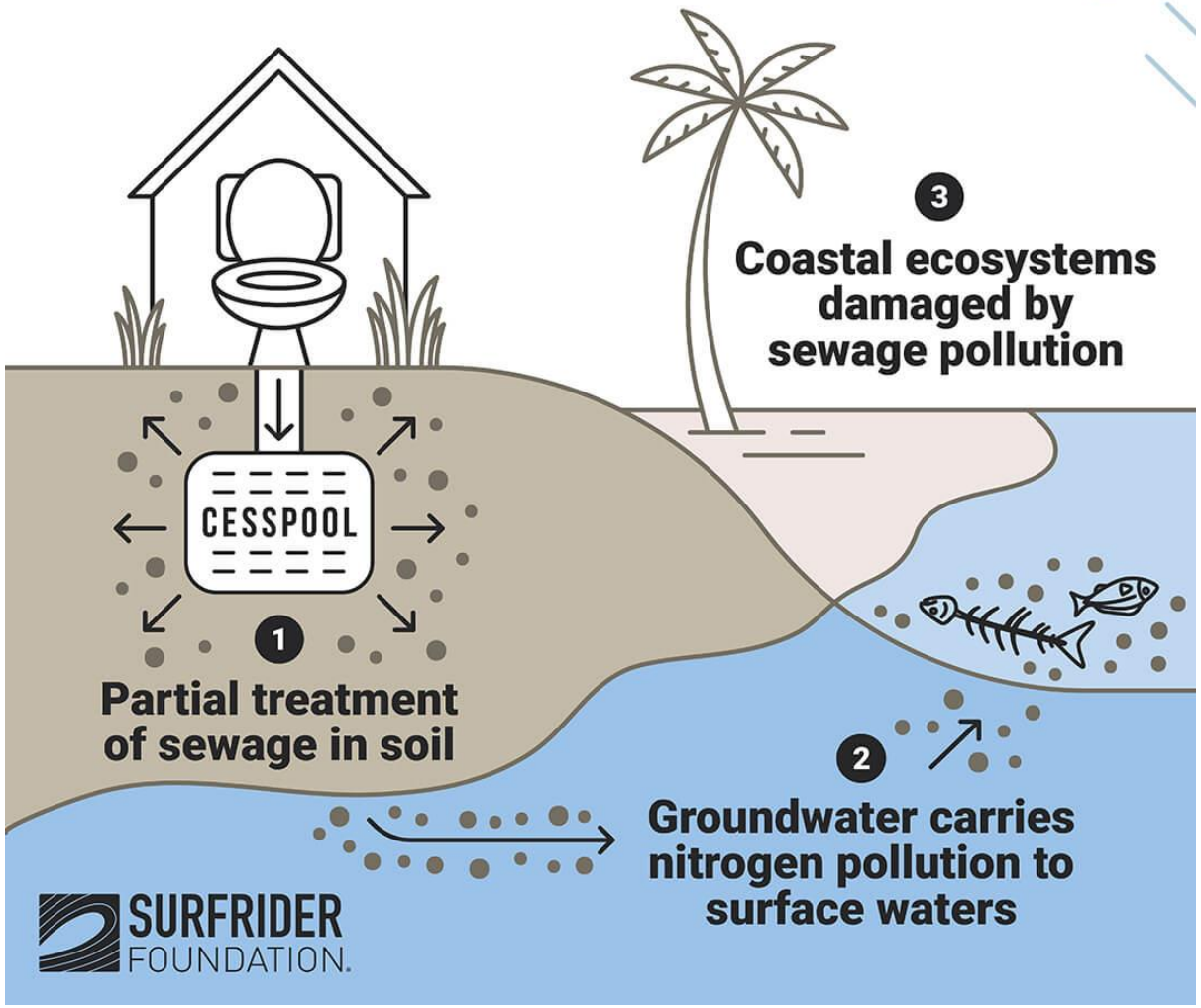
Impacts of individual wastewater systems on water quality

- Human Health
- Environmental Impact
- Recreation
- Economy



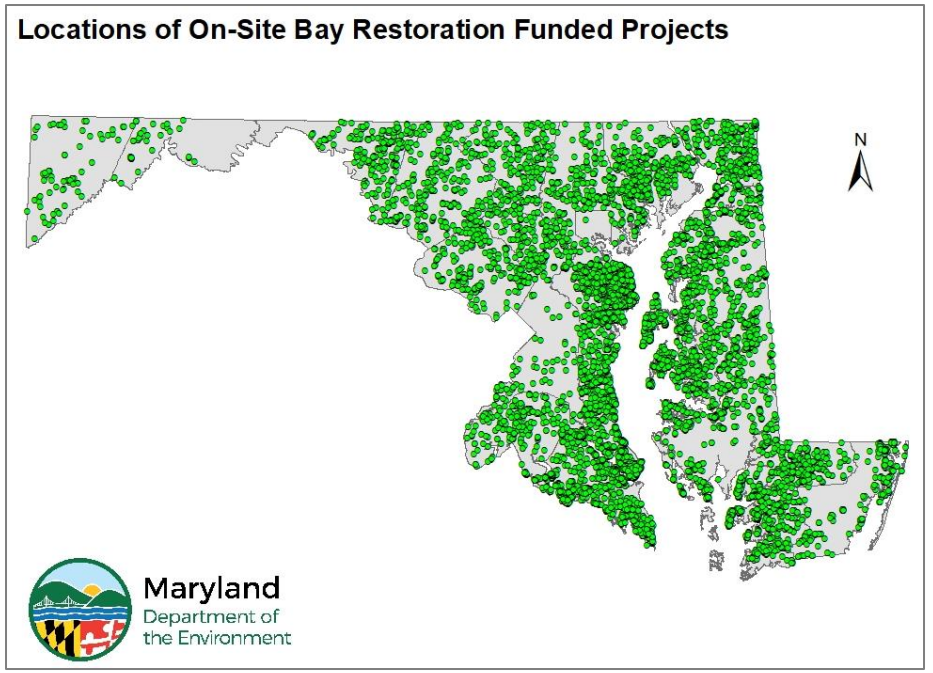
https://www.surfrider.org/news/how-do-cesspools-pollute-coastal-watersheds


Adrienne

Impacts of individual wastewater systems on water quality

Nationwide efforts to upgrade systems

- **Bay Restoration Fund, Maryland**
  - » **Decline in Chesapeake Bay water quality**
    - Urban/agricultural runoff and insufficiently treated wastewater
    - Over enrichment of nutrients (phosphorus and nitrogen)
  - » **Senate Bill 320 signed into law May 2004**
    - Wastewater treatment plant users finance fund to upgrade plants
    - Septic system users contribute fee ($60/year) to upgrade individual wastewater systems
      - 420,000 systems with 52,000 in critical area
    - Overall, $1.9 billion collected, 67 treatment plants and 13,000 septic systems upgraded



https://storymaps.arcgis.com/stories/f9430590dc9949dfabf9df42a041b522

Impacts of individual wastewater systems on water quality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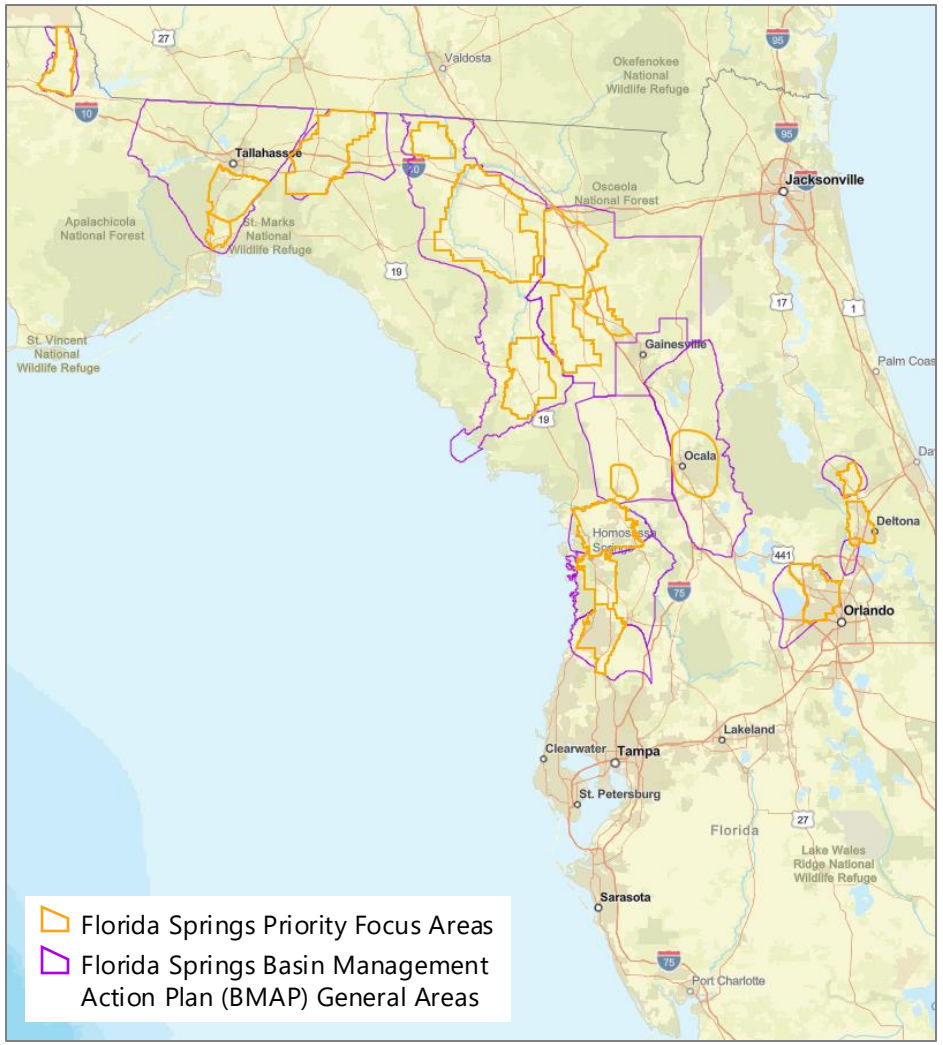
Nationwide efforts to upgrade systems

- **Springs and Aquifer Protection Act, Florida**
  - » **30 "Outstanding Florida Springs" in need of additional protections**
    - Excess nutrients from insufficiently treated wastewater, stormwater runoff, fertilizer use, densely clustered septic systems
  - » **2016 Legislation**
    - Basin Management Action Plans to identify and reduce nitrogen pollution
    - Septic System Remediation Plans in areas near impacted springs and in permeable (sandy) soil conditions
    - New septic systems in Priority Focus Areas are required to have enhanced treatment of nitrogen



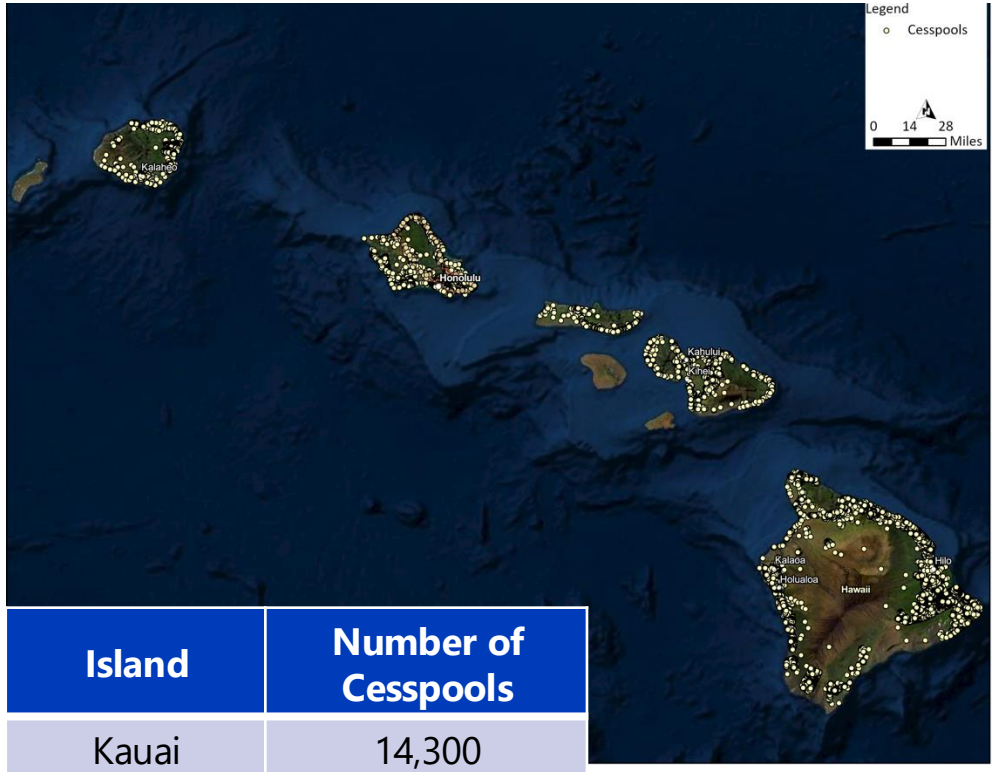
https://fdep.maps.arcgis.com/apps/MapSeries/index.html?appid=68b6aa46526a430189628c9319bbb02f

Impacts of individual wastewater systems on water quality


Adrienne

Nationwide efforts to upgrade systems

- **Cesspool Conversion Working Group, Hawaii**
  - » **State with the largest number of cesspools per capita**
    - Wastewater impacts on nearshore waters, coral reefs, and groundwater
    - Cesspools inject over 50 million gallons of untreated sewage into the ground per day
  - » **Act 125 "Cesspool Ban" passed in 2017**
    - All cesspools must be upgraded or connected to a sewer by 2050
    - Counties developing Integrated Wastewater Management Plan to evaluate opportunities for decentralized wastewater systems



Island	Number of Cesspools
Kauai	14,300
Oahu	7,500
Molokai	1,400
Maui	11,000
Hawaii	49,000
Total	**83,200**

https://www.civilbeat.org/2024/03/hawaii-still-has-a-serious-cesspool-problem/

Where are the individual wastewater systems?


Adrienne

- Approximately 20% of U.S. households have an individual wastewater system
- All 50 states have banned installation of new cesspools
- States with legacy policies still allow for existing cesspools
  - » Suffolk County, NY: 250,000 cesspools and 110,000 septic systems

Brown tide algae blooms worsen with crash of hard clam population in Great South Bay.

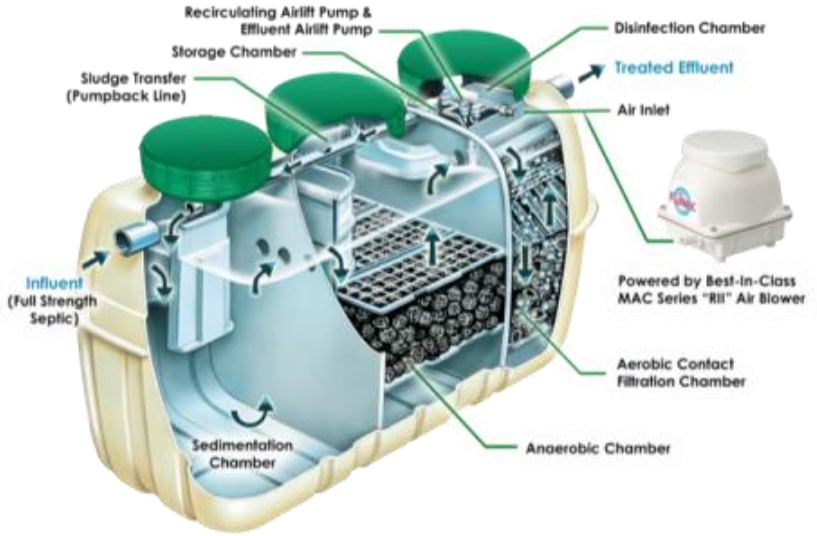
https://www.suffolkcountyny.gov/Portals/0/FormsDocs/Health/EnvironmentalQuality/ComprehensiveWaterResourceManagementPlan/Executive_Summary.pdf

Conversions of individual wastewater systems to…


Adrienne

- New decentralized, cluster, or satellite wastewater system

- Existing centralized wastewater system



- Enhanced individual wastewater systems

https://gis.hawaiicounty.gov/arcgisportal/apps/webappviewer/index.html?id=9517e052e2464706bfc81165e35b7fcc
https://twri.tamu.edu/publications/txh2o/2022/winter-2022/bigger-is-not-always-better-decentralizing-texas-wastewater-infrastructure/
https://www.fujicleanusa.com/cen-models-residential/model-cen-5

Centralized Systems

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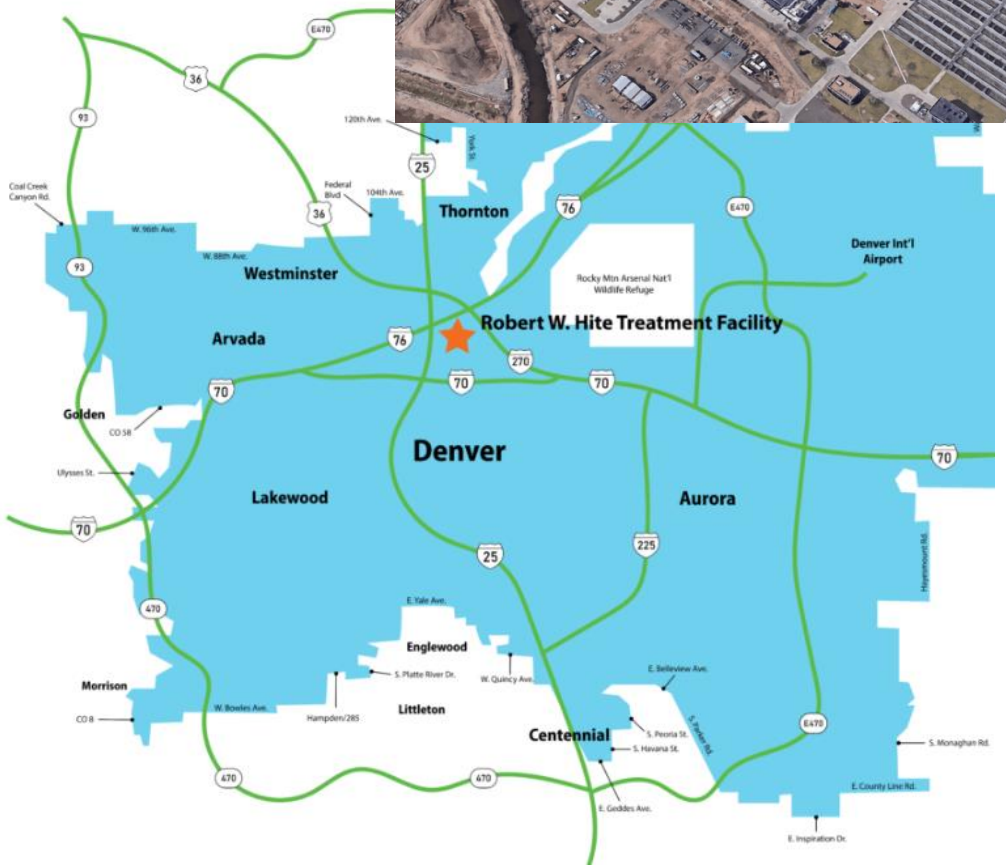
- Wastewater collection (sewer)
- Treatment
- Effluent management



https://www.metrowaterrecovery.com/about-us/our-service-area/#:~:text=Metro's%20service%20area%20includes%2062,for%20most%20of%20metropolitan%20Denver
https://www.hazenandsawyer.com/projects/metro-water-recovery-2018-facility-plan

Centralized Systems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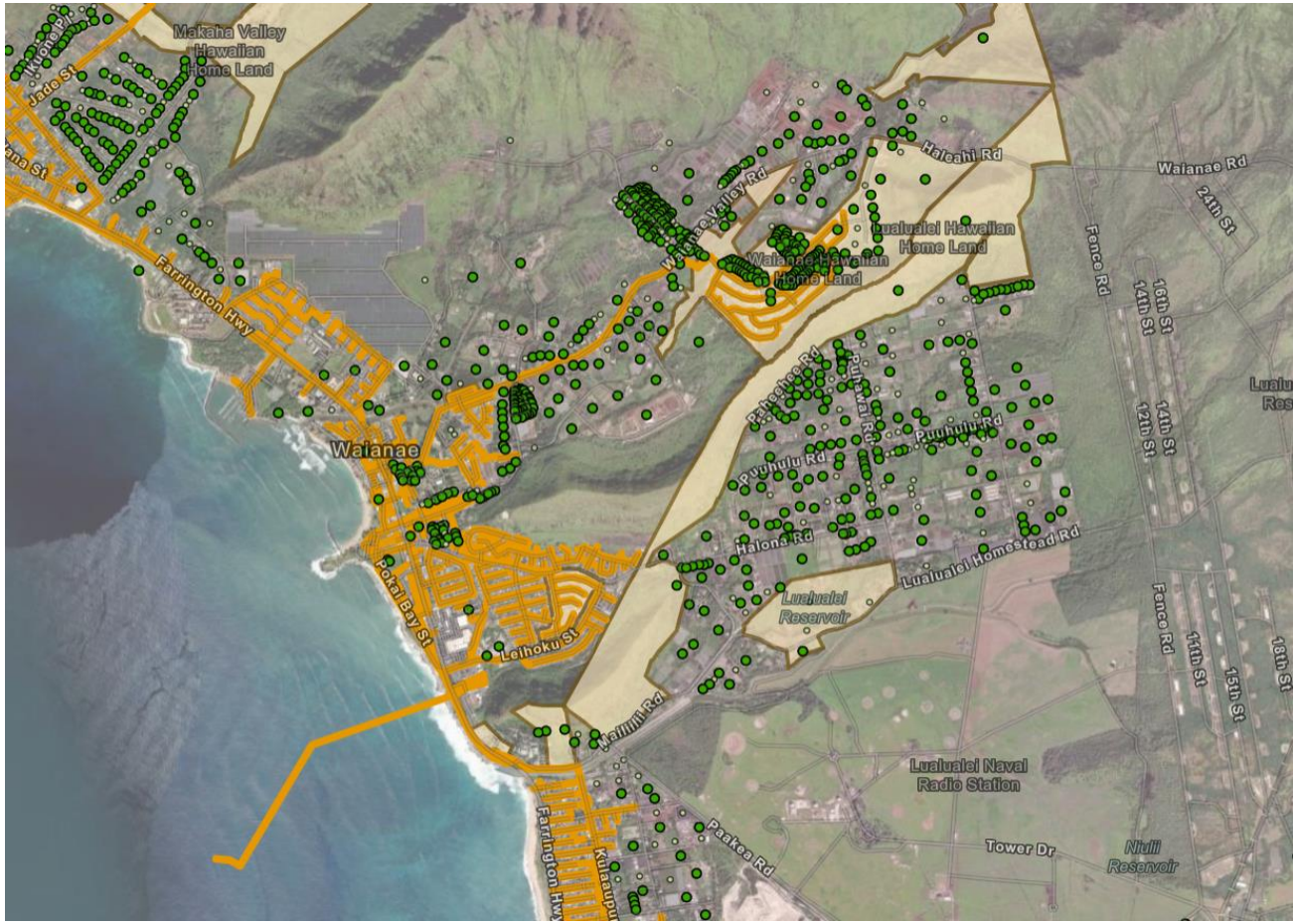
Conversion considerations

- Proximity to existing collection system
- Feasibility of extending the collection system
- Available capacity at the wastewater treatment plant
- Cost of upgrades and sewer fees



Example of cesspools within reasonable proximity to an existing centralized system.

Decentralized Systems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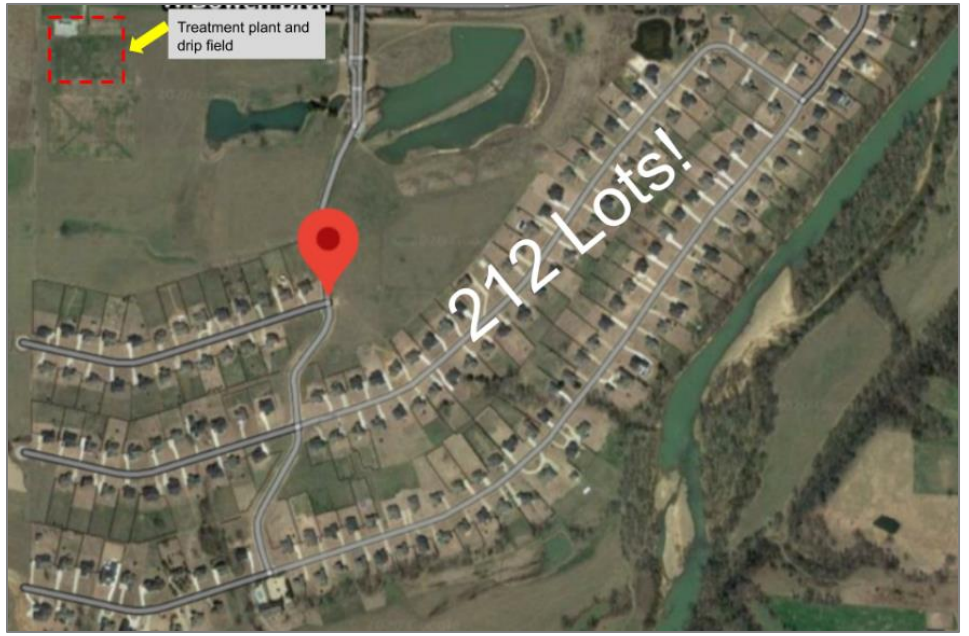
- Connecting groups of homes or commercial/industrial sites
- Smaller version of a centralized WWTP
- Larger version of an individual wastewater system



https://communitysewer.com/wastewater-treatment-package-plants/
https://www.fluencecorp.com/what-is-decentralized-treatment/

Decentralized Systems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Application

- Customizable
  - » Serve communities or groups of homes
  - » Scalable and modular
- Reliable
  - » Level of treatment matches that of centralized WWTPs
  - » Specialized personnel to operate and maintain systems
- Cost-Effective
  - » Eliminates need to pipeline wastewater customer to distant plant
  - » Expand capacity with demand


Single wastewater plant


Tandem wastewater plants


three wastewater plants


four wastewater plants

https://communitysewer.com/wastewater-treatment-package-plants/

Decentralized Systems


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Application

- Hotels and resorts
- Remote mine and construction sites
- Campgrounds and parks
- Highway rest areas and truck stops
- Apartment complexes
- Military bases
- Power stations
- Schools and universities
- Towns and small residential communities
- Hospitals and nursing homes
- Churches

https://haydukengineering.com/projects/water-and-wastewater-engineering/hampton-inn-advanced-wastewater-treatment-plant-islandia-ny/

Decentralized Systems


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Benefits and Challenges

- Highly regulated system to ensure human health and environmental protection
- Need for licensed, skilled operators
- Homeowners will not have to operate and maintain an individual system
- Potential to reduce the burden of homeowner individual wastewater system upgrades by limiting scope to sewer lateral
- Land/space requirements

Decentralized Systems


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Benefits and Challenges

- Potential to reduce potable water use and increase recycled water use
- Broadens range of funding opportunities, but may need funds for up-front planning, design, and construction
- Potential for rapid conversions of individual wastewater systems
- Neighborhood coordination needed (e.g., Sewer Improvement District)

Decentralized Systems

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Conversion Considerations

- **Number of individual wastewater systems, density, zoning**
- Feasibility of constructing a collection system
- Effluent disposal options
- Biosolids handling options
- Cost of upgrades and sewer fees

Example of feasible conversion

- Clusters close together, densely spaced cesspools

Example of infeasible conversion

- Low density, spread out; far from existing sewer

Decentralized Systems


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Conversion Considerations

- Number of individual wastewater systems, density, zoning
- **Feasibility of constructing a collection system**
- Effluent disposal options
- Biosolids handling options
- Cost of upgrades and sewer fees

https://www.dezeen.com/2013/10/15/car-park-house-by-anonymous-architects/

Decentralized Systems


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Conversion Considerations

- Number of individual wastewater systems, density, zoning
- Feasibility of constructing a collection system
- **Effluent disposal options**
- Biosolids handling options
- Cost of upgrades and sewer fees

https://www.pomonaca.gov/government/departments/water-resources-department/recycled-water

Decentralized Systems


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Conversion Considerations

- Number of individual wastewater systems, density, zoning
- Feasibility of constructing a collection system
- Effluent disposal options
- **Biosolids handling options**
- Cost of upgrades and sewer fees

https://www.synagro.com/offerings/thermal-drying-pelletization/

Decentralized Systems


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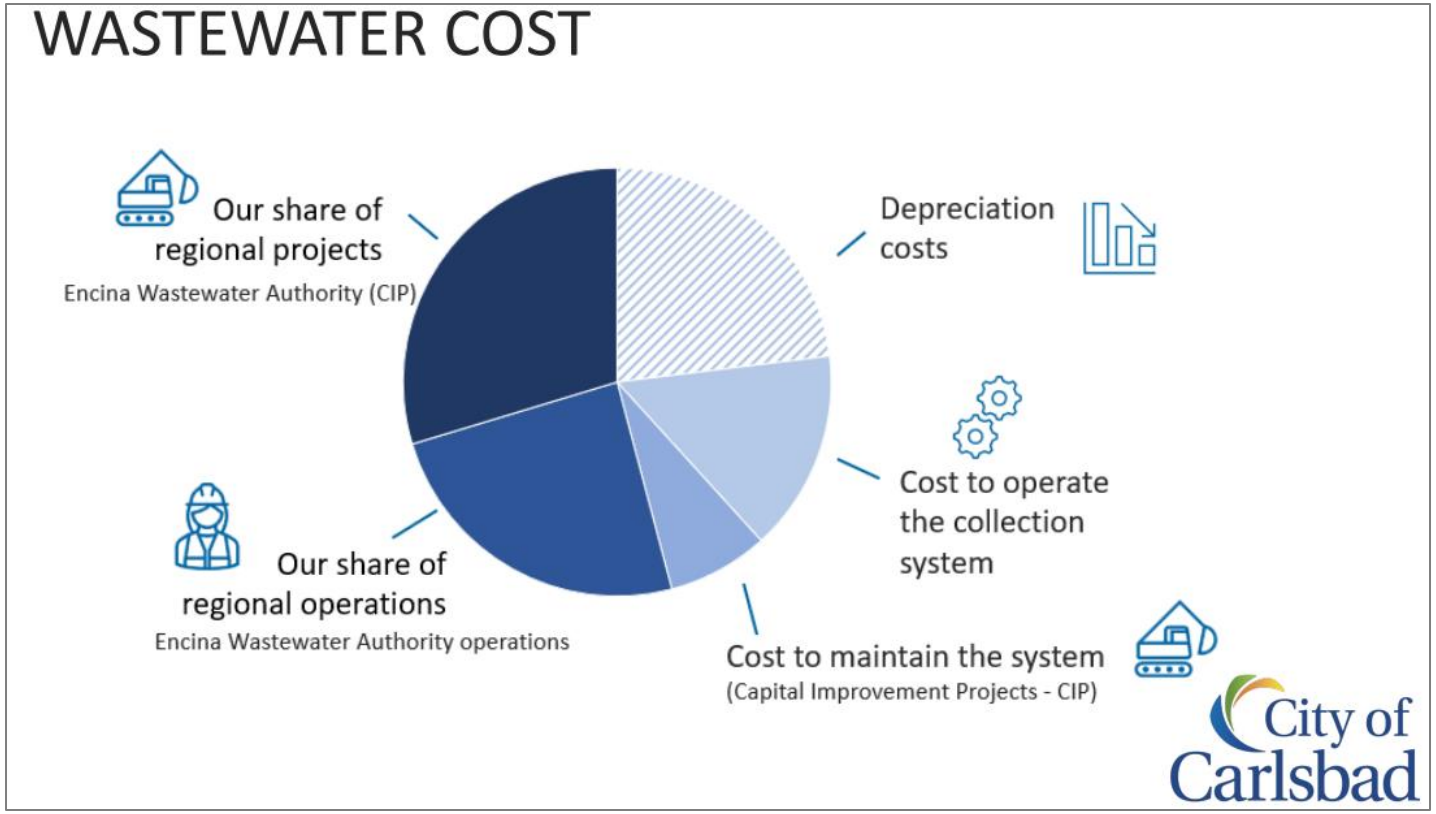
Conversion Considerations

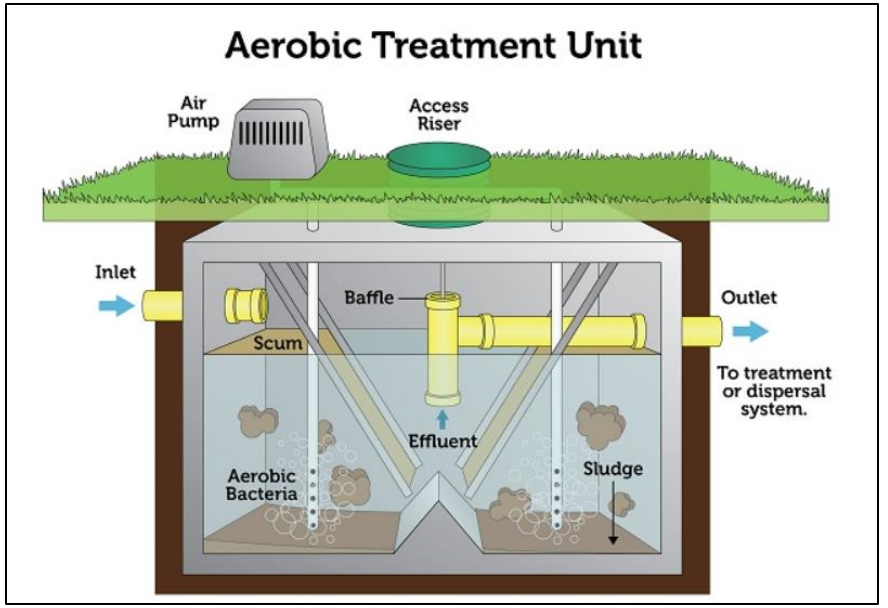
- Number of individual wastewater systems, density, zoning
- Feasibility of constructing a collection system
- Effluent disposal options
- Biosolids handling options
- **Cost of upgrades and sewer fees**

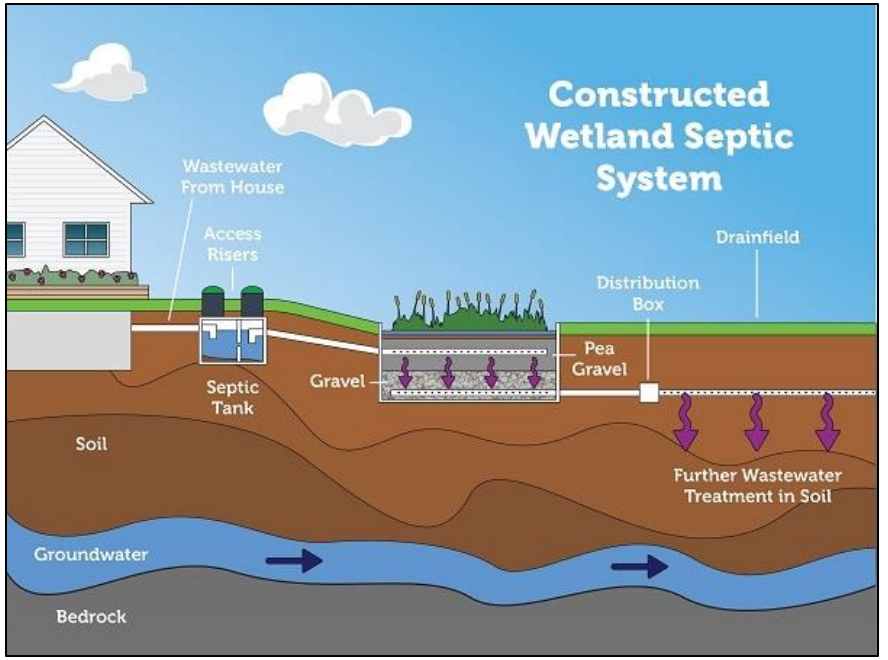


https://www.carlsbadca.gov/home/showpublisheddocument/8894/637776974805270000

Individual Wastewater Systems

- Onsite system, usually max of 2,500 gallons per day
- Site evaluation and percolation test by licensed professional
- Application process with state agency
- Approved systems
  - » Testing
  - » Performance Criteria
- Typically operated and maintained by homeowner





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Individual Wastewater Systems


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Conversion Considerations

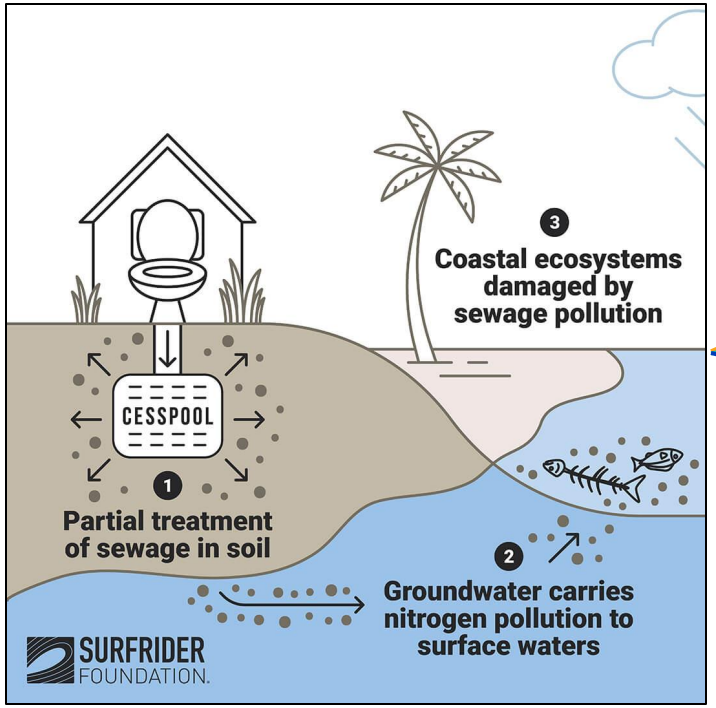
- Type of technology (level of treatment)
- Approval status
- Site characteristics
  - » Lot size
  - » Terrain
  - » Soil type
  - » Depth to groundwater
  - » Etc.

Home - ACSI (acsihawaii.com), Distributors | FujiClean USA | Wastewater Treatment Systems

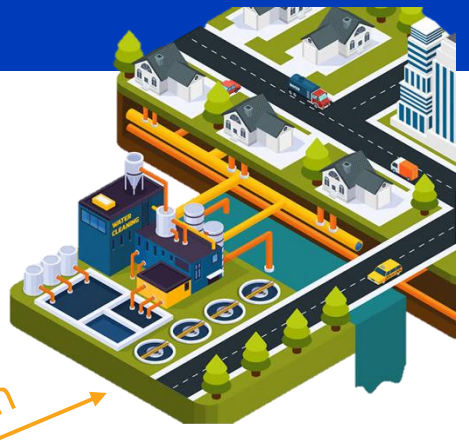
Recap of what was learned


Adrienne

Conversions of underperforming individual wastewater systems.

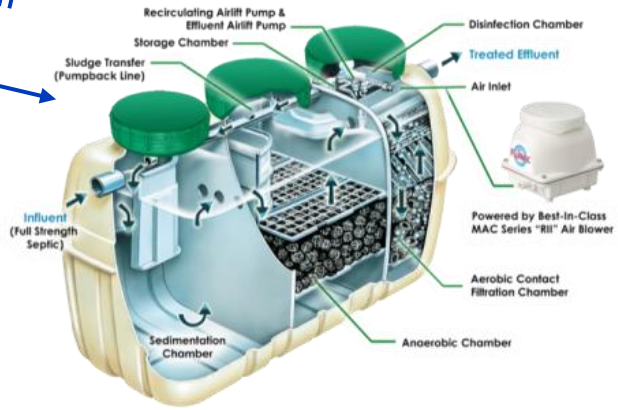


New Decentralized System



Existing Centralized System

Upgraded Individual Wastewater System



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https://www.fujicleanusa.com/cen-models-residential/model-cen-5


Cari

03

Planning, Design, Construction, and O&M Considerations

Module contents


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1. Collection systems
2. Treatment systems
3. Effluent management systems

Decentralized Systems


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- Customizable
- Reliable
- Cost-Effective

Key considerations of decentralized treatment


Cari

- Number of individual wastewater systems, density, zoning
- Feasibility of constructing a collection system
- Effluent disposal options
- Biosolids handling options
- Cost of upgrades and sewer fees

Collection system technology


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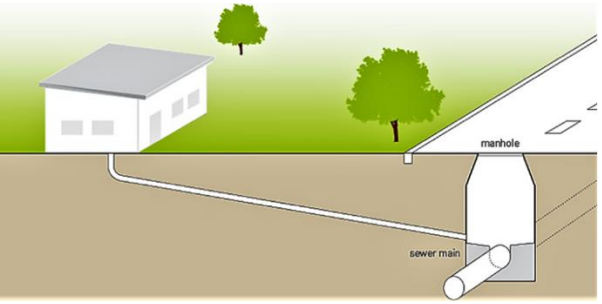
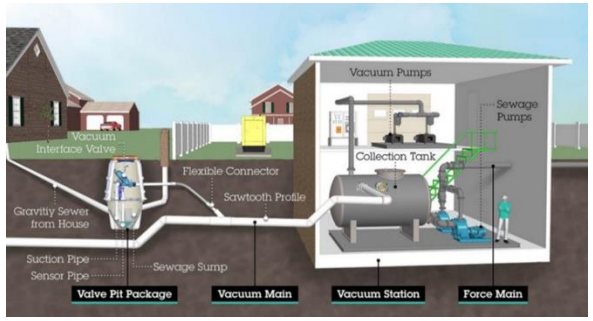
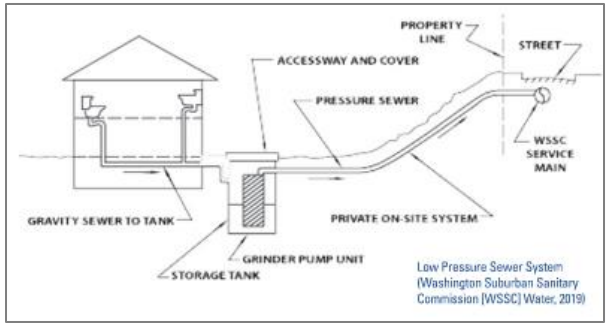






1

Gravity sewers

2

Vacuum sewers

3

Liquid-only pressure sewers

4

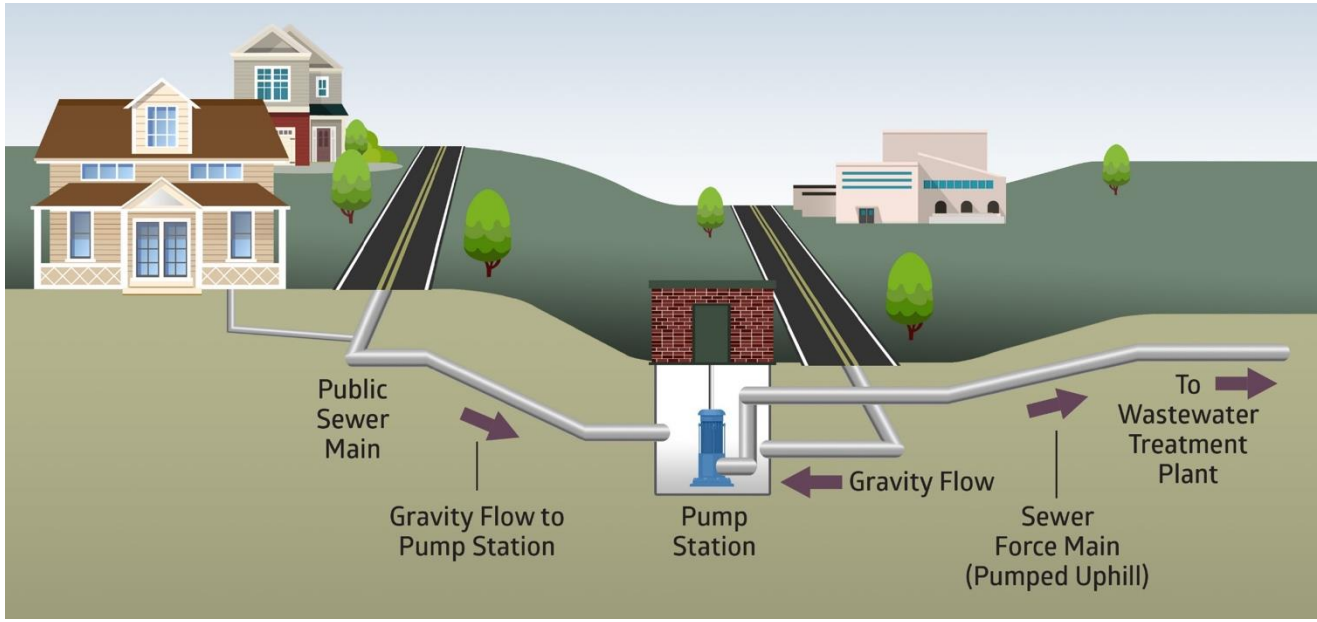
Low-pressure sewers

Gravity Sewers


Jill

Definition

- Pipes are installed on a **slope**, allowing **gravity** to direct the flow
- Pump stations can be used with gravity sewers in areas where terrain isn't ideal



Typical Gravity Sewer System.

Source: Town of Sudbury, 2024.

Gravity Sewers


Jill

Considerations

- Can handle **grit** and **other solids**, as well as **large volumes** of flow.
- **Does not require onsite treatment** or storage of the household wastewater before it is discharged.
- Presents a viable option if there is an appropriate **difference in elevation**.
- **No electricity** for pumping and no pump maintenance by the homeowner.

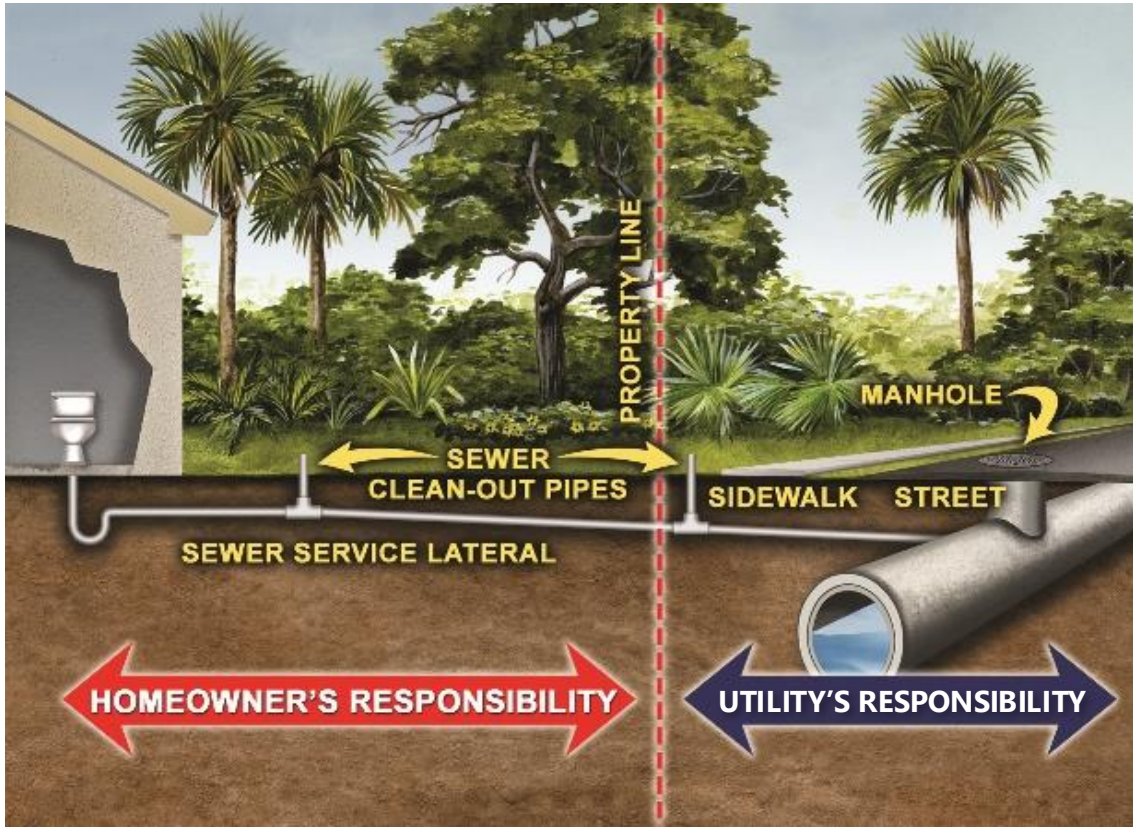


Image: https://loxahatcheeriver.org/septic-sewer-conversions/gravity-sewer-system/

Gravity Sewers


Jill

Considerations

- Flat or large variations in terrain can increase costs if pump stations or force mains are needed.
- **Larger pipes** compared to other collection system options.
- Requires **regular cleaning and inspections** to prevent clogging.
- Manholes associated with gravity sewers are a potential source of **inflow and infiltration**.

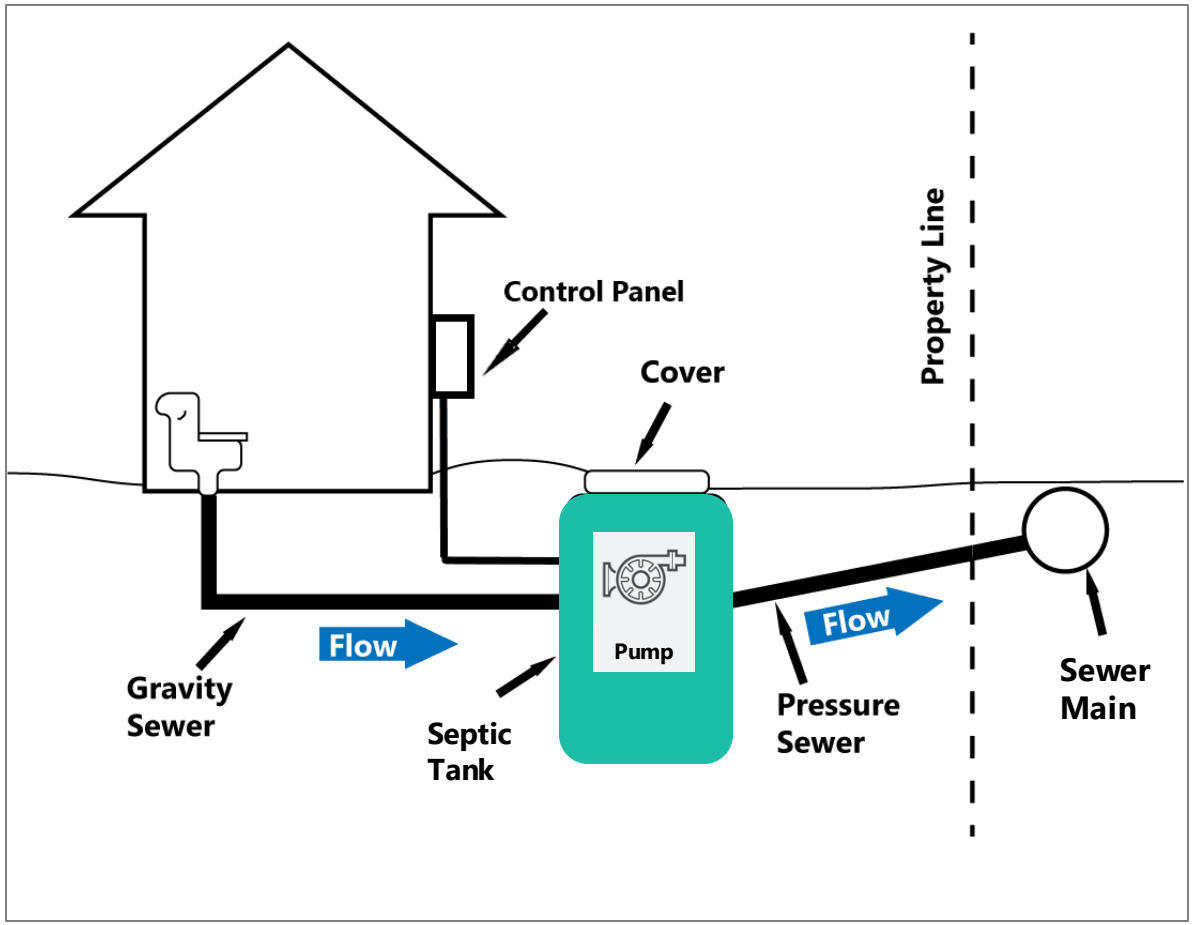
Image: https://www.midwaycitysanitaryca.gov/sewer-maintenance-activities

Liquid-only pressure sewers


Jill

Definition

- Operation in pressure sewers is **driven** by **pumps**.
- **Onsite septic tank** retains most of the solids.
- **Pump** to **discharge** the **liquid** portion to the sewer network.



https://www.cfpua.org/791/Grinder-Pumps

Liquid-only pressure sewers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Considerations

- **Independent** from land **topography restrictions**.
- Can be installed at a **shallow depth** and **do not require a minimum velocity** or slope to function.
- Septic tank retains most of the FOG and solids **reducing clogging** problems in the pressure sewers.
- Septic tanks have storage capacity to **operate during power outages**.
- **Smaller pipes** compared to conventional gravity sewers.

Liquid-only pressure sewers


Jill

Considerations

- Requires an **onsite septic tank** and **pump** on each property.
- **Grease and sludge must be pumped** from each individual septic tank.
- Anaerobic septic tanks can generate **odors and methane gas**.
- **Leaks** pose a risk of wastewater exfiltration.
- **Pumps** and **filters** must be **maintained** on each property.

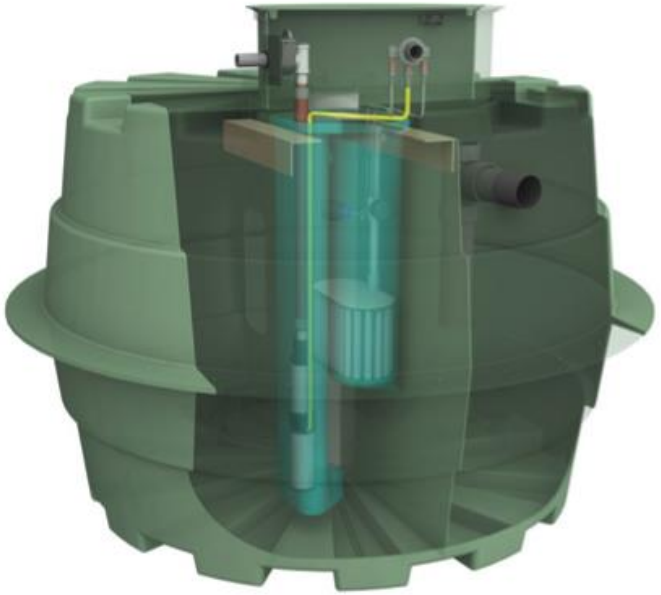

Image: https://www.nowra.org/Customer-Content/www/CMS/files/Pringle_NOWRA2021_Final.pdf

Low-pressure sewers


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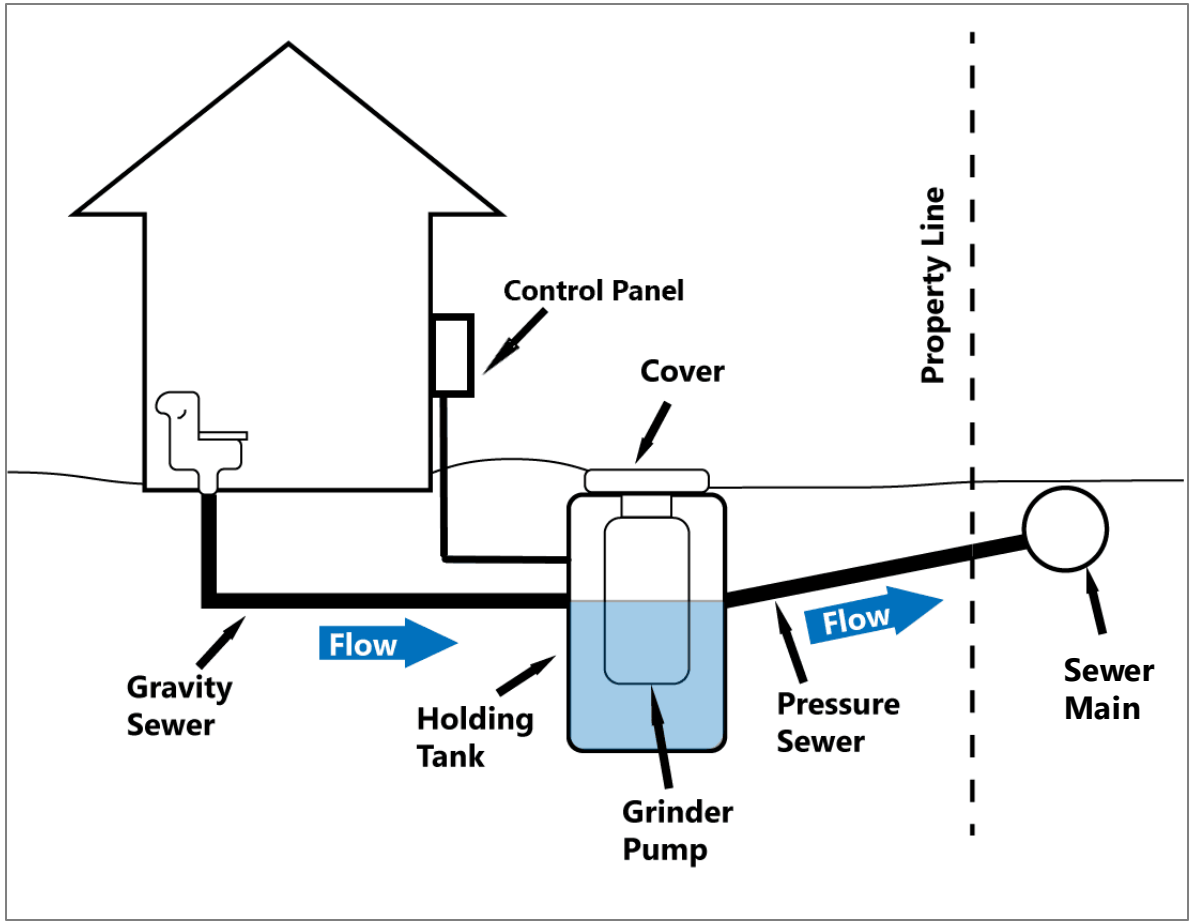
Definition

- Onsite tank houses **grinder pump** to shred sewage with cutting blades.
- **Wastewater** is then **pumped** through the collection system.



https://www.cfpua.org/791/Grinder-Pumps

Low-pressure sewers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Considerations

- **Small diameter** piping.
- **Shallow**.
- **Independent** from land **topography restrictions**.
- No manholes required, and **less inflow and infiltration**.
- **Less clogging** and therefore **less O&M** cleaning or flushing.

Image: https://sswm.info/sswm-university-course/module-2-centralised-and-decentralised-systems-water-and-sanitation/further/pressurised-sewers

Low-pressure sewers


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Considerations

- Requires **pump/vault installation** on each property.
- Requires an **energy source** for the grinder pumps.
- **Pumps** must be **maintained** on each property.

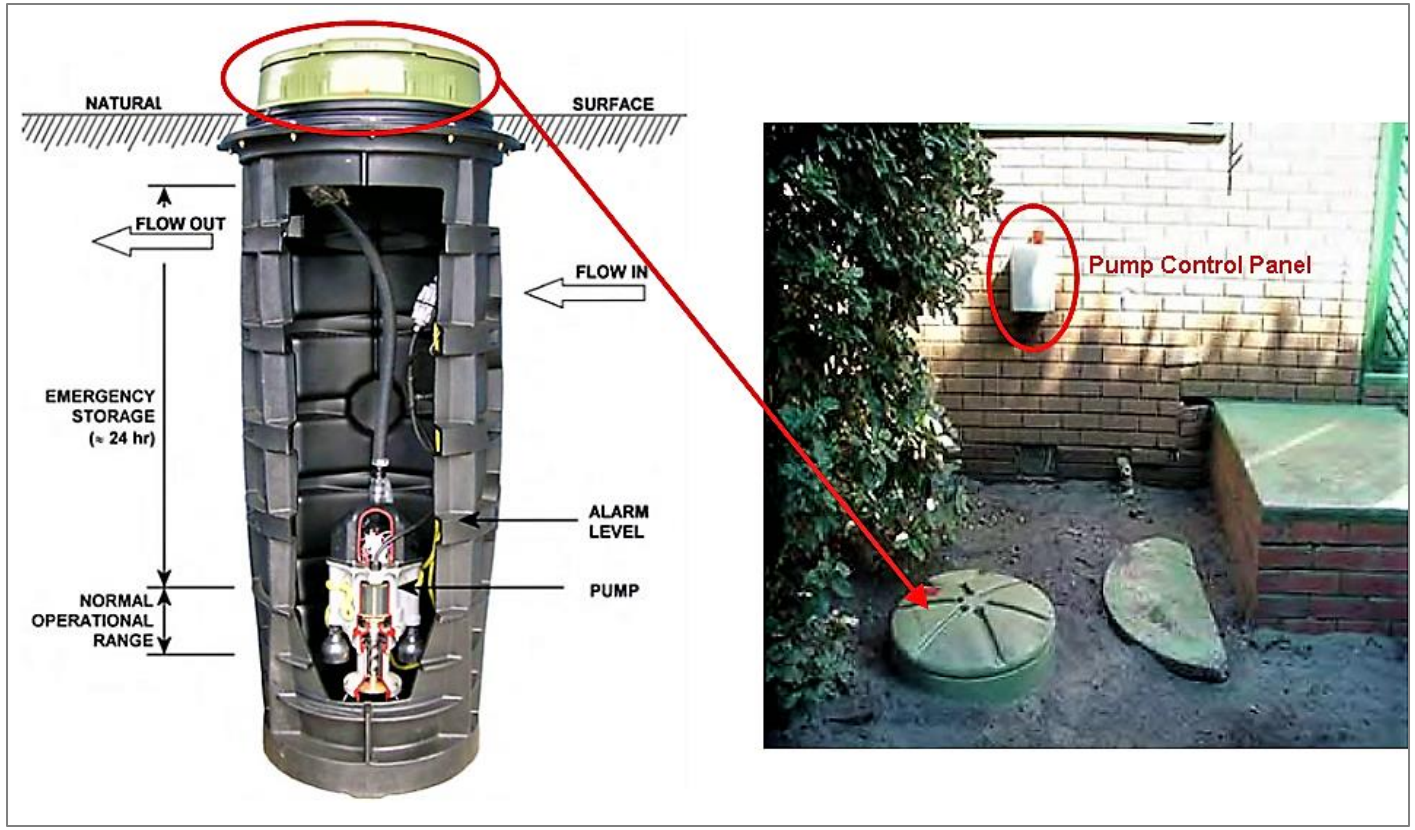

Image: https://sswm.info/sswm-university-course/module-2-centralised-and-decentralised-systems-water-and-sanitation/further/pressurised-sewers

Vacuum sewers


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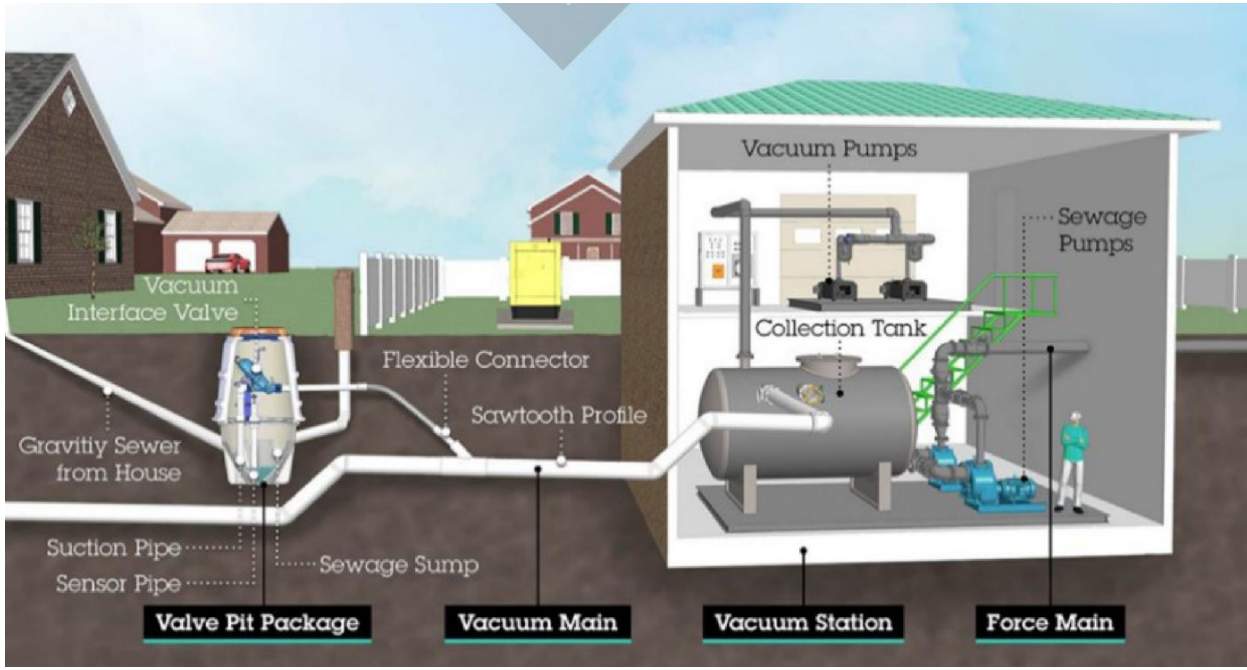
Definition

- **Partial vacuum** maintained with air pressure below atmospheric within pipe network and vacuum station's collection vessel.
- **Valve vaults at each home.**
- **Pressure difference** drives sewage to vacuum station and then treatment facility.



https://theqsmgroup.com/airvac-vacuum-sewer-systems/

Vacuum sewers


Jill

Considerations

- **Small diameter** piping.
- **Flexible installations** regardless of topography.
- **Shallow**.
- **No manholes** required, and **less inflow and infiltration**.
- Closed system with **no exfiltration or odors**.

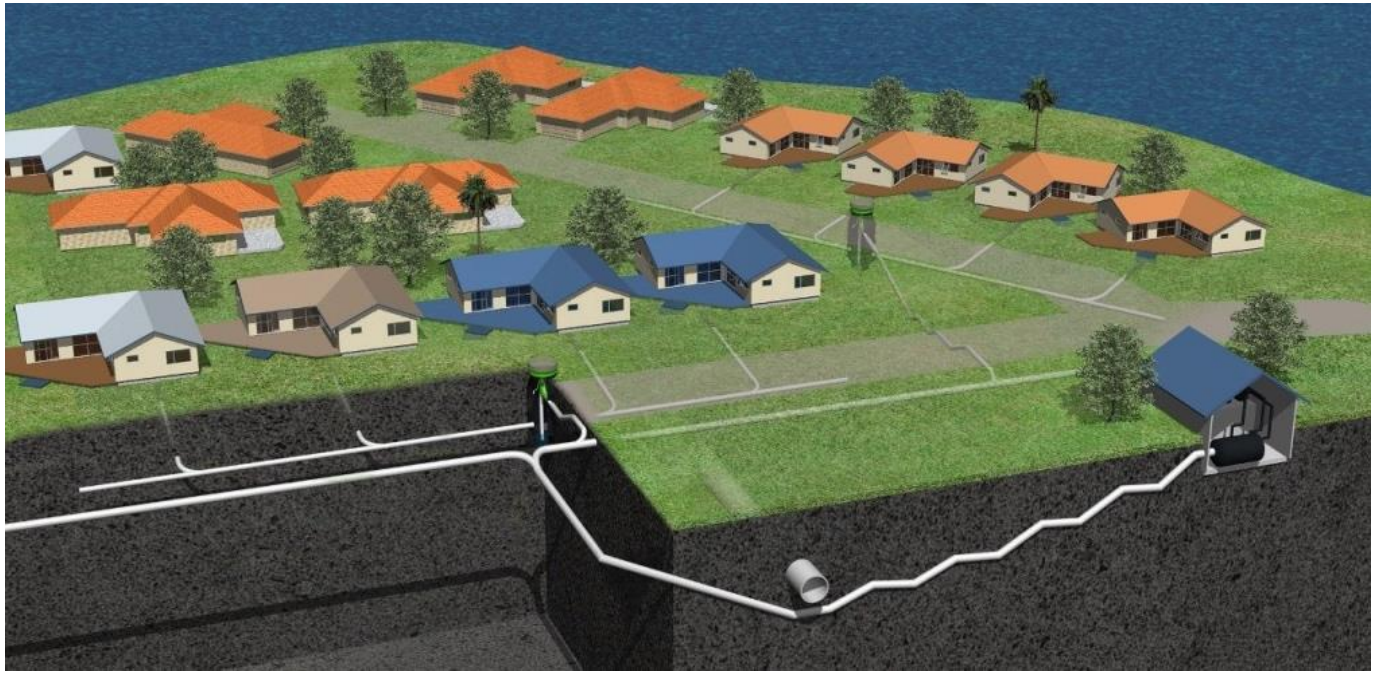


Image: https://www.aquate.co.nz/flovac-vacuum-sewer-systems/

Vacuum sewers


Jill

Considerations

- Requires **construction of vacuum equipment** at each home.
- Requires **land** for **central vacuum stations**.
- The **more homes** served the **more economic**.
- Requires **energy** to create a permanent vacuum.
- Vacuum stations require **regular O&M** checks.

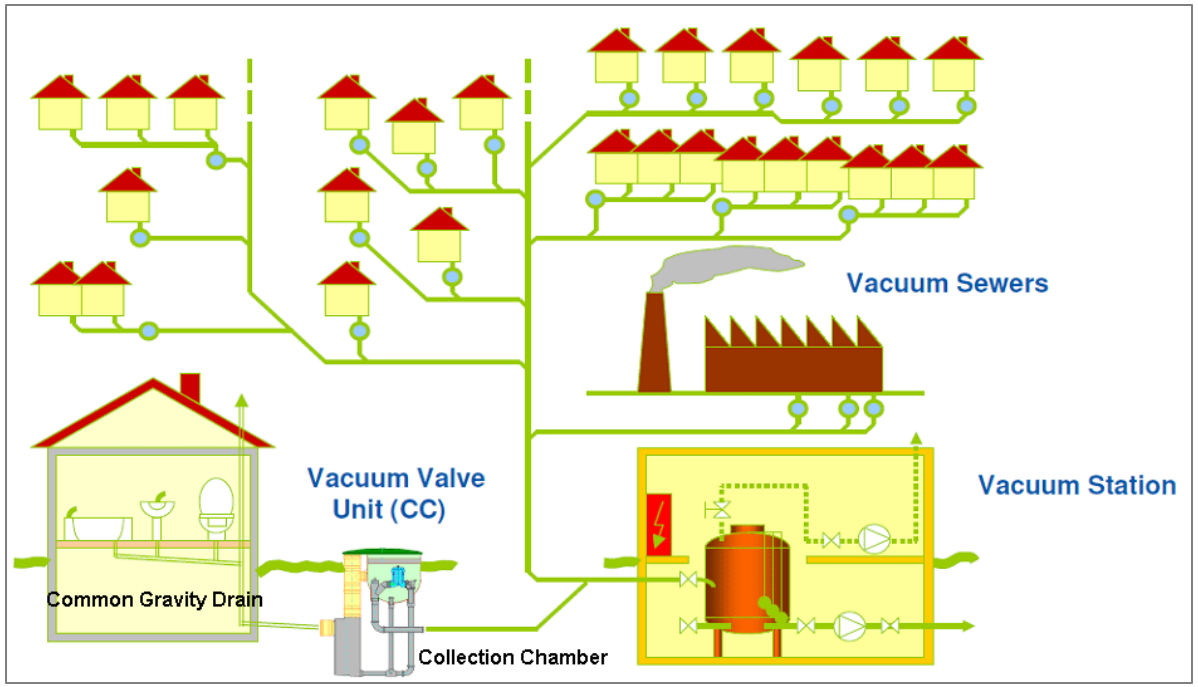


Image: https://i0.wp.com/www.sswm.info/sites/default/files/toolbox/ROEDIGER%202007%20Design%20Overview.png


Cristen

04

5 minute BREAK

Andrew

05

Treatment Technologies

Treatment system options evaluated


Andrew

Types of treatment systems

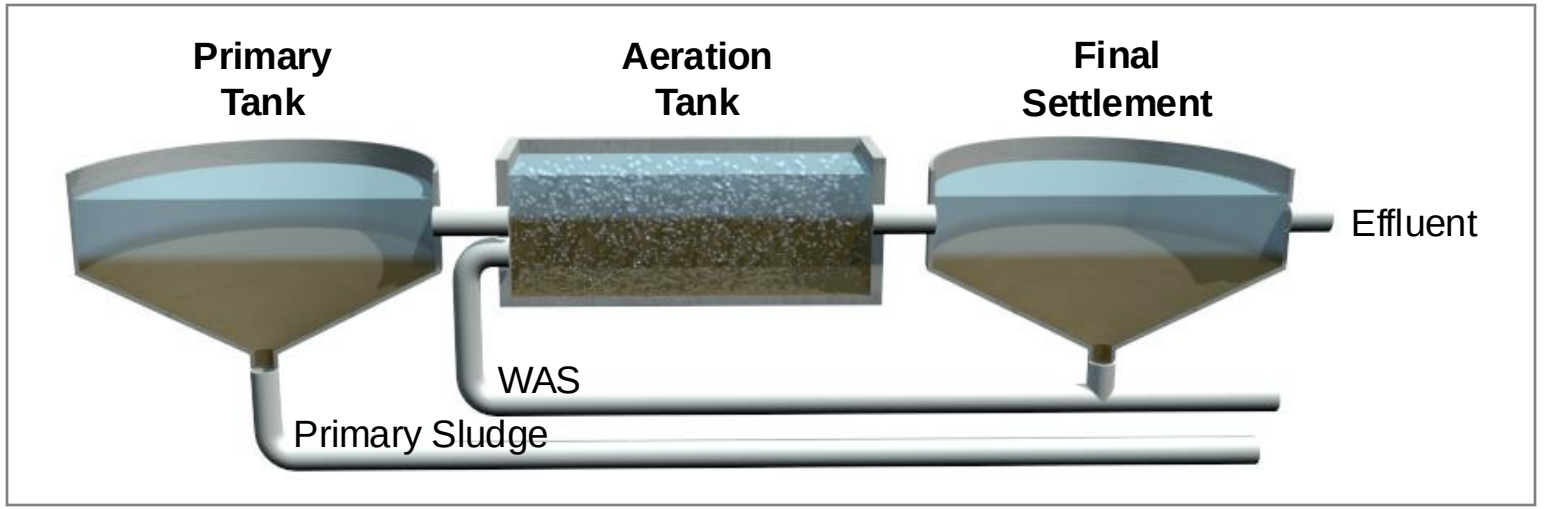
- Conventional activated sludge
- Extended aeration activated sludge
- Membrane bioreactor (MBR) activated sludge
- Attached growth systems
- Moving bed biofilm reactor
- Constructed wetland

Conventional activated sludge


Andrew

Definition

- **Biological treatment** using **flocs** of active **bacteria**.
- **Aeration** tank to facilitate biological treatment.
- **Secondary clarifier** to **separate the sludge**.



Conventional activated sludge

Considerations

- High **BOD** and **nitrogen removal**.
- Good **effluent quality**.
- Self-sustaining system.
- Can be **modified** to meet specific discharge limits.
- Available in **modular package** plant configuration.

Aeration Tank at Robert W. Hite Water Reclamation Facility, Denver Colorado.

Conventional activated sludge


Andrew

Considerations

- **High electricity** consumption.
- Requires **licensed wastewater operator**(s).
- Potential for **bulking** and biological surface **foaming**.
- **Requires filtration** and **disinfection** downstream.

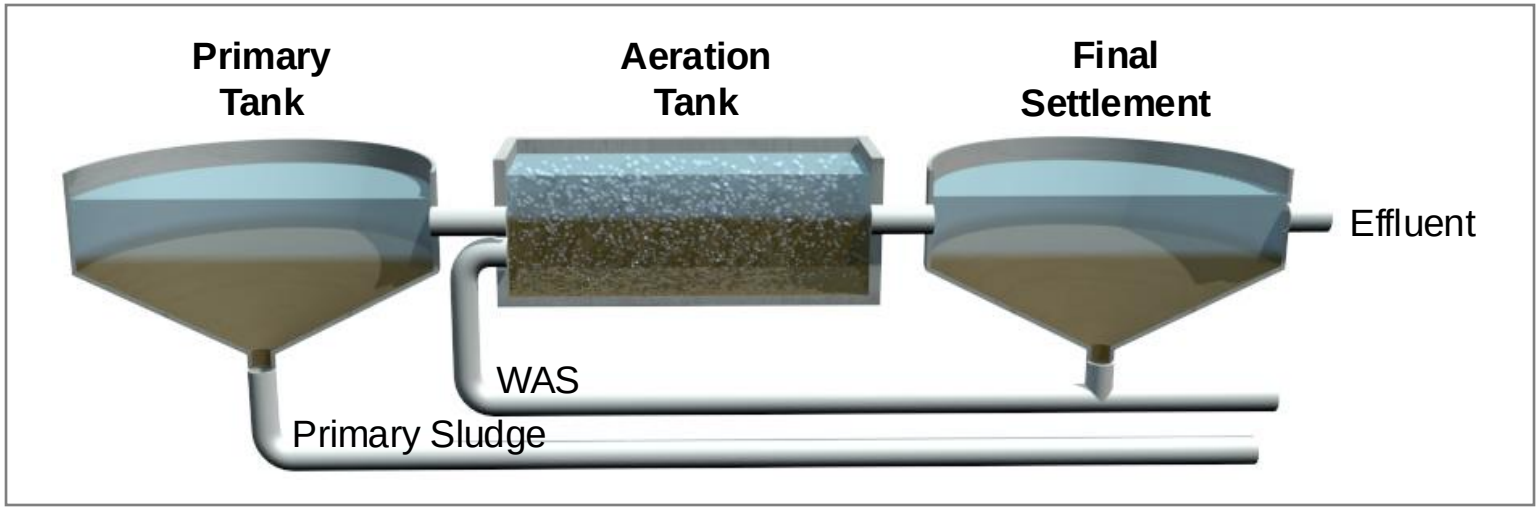
Secondary Clarifier at Marana WRF, Marana – AZ.

Extended aeration activated sludge


Andrew

Definition

- **Variation of conventional activated sludge.**
  - » Longer aeration time and sludge age.
  - » Larger aeration tank.
  - » Higher BOD
    - » Removal.
    - » Efficiency.
  - » Less sludge (than CAS).

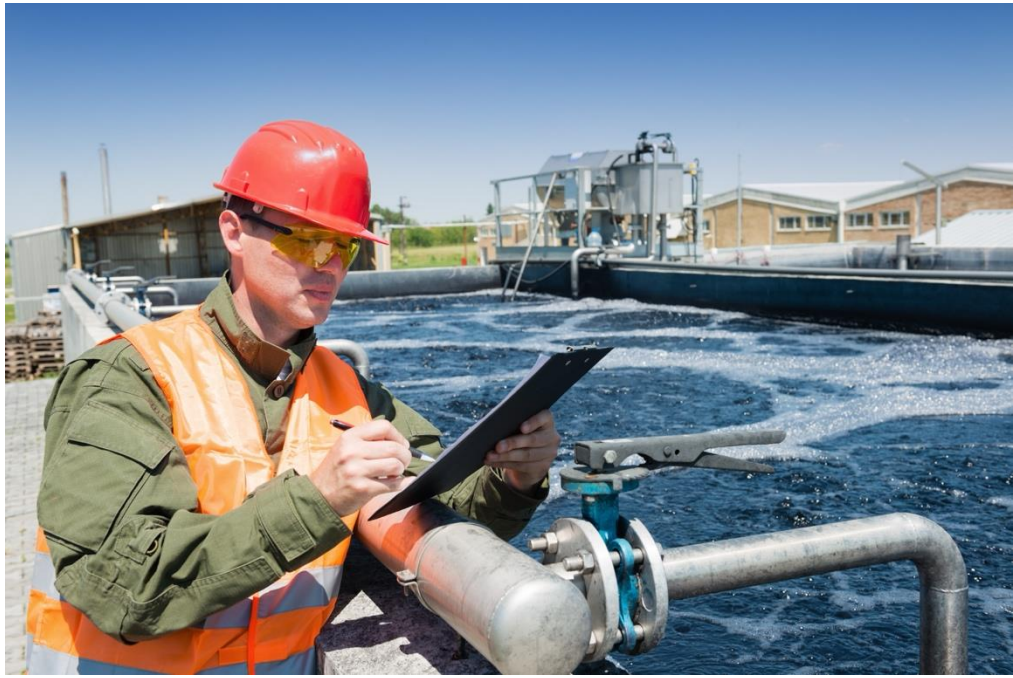


Extended aeration activated sludge


Andrew

Considerations

- **High quality effluent**.
  - » TSS, BOD5, Ammonia levels.
- **Long HRT** and complete mixing.
- Handles shock load and hydraulic surge.
- Produces **less sludge** (compared to CAS)
- Available in a **modular package** plant configuration.



Extended aeration activated sludge


Andrew

Considerations

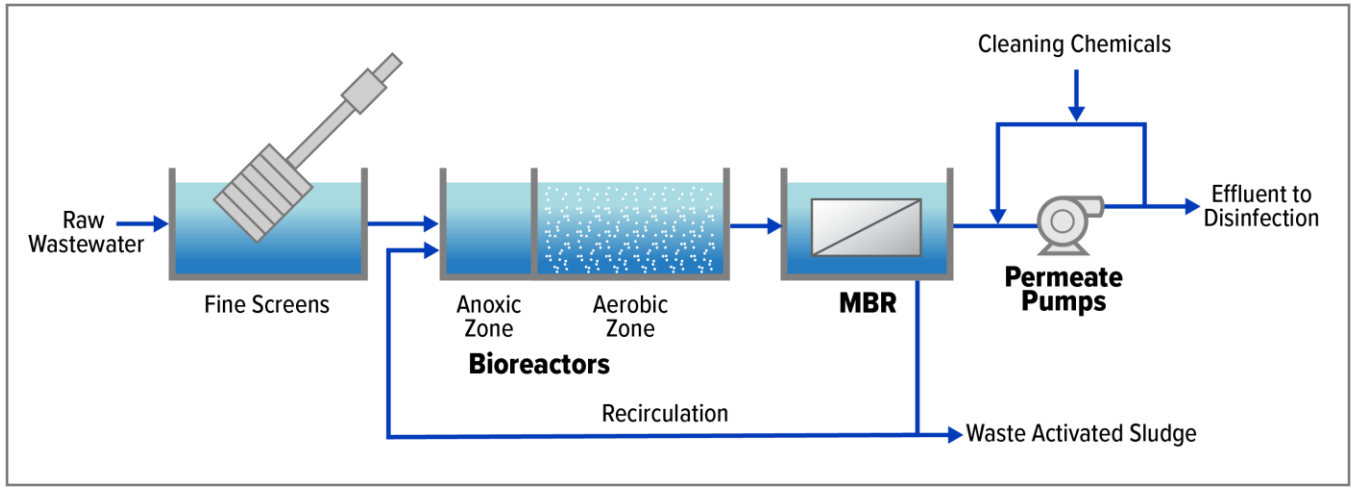
- **Higher energy** (longer aeration time).
- **Larger footprint** (than CAS & MBR).
- Requires **licensed wastewater operator**(s).
- Requires filtration and disinfection downstream
  - » To meet recycled water standards.

Membrane bioreactor (MBR) activated sludge


Andrew

Definition

- Variation of CAS.
- Uses membrane filtration instead of secondary clarifier and tertiary filters.
- Fine screening is required.
- Excellent process for water reuse applications.
- Bioreactor/Aeration tanks can be configured for nutrient removal.



Membrane bioreactor (MBR) activated sludge


Andrew

Considerations

- High **quality effluent**
  - » TSS, BOD5, Ammonia levels.
- **Excellent** process for **water reuse**.
- Available in a **modular package** plant configuration.
- **Small footprint**.
- Easily disinfected effluent
  - » To meet recycled water standards.

MBR Gallery at Riverside Water Quality Control Plant – CA.

Membrane bioreactor (MBR) activated sludge

Considerations

- Requires **fine screening**
  - » To protect the membranes.
- Higher
  - » Capital (sometimes).
  - » Operation.
  - » Energy costs.
- Requires **licensed wastewater operator**(s).

Hollow Fiber Membranes.

Attached growth systems


Andrew

Definition

- Variation of CAS.
- Biological mass grows as biofilm on surface of media or disk.
- Media should have large surface area to volume ratio.

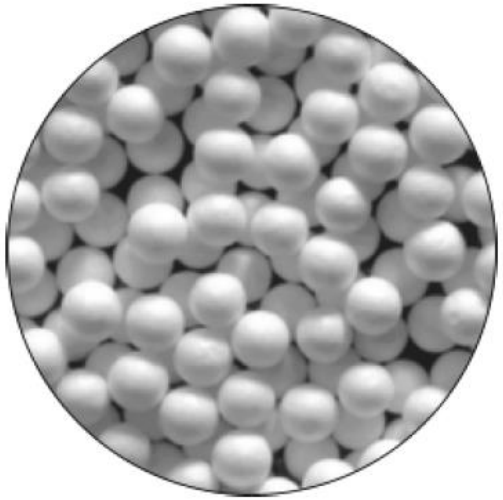
Photo of a Trickling Filter.

Attached growth systems


Andrew

Considerations

- Operates at a range of organic and hydraulic loads.
- **Lower energy** input
  - » Compared to CAS, extended aeration activated sludge, and MBR.
- **Low sludge** production
  - » Compared to CAS.
- Available in a **modular package** plant configuration.



Attached growth systems


Andrew

Considerations

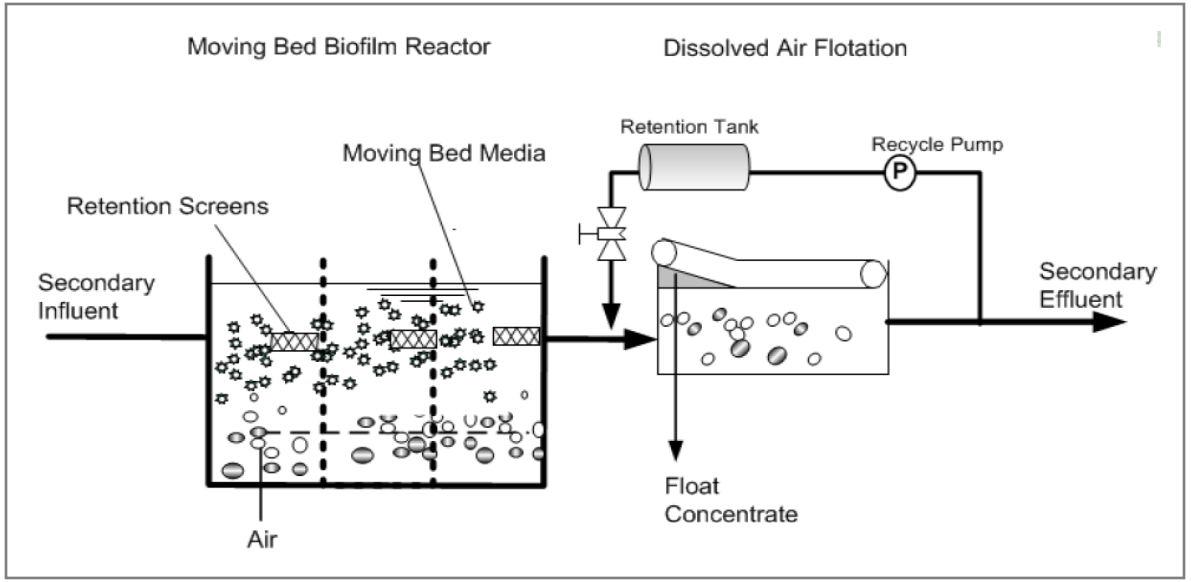
- Requires **expert** design, construction, operation, and maintenance.
- Some variations have **larger footprints**.
- **Risk of clogging**
  - » Depending on pre and primary treatment.
- **Challenges for filtration and disinfection** downstream
  - » To meet recycled water standards.

Moving bed biofilm reactor


Andrew

Definition

- Combination of activated sludge suspended and attached growth processes.
- Plastic floating media act as carriers of attached growth of biofilm.
- Aeration basin for treatment.
- Option for second basin for further treatment.



Presentation by R.M. Towill Corporation (2014) – for Sand Island WWTP and Sewer Basin Facilities – Honolulu, HI

Moving bed biofilm reactor


Andrew

Considerations

- **Efficient treatment**
  - » Low HRT
- Flexibility to adapt to fluctuating hydraulic and organic loads.
- Compact
  - » Maximized surface area of the media provide for biofilm growth.
- Available in a **modular package** plant configuration.

Moving bed biofilm reactor


Andrew

Considerations

- Requires **licensed wastewater operator**(s).
- Carriers can wash out of the system, necessitating supplemental additions.
- **Challenges for filtration and disinfection** downstream.
  - » To meet recycled water standards.

Media from Waimea WWTP – Hawaii.

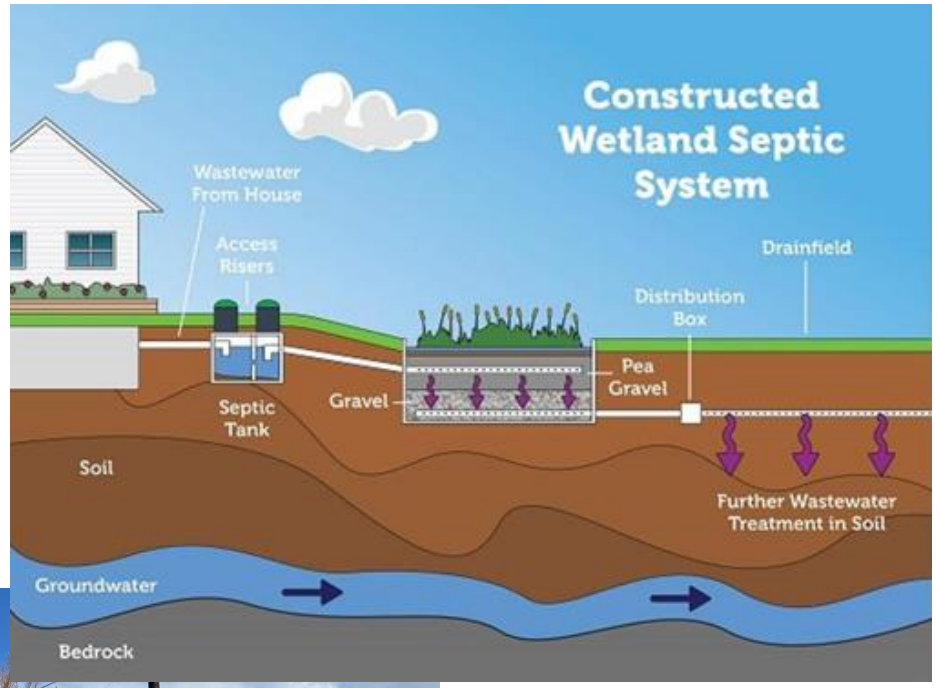
Presentation by R.M. Towill Corporation (2014) – for Sand Island WWTP and Sewer Basin Facilities – Honolulu, HI

Constructed wetland


Andrew

Definition

- **“Green”** technology to mimic natural processes.
- **Pre-treatment required**
  - » With septic tank or similar.
- **Lined** earthen basin or cell.
- Relies on
  - » Microorganism.
  - » Porous media.
  - » Plants.



https://www.wrrc.hawaii.edu/publication/performance-evaluation-of-a-wetland-type-on-site-wastewater-system/

Constructed wetland


Andrew

Considerations

- Simple.
- **Easily operated**.
- **Natural system**.
- Relatively **inexpensive**.
- Requires **little (to no) energy**.

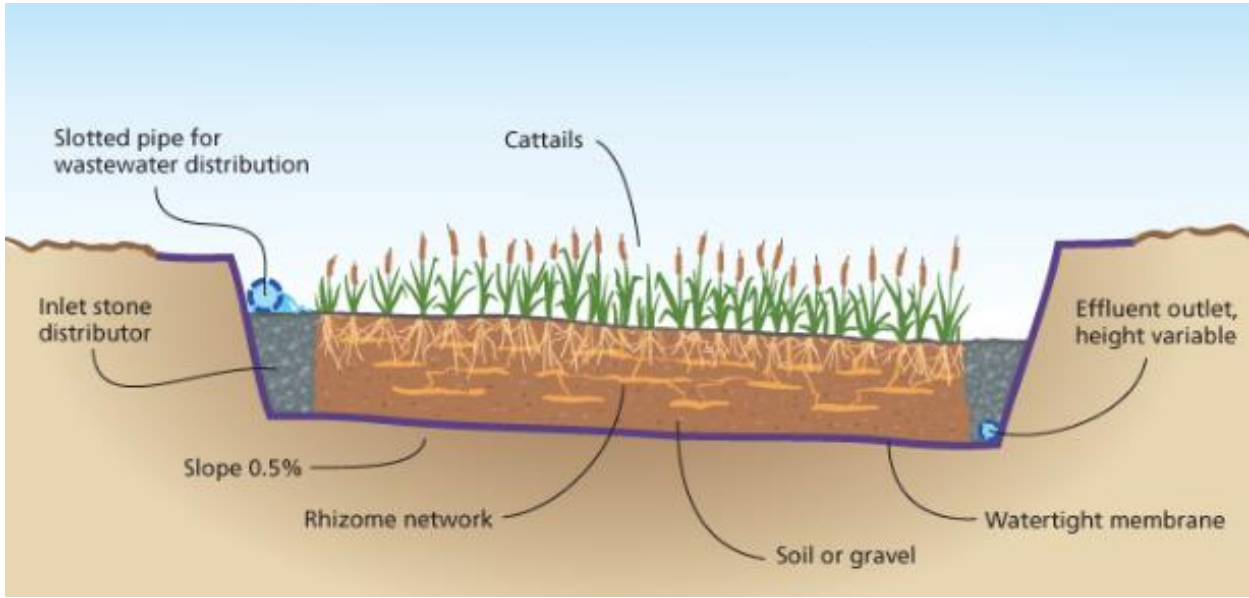
https://www.wrrc.hawaii.edu/publication/performance-evaluation-of-a-wetland-type-on-site-wastewater-system/

Constructed wetland


Andrew

Considerations

- **Large land** requirement.
- Not available as a package facility.
- **Vector and odor** nuisances.
- Pretreatment required
  - » Usually by a septic tank.
- Challenge of filtration and disinfection downstream
  - » To meet recycled water standards.



Jill

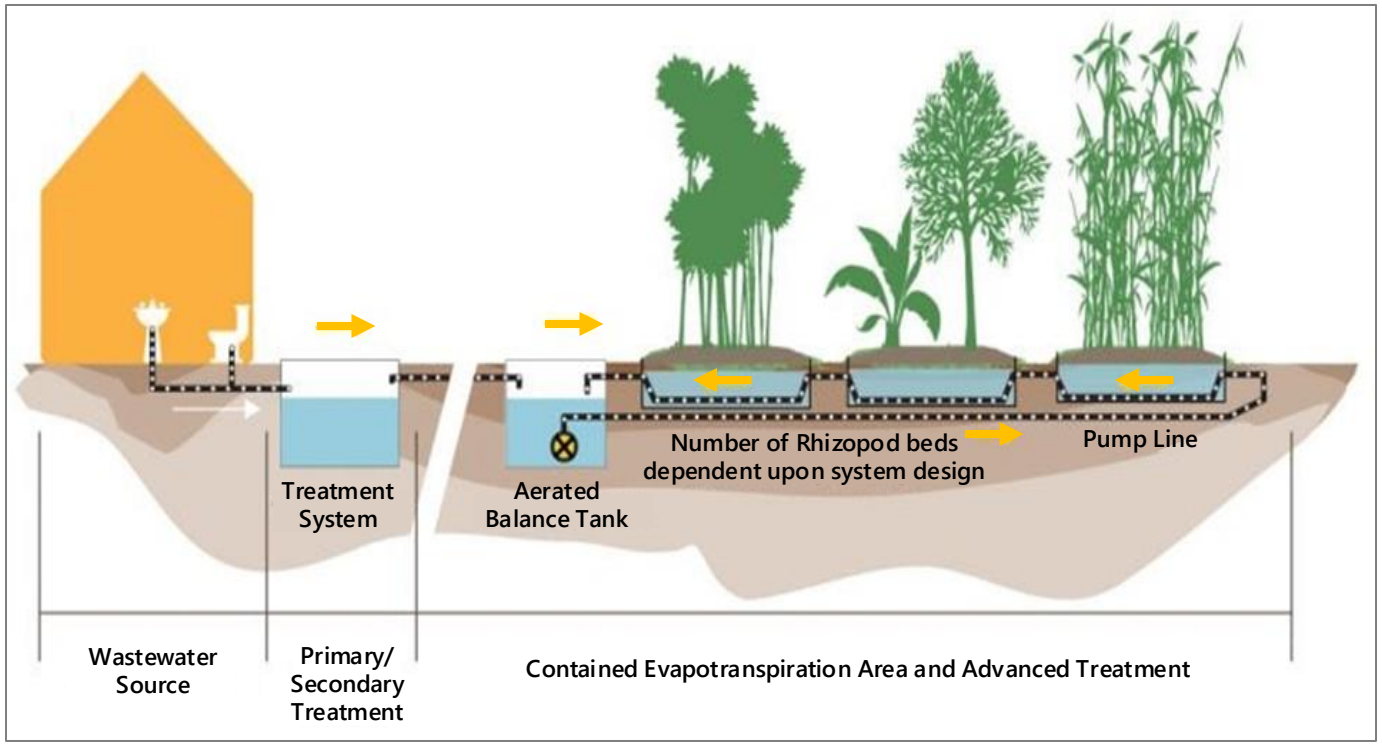
06

Effluent Management or Disposal Options

Effluent management options evaluated


Jill

- Water reuse
- Absorption trench/bed
- High or low-pressure drip
- Seepage pit
- Evapotranspiration
- Injection well
- Surface water discharge



Water reuse


Jill

Definition

- Meet state criteria for recycled water.
- Applications in
  - » Landscaping.
  - » Agricultural irrigation.
  - » Toilet flushing.

Water reuse


Jill

Considerations

- **More expensive** treatment is required to meet water quality requirements.
- **100 percent back-up** disposal component is required.

Absorption trench/bed


Jill

Definition

- Subsurface disposal.
- Trench or bed of perforated pipes.
- Treated effluent percolates into the soil.
- Depends on hydraulic properties of soil.

Home - ACSI (acsihawaii.com), Distributors | FujiClean USA | Wastewater Treatment Systems

Absorption trench/bed


Jill

Considerations

- **Common**, many examples of operating experience.
- **No power** is required.
- Generally, **no maintenance** necessary.
- Gravel-less dome systems require **less gravel backfill** and provide significant additional water storage volume.

Home - ACSI (acsihawaii.com), Distributors | FujiClean USA | Wastewater Treatment Systems

Absorption trench/bed


Jill

Considerations

- **Large** land requirements.
- **Overloading**, rainfall, or unsuitable soils may cause contaminants to spill out into the surroundings.
- **Root intrusion** can adversely impact performance.

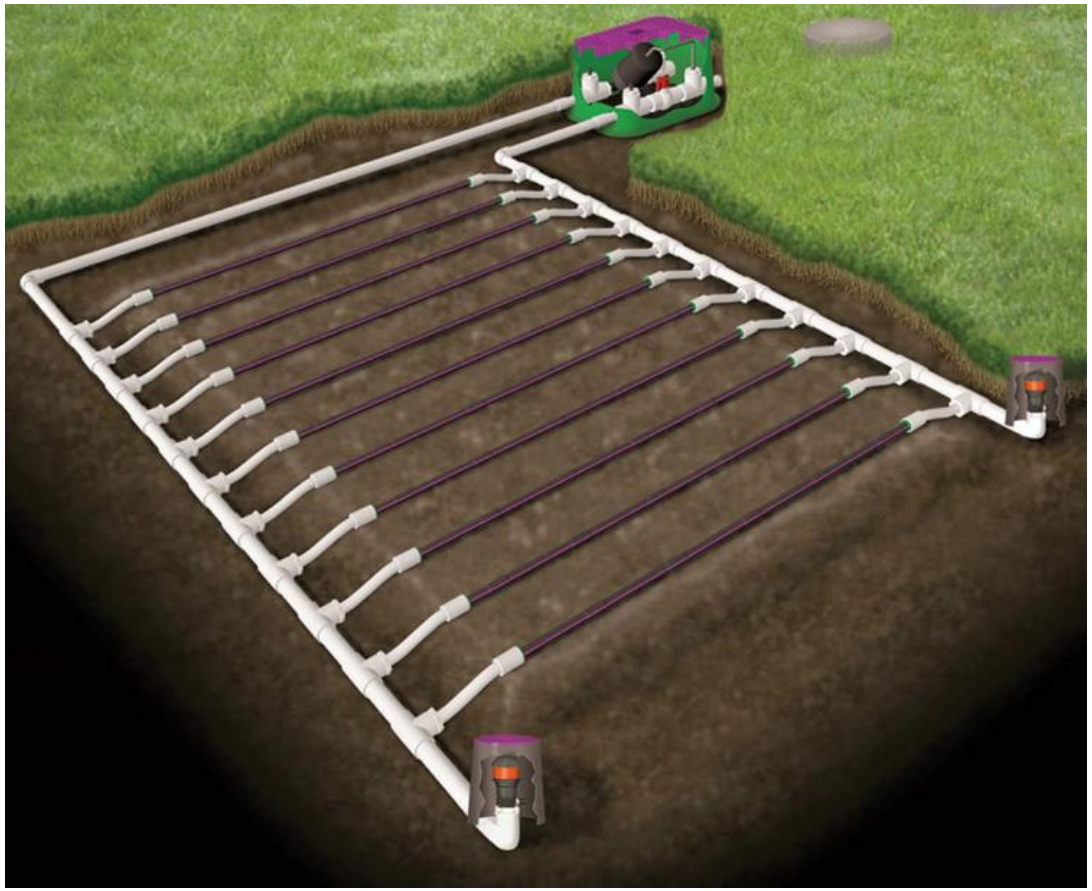
Home - ACSI (acsihawaii.com), Distributors | FujiClean USA | Wastewater Treatment Systems

High-pressure or low-pressure drip


Jill

Definition

- Subsurface disposal.
- Network of pipes with emitters.
- Installed in excavations.
- Receive treated effluent in pumped doses from tank.
- Act partially as evapotranspiration system for plants at ground surface.

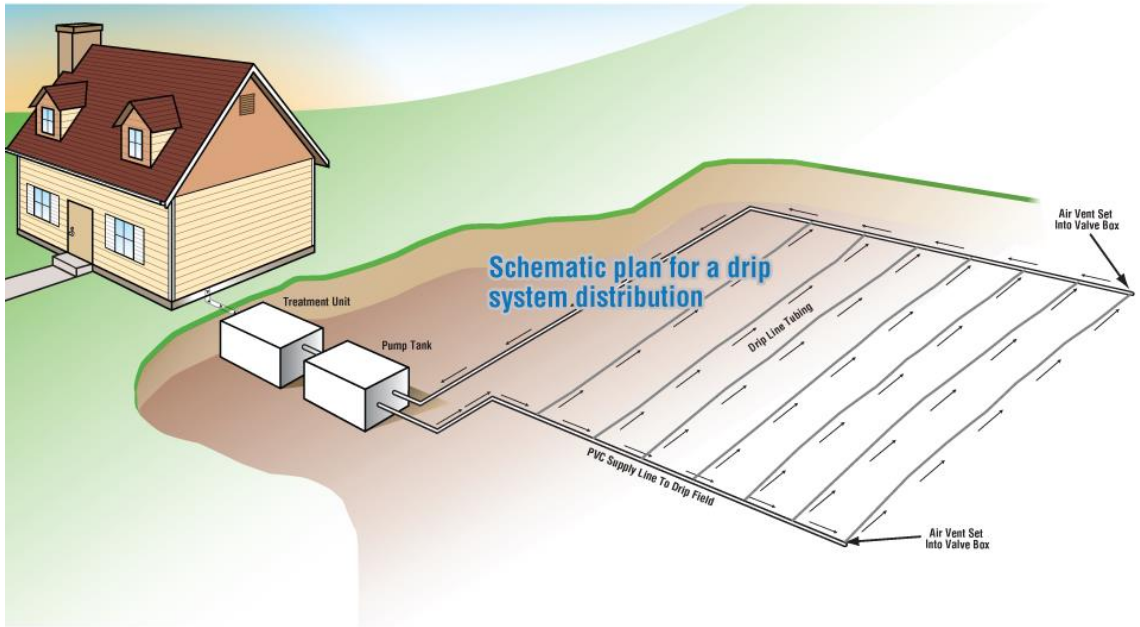


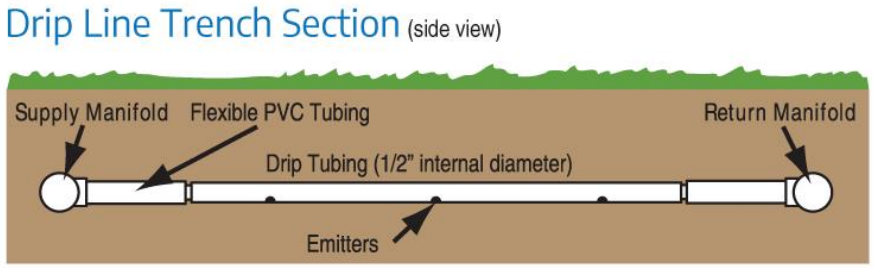
High-pressure or low-pressure drip


Jill

Considerations

- **Reliable** for areas with
  - » low permeability.
  - » seasonal high-water tables.
  - » severe slopes.
- Ability to **control dose/rest cycles**
  - » Even spacing or dosing of effluent.
- **Significant evapotranspiration** is possible.





Drip Irrigation - Missouri Smallflows Organization (mosmallflows.org)

High-pressure or low-pressure drip


Jill

Considerations

- A **large dose tank** may be needed to accommodate timed dose delivery.
- **Power is required** to run pumps, sensors, and controls.
- **Clogging of emitters** can occur.

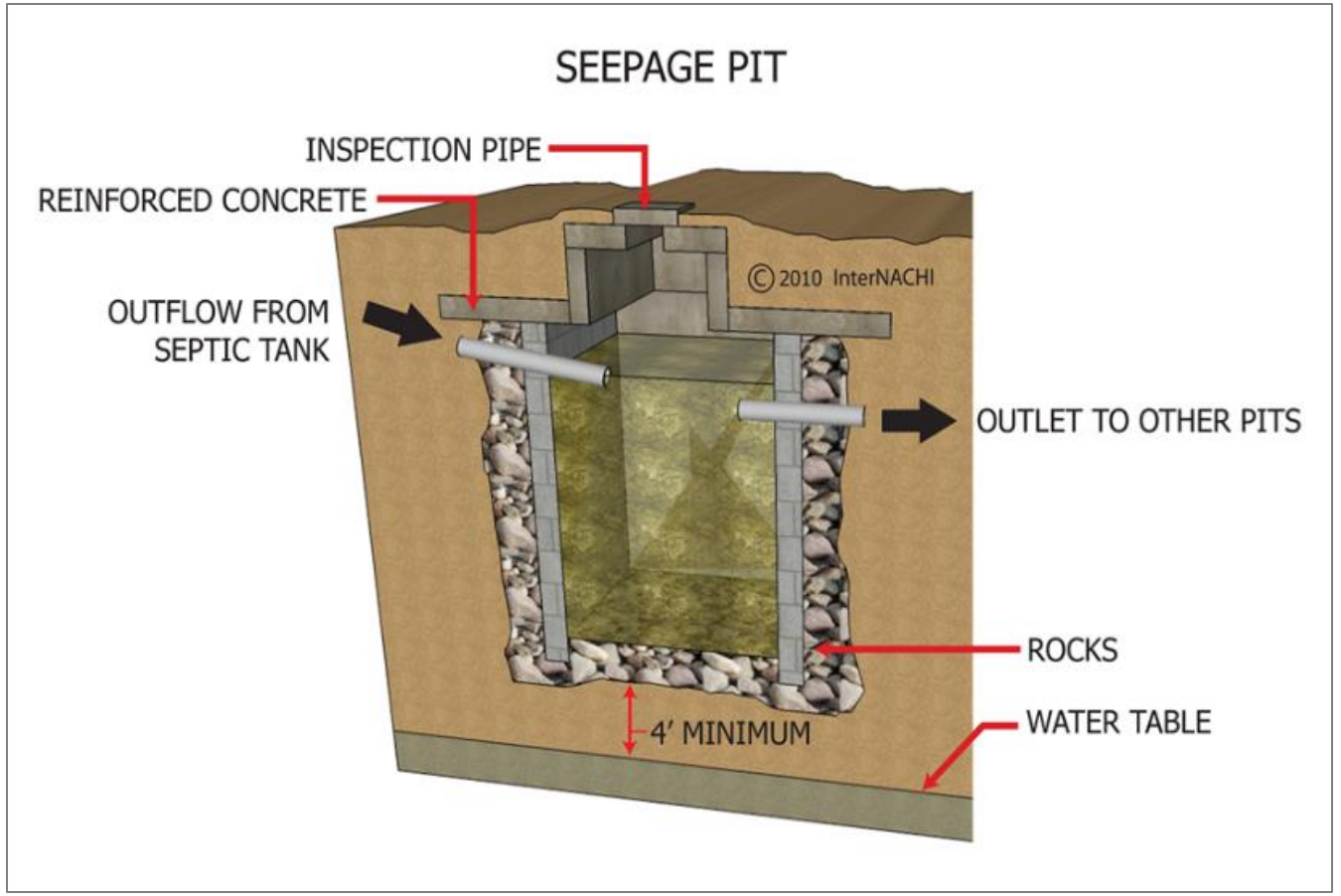
Drip Dispersal | OSCAR On-Site Technologies (oscaronsite.com)

Seepage pit


Jill

Definition

- Constructed the same as a cesspool
  - » Except receives treated wastewater.
- Stacked concrete rings.
- Performance depends on percolation rate of surrounding soil.



Seepage pit

Considerations

- **Simple** and **compact**.
- Possible option when available **land is insufficient**.
- Can be **maintained by pumping** out solids.
- **Unlikely to be approved** by states.

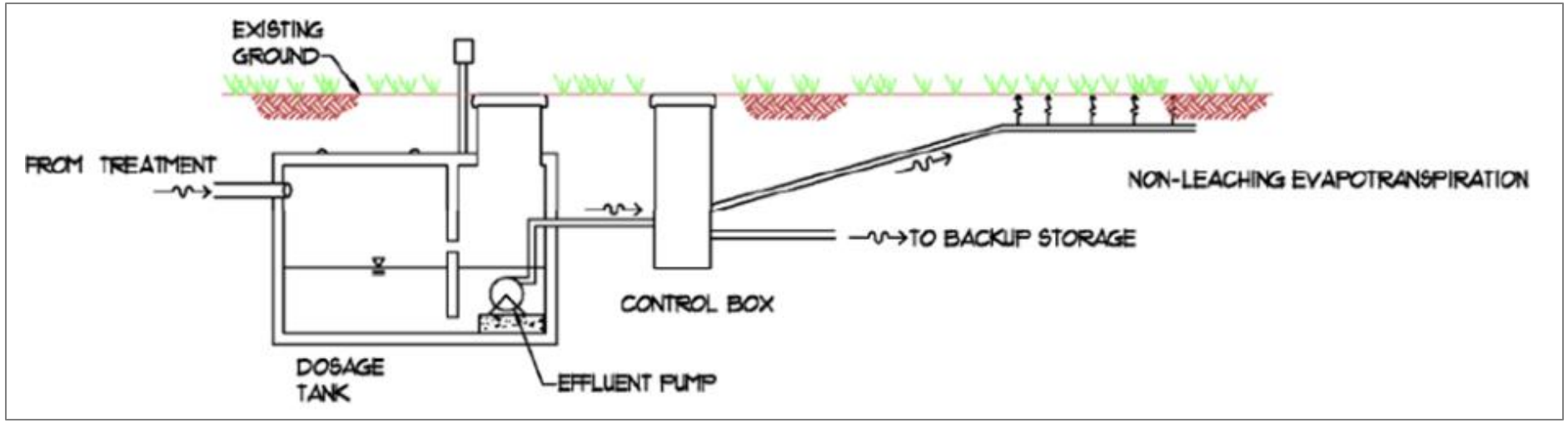
Home - ACSI (acsihawaii.com), Distributors | FujiClean USA | Wastewater Treatment Systems

Evapotranspiration


Jill

Definition

- Combines direct evaporation and plant transpiration.
- Treated effluent conveyed to porous bed with water-tolerant plants.
- Water is taken up by plants and transpired, or percolates from bottom of the bed.



Evapotranspiration


Jill

Considerations

- If an impermeable liner is included for a "zero discharge" system, then 100 percent nitrogen removal is achieved.

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Evapotranspiration


Jill

Considerations

- **Large surface areas** are needed.
- Systems are **more effective in arid climates**.
  - » where evaporation rates > precipitation rates.
- **Recordkeeping of lysimeter data** is required to ensure proper functioning.

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Injection well


Jill

Definition

- Subsurface disposal.
- Allowed locations depend on state regulations.
- Some states use as aquifer recharge program.

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Injection well


Jill

Considerations

- **Simple** system.
- Little to **no maintenance** required.
- **Limited applicable** locations/siting.
- Very **difficult to obtain a permit**.
- Regulations may require a **NPDES permit**.

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Surface water discharge


Jill

Definition

- Discharge of treated wastewater to surface water.
- Requires NPDES permit.

Surface water discharge


Jill

Considerations

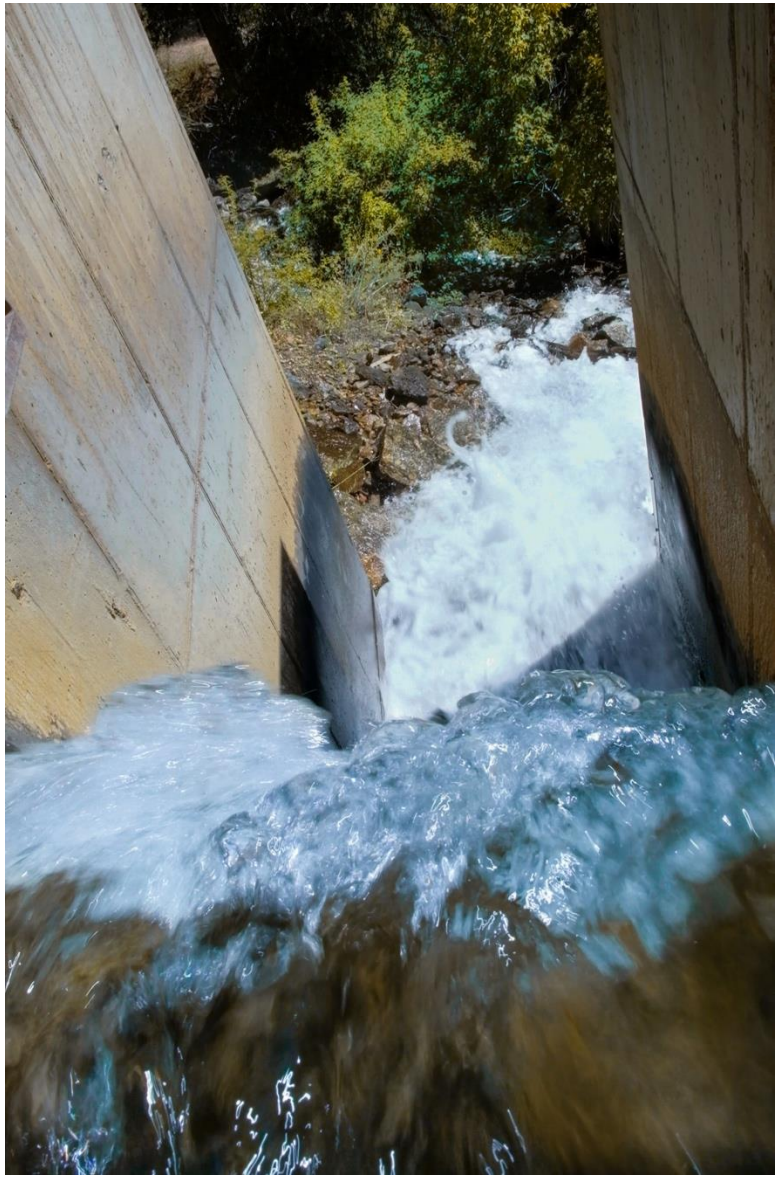
- **Simple** system.
- **Recycles** water back into the environment.
- Can **augment stream flow**.

Surface water discharge


Jill

Considerations

- Potential **negative impacts** on natural bodies of water or drinking water.
- **NPDES permit** required, entailing expensive monitoring and reporting.
- Very **difficult to obtain a permit**.
- **Very limited** applicable locations/siting.



Recap of what was learned


Cari

Collection

- Gravity Sewers
- Vacuum sewers
- Liquid-only pressure sewers
- Low-pressure sewers

Treatment

- Conventional activated sludge
- Extended aeration activated sludge
- Membrane bioreactor (MBR) attached growth systems
- Moving bed biofilm reactor (MBBR)
- Constructed wetland

Disposal

- Water reuse
- Absorption trench/bed
- High or low-pressure drip
- Seepage pit
- Evapotranspiration
- Injection well
- Surface water discharge


Cari

Mahalo!

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Carollo.com

Cristen

Q&A and Discussion

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