GUIDANCE FOR USING DECENTRALIZED WASTEWATER TREATMENT SYSTEMS IN SANTA BARBARA COUNTY
DISCLAIMER

The information in these Guidelines is provided to facilitate an environmentally aware approach to building design and construction. The strategies presented do not supersede applicable building codes and are not a substitute for the judgment and services of competent or licensed professionals. The mention of a particular product, business or manufacturer does not constitute an endorsement, expressed or implied, by the Authors, The Sustainability Project, the Bren School of Environmental Science and Management, or the University of California Santa Barbara.
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INTRODUCTION

This guidance document was created by a group of graduate students at the Bren School of Environmental Science and Management. It represents the culmination of their findings from a year-long research project titled “Assessing Decentralized Wastewater Treatment Options in Santa Barbara County.” More information on their project and the Bren School can be found at http://www.bren.ucsb.edu/research/masters_gp.htm

THE SUSTAINABILITY PROJECT

This guidance document was developed for The Sustainability Project, a Santa Barbara-based non-profit dedicated to inspiring change in the built environment to improve the quality of life, in harmony with nature, for this and future generations. Please visit http://www.sustainabilityproject.org/ for more information on this organization.

Freshwater resources of sufficient supply and quality are critical for meeting human needs, but California’s water supply is currently threatened due to increased demand from a growing population and the uncertainty presented by climate change. To address this future water shortage, one potential solution is reducing demand through the use of recycled water. Domestic wastewater, for example, can be treated and recycled for irrigation. However, access to municipal recycled water is limited due to existing infrastructure and typically cannot be used in many onsite applications when it is pumped to a centralized facility for treatment. Additionally, pumping water for treatment and reuse consumes large amounts of energy.

A variety of advanced onsite systems, such as constructed wetlands and membrane bioreactors, can be used to treat water for reuse. Onsite technologies have economic, social, and environmental benefits and can often be tailored to meet specific project needs. However, these systems are not widely used in Santa Barbara due to a lack of awareness and unfamiliarity with these technologies and the processes required to get them permitted.

This guidance document helps stakeholders such as architects, planners, and others make informed decisions when considering decentralized technologies to meet wastewater treatment and reuse needs. It also allows for comparison of the technologies based on economic, environmental, and social considerations. Lastly, the guidance document presents a case study highlighting how it can be used to guide decision-making.

IN THIS GUIDANCE DOCUMENT

- A list of applicable permits and a permitting flowchart
- A matrix tool for easy cross comparison of onsite technologies
- A catalog of onsite technology descriptions
- A case study to demonstrate an application of the matrix tool
Will the system discharge to surface waters?

Yes

Permits Needed
NDPES
SBC C.U.P.

No

Will you be using a conventional system?

Yes

Will the system flow rate be under 2,500 GPD?

Yes

Permit Needed
RWQCB INDIV.

No

No

Will you be using a mound or evapotranspiration system?

Yes

Permit Needed
RWQCB INDIV.

No

Will the system discharge to an underground injection well?

Yes

Permit Needed
SBC EHS
RWQCB INDIV.

No

Will the system use recycled water for irrigation?

Yes

Permit Needed
SBC EHS
RWQCB INDIV.

No

No

Permit Needed
RWQCB INDIV.

The flow chart identifies which permits are required for wastewater systems and tells the end user which regulatory agency issues the permit. By providing this information, the flow chart serves as a one-stop tool for wastewater treatment permitting.

The flowchart is not applicable to all projects. First, projects located within 200 feet of an existing sewer system are required to connect to the sewer by California law. This means that these projects could not consider using an onsite treatment system. Additionally, the flow chart is designed for systems under 20,000 GPD. It is recommended that you discuss the proposed project with the agencies early in the permitting process. All times and costs are approximate, and costs are based off of 2011-2012 fee schedules.
Permit Types and Agencies

SBC EHS
Santa Barbara County Environmental Health Services (SBC EHS) is the county agency responsible for onsite systems. An SBC EHS permit takes around 2-4 weeks and costs around $500. A small conventional septic tank will only need a permit from this agency.

RWQCB
The Regional Water Quality Control Board (RWQCB) is the state agency in charge of protecting California’s waters. The RWQCB issues the general order permit for established technologies, which requires around 6 weeks to obtain. The RWQCB also issues the individual permit, which is reviewed on a case-by-case basis and requires at least 6 months. These permits cost between $1,500 and $7,500. The fee is based on threat to water quality and complexity of the technology. The RWQCB has delegated some responsibility to the SBC EHS. It is possible that a permit will not need to go through the official RWQCB process.

SBC C.U.P.
The Santa Barbara County Planning Department requires a minor conditional use permit for an “alternative” technology. Currently only the evapotranspiration and mound systems are considered alternative under this definition. The minor conditional use permit costs up to $5000 and takes 6 months to process.

CDPH
The California Department of Public Health (CDPH) is responsible for regulating the reuse of treated discharge. Systems that reuse treated discharge require a recommendation from the CDPH showing that the system complies with Title 22, California’s recycled water policy. This recommendation costs around $2,500 and takes around 1 month to complete.

U.S. EPA
The United States Environmental Protection Agency (U.S. EPA) is the federal agency responsible for protecting America’s waters. Although many of its responsibilities are delegated to the RWQCB, the U.S. EPA is responsible for systems that discharge to underground injection wells.

NPDES
The National Pollution Discharge Elimination System (NPDES) permit is managed by the RWQCB and applies to discharge to waters of the United States. This permit is needed if the technology discharges to surface water.
Through a series of meetings with TSP and a stakeholder workshop, we developed a decision support matrix to assist architects and planners in making decisions about incorporating onsite wastewater treatment into development projects in Santa Barbara County. The primary objective of this matrix is to facilitate comparison of onsite technologies while eliminating the need for comprehensive technical knowledge of various systems. This tool scores each treatment system based on economic, environmental, and social characteristics.

The Decision Support Matrix, shown on page 6, utilizes a ‘stop light’ scoring approach to score the treatment systems according to individual parameters within each major category (environmental, economic, and social). Boxes highlighted in green indicate the most optimal potential outcome, yellow boxes are less desirable outcomes, and red boxes indicate least desirable outcomes.

It is important to note that a system receiving a ‘red’ score does not necessarily perform poorly overall, but only in comparison to other systems. Additionally, systems could achieve ‘green’ scoring in the environmental category by incorporating additional filtration and disinfection processes beyond what is described in the matrix.

These parameter descriptions explain how systems were scored. For example, Removal of Total Suspended Solids (TSS) is evaluated based on the total expected milligrams per liter of TSS in final effluent. These descriptions can be found on page 6.

The Scoring Choices chart indicates cutoffs for scoring decisions. For example, systems with land requirements less than 0.25 square feet per gallon per day (GPD) receive a ‘green’ score, while systems requiring greater than 0.75 square feet per GPD receive a ‘red’ score. In some cases, scores were assigned through qualitative assessment, which are described in the Scoring Choices chart. To learn more about sources used to make scoring decisions, please reference the Bren Wastewater Master’s Thesis located on the Bren School Website. These descriptions can be found on page 7.
# Decision Support Matrix

<table>
<thead>
<tr>
<th>Economic</th>
<th>Subsurface Treatment Systems</th>
<th>Constructed Wetlands Systems</th>
<th>Prefabricated and Modular Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Investment</td>
<td>Land Requirement</td>
<td>Recirculating Sand or Gravel Filter</td>
<td>Recirculating Media Filter</td>
</tr>
<tr>
<td>Construction</td>
<td></td>
<td>Recirculating Vertical Flow Wetlands (VF)</td>
<td>Membrane Bioreactors (MBR)</td>
</tr>
<tr>
<td>Operation &amp; Maintenance</td>
<td>Materials</td>
<td></td>
<td>Activated Sludge Systems</td>
</tr>
<tr>
<td>Energy Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operational Labor</td>
<td>Current Permitting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulation</td>
<td>Future Permitting</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| Environmental | | | |
| Performance | Reliability | | |
| Total Suspended Solids | | | |
| Total Nitrogen Concentration | | | |
| Biochemical Oxygen Demand | | | |
| Fecal Coliforms | | | |
| Site Constraints | Soil | | |
| Slope | | | |
| Natural Environment | Habitat Creation Potential | | |
| Aesthetics | Visual | | |
| Odor | | | |
| Noise | | | |
| Quality of Life | Educational Opportunity | | |
| Owner Supervision Requirements | | | |
| Health: Risk of Vector Contact | | | |</p>
<table>
<thead>
<tr>
<th>Economic</th>
<th>Initial Investment</th>
<th>Land Requirement</th>
<th>Different systems require different amounts of land to treat wastewater. Depending on the process utilized to treat wastewater, and the intended use, the amount of land required will vary.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Construction</td>
<td>Installation</td>
<td>Includes the costs to prepare a site for the construction of an onsite treatment system, as well as the construction process itself.</td>
</tr>
<tr>
<td>Operation &amp; Maintenance</td>
<td>Materials</td>
<td>Operation and Maintenance refers to all costs associated with maintaining system function, including parts replacement, monitoring, and the addition of chemicals or other products required for treatment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy Requirements</td>
<td>Different systems will utilize different processes to treat wastewater. Generally, passive systems utilizing biological processes will require less energy than active systems which use some mechanical processes.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operational Labor</td>
<td>Operational labor refers to the costs required to employ an operator to maintain and ensure system function.</td>
<td></td>
</tr>
<tr>
<td>Regulation</td>
<td>Permitting (Current &amp; Future)</td>
<td>Refers to the approximate time requirement needed to legally permit a system in Santa Barbara County. Independent of the number of agencies as most approvals work concurrently. Independent of costs, but the more complex the system, the higher the cost for permitting.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental Performance</th>
<th>Reliability</th>
<th>Refers to the level of sensitivity to influent wastewater strength and volume, as well as climatic fluctuations that could impact treatment.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Suspended Solids</td>
<td>This refers to the milligrams per liter of total suspended solids expected in final effluent.</td>
</tr>
<tr>
<td></td>
<td>Total Nitrogen Concentration</td>
<td>This refers to the milligrams per liter of Total Kjendahl Nitrogen expected in final effluent.</td>
</tr>
<tr>
<td></td>
<td>Biochemical Oxygen Demand</td>
<td>This refers to the biochemical oxygen demand expected in final effluent.</td>
</tr>
<tr>
<td></td>
<td>Fecal Coliforms</td>
<td>This refers to the total coliforms in final effluent.</td>
</tr>
<tr>
<td>Site Constraints</td>
<td>Soil</td>
<td>This refers to the degree to which soil characteristics are important for system function.</td>
</tr>
<tr>
<td></td>
<td>Slope</td>
<td>Slope refers to the degree to which the slope of the land on the site must meet certain standards for systems to function.</td>
</tr>
<tr>
<td>Natural Environment</td>
<td>Habitat Creation Potential</td>
<td>Habitat creation refers to the potential for a system to provide ecosystem services onsite. Ecosystem services are defined as &quot;the benefits of nature to households, communities, and economies.&quot;</td>
</tr>
</tbody>
</table>

| Social Aesthetics | Visual | This refers to the ability of a system to affect the visual aesthetic of a site.                                                  |
|                  | Odor   | Some systems are characterized by having increased likelihood of odor associated with treatment. Depending on the process utilized odor will be minimal. |
|                  | Noise  | Some systems generate noise during the treatment process. Generally, passive systems will not generate as much noise, while activated systems, which utilize aeration processes are more likely to generate noise. |

<p>| Quality of Life Educational Opportunity | This refers to the ability of a system to provide community education opportunities. All systems could provide educational opportunities for community members. However, some systems will require more effort to do so. For example, wetland systems have been used to explain wastewater treatment processes to the general public, while other systems, like leach fields, whose primary treatment methods are subsurface, do not provide that opportunity as easily. |
| Owner Supervision Requirements | This refers to the amount of participation required by owners of systems. As a system increases in complexity, ownership awareness and participation will increase. |
| Health: Risk of Vector Contact | This refers to the chance for humans to come in contact with disease vectors associated with wastewater. Generally, properly functioning subsurface treatment will have no risk for vector contact, while systems utilizing above surface processes, like Wetlands, may contain some risk for vector contact. |</p>
<table>
<thead>
<tr>
<th><strong>SCORING CHOICES</strong></th>
<th><strong>GREEN</strong></th>
<th><strong>YELLOW</strong></th>
<th><strong>RED</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECONOMIC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Investment</td>
<td>Land Requirement</td>
<td>less than 0.25 sq ft. per GPD</td>
<td>greater than 0.25 less than 0.75 sq ft. per GPD</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
<td>Low Cost expected</td>
<td>Intermediate Cost expected</td>
</tr>
<tr>
<td>Operation &amp; Maintenance</td>
<td>Materials</td>
<td>Low Cost expected</td>
<td>Intermediate Cost expected</td>
</tr>
<tr>
<td></td>
<td>Energy Requirements</td>
<td>Less than 1 kWh per 1000 gallons treated</td>
<td>Greater than 1 and less than 10 kWh per 1000 gallons treated</td>
</tr>
<tr>
<td></td>
<td>Operational Labor</td>
<td>Minimal Supervision</td>
<td>Informed Owner</td>
</tr>
<tr>
<td>Regulation</td>
<td>Permitting (Current &amp; Future)</td>
<td>Approximate time to permit approval less than 6 weeks</td>
<td>Approximate time to permit around 6 weeks (anticipated future)</td>
</tr>
<tr>
<td><strong>ENVIRONMENTAL</strong></td>
<td>Reliability</td>
<td>Tightly controlled; consistent minimal variation in final effluent</td>
<td>Climatic variation in final effluent</td>
</tr>
<tr>
<td></td>
<td>Total Suspended Solids</td>
<td>Meets Title 22 Restricted Requirements (less than or equal to 10 mg/L)</td>
<td>Meets Title 22 Restricted Requirements (less than or equal to 30 mg/L)</td>
</tr>
<tr>
<td></td>
<td>Total Nitrogen Concentration</td>
<td>equal to or less than 5 mg/L</td>
<td>equal to or less than 10 mg/L</td>
</tr>
<tr>
<td></td>
<td>Biochemical Oxygen Demand</td>
<td>Meets Title 22 Unrestricted (less than or equal to 10 mg/L)</td>
<td>Meets Title 22 Restricted (less than or equal to 30 mg/L)</td>
</tr>
<tr>
<td></td>
<td>Fecal Coliforms</td>
<td>greater than or equal to 3 log removal</td>
<td>2 log removal</td>
</tr>
<tr>
<td><strong>SOCIAL</strong></td>
<td>Site Constraints</td>
<td>Soil</td>
<td>Low requirements of soil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slope</td>
<td>No grading requirement</td>
</tr>
<tr>
<td></td>
<td>Natural Environment</td>
<td>Habitat Creation Potential</td>
<td>Habitat Potential Generated</td>
</tr>
<tr>
<td></td>
<td>Odor</td>
<td>No chance of odor</td>
<td>Possible seasonal odor or odor due to high organic loading</td>
</tr>
<tr>
<td></td>
<td>Noise</td>
<td>No noise generated during treatment</td>
<td>Minimal noise generated during treatment</td>
</tr>
<tr>
<td><strong>QUALITY OF LIFE</strong></td>
<td>Educational Opportunity</td>
<td>Creates Public Education Opportunities</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Owner Supervision Requirements</td>
<td>Low Supervision</td>
<td>Informed Owner</td>
</tr>
<tr>
<td></td>
<td>Health: Risk of Vector Contact</td>
<td>No risk of contact with vector</td>
<td>Minimal risk of contact with vector</td>
</tr>
</tbody>
</table>
This System Summary Infographic will accompany specific technology descriptions and is intended to help users recall information from the matrix when exploring a technology further. Each wedge indicates a criterion from the matrix. These criteria are grouped into environmental, economic, and social considerations and are listed by number in the table below as well as around the infographic.

Depending on how a system scored for a given criterion, part or all of the wedge will be colorized. This colorized area will be referred to as the ‘performance score’. The most inner ring will be red, the second ring, yellow, and the most outer ring, green, indicating that the system scored highly in the matrix.

In this sample infographic for the leach field technology, by looking at each ‘wedge’ of the infographic, the user knows how the system scored for each criterion. For example, wedge 11 in the infographic represents Biochemical Oxygen Demand (BOD) removal, an environmental criterion. The performance score reaches the green ring for wedge 11, indicating that the leach field received a high score for BOD removal.

The performance score reaches the outer green ring for most of the economic criteria for this technology, meaning that the leach field generally costs less compared to other technologies. However, the performance score generally only reaches the red or yellow rings for environmental considerations. This indicates that that the leachfield technology does not perform as well from an environmental perspective relative to other technologies included in the matrix.
**Economic**
1. Initial Investment: Land Requirement
2. Initial Investment: Construction
3. Materials
4. Energy Requirements
5. Operational Labor
6. Current Permitting
7. Predicted Future Permitting

**Environmental**
8. Reliability
9. Removal of Total Suspended Solids (TSS)
10. Final Total Nitrogen Concentration
11. Biochemical Oxygen Demand (BOD)
12. Removal of Potential Pathogens
13. Soil Site Constraints
14. Slope Site Constraints
15. Habitat Creation Potential

**Social**
17. Aesthetics: Odor
18. Aesthetics: Noise
19. Education
20. Owner Supervision Requirements
21. Quality of Life: Risk of Vector Contact
In the following pages, you will find detailed technology descriptions for each system described in the Matrix. These descriptions are organized into the following categories: Treatment descriptions, System Pros, System Cons, a System Diagram, a System Summary Infographic, and Additional Links for Further Education.

Subsurface Treatment Systems

The systems within this section incorporate a process of water filtration that use natural soil properties, including soil pores space, vegetation and root systems. These treatment systems are largely reliant on soil type, land availability, and climactic conditions.

Leach Field Systems

Leach field systems are used as a dispersal method for primary treated wastewater, otherwise known as the outflow, or ‘effluent’ that comes from a septic tank. A leach field, also known as a drain field, is constructed with drainage pipes that convey effluent to the soil. This distribution is passive in nature, utilizing the force of gravity for conveyance and also for water percolation in the soil.

The best types of soil media are those that allow a slow rate of water percolation. Slow rates allow filtration of various harmful constituents via biological and physical processes before the wastewater reaches the water table.

These systems can be installed inexpensively and operated with minimal input. Limited owner input is measured by limited maintenance and typically zero energy use. Additionally, water that is filtered through the leach field recharges the groundwater aquifers, which is important for water supply and habitat.

While inexpensive to install and operate, these systems require significant land area for proper functioning, and are thus not appropriate for high-density sites. Leach field treated water is not available for reuse onsite, since it is filtered back to the groundwater.
Mound System

This system offers filtration through a slow rate of wastewater percolation through a constructed mound of porous media above the surface of the topsoil. Treatment is achieved through biological and physical filtration within the mound. In a properly functioning system, dangerous components within the wastewater are reduced and eliminated before the water reaches the groundwater. Percolation and filtration rates are dependent upon the properties of the media and soil. While energy use is minimal, a small amount is typically required for the pumping of water to the mound; this is due to the elevated relation of the mound to the subsurface piping structure.


With its above grade mound structure, this system can effectively eliminate harmful wastewater constituents and offer a solution for sites with high water tables. These systems offer effective treatment with minimal input from the owner in terms of maintenance and energy requirements. Since soil media is typically imported for mounds, they are not as restrained by native soil types.

While mound systems require substantial land area, they also require the use of above-surface construction; this may take away aesthetic quality of a landscape. Water treated with these systems is not available for reuse onsite, other than recharging groundwater.

**Economic**
1. Initial Investment: Land Requirement
2. Initial Investment: Construction
3. Materials
4. Energy Requirements
5. Operational Labor
6. Current Permitting
7. Predicted Future Permitting

**Environmental**
8. Reliability
9. Removal of Total Suspended Solids (TSS)
10. Final Total Nitrogen Concentration
11. Biochemical Oxygen Demand (BOD)
12. Removal of Potential Pathogens
13. Soil Site Constraints
14. Slope Site Constraints
15. Habitat Creation Potential

**Social**
17. Aesthetics: Odor
18. Aesthetics: Noise
19. Education
20. Owner Supervision Requirements
21. Quality of Life: Risk of Vector Contact
Evapotranspiration systems typically use the presence of select vegetation to draw water from the subsurface and into the plant structure. Water is then released to the atmosphere via plant respiration. Simultaneously, water is evaporated from the soil media, which creates a complete treatment of water through evapotranspiration. Primary treated wastewater is typically dispersed to sand bedding, atop an impermeable surface, usually an impermeable liner or clay.

Water levels within the Evapotranspiration (ET) bed are maintained at a suitable level to ensure efficient evapotranspiration. These systems are effective, and chosen in situations where native soil properties are inappropriate for infiltration or ground water levels are too high, and where evaporation rates are higher than precipitation rates.

**LEARN MORE ABOUT SUBSURFACE TREATMENT**

**UNIVERSITY OF WISCONSIN-MADISON**
Small-Scale Waste Management Project
http://www.soils.wisc.edu/sswmp/

**EPA: SEPTIC SYSTEMS**
EPA Evapotransporation Factsheet
http://www.epa.gov/nrmrl/pubs/625r00008/htm/tfs6.htm

**EPA MOUND SYSTEM FACTSHEET**
http://water.epa.gov/scitech/wastetech/mtbfact.cfm

Pros
When soil properties, or water table heights do not allow another form of subsurface onsite treatment, evapotranspiration can offer a solution. Maintenance of these systems requires minimal input, only requiring weeding and minor landscape upkeep. These systems often utilize plant species in landscaping that can enhance site aesthetics.

Cons
Evapotranspiration systems are highly limited by climatic conditions, which has lead to their use only in arid to semi-arid regions where evaporation greatly outweighs precipitation. Evapotranspiration systems also require a significant amount of land area, meaning that they will be limited to areas with

ECONOMIC
1. Initial Investment: Land Requirement
2. Initial Investment: Construction
3. Materials
4. Energy Requirements
5. Operational Labor
6. Current Permitting
7. Predicted Future Permitting

ENVIRONMENTAL
8. Reliability
9. Removal of Total Suspended Solids (TSS)
10. Final Total Nitrogen Concentration
11. Biochemical Oxygen Demand (BOD)
12. Removal of Potential Pathogens
13. Soil Site Constraints
14. Slope Site Constraints
15. Habitat Creation Potential

SOCIAL
17. Aesthetics: Odor
18. Aesthetics: Noise
19. Education
20. Owner Supervision Requirements
21. Quality of Life: Risk of Vector Contact
**Constructed Wetland Treatment**

Constructed Wetland Treatment systems are characterized by utilizing physical and biological treatment processes meant to emulate natural processes found in wetland ecosystems. These systems are often aesthetically pleasing and offer high educational opportunities to local classrooms due to the biological complexity of these systems.

**Free Water Surface (FWS) Wetlands**

Free Water Surface (FWS) Wetlands are natural wastewater treatment systems designed such that the water surface is exposed to the atmosphere. Wastewater in these systems flows over a soil surface with wetland plant species that encourages high levels of microbiological activity, which allows for effective biological treatment.

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**FWS Wetlands Attributes**

**Pros**
Free Water Surface Wetlands are an inexpensive, low energy method to achieve a moderate level of treatment. Due to the wetland plants and exposed water surface, these systems can provide habitat for animal and plant species.

**Cons**
The passive nature of these systems and exposure to the elements can cause the effectiveness of treatment to seasonally vary and potentially cause seasonal odors. Additionally, the exposed water surface can provide opportunities for mosquitos and will require management to keep their numbers down.

**Economic**
1. Initial Investment: Land Requirement
2. Initial Investment: Construction
3. Materials
4. Energy Requirements
5. Operational Labor
6. Current Permitting
7. Predicted Future Permitting

**Environmental**
8. Reliability
9. Removal of Total Suspended Solids (TSS)
10. Final Total Nitrogen Concentration
11. Biochemical Oxygen Demand (BOD)
12. Removal of Potential Pathogens
13. Soil Site Constraints
14. Slope Site Constraints
15. Habitat Creation Potential

**Social**
17. Aesthetics: Odor
18. Aesthetics: Noise
19. Education
20. Owner Supervision Requirements
21. Quality of Life: Risk of Vector Contact
Recirculating Vertical Flow Wetlands are natural wastewater treatment systems that combine the functionality of pre-fabricated sand and gravel filters with the microbiologically active soil surface and plant species found in constructed wetlands. These systems encourage high levels of physical and biological treatment of wastewater through multiple rounds of physical vertical filtration, combined with high rates of biological activity.³

³ City & County of San Francisco. (2009). Green Treatment Plant Technologies City and County of San Francisco- 2030 Sewer System Master Plan.
**Recirculating Vertical Flow Wetland Attributes**

**Pros**
Vertical flow constructed wetlands can achieve a relatively reliable and high level of treatment while having a smaller land footprint when compared to Free Water Surface and Horizontal Subsurface Wetlands.

**Cons**
These systems do not effectively treat total nitrogen and are often paired with Horizontal Subsurface Wetlands in order to facilitate its removal. Additionally, these systems have a higher energy use and require a higher amount of operational labor when compared to passive wetland systems due to recirculation of wastewater via pumps. Due to the smaller land footprint of these systems, they will not provide the same habitat creation potential as the larger wetland systems.

**Economic**
1. Initial Investment: Land Requirement
2. Initial Investment: Construction
3. Materials
4. Energy Requirements
5. Operational Labor
6. Current Permitting
7. Predicted Future Permitting

**Environmental**
8. Reliability
9. Removal of Total Suspended Solids (TSS)
10. Final Total Nitrogen Concentration
11. Biochemical Oxygen Demand (BOD)
12. Removal of Potential Pathogens
13. Soil Site Constraints
14. Slope Site Constraints
15. Habitat Creation Potential
17. Aesthetics: Odor
18. Aesthetics: Noise
19. Education
20. Owner Supervision Requirements
21. Quality of Life: Risk of Vector Contact
Horizontal Subsurface Flow Wetlands are a natural wastewater treatment system where wastewater flows horizontally through a microbiologically active soil with wetland plant species. These systems physically and biologically treat wastewater through a single round of horizontal filtration combined with metabolic activity of microbiological organisms.\(^4\)

Horizontal Subsurface Constructed Wetlands can achieve a moderate level of treatment through passive treatment processes with little operational oversight. Unlike Free Water Surface Wetlands, these systems’ water surface are not exposed to the atmosphere and do not require mosquito management.

These systems may not be able to be installed in all areas due to necessary grading requirements over a moderately large area.

**Economic**
1. Initial Investment: Land Requirement
2. Initial Investment: Construction
3. Materials
4. Energy Requirements
5. Operational Labor
6. Current Permitting
7. Predicted Future Permitting

**Environmental**
8. Reliability
9. Removal of Total Suspended Solids (TSS)
10. Final Total Nitrogen Concentration
11. Biochemical Oxygen Demand (BOD)
12. Removal of Potential Pathogens
13. Soil Site Constraints
14. Slope Site Constraints
15. Habitat Creation Potential

**Social**
17. Aesthetics: Odor
18. Aesthetics: Noise
19. Education
20. Owner Supervision Requirements
21. Quality of Life: Risk of Vector Contact
Tidal Flow Living Machines® are proprietary natural treatment systems developed by Worrell Water technologies. These systems treat wastewater by manipulating various biological processes through multiple wetland cells that mimic natural tidal flows. Tidal flows are simulated through multiple fill and drain cycles of cells that promote biological treatment through wetland plant species and metabolism of microbiological organisms.\textsuperscript{5}

\textsuperscript{5} Worrell Water Technologies (2007). Tidal wetland Living Machine® system description and scientific basis

\textsuperscript{5} Worrell Water Technologies (2007). Tidal wetland Living Machine® system description and scientific basis

Living Machine® systems provide consistent high levels of treatment with a small land footprint. These systems can be integrated into the indoor environment providing unique interior design opportunities.

The proprietary nature of Living Machine® systems invoke a high construction cost, additionally due to the non-passive nature of these systems they require a higher energy use when compared to passive Constructed Wetland systems. Additionally, these systems require a highly trained operator to maintain function due to the complexity of the treatment processes.

1. Initial Investment: Land Requirement
2. Initial Investment: Construction
3. Materials
4. Energy Requirements
5. Operational Labor
6. Current Permitting
7. Predicted Future Permitting
8. Reliability
9. Removal of Total Suspended Solids (TSS)
10. Final Total Nitrogen Concentration
11. Biochemical Oxygen Demand (BOD)
12. Removal of Potential Pathogens
13. Soil Site Constraints
14. Slope Site Constraints
15. Habitat Creation Potential
17. Aesthetics: Odor
18. Aesthetics: Noise
19. Education
20. Owner Supervision Requirements
21. Quality of Life: Risk of Vector Contact
Prefabricated and Modular Systems include engineered box systems, which perform treatment through biological, physical, and chemical processes in a tightly controlled environment. Some overarching features of these systems include a decreased overall land footprint and consistent high quality effluent.

Recirculating Filters

Sand and gravel recirculating filters “are essentially aerobic fixed film bioreactors” similar to activated sludge or MBR systems. These systems contain a sand or gravel filter medium, typically 2 feet in depth, which is dosed with septic tank effluent. Dissolved pollutants sorb to media while suspended solids are removed via sedimentation and straining processes. Generally, the dosing process is managed via automated timers and control panels. Filtrate is then collected into “underdrains” where effluent may be disinfected further or discharged following requisite guidelines.

Advanced media filters use essentially the same processes as sand and gravel recirculating filters. The main benefit of advanced media filters exists in the form of increased hydraulic loading capabilities and improved treatment potential of specific pollutants. This translates into a reduced footprint in terms of system size. Advanced medias may include biotextiles, peat, shale, glass, crushed brick or other engineered materials. Different materials are associated with increased treatment potential for pollutants. For example, crushed brick systems have increased ability to treat for phosphorous if this is a particular concern.

7 City & County of San Francisco. (2009). Green Treatment Plant Technologies City and County of San Francisco- 2030 Sewer System Master Plan.
Recirculating Filter systems have a minimal land footprint and can achieve reliable, high quality effluent, with the exception of nitrogen removal. Additionally, these systems are not expected to negatively impact the visual aesthetic of the area where they are constructed, or produce unwanted noise or odors.

These systems can be moderately expensive due to costs for construction and for operational labor, as these systems require a licensed operator. The use of advanced media may result in associated increased materials costs.

**Sand/Gravel System**

**Advanced Media System**

**Economic**
1. Initial Investment: Land Requirement
2. Initial Investment: Construction
3. Materials
4. Energy Requirements
5. Operational Labor
6. Current Permitting
7. Predicted Future Permitting

**Environmental**
8. Reliability
9. Removal of Total Suspended Solids (TSS)
10. Final Total Nitrogen Concentration
11. Biochemical Oxygen Demand (BOD)
12. Removal of Potential Pathogens
13. Soil Site Constraints
14. Slope Site Constraints
15. Habitat Creation Potential

**Social**
17. Aesthetics: Odor
18. Aesthetics: Noise
19. Education
20. Owner Supervision Requirements
21. Quality of Life: Risk of Vector Contact
Membrane bioreactors are characterized by a suspended growth activated sludge process similar to conventional activated sludge systems, with the addition of a membrane filter to separate and confine solid particles as water flows through. The MBR system uses a cross-flow process that prevents accumulation of solid particles on the membrane, and allows for them to be collected for recovery or disposal. Through this highly mechanized process, reliably high quality effluent is produced.


MEMBRANE BIOREACTOR ATTRIBUTES

PROS
MBR systems achieve consistently high quality effluent that can meet near disinfection standards. These systems may be placed above or below ground allowing for decreased impacts on the visual aesthetic of the area where they are constructed.

CONS
MBR systems tend to be an expensive investment due to high costs for membranes, construction costs and increased energy requirements to avoid membrane fouling. Additionally, these systems require a licensed operator.

ECONOMIC
1. Initial Investment: Land Requirement
2. Initial Investment: Construction
3. Materials
4. Energy Requirements
5. Operational Labor
6. Current Permitting
7. Predicted Future Permitting

ENVIRONMENTAL
8. Reliability
9. Removal of Total Suspended Solids (TSS)
10. Final Total Nitrogen Concentration
11. Biochemical Oxygen Demand (BOD)
12. Removal of Potential Pathogens
13. Soil Site Constraints
14. Slope Site Constraints
15. Habitat Creation Potential

SOCIAL
17. Aesthetics: Odor
18. Aesthetics: Noise
19. Education
20. Owner Supervision Requirements
21. Quality of Life: Risk of Vector Contact
Activated sludge treatment utilizes an aerobic suspended-growth microbial process to degrade organic matters as well as some inorganic compounds. Biomass generated through this process is settled out through a secondary clarifying process. A basic activated sludge system consists of an aeration tank and a clarifier, although some systems incorporate modifications to enhance treatment.
Activated Sludge Treatment System Attributes

**Pros**
Activated Sludge systems have a very minimal land footprint, perhaps the least of all the systems when designed properly, and require minimal landscape modification unless they are placed below grade.

**Cons**
These systems tend to be fairly expensive to maintain due to high energy costs for aeration processes. Additionally, these systems may produce unwanted odors at times of high organic loading and require a licensed operator to function properly.

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**Economic**
1. Initial Investment: Land Requirement
2. Initial Investment: Construction
3. Materials
4. Energy Requirements
5. Operational Labor
6. Current Permitting
7. Predicted Future Permitting

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**Environmental**
8. Reliability
9. Removal of Total Suspended Solids (TSS)
10. Final Total Nitrogen Concentration
11. Biochemical Oxygen Demand (BOD)
12. Removal of Potential Pathogens
13. Soil Site Constraints
14. Slope Site Constraints
15. Habitat Creation Potential

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**Social**
17. Aesthetics: Odor
18. Aesthetics: Noise
19. Education
20. Owner Supervision Requirements
21. Quality of Life: Risk of Vector Contact
This Guidance Document can be a helpful tool in identifying which wastewater treatment systems might be appropriate for a planned development. As an example, we have applied our tool to a development project in Santa Barbara County called The Children’s Project Academy (CPA), designed by Peikert Group Architects (PGA). This section shows the results from this case study and provides an example of how to effectively use the Guidance Document as an educational tool.

The Children’s Project Academy will be a residential charter school for 120 foster youth to live with dedicated foster families and alongside teachers and staff, creating permanent relationships with caring adults.

The campus will incorporate principles of sustainable design, not only for the benefit of the environment, but to educate the students minimizing the impact humans have on the planet for this and future generations.
PGA was interested in a decentralized wastewater treatment system to meet the CPA's strict water restrictions. Due to zoning laws, the CPA was required to reduce the amount of wastewater generated onsite by 20%. The design team believed that a decentralized system could recycle water onsite, reducing the demand for freshwater for irrigation, and decreasing the amount of wastewater generated onsite. However, they were unfamiliar with decentralized systems and needed some targeted information before consulting engineers. PGA turned to the Guidance Document for information and assistance in identifying potential wastewater systems.

To effectively use this tool, the first step was to identify project constraints. For the CPA, the most important constraints were:

1. Economic Limitations: As a non-profit organization that relies on donations and government grants for funding, the CPA has a limited budget of $1 million for its wastewater treatment plant.

2. Land Availability: There is a limited amount of land available for a wastewater treatment system on the campus because much of the property will be used for other built structures. Also, many parts of the property are physically unable to support a treatment system because of their steep slope and location in a floodplain.
3. Reuse Requirements: The main objective in using an alternative treatment system is to reuse the treated water onsite for irrigation of landscape and recreational fields. As such, the system must reliably produce high quality treated water that meets California’s reuse requirements.

4. Education: Because the treatment plant will be located at a school, a system that would allow for education and involvement is preferred, as a way to foster education and involvement in the students and residents.

After defining the project constraints, the matrix tool is used to eliminate treatment systems that do not meet the project needs. For the economic limits, membrane bioreactors were eliminated as a possible option because this system had a red scoring for four of the five cells indicating cost. The restraints on land availability resulted in the elimination of the three subsurface treatment options, leachfield, mound system, and evapotranspiration, because of their high demand for land space (as indicated by the red colored cells in the row “land requirement”). For water reuse, the remaining systems all had similar performance standards and therefore no systems could be eliminated based on that criteria. Lastly, activated sludge systems and recirculating filters were eliminated because of their low score in the education category.

After narrowing down the choices based on constraints, the only remaining systems were the four constructed wetlands. Upon closer inspection, the Free Water Surface System and the Subsurface Horizontal Flow were eliminated because of their poor scoring under soil and slope restraints.

**CONCLUSIONS**

The two remaining technologies that meet most of the requirements for the CPA are Recirculating Vertical Flow Wetlands and the Tidal Flow Living Machine®. The Guidance Document provides more detailed information on these systems on pages 18-23 and includes how the systems work, their overall strength and weaknesses, and permitting information.

After using the Guidance Document, PGA have a clear idea of which wastewater systems might be appropriate for the CPA, and are better prepared to discuss system options with designers or engineers.

However, it is important to note that the matrix can assist in eliminating technologies that are not feasible for a project so that the user can then pursue further information on possible systems; its purpose is not to choose the perfect wastewater system, nor is it capable of doing this. The matrix user is expected to seek out the advice of an expert, who can perform a site visit and a financial quote, before choosing to implement a system.
Helpful Organizations and Webpages

Water Environmental Research Foundation (WERF)
www.werf.org

Regional Water Quality Control Board
http://www.swrcb.ca.gov/rwqcb5/

Santa Barbara County Environmental Health Services
http://www.countyofsb.org/phd/environmentalhealth.aspx?id=1444

Santa Barbara County Planning Department
http://www.sbcountyplanning.org/

California Department of Public Health
http://www.cdph.ca.gov/

EPA Technology Factsheets
http://water.epa.gov/scitech/wastetech/mtbfact.cfm

Water Environmental Foundation (WEF)
http://wef.org/

National Environmental Services Center: Wastewater and Onsite Systems
http://www.nesc.wvu.edu/wastewater.cfm
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