San Francisco Public Utilities Commission
San Francisco, CA

LIVING MACHINE SYSTEMS, L3C
Living Machine® Systems, L3C (LMS) - based in Charlottesville, Virginia - is a social benefit corporation, focused on ensuring lasting water resources for communities across the globe. Our proven ecological wastewater treatment and reuse system is compact, efficient, and cost effective. From Ghana to San Francisco and from schools and office towers to resorts, the Living Machine® system has been installed in dozens of locations around the world.

LMS and its predecessor, Living Technologies, Inc., have designed and refined ecological wastewater treatment systems since 1995. While constructed wetlands and other natural treatment technologies have been successfully utilized for decades, today’s Living Machine technology allows a radically smaller footprint and higher treatment performance relative to other natural treatment systems. In comparison to conventional wastewater treatment technologies the Living Machine system offers reduced energy use and significant savings in both capital and life cycle costs while achieving the highest treatment and reuse water quality standards. LMS designs beautiful, energy-efficient, high-performance wastewater treatment systems that foster water reuse in rural, suburban, and urban areas.

SYSTEM BENEFITS
• The building reduces water use by over 70% and saves approximately 750,000 gallons of water per year while providing an additional 900,000 gallons per year for nonpotable uses off-site.

• The system provides attractive exterior and interior foliage and a pleasant public space.

• Treats all wastewater generated by the building’s employees and produces high quality water to flush toilets and for future off-site irrigation.

CASE STUDY
San Francisco Public Utilities Commission
San Francisco, CA

COMPLETION DATE 2012
APPLICATION municipal
SYSTEM CAPACITY 5,000 gpd
REUSE flush toilets + irrigate nearby park

Living Machine® Systems
www.livingmachines.com

Design by KMD/Stevens Architects

Interior Vertical Flow Wetland Cell
**Design Basis + Architectural Integration**

**PROJECT OVERVIEW**
When planning its 277,500 square foot Administration Building in downtown San Francisco, the Public Utilities Commission - the area's provider of power, drinking water and wastewater services - was strongly committed to being a national leader in sustainable design. The challenge was to identify and use green technologies that could work within the constraints of the building's urban environment, as well as fulfill long-term cost-saving measures.

**WHY A LIVING MACHINE?**
The SFPUC opted for integrated solar panels and wind turbines to generate energy and a Living Machine® system to treat and reuse its wastewater. As the only ecological system capable of treating blackwater with a small physical footprint, appropriate to an urban setting, the Living Machine was the obvious choice. Beyond size and integration issues, energy efficiency, low maintenance costs, water quality results and aesthetics were key elements for the SFPUC. The American Institute of Architects (AIA) Committee on the Environment (COTE) awarded the SFPUC Administration Building with a Top Ten Green Project Award for 2013.

**WETLAND SIZE PARAMETERS**

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<tr>
<th>Tidal Wetland Cells</th>
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<td>Parameters</td>
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<table>
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<td>Units</td>
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**ARCHITECTURAL INTEGRATION**
- One of the wetland treatment cells is incorporated into the lower lobby of the building.
- The remaining wetland cells are incorporated into the city sidewalk on Polk and Golden Gate Streets.
- Materials and plantings for both interior and exterior wetland cells were coordinated with project architect and landscape architects to integrate with site and building aesthetics.

**PROJECT PARTNERS**

**Clients:** San Francisco Public Utilities Commission  
Project Manager: San Francisco Department of Public Works  
**Architect:** KMD/Stevens Architects  
**Landscape Architect:** Antonia Bava Landscape Architecture  
**General Contractor:** Webcor Builders  
**Engineering Partners:** Aqua Nova Engineers, SJ Engineers

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Exterior of 525 Golden Gate Avenue with Vertical Flow Wetland Cell

www.livingmachines.com
Site Plan

- TFW Cell 1A
- TFW Cell 1B
- TFW Cell 2A
- TFW Cell 2B
- TFW Cell 2C
- Primary Tank
- Equalization Tank
- Rain Tank
- Reuse Tank

Exterior Cells
Interior Cells

www.livingmachines.com
EXTERIOR PLANTS
• Plants are native or naturalized species.
• Plants suited to very low light conditions and require low maintenance
• Capable of withstanding strong seasonal winds and demanding urban environment

INTERIOR PLANTS
• Plants specifically chosen for low light conditions within the lobby.
• Striking foliage and flowers for aesthetic qualities.
• Three distinct canopy heights:
  Low = Rumohra  
  Med = Zantedeschia + Agapanthus  
  High = Acorus

Acanthus mollis, Bear’s Breach
Chronopetalum tectorum, Cape Rush
Acorbus alternifolius gracilis, Umbrella Plant
Acorus gramineus, Japanese Sweet Flag
Rumohra adiantiformis, Leather Leaf Fern
Zantedeschia aethiopica, Giant Calla Lily
Agapanthus Praecox, Lily of the Nile
Cyperus alternifolius gracilis, Umbrella Plant

WWW.LIVINGMACHINES.COM
Engineering Details + Performance Data

TREATMENT SYSTEM DESIGN

• The Living Machine system consists of two tidal-flow Stage 1 treatment cells and three vertical-flow Stage 2 treatment cells, filled with a Lightweight Expanded Shale Aggregate (LESA) media. A diversity of microbial organisms comprise a fixed film (biofilm) that grows on and adheres to the exterior surface and within the pore space of the LESA media.

• In Stage 1, the biofilm is exposed to the atmosphere several times daily through LMS’s patented fill and drain cycling. Recurrent exposure to aerobic and anoxic environments helps to eliminate odors and enhances nitrification, denitrification and removal of BOD, TSS and an array of organic and man-made compounds. After Stage 1, water moves on to Stage 2.

• Stage 2 consists of three vertical flow wetland cells. The first two cells are internally recycled and the final cells provides a single pass. Stage 2 removes remaining BOD, TSS, and completes nitrification. The water leaving this stage is very clean but requires final filtration and disinfection for re-use.

• Wastewater from the Living Machine is pumped through a two stage filtration system, followed by two stage ultraviolet (UV) and chlorine disinfection. The first filter is an automatic self-cleaning filter, which removes any coarser particles, followed by a cartridge filter designed to catch any remaining small particles. Filtering of the effluent is necessary to remove fine particles that will inhibit UV disinfection. Online turbidity, UV transmissivity, and chlorine sensors assure that reuse water quality standards are continuously being achieved.

PERFORMANCE SUMMARY

<table>
<thead>
<tr>
<th>Units (mg/l)</th>
<th>Influent</th>
<th>Primary</th>
<th>Effluent</th>
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<tbody>
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<td>228.5</td>
<td>ND*</td>
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<tr>
<td>TSS</td>
<td>400</td>
<td>69</td>
<td>ND*</td>
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<tr>
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* Below Detection Limits
Living Machine Process Diagram

Stage 1
Coarse lightweight expanded shale (LESA) treatment media prevents clogging

Stage 2
Finer LESA media provides final treatment

Living Machine Control Panel
Web enabled panel allows remote operation and oversight

Magnetic and ultrasonic flow meters monitor flow

Transition media Protects underdrain

Tidal Flow Cells 1 + 2

Vertical Flow Cells 1-3

Underdrain system Allows cells to drain quickly allowing rapid cycling

Recirculation Tank
Water is pumped from recirculation tank to tidal flow cells 1 + 2 alternately

Reuse Tank Provides water for toilet flushing

Trash Tank Solids are periodically pumped to sewer

Settling Tank Anaerobic degradation of organic material

Flow Equalization Tank

Recirculation Tank

Online Chlorine Sensor

Online Turbidity Sensor

Screen Filter

Chlorine Tablet Feeder

Cartridge Filter

UV

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CONTROL SYSTEM DESIGN

The Living Machine system operation is fully automated through the control panel which operates all mechanical components of the system based on operator settings and sensor signals. A touch-panel human-machine interface (HMI) display is integrated into the inner door of the control panel. This touch panel provides a graphical interface to monitor system performance and to change system parameters. Within the control panel is a programmable logic controller (PLC). This microcomputer interfaces with the HMI and electromechanical devices through motor starters and relays.

The control system acquires readings from field sensors and switches within the panel, as well as user entered parameters provided through the HMI to make operational decisions based on these inputs. Example screens from the HMI are provided below. The Control System for this project integrates operation of the rainwater collection and reuse system as well. In 2012, the SFPUC building received a “Best Intelligent Building Projects” award for the building’s control systems.