City and County of San Francisco
2030 Sewer System Master Plan

TASK 800
TECHNICAL MEMORANDUM NO. 803
DISTRIBUTED TREATMENT AND LOCAL REUSE: FEASIBILITY AND REGULATORY CONSIDERATIONS

FINAL DRAFT
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CITY AND COUNTY OF SAN FRANCISCO
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DISTRIBUTED TREATMENT AND LOCAL REUSE: FEASIBILITY AND REGULATORY CONSIDERATIONS

1.0 INTRODUCTION

This technical memorandum (TM) discusses the feasibility and regulatory process of the collection, treatment and reuse of rainwater and wastewater on-site at larger multi-residence, commercial, or industrial buildings that would be located within the City and County of San Francisco.

San Francisco has a centralized wastewater treatment system, which collects and treats stormwater and wastewater from a relatively large area, taking advantage of economies of scale. In contrast, distributed or decentralized treatment (herein distributed treatment) is the concept of treating rainwater and/or wastewater from smaller areas such as a large high-rise apartment building, a cluster of residential homes, or a commercial or industrial park, and reusing the treated effluent locally to offset potable water use. The treated wastewater and/or rainwater is typically reused on-site or at adjacent properties for a variety of uses, including toilet flushing, irrigation of parks or gardens, or other non-potable water uses such as heating/cooling systems.

Buildings that incorporate these strategies are called “green” buildings and typically incorporate other energy efficient, sustainable technologies within the building and on the property (i.e. permeable pavements, landscape design). The U.S. Green Building Council can certify these buildings through the Leadership in Energy and Environmental Design (LEED) Green Building Rating System. Smaller residential homes are often certified through the GreenPoints Rated program.

Distributed treatment may be appropriate for San Francisco for several reasons. First, the Recycled Water Master Plan (March 2006) estimated a recycled water demand within the City and County of San Francisco of approximately12 million gallons per day (mgd) based on identified users. Using recycled water for non-potable uses decreases the demand and associated costs for imported potable water. Secondly, reuse within the system would decrease the amount of wastewater and rainwater that enters the existing sewer system, which reduces the costs associated with operation of the system. Reusing treated water locally reduces the cost of piping and pumping water back to remote reuse sites from the centralized treatment plant. Finally, less wastewater and rainwater in the system during extreme storm events may reduce local flooding, and the volume of combined sewer discharges (CSDs).

2.0 OVERVIEW OF ON-SITE WASTEWATER TREATMENT AND REUSE

There are many ways to be more water efficient on-site to minimize the wastewater and stormwater that enters the sewer system and to decrease the amount of imported potable water used. For example, rainwater may be routed through low impact design techniques such as on-site bioswales, permeable pavements, or green roofs. Rainwater may also be collected from rooftops in cisterns or from land in infiltration basins and reused for toilet flushing, irrigation, cooling towers, or building heating/cooling systems. Wastewater produced on-site can be collected, treated, and reused for similar applications, depending on the regulations.

Wastewater from toilets and kitchen sinks, or blackwater, may be separated out from other sources of wastewater. Graywater (also “graywater”, “gray water”, or “grey water”) is the portion of wastewater that comes from showers, bathtubs, sinks (other than kitchen), and washing machines. By collecting and treating only graywater, instead of all wastewater from a building, exposure to harmful bacteria contained in toilet and kitchen wastes is minimized. The treatment requirements and complexity of the system for graywater may also be less than for all wastewater.

The sources of water used and the techniques, treatment, and processes applied in a building site to conserve water depend on the opportunities for reuse at the site, as well as the state and local requirements. A generalized summary of the potential reuse applications for rainwater, graywater, and treated wastewater is presented in Table 1.

Typical treatment processes for distributed wastewater treatment systems include either mechanical systems such as Membrane Bioreactors (MBR), advanced filtration (microfiltration followed by reverse osmosis, etc.) or natural systems that incorporate wetlands such as the Living Machine®. On-site or distributed treatment systems that use soil-based treatment and/or a leach field (e.g. a septic system) have not been allowed in San Francisco, and are not discussed further due to their limited applicability to the focus of this TM.

Sludge produced from on-site treatment can be discharged to the sewer system for ultimate disposal to the wastewater treatment plant. If connection to the sewer system is not available, a septic hauler may come and remove the biosolids on a regular basis. Therefore, it should be noted that in the case of San Francisco, a “distributed treatment” system is integral with the existing centralized wastewater treatment system for solids management.

Maintenance requirements depend on the size and design of the system. On-site MBR plants tend to have minimal maintenance staffing requirements. For example, both the Solaire Building, a MBR plant at the bottom of a 27-story high-rise residential building in

Table 1 Potential Reuse Opportunities for Various Water Sources
2030 Sewer System Master Plan
City and County of San Francisco

Residential Uses	Potable Water	Untreated to Partially Treated Rainwater (1)	CAC Title 24 Treated Graywater (2)	CAC Title 22 Treated Rainwater, Graywater, Wastewater (3)
Consumptive Use	X			
Toilet	X	X		X (4)
Sink	X			
Surface Irrigation	X	X	X (5)	X
Subsurface Irrigation	X	X	X	X
Dishwasher	X			
Shower	X			
Laundry	X	X		
Commercial Uses				
Consumptive Use	X			
Toilet	X	X		X
Sink	X			
Non-subsurface Irrigation	X	X		X
Subsurface Irrigation	X	X	X	X
HVAC processes	X	X		X
Commercial Laundry	X	X		X

CAC = California Administrative Code
(1) Level of treatment and final use depends on acceptance of local building and health departments and State DPH depending on cross-connection concerns.
(2) Treated to CAC Title 24, Part 5, Appendix G level of treatment (screening)
(3) Treated to CAC Title 22 Tertiary Reuse Requirements.
(4) Not allowed in individually-owned residential homes, excluding condominiums.
(5) For clothes washer and single fixture systems, provided at least two inches of mulch, rock, or soil, or a solid shield covers the release point.

New York, and the Oregon Science and Health University building, a teaching medical building also with a MBR plant on-site, have a contract operator who visits the site several times per week to maintain operations. For wastewater reuse in California, additional requirements may apply based on the conditions in the recycled water permit (e.g. daily fecal coliform sampling, etc.).

Dual-plumbed recycled water systems (i.e. “purple piping”), which are required to convey recycled water, has been a mandatory part of new building construction in areas throughout the City. Originally intended to distribute recycled water from the City’s wastewater treatment system, dual-plumbed recycled water systems could also be used to convey recycled water generated on-site if permitted by the RWQCB and the CA DPH. The opportunities for reuse of recycled water from the City's wastewater treatment plants are more fully explored in the City and County of San Francisco Recycled Water Master Plan (March 2006).

3.0 GREEN BUILDING CERTIFICATION PROGRAMS

The U.S. Green Building Council certifies green buildings as environmentally responsible through the LEED Green Building Rating System. In order to be LEED certified, buildings need to implement certain energy efficient, water conservation, stormwater/wastewater reuse, air pollution, and/or sustainable controls that make the building more sustainable, healthy, and environmentally friendly. These controls are called credits. For each credit implemented in the building, points are awarded. There are a total of 69 points that can be awarded to a building, of which seven are related to the conservation of water and reuse of wastewater and stormwater. A building receives a certification depending on the number of points awarded.

The list of all of the LEED credits and the point awarded that credit is provided in Appendix A. The water related credits include the following:

- Credit 6.1 Stormwater Design, Quantity Control – 1 point
- Credit 6.2 Stormwater Design, Quality Control – 1 point
- Credit 1.1 Water Efficient Landscaping, Reduce by 50% - 1 point
- Credit 1.2 Water Efficient Landscaping, No Potable Use or No Irrigation – 1 point
- Credit 2 Innovative Wastewater Technologies – 1 point
- Credit 3.1 Water Use Reduction, 20% Reduction – 1 point
- Credit 3.2 Water Use Reduction, 30% Reduction - 1 point

A more detailed description of the water related credits and the requirements and potential strategies or technologies to implement those credits as described by the LEED requirements is provided in Appendix B.

The following certification categories indicate the number of points needed to be awarded to receive certification:

- Certified : 26-32 points
- Silver : 33-38 points
- Gold : 39-51 points
- Platinum : 52-69 points

GreenPoint Rated (GPR) is an alternative certification process for non high-rise residential uses. GPR is a program of Build It Green, a professional non-profit membership organization whose mission is to promote healthy, energy, and resource-efficient buildings in California. Similar to the LEED point system, GPR has a point system. Greater than 50 points earns you the ability to bear the GreenPoint Rated home label.

4.0 CITY INITIATIVES AND EFFORTS

There have been several ordinances that have been issued to support on-site collection and reuse of wastewater and rainwater. The following identify major efforts:

- Reclaimed Water Use Ordinance 390-91, 391-91 (amended in 1994 by Ordinance 393-94), and 175-91 (San Francisco City Code Article 21 and Articles 22) requires that dual-plumbing systems (i.e. "purple pipe") be installed in new construction and building remodels, as applicable.

- Ordinance No. 88-04 (04/26/04) requires all municipal building projects (i.e. new construction and major renovations greater than 5,000 square feet) achieve LEED Silver certification.

- Ordinance 115-04 requires that Planning Department applicants receive equitable treatment, and that applications are reviewed in the order received, except in four instances. The first of these instances is a project application for a Green Building. The project must meet or exceed a Gold LEED rating to receive priority treatment.

- As a result of the Mayor's Task Force on Green Building for the City and County of San Francisco, Report and Recommendations (June 2007), a Green Building Ordinance was passed in 2008. The ordinance addresses all major renovation, new residential construction, and commercial construction greater than 5,000 square feet (public and private). The ordinance is based on the findings made by the Task Force which recommend that these buildings achieve either LEED or GPR certification to varying levels, phased in over the course of 4 years. The recommended levels are summarized in Figure 1.

- The Mayor has convened a new taskforce, The Existing Buildings Efficiency Initiative Task Force, to tackle greening existing buildings in San Francisco. The combination of new construction and major renovation in San Francisco adds up to less than 1 percent of the city's real estate, so this task force is set to advance the greening of existing buildings. The task force will recommend how the City, in partnership with the private sector, can accelerate improvements in energy and resource efficiency of existing commercial buildings in San Francisco.

Figure 1 Summary of Recommended Certification Levels

	2008	2009	2010	2011	2012
A. **New Large Commercial**	LEED Certified	LEED Silver	LEED Silver	LEED Silver	LEED Gold
B. **New High-Rise Residential**	LEED Certified	LEED Certified	LEED Silver	LEED Silver	LEED Silver
C. **Large CTIs & Major Alterations**	LEED Certified	LEED Silver	LEED Silver	LEED Silver	LEED Gold
D. **Mid-Size Com'l: New & Alterations**	LEED Checklist	LEED Checklist	LEED Checklist	LEED Checklist	LEED Checklist
E. **New Mid-Size Multi-Family**	GPR Guidelines	25 points GPR	50 points GPR	75 points GPR	75 points GPR
F. **New Small Residential (1–4 Units)**	GPR Guidelines	25 points GPR	50 points GPR	50 points GPR	75 points GPR

Source: The Mayor's Task Force on Green Building for the City and County of San Francisco, Report and Recommendations (June 2007).

5.0 REGULATIONS AND REQUIREMENTS FOR ON-SITE REUSE

5.1 Reuse of Wastewater

The California Department of Public Health (California DPH, formerly Department of Health Services or DHS) is the primary State agency responsible for public health, whereas the SWRCB and the RWQCB are the primary State agencies charged with protection, coordination, and control of water quality. These agencies work together to develop discharge permits for recycling projects. A Memorandum of Agreement (MOA) was developed between California DPH and the SWRCB on water recycling. The MOA is designed to provide coordinated regulation of recycled water and eliminate overlap of activities, duplication of effort, and inconsistency of action. The MOA allocates primary areas of responsibility and authority between California DPH, the SRWCB, and the RWQCBs. Generally, California DPH interprets the requirements outlined in the California Code of Regulations applicable to water recycling health and safety and makes recommendations on individual projects to the RWQCB, which is overseen by the SWRCB. Through issuance of NPDES discharge permits or a Recycled Water Permit, the RWQCB allows recycled water uses and specifies required quality levels.

The Water Recycling Criteria are contained in the California Code of Regulations, Title 22, Division 4, Chapter 3, Sections 60301 through 60355, or "Title 22". Title 22 contains provisions for the uses of recycled water; sources of recycled water; methods of treatment; levels of treatment; sampling and analysis; the preparation of an engineering report; general requirements of design; and operational and reliability requirements.

In addition to Title 22, there are other laws that regulate recycled water that are located in the Health and Safety Codes, Water Code, and Titles 17 of the California Code of

Regulations. All of the state laws that pertain to recycled water are compiled into a single document, *California Health Laws Related to Recycled Water*, most often referred to as the “Purple Book.” The most recent version of the Purple Book is dated June 2001. The specific treatment requirements and allowable uses for recycled water are presented in greater detail in TM 805 - Recycled Water Regulations and Opportunities.

For uses such as flushing toilets and urinals, surface irrigation with unrestricted access, and cooling the level of treatment required is disinfected tertiary treatment. For recycled water uses in areas accessible to the public, signs must be posted that state “Recycled Water – Do Not Drink.”

In the past, Title 22 requirements have not allowed recycled water to be delivered to individually-owned residential units, including condominiums, for inside use. The purpose of this restriction was to eliminate the risk that may occur if an individual home-owner were to inadvertently manipulate the plumbing, causing a cross-connection. Consequently, in California, residential homes or condominium buildings were not able to use recycled water for toilet and urinal flushing. However, the Governor just recently signed a bill (AB 1406) that will allow recycled water use for toilet and urinal flushing in multi-unit condominiums.

On the local level, distributed treatment projects must also follow the requirements outlined in the City’s Municipal Plumbing Code. In San Francisco, the San Francisco Department of Building Inspection (SF DBI) approves plans and specifications. SF DBI may consult with the San Francisco Department of Public Health (SF DPH) on a project. Additionally, the San Francisco Public Utilities Commission (SFPUC) will also provide guidance in the approval of buildings that have an alternative wastewater system.

5.2 Reuse of Graywater

California was the first state to establish graywater reuse regulations (in 1994). California’s graywater standards are located in Appendix G of the California Administrative Code Title 24, Part 5. The California Water Code, Division 7. Chapter 22 *Graywater for Home Irrigation*, also includes a small section that defines graywater. This section of the California Water Code can also be found in the Purple Book. On August 4, 2009, emergency graywater regulations, which added Chapter 16A “Nonpotable Water Reuse Systems” into the 2007 California Plumbing Code, were filed with the California Secretary of State and deemed effective immediately. These emergency regulations were added in order to promote graywater use in residential homes.

A clothes washer and single fixture systems in compliance with all of the following is exempt from obtaining a construction permit:

- If required, notification has been provided to the Enforcing Agency regarding the proposed location and installation of a graywater irrigation or disposal system.

- The design shall allow the user to direct the flow to the irrigation or disposal field or the building sewer. The direction control of the graywater shall be clearly labeled and readily accessible to the user.
- The installation, change, alteration or repair of the system does not include a potable water connection or a pump and does not affect other building, plumbing, electrical or mechanical components including structural features, egress, fire-life safety, sanitation, potable water supply piping or accessibility.
- The graywater shall be contained on the site where it is generated.
- Graywater shall be directed to and contained within an irrigation or disposal field.
- Ponding or runoff is prohibited and shall be considered a nuisance.
- Graywater may be released above the ground surface provided at least two (2) inches (51mm) of mulch, rock, or soil, or a solid shield covers the release point. Other methods which provide equivalent separation are also acceptable.
- Graywater systems shall be designed to minimize contact with humans and domestic pets.
- Water used to wash diapers or similarly soiled or infectious garments shall not be used and shall be diverted to the building sewer.
- Graywater shall not contain hazardous chemicals derived from activities such as cleaning car parts, washing greasy or oily rags, or disposing of waste solutions from home photo labs or similar hobbyist or home occupational activities.
- Exemption from construction permit requirements of this code shall not be deemed to grant authorization for any graywater system to be installed in a manner that violates other provisions of this code or any other laws or ordinances of the Enforcing Agency.
- An operation and maintenance manual shall be provided. Directions shall indicate the manual is to remain with the building throughout the life of the system and indicate that upon change of ownership or occupancy, the new owner or tenant shall be notified the structure contains a graywater system.

Simple systems, which exceed a clothes washer and or single-fixture system but discharge less than 250 gallons per day, and complex systems, which discharge more than 250 gallons per day, each require construction permits, unless exempted by that area’s administrative authority.

Graywater reuse systems are permitted by local city and county public health and building departments. In San Francisco, the permitting agency for graywater reuse is the SF DBI. The SF DBI would likely receive guidance from SF DPH.

5.3 Rainwater Use

Collection of rainwater and reusing it to irrigate landscape or gardens is a common practice in residential homes in California. Neither California DPH nor the RWQCB regulate the reuse of rainwater, yet local city and county public health and building departments may have public health concerns if rainwater is collected and then used for an application such as toilet flushing. In 2005 City staff amended the plumbing code via Ordinance 137-05, making it possible to direct rainwater to alternative locations such as rain gardens, rain barrels and cisterns.

In San Francisco, diversion of rainwater from the combined sewer system requires engineering plans be approved by the SF DBI. The municipal plumbing code section 306.2 states:

> "Roofs, inner courts, vent shafts, lightwells or similar areas having rain water drain, shall discharge directly into a building drain or building sewer, or to an approved alternate location based on approved geotechnical and engineering designs."

The permitting agency for a building project within the City is the SF DBI. Yet, depending on the reuse application, SF DBI may want input from SF DPH and/or SFPUC. A permit is not required to install a rain barrel as long as the barrel does not connect to your plumbing. To install a cistern for irrigation or toilet flushing, a permit is required from the Department of Building Inspection. If the system includes a pump or will be installed o the roof or underground, additional permits will be required.

5.4 Summary of the Regulatory Process

New City buildings or construction in San Francisco must attain at least Silver LEED certification (33-38 points) and new construction within the City must install dual-piping for potential reuse (i.e. typically for irrigation). In the future, all construction may be required to be LEED or HDR certified. Many building plans in San Francisco will likely opt for receiving recycled water from the City when it becomes available, as the California Academy of Science in Golden Gate Park has, rather than use on-site generated recycled water. Other building plans may include on-site wastewater treatment systems and use the dual-plumbing system for on-site reuse. Either way, plans and specifications for building construction must be submitted to the DBI for approval. The SF DPH and SFPUC may be called in to provide guidance. If wastewater is to be treated and re-used on-site, the California DPH must approve the project and the RWQCB issue a permit.

In San Francisco, a group called Literacy for Environmental Justice is developing the Living Classroom at Heron's Head Park, an educational facility dedicated to teaching environmental stewardship and green building by modeling and piloting various living and sustainable building systems. As part of the Living Classroom, the Eco Machine, a hybrid of mechanical and biological wastewater treatment systems, will treat all of the classroom's wastewater.

This is a precedent setting project in terms of permitting authority and governance for these types of small, distributed treatment systems without a discharge to a receiving water of the State. A detailed case study description of the permitting process and lessons learned for getting approval for the Living Classroom are presented in Appendix C.

A summary of the requirements that must be met for each type of source water and reuse are presented in Table 2. The role of each regulatory agency that is involved with the reuse is provided in Table 3.

Table 2 Requirements for Reuse Depending on Source Water
2030 Sewer System Master Plan
City and County of San Francisco

Source	Reuse Applications	App G Graywater Guidelines	Title 22 Reuse Guidelines	Local Plumbing Codes and Ordinances
Rainwater	Irrigation, Toilet Flushing, HVAC processes			X
Graywater (1)	Surface, Subsurface Irrigation	X		X
Additionally Treated Graywater (2)	Irrigation, Toilet Flushing, HVAC processes			X
Tertiary Treated / Disinfected Wastewater (3)	Irrigation, Toilet Flushing, HVAC processes		X	X

Notes:
(1) Treated and applied as outlined in the California Graywater Reuse Guidelines - Appendix G, Title 24, Part 5, California Administrative Code, and Chapter 16A "Nonpotable Water Reuse Systems" into the 2007 California Plumbing Code
(2) Treated to greater levels than outlined in the California Graywater Reuse Guidelines
(3) Treated to levels outlined in the Recycled Water Requirements – Title 22

The recommendations from the Mayor's Task Force on Green Building (*The Mayor's Task Force on Green Building for the City and County of San Francisco, Report and Recommendations, June 2007)* recognize that funding is necessary to revise the DBI application and review process and to educate City staff on green building designs. Other cities have already recognized this need. For example, the City of Santa Monica, California has hired a "Green Building Advisor" to help applicants navigate the permitting process. In order to streamline the permitting process, Santa Monica is also creating a checklist for applicants who would like to permit a graywater reuse system. This effort has become a greater priority due to the drought conditions in the area.

The San Francisco Department of the Environment has established a database of the green buildings that have been planned and/or constructed within the City. The database

Table 3 Responsible Regulatory Agency for Reuse Depending on Source Water 2030 Sewer System Master Plan City and County of San Francisco				
Source	**Reuse Applications**	**RWQCB**	**California DPH**	**SF DBI / SF DPH**
Rainwater	Irrigation, Toilet Flushing, HVAC processes	Review	Review	Permits the project
Graywater (1)	Subsurface Irrigation	Review	Review	Permits the project
Additionally Treated Graywater (2)	Irrigation, Toilet Flushing, HVAC processes	Review	Review	Permits the project
Tertiary Treated /Disinfected Wastewater (3)	Irrigation, Toilet Flushing, HVAC processes	Permits the project	Review and comment	Review and comment

Notes:

RWQCB = Regional Water Quality Control Board

SF DPH = City and County of San Francisco Department of Public Health

SF DBI = City and County of San Francisco Department of Building Inspection, which enforces the Uniform Plumbing Code (UPC).

"Review" = Review and comment depending on size and scope of project.

1) Treated and applied as outlined in the California Graywater Reuse Guidelines - Appendix G, Title 24, Part 5, California Administrative Code
2) Treated to levels greater than outlined in the California Graywater Reuse Guidelines
3) Treated to levels outlined in the Recycled Water Requirements – Title 22

provides information such as the LEED checklist and an environmental scorecard that calculates the energy saved and potable water use avoided. This information can be found at www.sfgreenprint.org.

6.0 SURVEY OF GREEN BUILDING PERFORMANCE AND CASE STUDIES

A research effort of green buildings around the country that have implemented wastewater or graywater reuse was conducted. A summary of the types of treatment and the total potable water savings at the building site are presented in Table 4. The percent potable water reduced values include the water reductions from water conservation methods such as low-flow toilets, sinks, showers, and urinals as well as modified irrigation practices in addition to the potable water offset from the use of recycled water. The percentage of water saved is in comparison to the typical water usage in a non-green building.

A detailed case study description is provided for the Living Classroom at Heron's Park in San Francisco in Appendix C. A second detailed case study description is provided for the Solaire Building in New York City, New York in Appendix D. The Solaire building is a 27-story high-rise apartment building in the Battery Park City area of Manhattan. This building uses solar energy, collects stormwater, reuses wastewater and has roof gardens. The wastewater system is a custom designed membrane bioreactor-based wastewater

Table 4 Distributed Treatment System Case Studies
2030 Sewer System Master Plan
City and County of San Francisco

Project	Location	LEED Rating	Use	Size (sf)	Treated	Treatment	Reuse	Total Potable Water Savings[1]
Living Room at Heron's Park	San Francisco, CA	Gold	Classroom	1,500	wastewater	EcoMachine	subsurface irrigation	
EcoHouse	Berkeley, CA	Not Rated	Residential Home	825	graywater	wetlands	subsurface irrigation (savings of 30,000 gal/yr otherwise sent to sewer)	
Solaire Building	New York, NY	Gold	Large Multi-Unit Residential	357,000	wastewater	MBR + UV + Ozone	toilet flushing, HVAC cooling, subsurface irrigation on-site and in adjacent parks and buildings	50%
					rainwater	sand filtration + chlorination	irrigate two on-site green roofs	
NRDC Office Building	Santa Monica, CA	Platinum	Office Building	15,000	rainwater + graywater	bacterlogical treatment+ Ozone + RO + UV	toilet flushing, irrigation	60%
Oregon Health and Science University	Portland, OR	Platinum	Medical Building	400,000	wastewater	MBR	toilet flushing, irrigation, building cooling (reduces flow to sewer by 27,000 gal/day)	56%
					rooftop and ecoroof rainwater	filtration (75 uM) +UV (w/ 5 uM inline)	toilet flushing, irrigation, building cooling	

Table 4 Distributed Treatment System Case Studies
2030 Sewer System Master Plan
City and County of San Francisco

Project	Location	LEED Rating	Use	Size (sf)	Treated	Treatment	Reuse	Total Potable Water Savings[1]
Heifer International Headquarters	Little Rock, AR	Platinum	Commercial Office	94,000	rainwater	permeable pavement to bioswales	4 MG wetlands	50%
					condensate + rooftop rainwater	filtration	toilet flushing, cooling tower	
Hawaii Gateway Energy Center	Kailua-Kona, HI	Platinum	Office/ Interpretative Center	3,600	seawater	condensation	toilet flushing, cooling	70%
					wastewater	septic tank	groundwater recharge	
Gerding Theater at the Armory	Portland, OR	Platinum	Theater	55,000	rooftop rainwater	circulating UV with 10uM dual filtration	toilet and urinal flushing (alone reduces potable water use >50%)	88%
					rainwater	pervious pavement and bioswales	natural irrigation (reduces flow to sewer by 26%)	
Sisters, Servants of the Immaculate Heart of Mary	Monroe, MI	Not Rated	Special Needs Housing	380,000	graywater + rainwater	wetlands	toilet flushing	50%
					rainwater	bioswales + wetlands	natural irrigation	

Notes:
(1) The percentage of total potable water savings takes into consideration water conservation controls such as low-flow faucets, showers, toilets and urinals and landscape design. Savings are in comparison to if the building did not implement reuse and/or conservation.

treatment and recycling system that treats 25,000 gpd. The recycled water is reused for toilet flushing, HVAC cooling, subsurface irrigation within the building and will also be used for irrigation and toilet flushing in adjacent parks and buildings.

An interesting article on Skyfarming, a visionary look at the future of green buildings, from the New York Times is included in Appendix E.

7.0 SUMMARY OF FINDINGS / RECOMMENDATIONS

Currently, if wastewater is to be treated and re-used on-site, the regulatory approval for plans and specifications for construction of on-site distributed wastewater treatment systems must be submitted to the SF DBI for approval. The SF DPH and SFPUC may be consulted for guidance. The RWQCB must also issue a permit and the California DPH needs to approve the project. Working with these agencies and departments is imperative to getting a project approved. Changing City ordinances to make green building a bigger part of the picture and educating staff so that the approval process is more streamlined is necessary. Additionally, establishing partnerships and leadership roles within the City to make green building easier for developers and the community would also prove beneficial.

It is desirable to provide the institutional flexibility to implement selected distributed treatment systems in the City as an economical means to supply recycled water on-site or to nearby locations and to offset imported potable water needs. Due to the complexity with permitting distributed treatment systems within San Francisco and the technicalities of operating such a system, it may be beneficial for the City to start with implementing distributed treatment systems within specified civic buildings as demonstration projects. Once the City has become more familiar with these systems, the City could then implement a program to monitor and oversee the operation of distributed wastewater treatment systems in larger private buildings.

APPENDIX A - LEED CERTIFICATION POINT LIST

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Sustainable Sites 14 Possible Points

Prereq 1 **Construction Activity Pollution Prevention** Required
Credit 1 **Site Selection** 1
Credit 2 **Development Density & Community Connectivity** 1
Credit 3 **Brownfield Redevelopment** 1
Credit 4.1 **Alternative Transportation**, Public Transportation Access 1
Credit 4.2 **Alternative Transportation**, Bicycle Storage & Changing Rooms 1
Credit 4.3 **Alternative Transportation**, Low Emitting & Fuel Efficient Vehicles 1
Credit 4.4 **Alternative Transportation**, Parking Capacity 1
Credit 5.1 **Site Development**, Protect or Restore Habitat 1
Credit 5.2 **Site Development**, Maximize Open Space 1
Credit 6.1 **Stormwater Design**, Quantity Control 1
Credit 6.2 **Stormwater Design**, Quality Control 1
Credit 7.1 **Heat Island Effect**, Non-Roof 1
Credit 7.2 **Heat Island Effect**, Roof 1
Credit 8 **Light Pollution Reduction** 1

Water Efficiency 5 Possible Points

Credit 1.1 **Water Efficient Landscaping**, Reduce by 50% 1
Credit 1.2 **Water Efficient Landscaping**, No Potable Use or No Irrigation 1
Credit 2 **Innovative Wastewater Technologies** 1
Credit 3.1 **Water Use Reduction**, 20% Reduction 1
Credit 3.2 **Water Use Reduction**, 30% Reduction 1

Energy & Atmosphere 17 Possible Points

Prereq 1 **Fundamental Commissioning of the Building Energy Systems** Required
Prereq 2 **Minimum Energy Performance** Required
Prereq 3 **Fundamental Refrigerant Management** Required
Credit 1 **Optimize Energy Performance** 1–10
(2 points mandatory for LEED for New Construction projects registered after June 26, 2007)
Credit 2 **On-Site Renewable Energy** 1–3
Credit 3 **Enhanced Commissioning** 1
Credit 4 **Enhanced Refrigerant Management** 1
Credit 5 **Measurement & Verification** 1
Credit 6 **Green Power** 1

Materials & Resources 13 Possible Points

Prereq 1 **Storage & Collection of Recyclables** Required
Credit 1.1 **Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof 1
Credit 1.2 **Building Reuse**, Maintain 95% of Existing Walls, Floors & Roof 1

Credit 1.3 **Building Reuse**, Maintain 50% of Interior Non-Structural Elements 1
Credit 2.1 **Construction Waste Management**, Divert 50% from Disposal 1
Credit 2.2 **Construction Waste Management**, Divert 75% from Disposal 1
Credit 3.1 **Materials Reuse**, 5% 1
Credit 3.2 **Materials Reuse**, 10% 1
Credit 4.1 **Recycled Content**, 10% (post-consumer + 1/2 pre-consumer) 1
Credit 4.2 **Recycled Content**, 20% (post-consumer + 1/2 pre-consumer) 1
Credit 5.1 **Regional Materials**, 10% Extracted, Processed & Manufactured Regionally 1
Credit 5.2 **Regional Materials**, 20% Extracted, Processed & Manufactured Regionally 1
Credit 6 **Rapidly Renewable Materials** 1
Credit 7 **Certified Wood** 1

Indoor Environmental Quality 15 Possible Points

Prereq 1 **Minimum IAQ Performance** Required
Prereq 2 **Environmental Tobacco Smoke (ETS) Control** Required
Credit 1 **Outdoor Air Delivery Monitoring** 1
Credit 2 **Increased Ventilation** 1
Credit 3.1 **Construction IAQ Management Plan**, During Construction 1
Credit 3.2 **Construction IAQ Management Plan**, Before Occupancy 1
Credit 4.1 **Low-Emitting Materials**, Adhesives & Sealants 1
Credit 4.2 **Low-Emitting Materials**, Paints & Coatings 1
Credit 4.3 **Low-Emitting Materials**, Carpet Systems 1
Credit 4.4 **Low-Emitting Materials**, Composite Wood & Agrifiber Products 1
Credit 5 **Indoor Chemical & Pollutant Source Control** 1
Credit 6.1 **Controllability of Systems**, Lighting 1
Credit 6.2 **Controllability of Systems**, Thermal Comfort 1
Credit 7.1 **Thermal Comfort**, Design 1
Credit 7.2 **Thermal Comfort**, Verification 1
Credit 8.1 **Daylight & Views**, Daylight 75% of Spaces 1
Credit 8.2 **Daylight & Views**, Views for 90% of Spaces 1

Innovation & Design Process 5 Possible Points

Credit 1.1 **Innovation in Design** 1
Credit 1.2 **Innovation in Design** 1
Credit 1.3 **Innovation in Design** 1
Credit 1.4 **Innovation in Design** 1
Credit 2 **LEED Accredited Professional** 1

Project Totals 69 Possible Points

Certified : 26–32 points
Silver : 33–38 points
Gold : 39–51 points
Platinum : 52–69 points

APPENDIX B - WATER RELATED LEED CREDIT DESCRIPTIONS

APPENDIX B - WATER RELATED LEED CREDIT DESCRIPTIONS

This appendix presents the description for the Credits associated with stormwater, water efficiency, and wastewater for LEED certification.

Sustainable Sites (SS)
Credit 6.1 **Stormwater Design**, Quantity Control 1
Credit 6.2 **Stormwater Design**, Quality Control 1

Water Efficiency (WE)
Credit 1.1 **Water Efficient Landscaping**, Reduce by 50% 1
Credit 1.2 **Water Efficient Landscaping**, No Potable Use or No Irrigation 1
Credit 2 **Innovative Wastewater Technologies** 1
Credit 3.1 **Water Use Reduction**, 20% Reduction 1
Credit 3.2 **Water Use Reduction**, 30% Reduction 1

Source: LEED for New Construction Version 2.2 October 2005 (revised EA section for projects registered after June 26, 2007)

SS Credit 6.1: Stormwater Design: Quantity Control
1 Point

Intent

Limit disruption of natural water hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff, and eliminating contaminants.

Requirements

CASE 1 — EXISTING IMPERVIOUSNESS IS LESS THAN OR EQUAL TO 50%
Implement a stormwater management plan that prevents the post-development peak discharge rate and quantity from exceeding the pre-development peak discharge rate and quantity for the one- and two-year 24-hour design storms.

OR

Implement a stormwater management plan that protects receiving stream channels from excessive erosion by implementing a stream channel protection strategy and quantity control strategies.

OR

CASE 2 — EXISTING IMPERVIOUSNESS IS GREATER THAN 50%
Implement a stormwater management plan that results in a 25% decrease in the volume of stormwater runoff from the two-year 24-hour design storm.

Potential Technologies & Strategies

Design the project site to maintain natural stormwater flows by promoting infiltration. Specify vegetated roofs, pervious paving, and other measures to minimize impervious surfaces. Reuse stormwater volumes generated for non-potable uses such as landscape irrigation, toilet and urinal flushing and custodial uses.

SS Credit 6.2: Stormwater Design: Quality Control
1 Point

Intent

Limit disruption and pollution of natural water flows by managing stormwater runoff.

Requirements

Implement a stormwater management plan that reduces impervious cover, promotes infiltration, and captures and treats the stormwater runoff from 90% of the average annual rainfall using acceptable best management practices (BMPs).

BMPs used to treat runoff must be capable of removing 80% of the average annual post development total suspended solids (TSS) load based on existing monitoring reports. BMPs are considered to meet these criteria if (1) they are designed in accordance with standards and specifications from a state or local program that has adopted these performance standards, or (2) there exists in-field performance monitoring data demonstrating compliance with the criteria. Data must conform to accepted protocol (e.g., Technology Acceptance Reciprocity Partnership [TARP], Washington State Department of Ecology) for BMP monitoring.

Potential Technologies & Strategies

Use alternative surfaces (e.g., vegetated roofs, pervious pavement or grid pavers) and nonstructural techniques (e.g., rain gardens, vegetated swales, disconnection of imperviousness, rainwater recycling) to reduce imperviousness and promote infiltration thereby reducing pollutant loadings.

Use sustainable design strategies (e.g., Low Impact Development, Environmentally Sensitive Design) to design integrated natural and mechanical treatment systems such as constructed wetlands, vegetated filters, and open channels to treat stormwater runoff.

1) In the United States, there are three distinct climates that influence the nature and amount of rainfall occurring on an annual basis. Humid watersheds are defined as those that receive at least 40 inches of rainfall each year, Semi-arid watersheds receive between 20 and 40 inches of rainfall per year, and Arid watersheds receive less than 20 inches of rainfall per year. For this credit, 90% of the average annual rainfall is equivalent to treating the runoff from:

(a) Humid Watersheds – 1 inch of rainfall;
(b) Semi-arid Watersheds – 0.75 inches of rainfall; and
(c) Arid Watersheds – 0.5 inches of rainfall

WE Credit 1.1: Water Efficient Landscaping: Reduce by 50%
1 Point

Intent

Limit or eliminate the use of potable water, or other natural surface or subsurface water resources available on or near the project site, for landscape irrigation.

Requirements

Reduce potable water consumption for irrigation by 50% from a calculated mid-summer baseline case.
Reductions shall be attributed to any combination of the following items:

- Plant species factor
- Irrigation efficiency
- Use of captured rainwater
- Use of recycled wastewater
- Use of water treated and conveyed by a public agency specifically for non-potable uses

Potential Technologies & Strategies

Perform a soil/climate analysis to determine appropriate plant material and design the landscape with native or adapted plants to reduce or eliminate irrigation requirements. Where irrigation is required, use high-efficiency equipment and/or climate-based controllers.

WE Credit 1.2: Water Efficient Landscaping: No Potable Water Use or No Irrigation
1 Point in addition to WE Credit 1.1

Intent

Eliminate the use of potable water, or other natural surface or subsurface water resources available on or near the project site, for landscape irrigation.

Requirements

Achieve WE Credit 1.1.and:

Use only captured rainwater, recycled wastewater, recycled graywater, or water treated and conveyed by a public agency specifically for non-potable uses for irrigation.

OR

Install landscaping that does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment are allowed only if removed within one year of installation.

Potential Technologies & Strategies

Perform a soil/climate analysis to determine appropriate landscape types and design the landscape with indigenous plants to reduce or eliminate irrigation requirements. Consider using stormwater, graywater, and/or condensate water for irrigation.

WE Credit 2: Innovative Wastewater Technologies
1 Point

Intent

Reduce generation of wastewater and potable water demand, while increasing the local aquifer recharge.

Requirements

OPTION 1

Reduce potable water use for building sewage conveyance by 50% through the use of water-conserving fixtures (water closets, urinals) or non-potable water (captured rainwater, recycled graywater, and on-site or municipally treated wastewater).

OR

OPTION 2

Treat 50% of wastewater on-site to tertiary standards. Treated water must be infiltrated or used on-site.

Potential Technologies & Strategies

Specify high-efficiency fixtures and dry fixtures such as composting toilet systems and non-water using urinals to reduce wastewater volumes. Consider reusing stormwater or graywater for sewage conveyance or on-site wastewater treatment systems (mechanical and/or natural). Options for on-site wastewater treatment include packaged biological nutrient removal systems, constructed wetlands, and high-efficiency filtration systems.

WE Credit 3.1: Water Use Reduction: 20% Reduction
1 Point

Intent

Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

Requirements

Employ strategies that in aggregate use 20% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements. Calculations are based on estimated occupant usage and shall include only the following fixtures (as applicable to the building): water closets, urinals, lavatory faucets, showers and kitchen sinks.

Potential Technologies & Strategies

Use high-efficiency fixtures, dry fixtures such as composting toilet systems and non-water using urinals, and occupant sensors to reduce the potable water demand. Consider reuse of stormwater and graywater for non-potable applications such as toilet and urinal flushing and custodial uses.

WE Credit 3.2: Water Use Reduction: 30% Reduction
1 Point in addition to WE Credit 3.1

Intent

Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

Requirements

Employ strategies that in aggregate use 30% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements. Calculations are based on estimated occupant usage and shall include only the following fixtures (as applicable to the building): water closets, urinals, lavatory faucets, showers and kitchen sinks.

Potential Technologies & Strategies

Use high-efficiency fixtures, dry fixtures such as composting toilets and waterless urinals, and occupant sensors to reduce the potable water demand. Consider reuse of stormwater and graywater for non-potable applications such as toilet and urinal flushing, mechanical systems and custodial uses.

APPENDIX C - CASE STUDY 1

APPENDIX C - CASE STUDY 1

The Living Classroom: the Eco Center at Heron's Head Park, a Case

Study of the Eco Machine.

Written by Ms. Laurie Schoeman, Project Manager of the Living Classroom, September 2007, in coordination with Patricia McGovern.

San Francisco's Bayview-Hunters Point (BVHP) community is the largest community of color in San Francisco with the highest ratio of youth in the city with over 37% percent of the community age 15 or younger. BVHP is also one of the most environmentally challenged communities in the nation housing an array of toxic and polluted areas hosting: two super fund sites including San Francisco's former Naval Shipyard, hundreds of brownfield sites, two major highways, as well as San Francisco's largest and most active industrial/manufacturing district. San Francisco's Southeast Wastewater Treatment Plant (SEP) is also located in BVHP.

The Living Classroom is a community based initiative, spearheaded by Literacy for Environmental Justice, a community based environmental justice advocacy group, to build an educational facility dedicated to teaching low income youth of color about environmental stewardship and green building by modeling and piloting various living and sustainable building systems. The building initiative is a partnership between Literacy for Environmental Justice (LEJ), the Port of San Francisco, San Francisco's Department of the Environment, and the California Coastal Conservancy.

The classroom facility, to be completed in 2008, will be located on a fifty-year old industrial landfill, which has been restored to one of the most pristine wetlands habitats in San Francisco. The site itself is over 900 feet from any sewer or primary electrical connection. To "tie in" to the nearest sewer line, which happens to be an industrial sewer line or to "tie" in to the nearest electrical line was estimated to be prohibitively expensive. Designers of the facility are using the site challenges as an opportunity to showcase off-grid technology and will feature San Francisco's first off-grid solar array, a simulated wetlands living roof which will harness and reuse stormwater, and a blackwater wastewater treatment system, called the Eco Machine.

Eco Machines, otherwise known as Living Machines, are a form of biological wastewater treatment designed to mimic the cleansing functions of wetlands. They are intensive bioremediation systems that can also produce beneficial by-products such as methane gas. Eco Machines can provide quality water to sustain edible and ornamental plants, and fish. Aquatic and wetland plants, bacteria, algae, protozoa, plankton, snails, clams, fish and other organisms are used in the system to provide specific cleansing or trophic functions. Eco Machines comprise prominent industrial, municipal, and commercial facilities throughout the United States most notably in Nevada, New Mexico, Vermont, Southern California, Utah, Florida, and in many of the counties in Northern California.

The Living Classroom's Eco Machine will treat all of the classroom's wastewater, including all septic waste on site which will amount to between 300-600 gpd. The Living Classroom's unique brand of Eco Machine is a hybrid of mechanical and biological wastewater treatment. The mechanical treatment process known as Smith and Loveless's Fast Activated Sludge Treatment will be implemented in the primary treatment, or digestion tank, to ensure quick and efficient anaerobic treatment in the first treatment stage. In the secondary stage, biological treatment will be used to further treat, refine, and "polish" the wastewater by using tanks of housed constructed wetlands. In the tertiary treatment stage, UV filtration will be used to irradiate potential contaminants in the treated water prior to disposal in a series of subsurface irrigation lines used to irrigate ornamental landscape abutting the classroom. The Eco Machine system has been designed by Rana Creek Living Systems, designers of the California Academy of Sciences Green Roof; h20 Biotech, a San Francisco based wastewater consultant firm; and Jonathon Todd Ecological Design, inventor of the Living Machine. John Todd Ecological Design will be working with a conventional wastewater installer to install the eco-machine in the Living Classroom.

Regulatory and Permitting Challenges

One of the greatest challenges for the project has been integrating the Eco Machine into the design plans for the facility in terms of permitting and regulation of the system. Because the Living Classroom is sited on Port of San Francisco land, the Port of San Francisco is the formal permitting agency for the project. Due to limited capacity, the Port of San Francisco vettes much of their document review, specifically around plumbing and electrical review, through the San Francisco Department of Building Inspection, who ensure that all plans comply with San Francisco City Code, in this case, San Francisco Plumbing Code.

According to Laurie Schoeman, the Living Classroom project manager, the question of whether the Eco Machine can be implemented in the facility, has gone unanswered both by the Port of San Francisco and the Department of Building Inspection (DBI) for over two and a half years. Neither agency has been able to offer a solution as to how to permit and regulate the proposed system and at this point, she has received no technical feedback from either agency as to how to viably regulate the proposed wastewater project. DBI has recommended on two occasions, that the only way to get a "permit" for the system is to get a formal permit from both the California Department of Public Health (DPH, formally the California of Health Services, or DHS), and the Regional Water Quality Control Board (RWQCB).

RWQCB/California DPH

A Report of Waste Discharge (ROWD) to start the permitting process was submitted to the RWQCB, which "approved" proceeding ahead with the system but because of its small size and its lack of impact on adjacent water bodies, the RWQCB did not feel it was necessary to issue a formal permit. The California DPH, at the district level, however, seemingly does not have the capacity to review the proposed system and essentially claimed that it was "non permissible" and was unable to offer a solution or refer the system to another agency.

Consequently, the project proponents approached the SF PUC wastewater division and SF DPH environmental health division at the municipal level, to try to figure out a viable municipal based solution to the permitting and regulatory challenges that the Eco Machine was facing. The SF DPH's environmental health division agreed to stand in place of California DPH as legal regulator thereby providing oversight of the installation and implementation of the proposed wastewater system; the SFPUC agreed to provide water quality testing, and offer expertise around the ongoing implementation of the system. The RWQCB was then approached by S FDPH to endorse the proposed regulatory team—that is working with SF DPH in lieu of California DPH. Currently the proposed team in place has been fully endorsed and supported by the RWQCB and the Living Classroom team is moving forward to submit the Eco Machine, as proposed, to be integrated into the final designs of the Living Classroom.

Lessons Learned and Inter-agency partnerships

One of the great "lessons learned" from the permitting of the Eco Machine, has been in the establishment of relevant inter-agency partnerships, that has and will help to create more of a synergy among municipal agencies that are relevant to the conservation and environmental stewardship movement in San Francisco. The process of bringing together various municipal agencies to help map out the process of regulating gray, or in this case blackwater projects in the City of San Francisco, will hopefully add value to future water reuse projects. Culling the expertise of various municipal public work's divisions and convening partnerships, among these agencies, is, Schoeman believes, a critical step towards establishing guidelines and protocols to achieve a realistic set of municipal standards around the regulation and implementation of water reuse projects in San Francisco.

SF Plumbing Code

The San Francisco plumbing code, with regards to permitting of innovative water reuse projects, is in need of review and revision. Additional staffing capacity to review alternative treatment projects is also desirable As San Francisco, begins to adopt national and even international water reuse projects in the scope of their buildings, it is important that San Francisco's code can be more flexible and adapt to upcoming changes in the building industry with regards to water reuse projects while ensuring public safety.

The Living Classroom team is positioning the project to break ground in late 2007 to be completed in 2008. Moving forward, LEJ will be working with DPH to create an operation and maintenance manual. Once the system is up and running, LEJ will hire a certified wastewater technician who will be in charge of operation and maintenance and all water testing for *E. coli* and *Giardia*. The samples will be analyzed at the Southeast Plant lab. The community will do additional testing (nutrients, minerals) to monitor trends in the systems performance. SF DPH will inspect the system every quarter.

The Living Classroom Team intends that the Eco Machine be a critical educational tool for all visitors to the Living Classroom, educating visitors about wastewater treatment, water conservation, and water reuse. The Living Classroom will also be a viable way of resolving the lack of sewer connection for the facility and will help the classroom manage its waste, while providing water inputs to its ornamental landscape.

Reference: Ms. Laurie Schoeman, personal communication (September 2007).

APPENDIX D - CASE STUDY 2

APPENDIX D - CASE STUDY 2

Solaire Building, New York City, New York.

The Solaire building is a 27-story, 357,000 sq.ft. high-rise building in the Battery Park City area of Manhattan. This building is the first green Leadership in Energy and Environmental Design (LEED) Gold Certified buildings of its kind in the United States. It uses solar energy, collects stormwater, reuses wastewater and has roof gardens. The wastewater system, occupying 2,130 square feet in the basement of the building, is a custom designed membrane bioreactor-based wastewater treatment and recycling system that treats 25,000 gpd. The recycled water is reused for toilet flushing, HVAC cooling, subsurface irrigation within the building and will also be used for irrigation and toilet flushing in adjacent parks and buildings.

The Solaire building wastewater features are described in an article by Michael Zavada in the February 2006 issue of *Water & Wastewater International.*

> The water reuse system designer was involved with the early civil and structural design decisions of the building, ensuring adequate success for installation, operation and maintenance of all equipment, and providing proper planning for the disposal of excess wastewater and the removal of biosolids. In the early planning stages, the New York City Health Department had to be convinced that the reuse system was safe and not going to pose any health hazards to Solaire residents. Several meetings were held to determine acceptable effluent requirements and performance testing protocol; early tests demonstrated that highly disinfected water would be provided on a consistent basis.
>
> The wastewater reuse system is designed to produce and supply only the water that is necessary for daily building usage; if the demand is low, it processes less, and vice-versa -- up to 25,000 gpd. The treatment system moves wastewater through a series of concrete tanks built into the basement wall:
>
> 1) A collection tank and trash trap removes plastic and other solids.
>
> 2) Wastewater then enters the bio-reactor, which contains very active bacteria used to consume or digest the biodegradable waste products in the wastewater.
>
> 3) The bioreactor contains two chambers: the anoxic, which operates without air, and the aerobic, which is aerated. Different kinds of bacteria thrive in each environment; pumps draw the mixture through spaghetti-like membranes that filter the liquid in the osmotic process.
>
> 4) Treated, filtered water passes through an ultraviolet disinfection system that kills any pathogens still present in the treated wastewater.
>
> 5) An ozone generator removes any traces of color and remaining pathogens.

6) Water flows to storage tanks, which serve as reservoirs for treated water. The water is ultimately used to flush toilets and as makeup water for the building's cooling towers.

Engineers designed the reuse system to be highly automated with remote alarm and monitoring capability; a programmable controller that takes readings of flow rates and oxygen levels monitors overall system performance. The system requires an operator to visit twice a week for a few hours each visit.

In addition, the water reuse system includes a separate system that collects rainwater and stores it in a 10,000-gallon tank, also in the Solaire's basement. The water is run through a sand filter and then chlorinated per New York City requirements. The captured stormwater is used to irrigate two planted, green roofs, located on the 19th and 28th floors, reducing the need for city-supplied potable water and minimizing flash flooding due to storm drain overflow.

The Solaire building consumes 50 percent less water than comparable New York City apartment buildings unequipped with water reclamation systems. Additionally, it uses 35 percent less energy than a similar building designed to New York State's code requirements and 65 percent less electricity during peak demand periods. The building's design incorporated 382 solar panels, which generate no less than 5 percent of the building's base electrical load. Water reuse, especially, reduces the amount of potable water that is taken from the city's water supply, while at the same time, saving the energy necessary to pump wastewater into a city treatment facility.

Reference: Zavada, M., *NYC high-rise reuse proves decentralized system works.* Water & Wastewater International. February 2006.

APPENDIX E - SKYFARMING

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NEW YORK nymag.com

Find this article at:
http://www.nymag.com/news/features/30020

Skyfarming

A Columbia professor believes that converting skyscrapers into crop farms could help reduce global warming and make New York cleaner. It's a vision straight out of *Futurama*—but here's how it might work.

By Lisa Chamberlain - April 9, 2007 issue

(Photo: Architectural Designs by Rolf Mohr, Modeling and Rendering by Machine Films; Interiors by James Nelms Digital Artist @ Storyboards Online)

Urban farming has always been a slightly quixotic endeavor. From the small animal farm that was perched on the roof of the Upper West Side's Ansonia apartment building in the early 1900s (fresh eggs delivered by bellhop!) to community gardens threatened by real-estate development, the dream of preserving a little of the country in the city is a utopian one. But nobody has ever dreamed as big as Dr. Dickson Despommier, a professor of environmental sciences and microbiology at Columbia University, who believes that "vertical farm" skyscrapers could help fight global warming. Imagine a cluster of 30-story towers on Governors Island or in Hudson Yards producing fruit, vegetables, and grains while also generating clean energy and purifying wastewater. Roughly 150 such buildings, Despommier estimates, could feed the entire city of New York for a year. Using current green building systems, a vertical farm could be self-sustaining and even produce a net output of clean water and energy.

Despommier began developing the vertical-farming concept six years ago (his research can be found at verticalfarm .com), and he has been contacted by scientists and venture capitalists from the Netherlands to Dubai who are interested in establishing a Center for Urban Sustainable Agriculture, either independently or within Columbia. He estimates it could take a working group of agricultural economists, architects, engineers, agronomists, and urban planners five to ten years to figure out how to marry high-tech agricultural practices with the latest sustainable building technology.

What does this have to do with climate change? The professor believes that only by allowing significant portions of the Earth's farmland to return to forest do we have a real chance of stabilizing climate and weather patterns. Merely reducing energy consumption—the centerpiece of the proposal Al Gore recently presented to Congress—will at best slow global warming. Allowing forests to regrow where crops are now cultivated, he believes, would reduce carbon dioxide in the atmosphere as least as much as more-efficient energy consumption.

There is another reason to develop indoor farming: exploding population growth. By 2050, demographers estimate there will be an additional 3 billion people (a global total of 9.2 billion). If current farming practices are maintained, extra landmass as large as Brazil would have to be cultivated to feed them. Yet nearly all the land that can produce food is already being farmed—even without accounting for the possibility of losing more to rising sea levels and climate change (which could turn arable land into dust bowls).

Depending on the crops being grown, a single vertical farm could allow thousands of farmland acres to be permanently reforested. For the moment, these calculations remain highly speculative, but a real-life example offers a clue: After a strawberry farm in Florida was wiped out by Hurricane Andrew, the owners built a hydroponic farm. By growing strawberries indoors and stacking layers on top of each other, they now produce on one acre of land what used to require 30 acres.

Why build vertical farms in cities? Growing crops in a controlled environment has benefits: no animals to transfer disease through untreated waste; no massive crop failures as a result of weather-related disasters; less likelihood of genetically modified "rogue" strains entering the "natural" plant world. All food could be grown organically, without herbicides, pesticides, or fertilizers, eliminating agricultural runoff. And 80 percent of the world's population will be living in urban areas by 2050. Cities already have the density and infrastructure needed to support vertical farms, and super-green skyscrapers could supply not just food but energy, creating a truly self-sustaining environment.

Like the Biosphere 2 project in Arizona, a real vertical farm will probably require a utopian philanthropist with deep pockets. In the eighties, Edward Bass spent $200 million of his own money to construct the Biosphere. A smaller and less complex vertical farm would probably cost that much to build today and could be funded by someone from a country where arable land is already in short supply, such as Japan, Iceland, or more likely Dubai. Despommier is convinced the first vertical farm will exist within fifteen years—and the irony is, oil money could very well build it.

(Photo: Architectural Design by Rolf Mohr; Modeling and Rendering by Machine Films; Interiors by James Nelms Digital Artist @ Storyboards Online)

1. The Solar Panel

Most of the vertical farm's energy is supplied by the pellet power system (see over). This solar panel rotates to follow the sun and would drive the interior cooling system, which is used most when the sun's heat is greatest.

2. The Wind Spire

(Photo: Architectural Designs by Rolf Mohr)

An alternative (or a complement) to solar power, conceived by an engineering professor at Cleveland State University. Conventional windmills are too large for cities; the wind spire uses small blades to turn air upward, like a screw.

3. The Glass Panels

A clear coating of titanium oxide collects pollutants and prevents rain from beading; the rain slides down the glass, maximizing light and cleaning the pollutants. Troughs collect runoff for filtration.

4. The Control Room

(Photo: Interiors by James Nelms Digital Artist @ Storyboards Online)

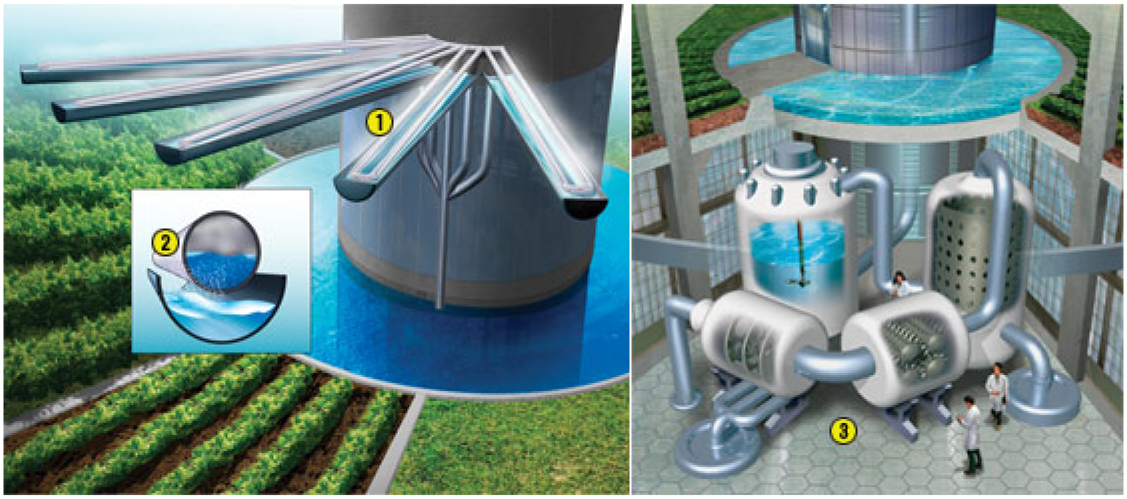
The vertical-farm environment is regulated from here, allowing for year-round, 24-hour crop cultivation.

5. The Architecture

Inspired by the Capitol Records building in Hollywood. Circular design uses space most efficiently and allows maximum light into the center. Modular floors stack like poker chips for flexibility.

6. The Crops

The vertical farm could grow fruits, vegetables, grains, and even fish, poultry, and pigs. Enough, Despommier estimates, to feed 50,000 people annually.



(Photo: Architectural Design by Rolf Mohr; Modeling and Rendering by Machine Films; Interiors by James Nelms Digital Artist @ Storyboards Online)

The vertical farm doesn't just grow crops indoors; it also generates its own power from waste and cleans up sewage water.

1. The Evapotranspiration Recovery System
Nestled inside the ceiling of each floor, its pipes collect moisture, which can be bottled and sold.

2. The Pipes
Work much like a cold bottle of Coke that "sweats" on a hot day: Super-cool fluid attracts plant water vapors, which are then collected as they drip off (similar systems are in use on a small scale). Despommier estimates that one vertical farm could capture 60 million gallons of water a year.

3. Black-Water Treatment System
Wastewater taken from the city's sewage system is treated through a series of filters, then sterilized, yielding gray water—which is not drinkable but can be used for irrigation. (Currently, the city throws 1.4 billion gallons of treated wastewater into the rivers each day.) The Solaire building in Battery Park City already uses a system like this.

(Photo: Architectural Design by Rolf Mohr; Modeling and Rendering by Machine Films; Interiors by James Nelms Digital Artist @ Storyboards Online)

4. The Crop Picker
Monitors fruits and vegetables with an electronic eye. Current technology, called a Reflectometer, uses color detection to test ripeness.

5. The Field
Maximization of space is critical, so in this rendering there are two layers of crops (and some hanging tomatoes). If small crops are planted, there might be up to ten layers per floor.

6. The Pool
Runoff from irrigation is collected here and piped to a filtration system.

7. The Feeder
Like an ink-jet printer, this dual-purpose mechanism directs programmed amounts of water and light to individual crops.

(Photo: Architectural Design by Rolf Mohr; Modeling and Rendering by Machine Films; Interiors by James Nelms Digital Artist @ Storyboards Online)

8. The Pellet Power System

Another source of power for the vertical farm, it turns nonedible plant matter (like corn husks, for example) into fuel. Could also process waste from New York's 18,000 restaurants.

9 to 11. The Pellets

Plant waste is processed into powder (9), then condensed into clean-burning fuel pellets (10), which become steam power (11). At least 60 pellet mills in North America already produce more than 600,000 tons of fuel annually, and a 3,400-square-foot house in Idaho uses pellets to generate its own electricity.

Find this article at:

http://www.nymag.com/news/features/30020