*TOXICS USE REDUCTION INSTITUTE, UMASS LOWELL*
*Spring Continuing Education Conference, Sturbridge, MA*

## Water Conservation Workshop

April 11, 2013

**Amy Vickers**
Author, *Handbook of Water Use and Conservation*
(WaterPlow Press)
Amy Vickers & Associates, Inc.
Amherst, MA

## Workshop Agenda

1. Introduction
2. Water Conservation and Efficiency at Commercial, Industrial & Institutional (CII) Sites
3. Basic Steps In a CII Site Water Use Audit
4. Preparation of CII Conservation Plans
5. Resources to Learn More

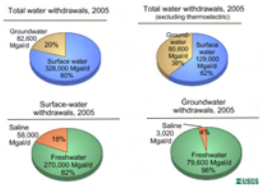
*Plus…*

– Case studies & short videos
– Interactive exercise

## I. INTRODUCTION

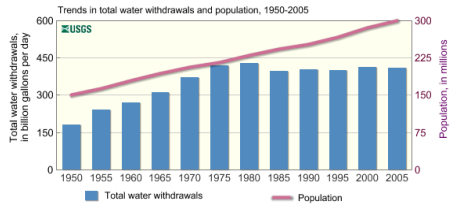
## U.S. Total Water Demands

- 410 billion gallons per day average is most recent USGS estimate (2005)
- Trend: water demands are declining somewhat relative to population
- Current U.S. population is about 315 million



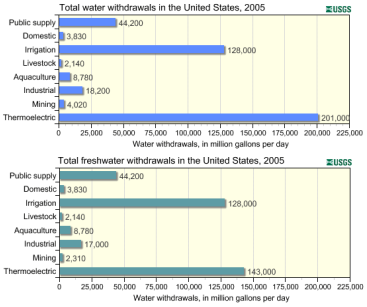

*Source: USGS, Total Water Use in the United States, 2005. http://ga.water.usgs.gov/edu/wateruse-total.html*

## U.S. Water Demands and Population Trends




*Source: USGS, Total Water Use in the United States, 2005. http://ga.water.usgs.gov/edu/wateruse-total.html*

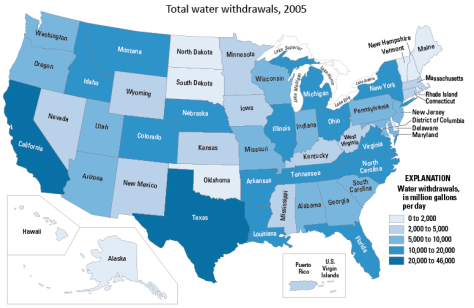
## U.S. Total Water Use, By Category of Use



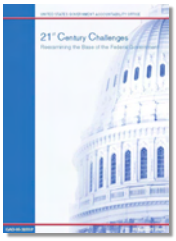

*Source: USGS, Total Water Use in the United States, 2005. http://ga.water.usgs.gov/edu/wateruse-total.html*

## U.S. Total Water Withdrawals By State

Total water withdrawals, 2005




*Source: USGS, Total Water Use in the United States, 2005. http://ga.water.usgs.gov/edu/wateruse-total.html*




**"…water managers in 36 states expect water shortages to occur within the next 10 years under even normal conditions.** In many parts of the country, drought conditions are giving an early indication of what may occur on a much more widespread basis in the future."

***–U.S. General Accountability Office, 2005***

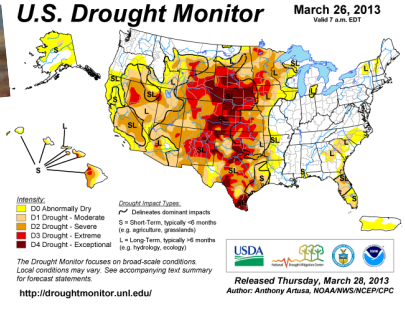
## *Study: Human activity produces drought*

**NEW YORK-- Columbia University scientists have linked recent water shortages… with human activities.** *(UPI)* 5/17/2006

*Photo: NOAA*

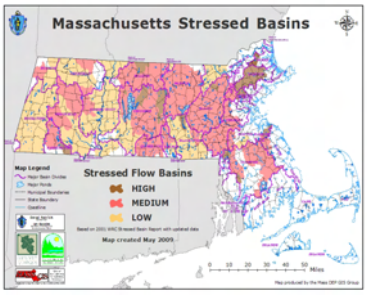
### *U.S. Drought Monitor*

**March 26, 2013**
Valid 7 a.m. EDT




*Source: U.S. Drought Monitor, National Drought Mitigation Center at the Univ. of Nebraska, USDA, and NOAA*

**Massachusetts Assessed River Basins:**
**80%+ Suffer from Medium-High Stress**



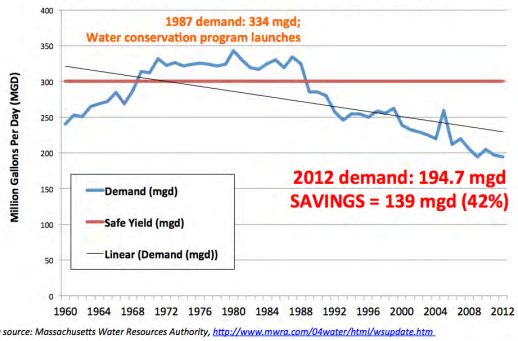

Private wells do NOT "save" water. In fact, they may be a key factor behind our diminishing rivers and streams.

*Source: Massachusetts Dept Environmental Protection http://www.mass.gov/dep/water/resources/stresmap.htm*

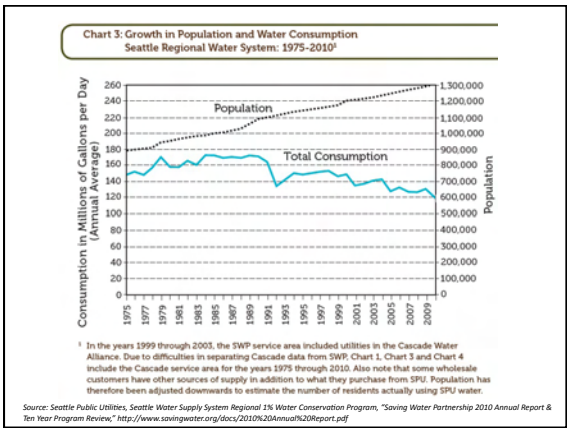
## II. WATER EFFICIENCY & CONSERVATION AT COMMERCIAL, INDUSTRIAL & INSTITUTIONAL (CII) SITES

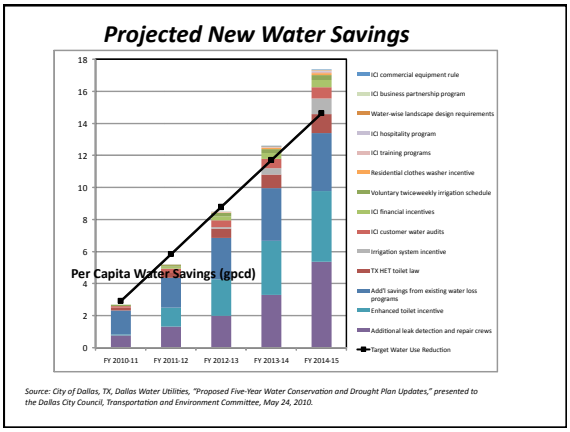
- Potential Water Savings from Conservation
- Definitions
- CII Water-Saving Measures
- Water Reuse And Alternative Water Sources
- Role of Water at "Sustainable Sites"
- Water Use Metrics
- Water-Energy Nexus

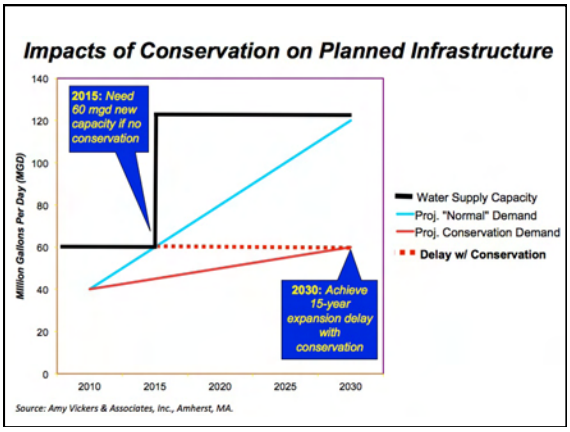
**MWRA Water Demand 1960 - 2012**




*Data source: Massachusetts Water Resources Authority, http://www.mwra.com/04water/html/wsupdate.htm*



## Definitions

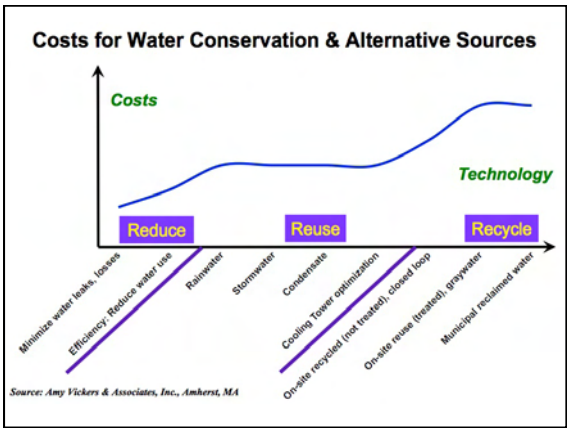
- **Demand Management**
  - Changing the time and frequency of water use (but not necessarily the volume)
- **Water Efficiency**
  - *Minimization* of water used to accomplish a task, leaks and losses
- **Water Conservation**
  - *Minimization* and–where appropriate–*elimination* of water uses, leaks and losses
    - Nonessential water uses
    - Environmentally sustainable
- **Water Productivity**
  - The amount of product, service, or value from a unit of water
  - "Water conservation boosts the productivity of water"

## CII Water-Saving Measures

- Leak detection and repair–piping, plumbing fixtures, appliances, equipment, outdoor
- Restroom plumbing fixtures
- Commercial kitchens and food service
- Cooling towers and cooling systems
- Heating systems and equipment
- Medical, dental, and hospital
- Commercial laundries
- Process water use
- Manufacturing
- Landscaping and irrigation
- Rainwater harvesting and alternative water sources

## Water Reuse and Alternative Water Sources (AWS)

- **Graywater** (domestic/residential)
  - On-site treated or untreated domestic effluent (excluding toilet and some other wastewater) for non-potable reuse, e.g. landscape irrigation
- **Recycled (untreated onsite wastewater)**
  - Reused in the same application or process, e.g., closed loop cooling tower; **Untreated reuse**–e.g., condensate from AC for irrigation
- **Water Reuse (min-max treated onsite wastewater)**
  - Reused in the same or another application or process, e.g., recycled rinse water (laundry, process), RO reject water
- **Reclaimed Water** (also "recycled" and "reuse")
  - Municipally supplied treated wastewater effluent
- **Onsite groundwater, ponds**
- **Rainwater**
  - **Stormwater**




## Role Of Water At "Sustainable Sites" –Several Definitions And Approaches

- Green building
- Water footprint
- Net zero water
- Living Building Challenge™
- Living Machine®

## Net Zero Water

"Similar to Net Zero Energy, which produces energy on-site and doesn't ever consume more than it produces, **Net Zero Water is a standard that sets out to close the loop of a household's [or facility's] water consumption. In order to achieve this goal, rainwater that falls on-site is collected and stored, and all wastewater produced by the building or its occupants is treated and re-used.**"

*–Net Zero Water Project,*
http://netzerowater.com/about.php

## Water Use Metrics

- **Gallons per capita per day, GPCD**
- **Gallons per square foot, GD/Ft2**
- **Gallons per employee, GD/Employee**
- **Water use per product production, e.g., 2 liters/plastic water bottle**
- **Total water demand by facility**
  - Annual, day, hour
  - Seasonal
  - max/min year, month, day hour
- **Water Use Intensity (WUI)**
  - EO 13514 and EO 13423: annual potable water/facility gross square footage

## Water-Energy Nexus

- **10% to 15% U.S. electricity consumption for water supply**
  - Pumping
  - Treatment
  - Distribution
  - Heating
  - Discharge
- **Energy demands vary greatly by water source**
  - Surface vs. ground water systems
  - Water pumped over mountains vs. gravity-fed
    - Southern California (~19%)
    - Boston and New York City (<5%)
- **Water use efficiency correlates with energy demand**
  - Embedded energy in water delivery
  - Onsite power use to use, move, heat and treat
- **Each end use of water has a unique energy profile**

## Water-Energy Nexus: Metrics

- **Water Usage Effectiveness (WUE)**
  - Green Grid: water usage at a data center

$$\text{WUE} = \frac{\text{Annual Water Use}}{\text{IT Equipment Energy}}$$

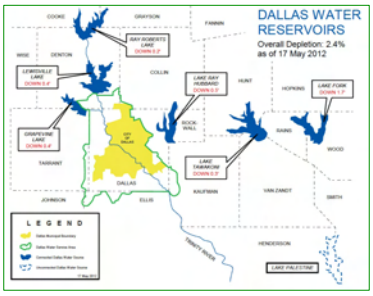
    - Site-based metric, includes water used for humidification and evaporation (e.g., cooling towers)
    - Units: liters/kilowatt-hour (L/kWh)
- **Water Usage Effectiveness–Source ($WUE_{source}$)**
  - Green Grid: water on-site and off-site (water used for power generation)

$$WUE_{source} = \frac{\text{Ann. Source Energy Water Use + Ann. Water Use}}{\text{IT Equipment Energy}}$$

## Water Metrics and Benchmarks

- Compare site water use metrics to known benchmarks, e.g., average and efficient water use
  - Plumbing fixture use per employee
  - Pre-rinse spray valves
  - Cooling tower cycles of concentration
  - Irrigation water applied, gal/ft2 or gal/acre
  - Swimming pool evaporative losses
- Water metrics and benchmarks are valuable when accurate, but junk data are a common problem

## Case Study: Dallas Water Utilities




*Map: Dallas Water Utilities*

***Dallas Water Utilities***

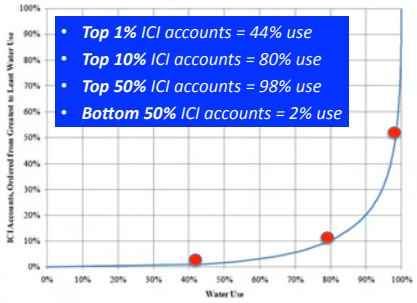
**Industrial/Commercial/Institutional (ICI) Customer Water Use by Percentile, Feb08-Jan09**

| Account Group | Number of Active Accounts | Average Account Demand (gal/day) | Average Account Indoor Demand[a] (gal/day) | Average Account Seasonal Demand[b] (gal/day) | Seasonal Water Use Percentage[c] |
|---|---|---|---|---|---|
| All ICI Accounts | 28,101 | 2,527 | 1,826 | 701 | 27.7% |
| Top 1% ICI Accounts | 281 | 110,288 | 70,627 | 39,661 | 36.0% |
| Top 10% ICI Accounts | 2,810 | 20,094 | 14,793 | 5,301 | 26.4% |
| Top 25% ICI Accounts | 7,025 | 9,380 | 6,774 | 2,606 | 27.8% |
| Top 50% ICI Accounts | 14,051 | 4,988 | 3,670 | 1,318 | 26.4% |
| Lower 50% ICI Accounts | 14,050 | 80 | 56 | 24 | 29.9% |

*Source: City of Dallas Water Conservation Five-Year Strategic Plan Update June 2010, prepared by Alan Plummer Associates, Inc. in association with Amy Vickers & Associates, Inc., CP&Y, Inc., Miya Water, and BDS Technologies, Inc., August 2, 2010, p. 5-28.*

*Dallas Water Utilities*

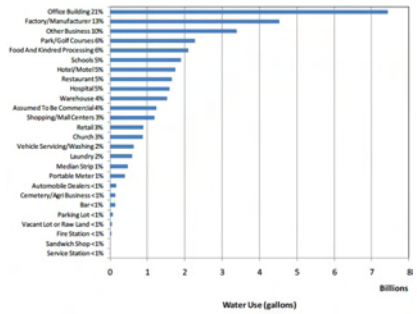
**Distribution of ICI Water Use by Number of Accounts, Feb08-Jan09**




*Source: City of Dallas Water Conservation Five-Year Strategic Plan Update June 2010, prepared by Alan Plummer Associates, Inc. in association with Amy Vickers & Associates, Inc., CP&Y, Inc., Miya Water, and BDS Technologies, Inc., August 2, 2010, p. 5-28.*

*Dallas Water Utilities*

**Total ICI Water Use by Premise Type, Feb08-Jan09**




*Source: City of Dallas Water Conservation Five-Year Strategic Plan Update June 2010, prepared by Alan Plummer Associates, Inc. in association with Amy Vickers & Associates, Inc., CP&Y, Inc., Miya Water, and BDS Technologies, Inc., August 2, 2010, p. 5-25.*

*Dallas Water Utilities*

**Top 100 ICI Customers By Premise Type and Avg. MGD, Feb08-Jun09**

| Premise Type | Number of Customers | Avg. Water Demand, MGD | Percentage of Top 100 Demand | Percentage of Total ICI Demand |
|---|---|---|---|---|
| Factory/Mfr | 12 | 7.2 | 30.3% | 10.6% |
| Office Building | 22 | 4.4 | 18.3% | 6.4% |
| Food/Kindred Processing | 10 | 3.5 | 14.6% | 5.1% |
| Park/Golf Course | 18 | 2.4 | 10.1% | 3.6% |
| Hospitals | 9 | 2.1 | 9.0% | 3.2% |
| Warehouse | 3 | 1.0 | 4.2% | 1.5% |
| Hotel/Motel | 8 | 1.0 | 4.1% | 1.5% |
| Other Business | 6 | 0.7 | 3.0% | 1.1% |
| Schools | 4 | 0.5 | 2.1% | 0.7% |
| Shopping Malls | 4 | 0.5 | 1.9% | 0.7% |
| Laundries | 2 | 0.2 | 0.8% | 0.3% |
| Restaurant | 1 | 0.2 | 0.8% | 0.3% |
| Church | 1 | 0.1 | 0.6% | 0.2% |
| Total | 100 | 23.8 | 100% | 35% |

*Source: Amy Vickers & Associates, Inc., Amherst, MA.*

*Dallas Water Utilities*

**Metrics for Customer-Specific Water Uses**

**Examples of Top 100 ICI Customer Water Use Compared to Benchmark Values, Feb08-Jun09**

| Premise Type | Top User Ranking | Customer Avg. Day, Gallons | Unit | No. Units | Avg. Use Per Unit, GD | Avg. Use Reported In Literature |
|---|---|---|---|---|---|---|
| Hospital A | 11 | 357,286 | Hospital Beds | 700 | 510 | 250 gd to 400 gd |
| Hospital B | 12 | 326,701 | | 266 | 1,224 | |
| Hospital C | 14 | 284,574 | | 875 | 325 | |
| Hotel A | 36 | 185,179 | Hotel Rooms (58% occupancy rate) | 1606 | 199 | Avg. use about 141 gd to 149 gd |
| Hotel B | 61 | 116,497 | | 1122 | 179 | |
| Hotel C | 84 | 76,397 | | 545 | 242 | |
| Golf Course A | 8 | 374,957 | Golf Course Holes | 18 | 20,831 | NA |
| Golf Course B | 34 | 187,966 | | 18 | 10,443 | |
| Golf Course C | 43 | 145,019 | | 18 | 8,057 | |

*Source: Amy Vickers & Associates, Inc., Amherst, MA.*

## III. BASIC STEPS IN A CII WATER USE AUDIT

*Understand facility water use:*
*Your roadmap to efficiency*

1. Data and information collection
2. Walk-through site survey
3. Create a baseline water balance
4. Identify water-saving measures
5. Calculate potential water savings, costs and benefits

## Scope of a CII Site Audit

- Entire facility water use
  - Indoor and outdoor
    - Flow and efficiency measurements, tests
  - Leaks, losses and theft
  - Potable and nonpotable sources and uses
- Partial facility water use
  - Targeted high uses only (if known)
  - Indoor only
  - Outdoor only

## 1. Data & Information Collection

- **Metered water data and information**
  - Water and sewer bills
  - Minimum past 2-3 years to present
  - Identify all metered and nonmetered water sources
    - Potable and nonpotable (e.g., well, reclaimed, rainwater)
    - Map distribution of sources (if relevant)
  - Evaluate condition and accuracy of meters (type, age, size)
- **Site water use history**
  - Total usage, seasonal, correlation to product/service or population
  - Prior water conservation evaluations and efficiency measures implemented?
- **Water audit worksheets**
  - Domestic indoor (toilets, faucets, etc.) (Appendix E*)
  - Irrigation and Landscape and irrigation (Appendix F*)
  - Industrial/commercial/institutional (Appendix G*)
  - Cooling towers (Appendix G*)

* Vickers, A. *Handbook of Water Use and Conservation* (pp.410-421)

(Continued)

## 1. Data & Information Collection (cont.)

- Building floor plan
- Landscape footprint and irrigation system
- Numbers of employees and visitors
- Facility hours of operation
- Maintenance and janitorial schedules, current practices
- Current and projected water, sewer, and energy rates and charges
- Names of water, sewer, and energy service providers
- Incentives for water conservation, e.g. rebates, bill credits, grants, tax breaks
- Applicable water use regulations and codes, e.g., irrigation restrictions
- Lists of all water-using equipment, including name, model numbers, and drawings if available
- HVAC inventory, e.g., cooling towers, evaporative coolers, boilers
- Number of plumbing fixtures by type, e.g., toilet, urinal, faucet
- Outdoor water use, e.g., turf and landscape irrigation, water features, pools (turf, plant and equipment types, schedule)

## 2. Walk-through Site Survey

- Meet with and interview staff
  - Management, facilities, water-green committee/task force
  - Goals, expectations for facility water conservation program
- Inspect and count all water-using equipment, fixtures, appliances, and leaks
  - Beginner's strategy: start with simple stuff first
- Measure or estimate water use for each end use of water
  - Estimate unauthorized uses, meter inaccuracies, and evaporative losses
  - Later: compare actual flow rate/use measured to manufacturer's rated for recommended flow
- Identify staff/occupant gender count in each building (#toilets/#urinals)
- Identify water-saving measures for each end use, e.g., fixture replacement, retrofit, adjustment
  - Onsite: Preliminary measure identification
  - Post-audit: Finalize list of measures
- Inspect meters, valves, hydrants, and connections
- Fill out information on water audit worksheets

## Checklist of Tools for a Water Audit

- ✓ Audit forms and clipboard
- ✓ Flow measurement bag
- ✓ Microweir pitcher or simple measuring cup
- ✓ Stopwatch
- ✓ Calculator
- ✓ Flashlight
- ✓ Small mirror (extendable)
- ✓ Magnifying glass
- ✓ Leak detection tablets or food coloring
- ✓ Digital camera
- ✓ Safety gear–glasses, hat, disposable gloves, face mask, ear plugs
- ✓ Pressure gauge
- ✓ Portable meter, data loggers
- ✓ Infrared temperature gun

## How to Read a Water Meter *(Old Style)*


*Source: Clayton County Water Authority, Morrow, GA*
*http://www.ccwa.us/system/media_files/attachments/123/original/How%20to%20read%20your%20meter.pdf?1310586514*

## Automatic Meter Information Management

- AMR - Automated Meter Reading
  - Automatic monthly meter reading
  - Mobile or other wireless
- AMI – Advanced Metering Infrastructure
  - Automatic hourly and daily readouts
- AMA – Advanced Metering Analytics
  - Software interprets data
  - Reporting
  - Alarms (high usage, leak, malfunction)
- Web portals
  - Track usage by site, end use (submeters)
- Dashboards

## Water Data Logging

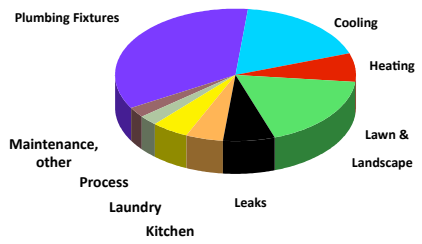
- Site-specific, e.g., building or facility
- Profiles customer or site's water use
  - Minute, hour, day
- Identify or target specific end uses
  - Leak
  - Faucet or equipment profile
- Track changes in use

*Photo source: A. Vickers*

## 3. Create a Baseline Water Balance Worksheet

- List all plumbing fixtures, appliances, equipment and other water-using devices
  - Category audit worksheets for specific end uses
- Identify each end use of water, by category summary and item detail
- Quantify each end use by volume, e.g., gallons/day, by category summary and item detail
  - Meter readings
  - Flow measurements
  - Engineering estimates
- Determine all water use, resource demands, and related costs
  - Potable and nonpotable water
  - Sewer and reclaimed water
  - Energy (e.g., water pumping and water heating)
  - Chemicals (e.g., process, cooling towers)
  - Pretreatment

## Common Facility End Uses of Water

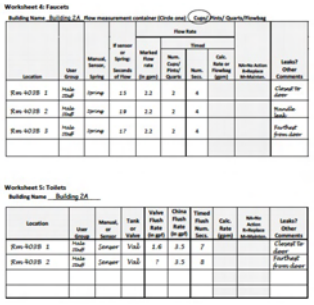



Source: *Amy Vickers, "Handbook of Water Use and Conservation" (WaterPlow Press)*

## Inventory of Building/Facility End Uses of Water

- Leaks
- Unaccounted-for water and theft
- Restroom fixtures
- Kitchen equipment: pre-rinse spray valves, dish and ware washing, ice machines, steamers
- Laundry facilities and clothes washers
- Utility sinks
- Cooling–cooling towers, evaporative coolers, equipment cooling
- Health care–medical, dental, laboratory, hospital
- Process uses
- Manufacturing/production
- Boilers
- Building fire suppression
- Turf and landscape irrigation
- Pools
- Water features
- Outdoor hose bibs
- Vehicle washing
- Firefighting- training and hydrant-flushing

## Sample Worksheets: Types of Data to Collect



Worksheet 4: Faucets

Building Name Building 2A Flow measurement container (Circle one) Cups/ Pints/ Quarts/Flowbag

| Location | User Group | Manual, Sensor, Spring | If sensor or spring: Seconds of Flow | Flow Rate: Marked Flow rate (in gpm) | Flow Rate: Timed: Num. Cups/ Pints/ Quarts | Flow Rate: Timed: Num. Secs. | Flow Rate: Timed: Calc. Rate or Flowbag (gpm) | Retrofit Action & Replace by Maximum | Leaks? Other Comments |
|---|---|---|---|---|---|---|---|---|---|
| Rm 403B 1 | Male staff | Spring | 15 | 2.2 | 2 | 4 | | | Closed to door |
| Rm 403B 2 | Male staff | Spring | 18 | 2.2 | 2 | 4 | | | Needle leak |
| Rm 403B 3 | Male staff | Spring | 17 | 2.2 | 2 | 4 | | | Farthest from door |
| | | | | | | | | | |



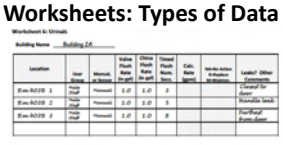
Worksheet 5: Toilets

Building Name Building 2A

| Location | User Group | Manual, Sensor | Tank or Valve | Valve Flush Rate (in gpf) | China Flush Rate (in gpf) | Timed Flush Num. Secs. | Calc. Rate (gpm) | Retrofit Action & Replace by Maximum | Leaks? Other Comments |
|---|---|---|---|---|---|---|---|---|---|
| Rm 403B 1 | Male staff | Sensor | Valve | 1.6 | 3.5 | 7 | | | Closed to door |
| Rm 403B 2 | Male staff | Sensor | Valve | 1 | 3.5 | 8 | | | Farthest from door |
| | | | | | | | | | |
| | | | | | | | | | |

*Source: South Florida Water Management District, Water Supply Section, "Water Efficiency Self-Assessment Guide for Commercial and Institutional Building Facility Managers," SFWMD, West Palm Beach, FL, Dec. 2011.*

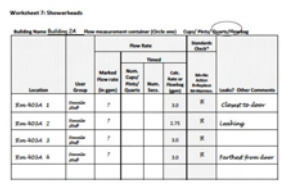
## Sample Worksheets: Types of Data to Collect



Worksheet 6: Urinals

Building Name Building 2A

| Location | User Group | Manual, or Sensor | Valve Flush Rate (in gpf) | China Flush Rate (in gpf) | Timed Flush Num. Secs. | Calc. Rate (gpm) | Retrofit Action & Replace by Maximum | Leaks? Other Comments |
|---|---|---|---|---|---|---|---|---|
| Rm 403B 1 | Male staff | Manual | 1.0 | 1.0 | 3 | | | Closed to door |
| Rm 403B 2 | Male staff | Manual | 1.0 | 1.0 | 5 | | | Needle leak |
| Rm 403B 3 | Male staff | Manual | 1.0 | 1.0 | 8 | | | Farthest from door |
| | | | | | | | | |



Worksheet 7: Showerheads

Building Name Building 2A Flow measurement container (Circle one) Cups/ Pints/ Quarts/Flowbag

| Location | User Group | Flow Rate: Marked Flow rate (in gpm) | Flow Rate: Timed: Num. Cups/ Pints/ Quarts | Flow Rate: Timed: Num. Secs. | Flow Rate: Timed: Calc. Rate or Flowbag (gpm) | Standards Check: Retrofit Action & Replace by Maximum | Leaks? Other Comments |
|---|---|---|---|---|---|---|---|
| Rm 403A 1 | Female staff | 7 | | | 3.0 | X | Closest to door |
| Rm 403A 2 | Female staff | 7 | | | 1.75 | X | Leaking |
| Rm 403A 3 | Female staff | 7 | | | 3.0 | X | |
| Rm 403A 4 | Female staff | 7 | | | 3.0 | X | Farthest from door |
| | | | | | | | |

*Source: South Florida Water Management District, Water Supply Section, "Water Efficiency Self-Assessment Guide for Commercial and Institutional Building Facility Managers," SFWMD, West Palm Beach, FL, Dec. 2011.*

## Sample Worksheets: Types of Data to Collect

Worksheet 8. Appliances

Building Name _____

| Location | Appliance (check one per line) | | | | | Energy Star? (if applic.) | Leaks? Other Comments (include Serial or Product Control Number) |
|---|---|---|---|---|---|---|---|
| | Dishwasher | Ice Machine | Clothes Wash | Grade: C=Comm. R=Res. | Other (indicate) | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Totals | | | | | | | |

*Source: South Florida Water Management District, Water Supply Section, "Water Efficiency Self-Assessment Guide for Commercial and Institutional Building Facility Managers," SFWMD, West Palm Beach, FL, Dec. 2011.*

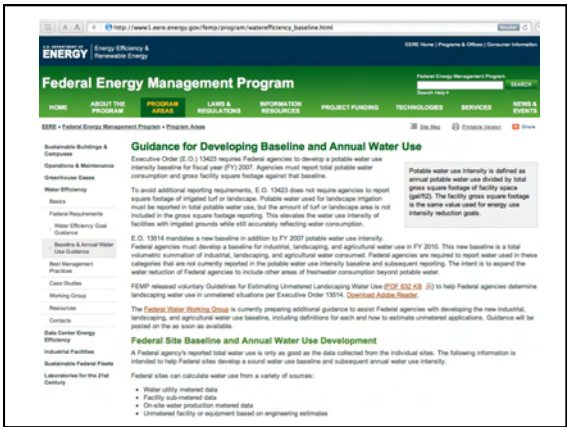
## Sample Worksheets: Types of Data to Collect

Worksheet 9. Commercial-Grade Kitchen Water Use

Building Name _____ Flow measurement container size [faucets & Pre-Rinse spray valves] (Circle one) Cups/ Pints/ Quarts

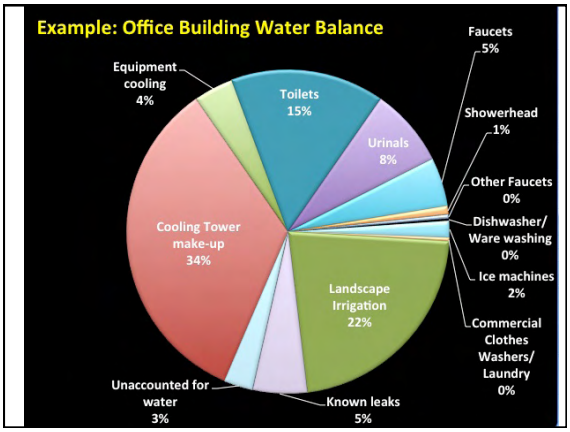
| Location | Appliance (check one per line) | | | | | | Fixture | | Flow Rate (Fixtures only) | | | | Leaks? Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dishwasher | Ice Machine | Steam Cooker | Combi. Oven | Other (indicate) | Make/Model | Energy Star? (if applic.) | Hand Faucet | Pre-Rinse Spray Valve | Marked (gpm) | Timed: Num. of Cups/ Pints/ Quarts. | Timed: Num. Secs. | Timed: Calc. Rate (gpm) | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Totals | | | | | | | | | | | | | | |

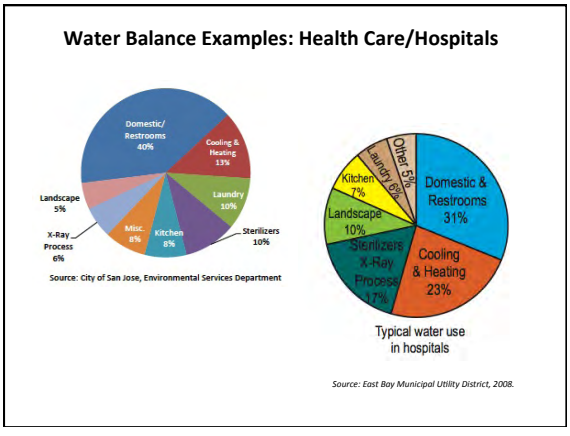
*Source: South Florida Water Management District, Water Supply Section, "Water Efficiency Self-Assessment Guide for Commercial and Institutional Building Facility Managers," SFWMD, West Palm Beach, FL, Dec. 2011.*



Example:
Office Building
Water Balance

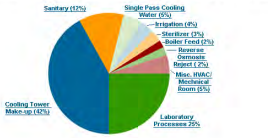
| Water End Use | Total Gallons/Year | Avg. Gallons/Day | Percent |
|---|---|---|---|
| **Pumbing Fixtures (restrooms, utility)** | | | |
| Toilets | 489,000 | 1,340 | 22% |
| Urinals | 251,000 | 688 | 12% |
| Faucets | 155,000 | 425 | 7% |
| Showerhead | 27,000 | 74 | 1% |
| Other Faucets | 12,100 | 33 | 0.6% |
| **Kitchen and Food Service** | | | |
| Pre-Rinse Spray Valves | | | |
| Dishwasher/Ware washing | 7,500 | 21 | 0.3% |
| Ice machines | 52,000 | 142 | 2% |
| Food steamers | | | |
| **Laundry and Linen** | | | |
| Commercial Clothes Washers/Laundry | 12,000 | 33 | 0.6% |
| **Medical and Laboratory** | | | |
| Autoclaves | | | |
| Animal cages | | | |
| **Cooling** | | | |
| Cooling Tower make-up | 1,080,000 | 2,959 | 50% |
| Equipment cooling | 127,000 | 348 | 6% |
| Once-through cooling | | | |
| **Heating** | | | |
| Boiler make-up | | | |
| **Production and Process** | | | |
| Manufacturing | | | |
| Materials transport | | | |
| **Maintenance** | | | |
| Steam cleaning | | | |
| Vehicle fleet wash | | | |
| **Outdoor** | | | |
| Landscape Irrigation | 705,000 | 1,932 | 32% |
| Pools | | | |
| Water fountains and features | | | |
| Other (describe) | | | |
| **Leakage and Losses** | | | |
| Known leaks | 171,000 | 468 | 8% |
| Unaccounted for water | 92,000 | 252 | 4% |
| Total | 2,175,000 | 5,959 | 100% |



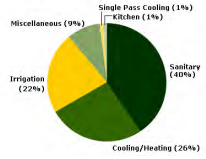
**Typical Laboratory Water Use**

The following chart illustrates the water consumption in a "typical" laboratory. Ref



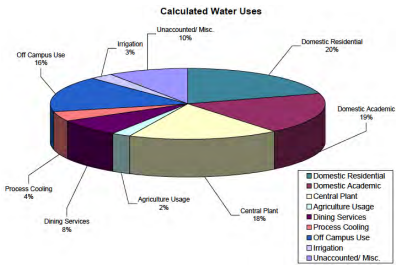

**Typical Office Water Use**

The following chart illustrates the water consumption in a "typical" office building.




*Source: U.S. Environmental Protection Agency, Laboratory Water Use vs. Office Water Use, Aug. 16, 2011, http://www.epa.gov/oaintrnt/water/lab_vs_office.htm*

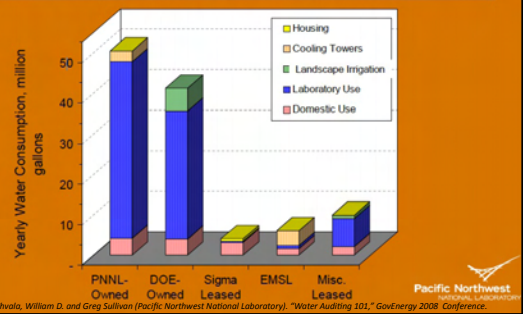
**Univ. of Connecticut-Storrs**



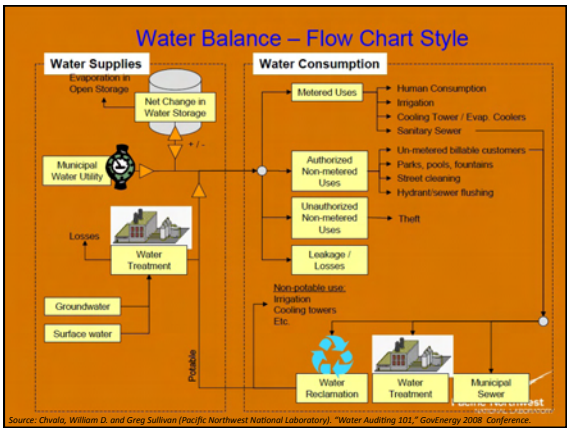

*Source: Water Management, Inc., Amy Vickers & Associates, Inc., and Resource Wise. 2009.*

**Water Consumption By End-Use**

Combination of metered data (whole building), water indices (human consumption, irrigation), and engineering estimates (cooling towers) used to create a water profile for PNNL-occupied buildings.




*Source: Chvala, William D. and Greg Sullivan (Pacific Northwest National Laboratory). "Water Auditing 101," GovEnergy 2008 Conference.*



Source: Chvala, William D. and Greg Sullivan (Pacific Northwest National Laboratory). "Water Auditing 101," GovEnergy 2008 Conference.

## Benchmark Flow Rates: Variable and Fixed

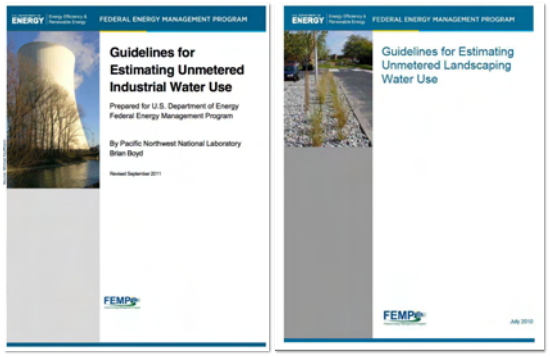
Table 1. Benchmarks for annual water use in various facility types.

| Facility Type | Benchmark |
|---|---|
| Hotels/Motels | 0.079 – 0.165 thousand gallons (Kgal)/ft²<br>30.2 – 39.5 Kgal/room |
| Nursing/ Assisted Living | 0.062 – 0.101 Kgal/ft²<br>32.8 – 40.7 Kgal/bed<br>25.4 – 39.6 Kgal/apartment |
| Restaurants | 0.17 – 0.21 Kgal/ft²<br>10.6 – 14.3 Kgal/seat |
| Schools | 0.012 – 0.019 Kgal/ft²<br>1.7 – 2.7 Kgal/student |

Source: Benchmarking Task Force Collaboration for Industrial, Commercial & Institutional Water Conservation, Colorado Waterwise Council, June 2007

| Energy Policy Act Flow Rates | |
|---|---|
| Fixture | Flow Rate |
| Toilets | 1.6 gallons per flush |
| Urinals | 1.0 gallons per flush |
| Showerheads | 2.5 gpm @ 80 psi or 2.2 gpm @ 60 psi |
| Lavatory Faucets* | 2.2 gpm @ 60 psi |
| Kitchen Faucets | 2.2 gpm @ 60 psi |

* Superseded by national plumbing codes (UPC, IPC, and NSPC), which limit "public" lavatory faucets to 0.5 gpm.




**Download here: Federal Emergency Management Program: Water Efficiency, http://www1.eere.energy.gov/femp/program/waterefficiency_resources.html**

## 4. Identify Water-Saving Measures

- Walk-through survey
- Post-survey, back at the office


## Examples of Some Typical Recommended Measures From a CII Water-Audit

- Leak detection and repair
- Cooling and heating systems
  - Optimize blowdown and make-up volumes, leak reduction, alt sources
- Process reuse and recycle
- Water-efficient fixtures
  - HE Toilets, urinals, etc.
- Kitchen
  - Pre-rinse spray valves
  - Rack dishwashers–full loads, efficient nozzles
- Medical/dental
  - Retrofit sterilizers
- Water brooms
- Irrigation upgrades
  - Replace broken heads, make adjustments
- Increase distribution uniformity (DU)
- Reprogram irrigation controller
- Install rain shut-off
- Plant native plants, grass

**Potential Water savings: 5%-35+%**

## Water Conservation & Efficiency Measures: Hundreds of Options

**Minimum: BMP Approach**

**E.O. 13423, Best Management Practices (BMPs)**

- BMP #1 - Water Management Planning
- BMP #2 - Information and Education Programs
- BMP #3 - Distribution System Audits, Leak Detection, and Repair
- BMP #4 - Water-Efficient Landscaping
- BMP #5 - Water-Efficient Irrigation
- BMP #6 - Toilets and Urinals
- BMP #7 - Faucets and Showerheads
- BMP #8 - Boiler/Steam Systems
- BMP #9 - Single-Pass Cooling Equipment
- BMP #10 - Cooling Tower Management
- BMP #11 - Commercial Kitchen Equipment
- BMP #12 - Laboratory/Medical Equipment
- BMP #13 - Other Water Intensive Processes
- BMP #14 - Alternate Water Sources

**More to Maximum: Better Approach**

- Latest industry standards
  - ASHRAE 189.1
  - IAPMO Green Code
- Customized site evaluation, plan

## 5. Calculate Potential Water Savings, Costs and Benefits

## Estimate Potential Water Savings, Costs & Benefits

- Estimate potential water savings
  - Each measure and each end use
  - One or more options for many; cost differentials
- Estimate costs to implement water-saving measures
  - Hardware
    - Adjust by available financial incentives, e.g, rebates, grants and tax incentives
  - Labor, service agreement, and consultants
  - O&M
  - Environmental and regulatory
- Estimate potential benefits (costs savings)
  - Reduced water and sewer bills
  - Labor, service agreement, and consultants
  - O&M: energy, chemicals, labor, other
  - Environmental and regulatory
- Estimate each measure's cost-effectiveness (ROI)
- Estimate paybacks for measures
- Rank and prioritize options

## Cost-Benefit & Payback Sampler

**ESTIMATED WATER SAVINGS AND COST-EFFECTIVENESS**

| Water Savings Measure Examples | Cost | Water Savings, Gal/Year | | Cost Savings, Year* | Simple Payback, Years |
|---|---|---|---|---|---|
| **Domestic** - HE Plumbing Fixtures & Appliances | $ 1,400,000 | 52,000,000 | 23% | $ 234,000 | 6.0 |
| **Central Plant** - upgrades | $ 1,200,000 | 20,000,000 | 22% | $ 90,000 | 13.3 |
| **Cooling** - new air-based units, cooling tower controls | $ 250,000 | 3,700,000 | 14% | $ 16,650 | 15.0 |
| **Kitchen** - HE PRSV, boilerless steamers, Dish/ware | $ 350,000 | 6,500,000 | 13% | $ 29,250 | 12.0 |
| **Irrigation** - minimization, drought-tolerant plants | $ 75,000 | 7,500,000 | 21% | $ 33,750 | 2.2 |
| **Farm** - drip and micropsray, dairy nozzles, brooms | $ 30,000 | 1,200,000 | 10% | $ 5,400 | 5.6 |
| **Leak** -repair | $ 25,000 | 6,000,000 | 10% | $ 27,000 | 0.9 |
| **TOTAL** | **$ 3,330,000** | **96,900,000** | **19%** | **$ 436,050** | **7.6** |

HE = high efficiency

*** Based on combined water and sewer cost of $4.50/kgal. Excludes energy cost savings.**

*Source: Univ. of Connecticut Report, Water Management, Inc., Amy Vickers & Associates, Inc., and Resource Wise. 2009.*

***CASE STUDY: Stanford University***

*SINCE 2000, has reduced potable use over 20%–from 2.74 mgd to 2.15 mgd in 2009–while adding over 1 million new square feet of campus buildings. Measures taken:*

- Retrofitted **toilets, faucets, showers, and urinals**
- Climate-based, **evapo-transpiration (ET) irrigation controllers**
- **Water misers** have been installed on all routinely used autoclaves, reducing water use in some Medical School and research buildings by more than 50%.
- **Re-circulating cooling systems in laboratories** have been replaced all once-through cooling systems
- SU maintains more than **1500 water meters**. The meters are read monthly, the data is analyzed, and water use data trends are evaluated.

*Source: Stanford University. "Water Sustainability, Effciency, and Conservation Program Details," 2011.*

## IV. PREPARATION OF CII CONSERVATION PLANS

## CII Conservation Plan: Roles

- Management
  - Establish and support water conservation goals
  - Provide financial support for program
  - Create employee recognition and awards program
- Facilities/Water Conservation Manager
  - Soup-to-nuts water efficiency planning, implementation, and monitoring
  - Report results (ongoing)
- Facility staff
  - Help identify water-saving opportunities
  - Implement efficiency measures
  - Incorporate conservation ethic into routine tasks
  - Provide feedback to management

## CII Conservation Plan: Prioritize Actions

- Builds on site audit
- Formalizes priorities, decisions, budget and schedule
- Select and rank measures for implementation
  - Highest potential water savings, cost savings
  - Implementation considerations
    - Short- and long-term goals
    - Budget
    - Available labor, expertise
    - Aesthetic considerations
- Budget
- Schedule
  - Hardware purchases
  - Labor, technical assistance
  - Contracts
  - Staff training (e.g., cooling tower treatment)

## CII Conservation Plan: Monitoring and Evaluation

- Monitor water use on an ongoing basis
  - Sewer, chemical, pretreatment
  - Labor, O&M
  - Staff feedback
- Read and track onsite water meters, utility bills
  - Submetering
- Evaluate results to projected savings, historical water demands and related costs
- Report results regularly
- Stay informed of new technologies and practices
- Revise program as needed
  - Pilot studies

## Online Calculators

## CASE STUDIES

- Leak Detection and Repair
- Food Service
- Efficient Cooling Systems
- Process Reuse and Recycling
- Hospital and Medical
- Commercial Laundries

## Leak Detection & Repair

- Pipes, valves, and connections
- Cool towers and systems
- Boilers
- Equipment
- Plumbing fixtures
- Appliances
- Irrigation
- Pools
- Fountains

***Leakage***

**Fix Leaks Promptly: Waiting is Expensive.**

- Dripping faucet, connection
  - 1.0 to 25 gal/hour . . .
  - = 8760 to 219,000 gal/year
- Toilets/urinals
  - Broken flush valve
  - > 40 gal/hour
- Timely leak repair minimizes costs and property damage.
- Closed buildings
  - Shut-off water supply
  - Exceptions
- Leak monitor devices

**"Denver Water made changes to its cooling tower to save more than 250,000 gallons of water a year.** Commercial, industrial and institutional customers can make similar water-saving changes to their cooling towers and earn an incentive for doing so."

*Photo: Denver Water, http://www.denverwater.org/conservation/incentiveprograms/indoorcommercial/coolingtower/*

**Example Water & Cost Savings:**
**Denver Water Cooling Tower Rebate Program**

- Required water efficiency measures (minimum)
  - Make-up and blowdown water meters
  - Controller capable of monitoring make-up and tower conductivity
  - Submetering; Monthly reports documenting water use
- Rebate basis
  - $18.50 for every 1,000 gallons of water saved over a one-year period
  - Amount is 50 percent of project cost up to $40,000
  - Must save at least 100,000 gallons per year
- Example estimated water savings and rebate
  - 800-ton cooling tower increases its cycles of concentration from 5 to 8
  - Over 337,000 gallons of water savings per year
  - $7,200 rebate
- Additional customer savings
  - Reduced water, sewer, and chemical bills

*Case Study: Rush University Medical Center*
**Condensate Reuse for Cooling Tower Make-up and Garden Irrigation; White roofs**

- 1.3 million gallons/year condensate collection from air handling units
  - Reused for tower make-up, irrigation
- White (and green) roofs reflect sunlight, reducing cooling needs
  - Green vegetation captures heat, reduces air temps
- Indigenous landscaping
- Hospital's butterfly shape boosts natural lighting, reduces electric lighting needs
- LEED Gold

*Images: Rush Medical Center, http://transforming.rush.edu/Sustainability/Pages/Green-Roofs.aspx*

## PROCESS AND MANUFACTURING: WAYS TO SAVE

**CASE STUDY:**

**The Coca Cola Company**

- 2.26:1, water to product ratio in 2010
- 16% savings since 2004
- Water efficiency measures
  - Lighter bottle packaging (less plastic)
  - Ionized air instead of water for bottle rinsing (sanitizing) prior to filling
  - Advanced water use monitoring

Photo: City of Rolla Recycling Center, http://www.rollacity.org/waste/recycle.shtml

**CASE STUDY:**

**Pacific Northwest National Laboratory, WA**

- Cooling pond water reused for onsite irrigation
- 15 million gallons annual water savings (potable)
- $30,000 annual cost savings (water and sewer)

*Photo: US Dept. of Energy, Water Best Management Practices: Pacific Northwest National Laboratory Grounds Maintenance, 2009*

***Baptist Memorial Hospital, San Antonio, TX***
**Case Study: Air-cooled Vacuum System**

- Water-cooled vacuum pumps replaced by air-cooled vacuum system
- Water savings
  - 8,409,600 gal/year
  - 23,040 gal/day
- Cost: $138,714
- Savings: $31,536/year
- Payback: 2.8 years in combination with SAWS* rebate

** SAWS–San Antonio Water System, TX*

## COMMERCIAL LAUNDRIES: WAYS TO SAVE

- Washer extractors, 35-800 lb capacity
  - 2 to 4 gal/lb
  - 30% water savings reusing final rinse water, reduced rinse cycles
  - Logic control systems
  - Speed adjustments save energy

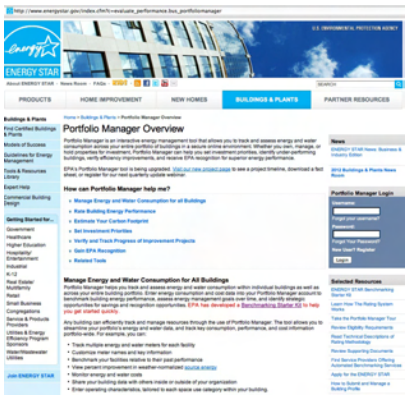
## COMMERCIAL LAUNDRIES: WAYS TO SAVE

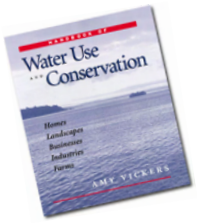
**Partial Reuse**

- Final rinse water reused next wash cycle, 30% savings
  - Holding tank, treated effluent
- Reuse wash water for rinse cycle, 10%-90% savings
  - Requires nanofiltration or RO, membranes; expensive
  - Discharges some TSS, TDS,BOD, other

## Resources to Learn More About CII Water Conservation & Efficiency

- **Alliance for Water Efficiency**
  - http://www.allianceforwaterefficiency.org/
- **EPA WaterSense Program**
  - http://www.epa.gov/watersense
- **Food Service Technology Center**
  - http://www.fishnick.com
- **U.S. DOE FEMP Water Efficiency Program**
  - http://www1.eere.energy.gov/femp/program/waterefficiency.html
- **South Florida Water Management District's Library & Multimedia, CII spreadsheets and calculators**
  - http://my.sfwmd.gov/portal/pls/portal/portal_apps.repository_lib_pkg.repository_browse?p_keywords=waterefficiency&p_thumbnails=no




**Amy Vickers**
Amy Vickers & Associates, Inc.
Amherst Office Park
441 West Street
Amherst, MA 01002
Tel. 413/253-1520
ava-inc@amyvickers.com

**www.waterplowpress.com**