Water Efficiency

Auditing Methodology and Tools

A facility water audit or survey is the key starting point of any water efficiency program. This chapter provides supplemental information and tools for the water audit team conducting the plant survey *(see Chapter 3)*.

Water Audit Preparation

Thorough preparation for the water audit will ensure maximum results and efficiency. Top management should be completely supportive of this effort. Collect the following information regarding the facility's water use, identify all personnel familiar with the operation and record information collected on the water survey data sheets *(see Data Sheet at end of this chapter)*:

1. The exact location of the facility included in the audit.
2. The age and physical size of the facilities, including the number of buildings and floor space (in square feet) for each.
3. Plumbing drawings, riser diagrams and irrigation plans.
4. Names, phone numbers and e-mails of facility contacts.
5. Specific services or products produced at the site:
    - Record the number of meals served, number of guest rooms and occupancy data for service estab

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lishments, such as restaurants, hotels, hospitals, military bases and schools.
- For manufacturing sites, identify the amount of water used per quantity of product produced (that is, gallons per ton of product or gallons per gross of widgets).
- For schools and other such institutions, calculate and record the amount of water used per person per day.

6. The operating schedule of the facility, number of employees per shift, maintenance shifts and other operating information.
7. A water use profile (graph) showing the total water use and water used per unit of product per month for the last three years (one year minimum).
8. Copies of the proposed billing rates for energy, water and wastewater for the next two years (if known).
9. List of all water-using equipment, including the manufacturer's recommended flow requirements.
10. Inventories of sanitary fixtures and any water-saving features.
11. Outdoor water use and irrigation controls.
12. Previous water and energy surveys.
13. All water delivery records from water meters, tank trucks or the facilities' own wells. Accurate water meters are essential for a valid water audit. Source water meters indicate the amount of water supplied to the site. Sub-meters indicate water used for specific processes and individual buildings on the site. Obtain the following meter information before starting the audit:
    - Location of all water supply meters that record deliveries from utilities, wells and other water sources.
    - Location of all on-site process and building meters.
    - Sizes of all meters.
14. Any calibration test results for meters to adjust past meter readings to reflect actual water use.

If the firm has never performed a significant water efficiency study, experienced help may be needed. Experienced assistants may be available from the following:

- Other units within the organization.
- Local, state or university technical assistance services.
- Consultants who understand the processes.
- Water, gas, energy and electric utilities.

15. Gather necessary tools needed for the audit: camera, bucket, stopwatch, etc.

Conducting the Water Audit

The next step is to conduct a walk-through survey with facility personnel who are knowledgeable of how water is used in each area of the facility. Use direct observation and measurements. Identify and record all pieces of equipment that use water. Check with equipment operators who may have important first-hand information. Record information on water survey data sheets (*see pp.* 112-116) Use the following procedure to conduct the step-by-step survey:

1. During the walk-through, record hours of operation for each piece of equipment, including domestic and kitchen operations. Identify water piping layouts, particularly in areas of older equipment, to aid with identifying water uses. Note those pieces of equipment that have multiple uses of water (e.g., water-cooled ice machines).

2. Identify water flow and quality as needed for each use. This information may be needed to determine if discharges from one use can be re-used as a potential supply for a different application. Include these parameters:
   - Temperature.
   - Water quality indicator parameters, such as pH, total dissolved solids and conductivity.
   - Other key water quality parameters such as biochemical oxygen demand, chemical oxygen demand, metals, or oil and grease.
3. Where possible, measure the actual amount of water being used. The most direct way to measure flow rates is with a bucket and a stopwatch (*see Figure 6-1, p. 110*). Consider installing meters on major water-using processes or plant departments to record the quantity of water used.
4. Check water quantity and quality of water specified within the equipment operating manuals. Equipment is sometimes operated at higher flows than required by the manufacturer's specifications. Ask qualified engineers to review the specifications and adjust flows accordingly. Further, investigate whether the processes can still operate properly with further reductions in water flow. Be sure to record flow rates before and after changes are made to evaluate the effects of reduced flow.
5. Read water meters regularly and compare actual water use to the facility's water reduction goal. After determining daily use rates, the frequency of the readings should be adjusted to be consistent

Measuring In-Plant Water Usage

Submetering is an excellent way to accurately account for large water uses in specific processing equipment for departments within the plant. Submetering helps personnel become familiar with water use for all operations and indicates whether equipment is using water when it is not needed. (In some rinses, water is left running continuously, even when the need is only occasional.)

To obtain the appropriate size for a submeter, use the actual flow rate rather than just pipe size. Use temporary strap-on meters to determine the approximate flow. Then, the correct size of the positive displacement meter can be determined before installation. Temporary meters also will indicate whether it will be cost-effective to install permanent meters.

Bucket and stopwatch is a simple and accurate measurement tool. To use this method, collect a specified amount of process water for a specific time period (e.g., one quart per minute, which is equivalent to 0.25 gpm).

Micro-weirs are small hand-held weirs that are used to measure low flows of water (0.5 to six gpm) in tight spaces, such as under lavatory faucets.

with the volume of water used, the cost of reading the meters, and potential excessive use fees. For example, large water users (more than 50,000 gpd) should continue to read meters daily. Commercial businesses using water for sanitary purposes only might read meters bi-weekly or monthly.

6. Identify flow and quality of wastewater resulting from each use.
7. Include any internally generated fluids in the water audit. Water may be generated as a byproduct of processing raw materials, such as fruits or from oil/water separation equipment. Determine the quantity and quality of these fluids and whether there are potential on-site uses for these fluids, such as housekeeping or cooling.

Use survey results to prepare a water balance diagram to depict all water uses from source through on-site processes, machines and buildings, and finally, to evaporation and discharge as wastewater. If unaccounted for water is greater than 10 percent, revisit the major areas of water use, talk further with plant operators, or take additional measurements.

Additional Water Auditing Tips

- Measuring tools should be used after the walk-through with facilities staff or the audit team. There is no time to start measuring flows while the assessors are being shown the facility.
- The quality of the audit depends on accurate information for the facilities manager or staff guiding the walk-through. Always try to speak directly to line operators or staff working in the water-consuming operations to confirm information.
- For external auditors, follow-up trips are almost a necessity when water balance calculations to estimating water use by category do not align with meter consumption records.
- Spikes on yearly water consumption graphs are a reminder to the auditor to find out the whole story of the water use history.
- While accounting for water use at large commercial and industrial facilities, it may be difficult to keep "unaccounted for" less than 10 percent. A range of six to 12 percent unaccounted for water is certainly acceptable.

Water Audit Report

Proper and efficient presentation of the water audit findings and recommendations is imperative for facility decision-makers. The water audit report should contain the following elements:

1. Executive summary of the recommendations, quantifying of savings, investment costs and payback periods.
2. Introduction.
3. Facility description.
4. Water use history for one or more years.
5. Water use balance.
6. Which efficiency option, technical discussions and savings calculations.
7. Energy savings if applicable.
8. Data normalization for follow-up with suggested time frame.

Leak Detection

All facilities will experience some leaks. Leaks may range from a fraction of a percent up to several percent of total water use. Telltale signs of a leak include low water pressure or dirty water, or both, as well as an unusually high volume of unaccounted for water. Common locations for leaks are in piping joints, restroom fixtures, pump seals, loose nozzles/shut-off valves, drinking fountains, processing equipment and other locations. Eliminating such leaks typically includes tightening or replacing fittings.

Leaks can be identified by visual or audio observations. Water fixtures and process equipment should be observed both during use and during down time. All employees should be responsible for notifying maintenance personnel of leaks, and maintenance personnel should make leak repair a priority.

Underground or under-the-floor leaks can be detected through a leak-detection survey using the facility's water meter. To do so, all water-consuming items inside and outside the building must be turned off. Alternatively, perform the survey after the last shift has left and no water is being used in the facility; then observe the water meter for a minute or more. If the meter dial moves continually during this time, a leak is indicated. Another method is to record the numbers on the meter and come back an hour later to check the reading, making sure that no water is used during this time. If the meter reading has increased, there is a leak.

Water Leak Equations

Rates of water loss for a roughly circular hole can be estimated using the Greely equation *(see Figure 6-2)*:

Q = (30.394)(A)(square root of P)
Where Q is leak rate in gpm, A is the cross-sectional area of the leak in square inches, and P is the line pressure in pounds per square inch.

Leaks in joints or cracks can be estimated by this equation:

Q = (22.796)(A)(square root of P)
Where Q is leak rate in gpm, A is the area of the leak in square inches, and P is the line pressure in psi. For example, a 1/32" wide crack, 1" long will use 4.5 gpm at 40 psi.

If an underground leak is suspected or detected using the water meter, but the leak's location is not readily identified, it may be necessary to have a leak detection survey performed by a service firm. Such firms use state-of the-art audio sound systems to pinpoint the leak's location. To identify a leak or problem area, a portable listening device allows the user to verify that a leak is present in a general area. The equipment consists of (1) a base unit that contains batteries and electronic components that amplify leak noise and filter extraneous noise, and, (2) an acoustic sensor that attaches to the road surface or pipe itself, as well as a pair of headphones. The cost of this equipment can range from $1,000 to $5,000.

Determining Water Loss by Leaks

Determining the volume of water loss by leaks is important to calculate both water and cost savings by repairing the leak. One of the simplest methods to determine leak loss is the bucket and stopwatch method. A small drip also can be measured by the bucket and stopwatch method. Mathematical estimates of leaks can also be used.

FIGURE 6-1

Drips/Second to GPM Conversion

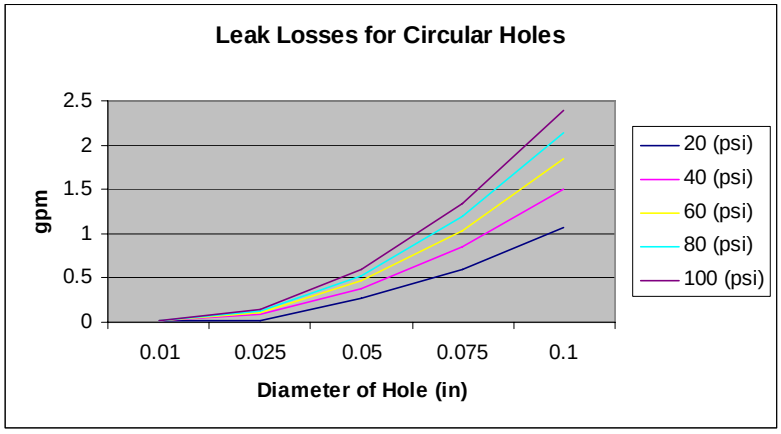
No. drips per second	Gallons per day
1	8.64
2	17.3
3	25.9
4	34.6
5	43.2

Five drips per second is a steady stream.

AWWA: Waterwiser 2008

Water Meter Issues

FIGURE 6-2



The size and accuracy of a facility's water meter is important when accurately accounting for water use. Typical types of meters used for commercial and industrial settings include positive displacement, turbine and compound meters. Figure 6-3 shows typical applications for meter types and sizes. Water meters can become less accurate when the intended water use of a facility has changed or when substantial water conservation activities have been implemented. Water meters should be of adequate size but not oversized. If a meter is oversized for the facility's needs, the facility could be paying unwarranted service charges for the oversized meter. Properly selected and sized water meters can become inaccurate due to wear, which is affected by age and water quality. In-place field testing using a pitotmeter for large meters and a portable meter test unit for smaller water meters can be conducted. In most cases, water used for landscaping, cooling towers, etc., that is not discharged to the sewer can qualify for a rebate from the sewer district. However, the volume of water not going to the sewer must be accurately measured by a separate meter or other device to qualify for the rebate.

FIGURE 6-3

Types of Meters and Applications

Type	Common sizes	Typical applications
Positive displacement	5/8 - 2 inches	Commercial, medium hotels, apartment complexes and industrial plants
Class II turbine	2 - 6 inches	Medium/large hotels, large apartment complexes to large manufacturing and processing plants
Class I turbine	8 - 12 inches	Industrial, manufacturing, processing, pump discharges
Compound, high velocity styles	2 - 4 inches	Special high and low demand applications for schools, public buildings and hospitals

Water Survey Data Sheet

This data collection sheet is designed to assist auditors during assessments. Some items may not be applicable for all assessment situations or conditions.

Assessment Information

Company name _____ Date of assessment _____

Address _____

Phone/FAX _____ Lead assessor _____

Company contact person/title _____

E-mail address _____

Assessment team members _____

_____

Assessment objectives (special concerns) _____

_____

Background Information About Water Use

Average water use/bill (for previous year) _____

Average water use/bill (for year before last) _____

Size and location of meter(s) _____

Primary water source _____

Secondary water source _____

Potential to reduce meter size? _____ Savings _____

Should credit be obtained for water that does not go to the sewer? (cooling towers, landscaping) _____

Is an additional meter required to monitor water not being sewered? _____

Water Balance and Costs

Source of water use	Gallons per Year (est.)	Percent of Total	Water Cost ($/yr)	Sewer Cost ($/yr)	Energy/Other Costs ($yr)
Domestic					
Heating/cooling					
Rinsing/cleaning					
Landscaping					
Unaccounted for					
Total					

Company Background Data

Number of employees _____ Shifts per day _____ Operating days/week _____

Size of and type of plant (sq. ft.) _____ Year built/renovated _____

Business type (manufacturing, college, office, etc.) _____

If manufacturing, list products and annual production rate _____

_____

If service or institutional sector, list clients, occupancy rates, meals served per year, etc.

_____

_____

Other pertinent facility data _____

Current and past water efficiency program measures (policies, training, awareness and goals)

_____

System Parameters

Number, types and sizes of buildings at complex _____

Grounds (approximate size in acres) _____ Garages/motor pool/support buildings (approx. sq. ft.) _____

On-site water treatment description, rate and costs

_____

Wastewater treatment description, rates and operating costs

_____

Notes

_____

Water Used in Manufacturing Processes

Volume used directly in product, per year _____

Description of water used in processing _____

Volume used in production (i.e., plating) _____

Notes _____

_____

Washing, Rinsing and Sanitation

Volume used in cleaning, rinsing and sanitation _____

Description of washing and sanitation processes _____

Number of mop sinks, etc. _____

Have improved rinsing techniques (such as counter-current systems, conductivity flow controls, improved spray nozzle/pressure rinsing, etc.) been considered? _____

Are "dry clean-up" practices used instead of hosing down and first-pass pre-cleaning conducted with squeegees, brushes or brooms? _____

Is water cut off when not in use by flow timers, limit switches or manually? _____

Notes _____

_____

Cooling and Heating

Description of cooling tower evaporative coolers (rated tonnage, types and uses) _____

_____

Water rate used in cooling towers and equipment _____

Is condensate being reused? _____

Description of once-through cooling requirements _____

Volume used in once-through cooling (air conditioners, air compressors, vacuum pumps, rectifiers, hydraulic equipment, degreasers, etc.) _____

Or has once-through cooling water for these uses been eliminated through use of chillers, cooling towers or air-cooled equipment? _____

Has blow-down bleed-off control on boilers and cooling towers been optimized?

Notes _____

_____

Domestic Use

Toilets (number, type and tank volume) _____

Urinals (number and volume) _____

Lavatory sinks (number and estimated flow) _____

Showers (number and estimated flow) _____

Are code-conforming commodes (1.6 gpf), faucet aerators (0.5-1.0 gpm) and low-flow showerheads (2.5 gpm) in use? _____

Notes _____

_____

Landscaping/Outdoor Use

Landscape irrigation (estimated gallons per unit of time) _____

Acreage/square footage landscaped and description _____

Watering/irrigation system techniques and schedule _____

Are low-flow sprinklers, trickle-drip irrigation, optimized watering schedules and water placement, preventive maintenance and xeriscaping techniques in place? _____

Notes _____

_____

Kitchen/Canteen

Dishwasher(s) description, use and volume _____

_____

Kitchen faucet/pre-rinse sprayers [number and flow rate (gpm)] _____

Icemakers, air-or water-cooled and water usage _____

Garbage disposals in use? _____

Are "electric eye" sensors for conveyor dishwashers installed? _____

Have new and water- and energy-efficient dishwashers been considered for future purchse? _____

Notes _____

_____

Other Uses, Leaks and Unaccounted-for Water

List any quantifiable leaks and estimated rates _____

_____

Any other miscellaneous uses of water (car washes, wet scrubbers, ornamental ponds, dust control, etc.) _____

_____

Notes _____

_____

Additional Needs

Factors that couuld affect, increase or decrease water use _____

_____

Any other major opportunities and assessment opportunities revealed, including

- Energy efficiency
- Lighting
- Heat recovery
- Solid waste reduction
- Pollution prevention

_____

_____

N.C. Division of Pollution Prevention and Environmental Assistance
Pollution Prevention Pays

The North Carolina Division of Pollution Prevention and Environmental Assistance provides free, non-regulatory technical assistance and education on methods to eliminate, reduce, or recycle wastes before they become pollutants or require disposal. Telephone DPPEA at (919) 715-6500 or (800) 763-0136 for assistance with issues in this fact sheet or any of your waste reduction concerns.

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