SECTION III ESTIMATING WASTEWATER FLOWS

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SECTION III DATA FOR ESTIMATING WASTEWATER FLOWS

A. Introduction

One of the first tasks that need to be completed before beginning actual design of an OWRS is predicting the wastewater flows and characteristics (physical and biochemical) that will be generated by the facilities to be served by the system. This section addresses wastewater flows, and Section IV addresses wastewater characteristics.

The unit flow allowances given in the Design Standards will govern the prediction of wastewater flows. Where the Design Standards do not prescribe unit flow allowances for a particular type of wastewater generating facility, the data given in this section may be found useful in assisting the development of such allowances.

This section is based on published information on wastewater flows that has become available since publication of Healy and May (1982). Also included herein is information on wastewater flows gleaned from the engineering reports and Discharge Monitoring Reports (DMRs) in the files of the Department for large-scale on-site wastewater renovation systems in Connecticut. In addition, information on wastewater flows contained in Healy and May (sic) is included in Appendix A and similar information in the CT DPH Technical Standards for Subsurface Sewage Disposal Systems is included in Appendix G.

The historic data given herein, that predates the most current data, will provide a perspective on changes in water use brought about by water saving fixtures and may be helpful in developing unit flow allowances where an existing OWRS is to be remediated and the existing water using fixtures will not be upgraded to the newer low flow fixtures.

B. Water Use vs. Wastewater Flows

In many cases the wastewater flows determined for individual buildings are normally based on metered water use, rather than on measured wastewater flows, because of the difficulty in accurately metering small wastewater flow rates. It is normally assumed that almost all of the metered water use inside the building is converted to wastewater discharged from the building because very little of the water used is consumed. That assumption is supported by the following publications.

Linaweaver and Wolfe (1963) stated that: " In the absence of more accurate data it is suggested that approximately 6 per cent of the water supplied for indoor use is not returned into the domestic sanitary sewer system. Table 2 in Chapter 11 of the National Handbook of Recommended Methods for Water Data Acquisition (USGS-19) indicates that domestic consumptive use amounted to about 2-3 percent of total indoor average annual use. Thus the water supplied for indoor use that is discharged as wastewater ranges from 94-98%.

Thus, it is not overly conservative to consider indoor domestic water use as equivalent to domestic wastewater discharge, absent any significant use of water for cooling or other purposes where the water is not discharged to the building sanitary drains.

C. Effect of Efficient Water Using Fixtures on Wastewater Flows

Perhaps the single most significant effect on water use and wastewater flows has been that of the relatively recent adoption of water conservation regulations by the Federal government and many of the states. Prior to about 1980, water use rates for the various fixtures were as follows (Fagan, D. April 1998): lavatories, 3.0 gal. per minute; sinks, 4.5 gal per minute; showers, 5.0 gal per minute; and water consumption for water closets, 4 to 7 gallons per flush.

In the late 70s, toilet manufacturers began introducing "water-saver" designs using 3.5 to 4 gal. per flush. By the early 1980s, most American plumbing codes had been revised to accept and ultimately require the installation of "water saver" toilets in new residential construction. The 1984 Building Officials and Code Administrators International (BOCA) Plumbing Code required that showers, lavatories, and sinks flow at not more than 3.0 gal per minute but no mention was made of a limit to water closet or urinal consumption (Osann, E.R. and J.E.Young 1998). However, the 1987 edition of that code specified that water closet and urinal water use rates should not exceed 4.0 gal and 1.5 gal per flush respectively.

One comparison of domestic water use before and after introduction of water saving fixtures is given in Table 2 of Chapter 11-Water Use, in the U.S. Geological Survey, National Handbook of Recommended Methods for Water Data Acquisition. Information abstracted from that table is given in the following Table R-1. This table shows that a 20% reduction in domestic water use below the pre-1980 use occurred where buildings were equipped with post 1980 fixtures.

TABLE R-1

PRE-1980 AND POST-1980 AVERAGE ANNUAL RESIDENTIAL INDOOR WATER USE

Activity	Pre-1980 Fixtures			Post 1980 Fixtures		
	Water Use, gpcd	Consumptive Use, gpcd	Consumptive Use, Percent	Water Use, gpcd	Consumptive Use, gpcd	Consumptive Use, Percent
Flushing	20	0	0	14	0	0
Bathing	28	0.5	2	19	0.4	0
Clothes Washing	14	1.0	7	14	1.0	7
Dish Washing	3	0	0	3	0	0
Other(Cooking& Cleaning)	10	0.5	5	8	0.4	5
Leaks	8	0	0	8	0	0
TOTAL gpcd	83	2	2	66	1.8	3

In 1990, the following minimum efficiency standards for plumbing fixtures and other water-saving devices were established in the Connecticut General Statutes (CGS Sec. 21a-86a and Sec. 21a-86b):

After October 1, 1990:

- Showerheads 2.5 gpm
- urinals 1.0 gal/flush
- bathroom sinks, lavatory and kitchen faucets and replacement aerators 2.5 gpm
- * lavatories in restrooms of public facilities shall be equipped with outlet devices which limit the flow to a maximum of 0.5 gpm

<u>After January 1, 1992:</u>

tank type toilets, flushometer-valve toilets, flushometer-tank toilets and electromechanical hydraulic toilets -1.6 gal per flush .

In 1992, Congress passed and the President signed the Energy Policy and Conservation Act, in part to "promote the conservation and the efficient use of energy and water." The Act established the following national water conservation standards for:

Showerheads -	2.5 gallons per minute
Toilets -	1.6 gal per flush
Faucets -	2.5 gal per minute
Urinals -	1.0 gal per flush

The Energy Policy and Conservation Act required that, effective January 1, 1994, all new toilets produced for home use must operate on 1.6 gallons per flush or less (Shepard, 1993). Toilets that operate on 3.5 gallons per flush were allowed to continue being manufactured, but their use would only be allowed for certain commercial applications through January l, 1997.

In 1993, the BOCA Plumbing Code maximum water consumption requirements were modified as follows:

Water Closet	1.6 gpf cycle (except as noted below)
Urinal	1.0 gpf cycle (except as noted below)
Shower head	2.5 gpm at 80 psi
Lavatory, Private	2.2 gpm at 80 psi
Lavatory, Public	0.5 gpm at 60 psi
Lavatory, public, metering or self closing	0.25 gal per metering cycle
Sink faucet	2.2 gpm at 60 psi

*Gpm = gal per minute; gpf = gal per flush.

A maximum water consumption of 4 gal per flushing cycle for toilets using Blowout Design fixtures, and 1.5 gal per flushing cycle for urinals was permitted under the BOCA code in the following cases:

- Fixtures for public use in theaters, night-clubs, restaurants, halls, museums,
- Fixtures provided for patients and residents in hospitals, nursing homes, sanitariums and similar occupancies.
- Fixtures provided for inmates and residents in prisons, asylums, reformatories and similar occupancies."

Thus, all new housing units now required to be equipped with water-saving fixtures including 1.6 gpf toilets, water efficient showerheads, faucets, and urinals. Existing housing equipped with higher gal/flush toilets are not required to switch to 1.6 gpf toilets, or the other water saving fixtures, although some municipalities have offered financial incentives to homeowners to make the switch voluntarily. Homeowners who may be renovating an older home are not required to switch to a 1.6 gpf toilet or the other water saving fixtures. If the existing fixtures are still functional, a homeowner may remove them, renovate the building, and re-install the same fixtures.

As of May 1, 1999 CGS Sec. 29-252-1c, the State Building Code-Connecticut Supplement, amended the Connecticut State Building Code. That amendment repealed the previous State Building Code. The BOCA National Building Code/1996, the 1997 International Plumbing Code, and the 1995 CABO One and Two Family Dwelling Code, except as amended, altered or deleted by the Connecticut Supplement, were adopted by reference as the State Building Code. (Note: there were no amendments, alteration or deletions in the Connecticut Supplement that effect the maximum water consumption requirements for water using fixtures.)

Section 604.4 of the 1997 International Plumbing Code established the following maximum water consumption requirements for plumbing fixtures and fixture fittings:

Lavatory, Private	2.5 gpm at 80 psi
Lavatory, Public	0.5 gpm at 60 psi
Lavatory, public, metering or self closing	0.25 gal per metering cycle
Shower head	2.5 gpm at 80 psi
Sink faucet	2.5 gpm at 80 psi
Urinal	1.0 gal per flushing cycle
Water Closet	1.6 gal per flushing cycle

The 1997 International Plumbing Code also provides for the same exceptions for toilets and urinals that were included in the 1993 BOCA National Plumbing Code.

Thus, other than for the exceptions noted above, all new buildings are required to install the new low-flow water fixtures. The use of these fixtures can be expected to reduce the wastewater flows generated in new or retrofitted buildings below the flows experienced before the adoption of water conservation regulations by the State and the Federal governments.

D. Published Studies on Residential Water Use

A study of residential water use had been conducted by the Johns Hopkins University in the mid-1960s for the U.S. Department of Housing and Urban Development prior to the advent of widespread use of water conservation fixtures. The final report of the study (Linaweaver, Geyer and Wolff-1967) provided information obtained in cooperation with sixteen water utilities located in various metropolitan areas of the U.S.

The study did not incorporate individual water use recorders, as this was not considered feasible for the number of study areas and homes involved. Instead, the flow data was determined by the installation of master meter-recorder systems to measure water supplied to small homogeneous residential areas and dividing the total water use during the non-sprinkling season by the number of homes in each area to obtain the domestic water use per residence. Domestic water use was defined as water used within the home for domestic purposes including drinking, cooking, bathing, washing, and carrying away wastes. The authors stated, "Practically all domestic water is discharged to the sewers or septic tank systems and thus is non-consumptive use". The characteristics of the study areas were as follows:

Statistic	Number of Dwelling Units	Persons per Dwelling Unit
Minimum	44	3.1
Mean	178	4.1
Maximum	307	4.9

The mean values of domestic (household indoor) water use in five eastern metropolitan areas[1] with metered public water supply and septic systems were as follows:

	Avg. Annual Day	Maximum Day	Peak Hour
	191 gal/du	247 gal/du	530 gal/du
Ratio to Avg.:	1.00	1.29	2.77

The mean values of domestic (household indoor) water use in 13 eastern metropolitan areas with metered public water supply and public sewers were as follows:

	Avg. Annual Day	Maximum Day	Peak Hour
	209 gal/du	271 gal/du	536 gal/du
Ratio to Avg.:	1.00	1.30	2.56

Thus, the average annual day and maximum average day domestic water use in areas served by septic systems was about 91% of that in areas served by public sewers. However, the peak hourly use to average annual daily use ratio in areas served by septic systems was somewhat higher.

[1] District of Columbia, Washington, D.C., Washington Suburban Sanitary District, Hyattsville, MD, City of Baltimore and Baltimore County, MD, City of Philadelphia, PA, and Philadelphia Suburban Water Company, Bryn Mawr, PA.

The most recent definitive study on the effects of low-flow fixtures on residential water use was underwritten by the American Water Works Association Research Foundation and reported in "Residential End Use of Water" (AWWARF, 1999). This report is based on data collected from 1,188 single- family homes in 12 North American locations (11 in the U.S., 1 in Ontario, Canada). This study involved the use of state-of-the art surveys, data loggers and trace analysis equipment.

In addition to providing overall water use data, the report (ibid.) provided a quantitative description of the various uses of water in the home and a comparison of such use with and without the use of low-flow water using fixtures. Some of the information included in this report is given in Tables No. R-2, R-3, and R-4.

TABLE R-2

CURRENT INDOOR WATER USE
(Adapted from AWWARF 1999 Report on Residential End Uses of Water)

		Mean Persons	Gallons per Capita per Day (gpcd)		
Study Site	Sample Size	per Household	Mean Daily	Median Daily	Std. Deviation
Waterloo/Cambridge, Ontario	95	3.1	70.6	59.5	44.6
Seattle, WA	99	2.8	57.1	54.0	28.6
Tampa, FL	99	2.4	65.8	59.0	33.5
Lompoc, CA	100	2.8	65.8	56.1	33.4
Eugene, OR	98	2.5	83.5	63.8	68.9
Boulder, CO	100	2.4	64.7	60.3	25.8
San Diego, CA	100	2.7	58.3	54.1	23.4
Denver, CO	99	2.7	69.3	64.9	35.0
Phoenix, AZ	100	2.9	77.6	66.9	44.8
Scottsdale/Tempe, AZ	99	2.3	81.4	63.4	67.6
Walnut Valley WD, CA	99	3.3	67.8	63.3	30.8
Las Virgenes MWD, CA	100	3.1	69.6	61.0	38.6
Total of Study Sites	1,188	2.8	69.3	60.5	39.6

TABLE R-3

MEAN DAILY PER CAPITA INDOOR WATER USE
(Adapted from AWWARF 1999 Report on Residential End Uses of Water)

Study Site	Sample Size	Toilets	Faucets	Showers	Baths	Dish washers	Clothes washers	Leaks	Other	Total
Waterloo/Cambridge, Ontario	95	20.3	11.4	8.3	1.9	0.8	13.7	8.2	6.0	70.6
Seattle, WA	99	17.1	8.7	11.4	1.1	1.0	12.0	5.9	0.0	57.1
Tampa, FL	99	16.7	12.0	10.2	1.1	0.6	14.2	10.8	0.3	65.8
Lompoc, CA	100	16.6	9.9	11.1	1.2	0.8	15.3	10.1	0.9	65.8
Eugene, OR	98	22.9	11.9	15.1	1.5	1.4	17.1	13.6	0.1	83.5
Boulder, CO	100	19.8	11.6	13.1	1.4	1.4	14.0	3.4	0.2	64.7
San Diego, CA	100	15.8	10.8	9.0	0.5	0.9	16.3	4.6	0.3	58.3
Denver, CO	99	21.1	10.5	12.9	1.6	1.2	15.6	5.8	0.5	69.3
Phoenix, AZ	100	19.6	9.6	12.5	1.2	0.8	16.9	14.8	2.2	77.6
Scottsdale/Tempe, AZ	99	18.4	11.2	12.6	0.9	1.1	14.5	17.6	5.0	81.4
Walnut Valley WD, CA	99	18.0	12.3	11.7	1.0	0.8	14.1	7.6	2.3	67.8
Las Virgenes MWD, CA	100	15.7	11.2	11.4	1.3	0.9	16.8	11.2	1.1	69.6
Total of Study Sites	1,188									
Mean Values gpcd		18.5	10.9	11.6	1.2	1.0	15.0	9.5	1.6	69.3

TABLE R-4

HOUSEHOLD END USE OF WATER

WITHOUT AND WITH CONSERVATION, POTENTIAL SAVINGS
(Adapted from the AWWARF Residential End Use of Water Study)

	Without Conservation**		With Conservation		Savings	
End Use	Share	gcd	Share	gcd	%	gcd
Toilets	27.7%	20.1	19.3%	9.6	52%	10.5
Clothes Washers	20.9%	15.1	21.4%	10.6	30%	4.5
Showers	17.3%	12.6	20.1%	10.0	21%	2.6
Faucets	15.3%	11.1	21.9%	10.8	2%	0.3
Leaks***	13.8%	10.0	10.1%	5.0	50%	5.0
Other Domestic	2.1%	1.5	3.1%	1.5	0%	0
Baths	1.6%	1.2	2.4%	1.2	0%	0
Dish Washers	1.3%	1.0	2.0%	1.0	0%	0
Inside Total	100%	72.5	100%	49.6	32%	22.9

** Based on the average inside uses measured in 1,188 homes in 14 North American cities including an additional 5% to account for estimated "in place" savings due to existing conservation.

*** The leakage rate shown is an average for the large population of homes monitored in the Residential End Use Study. Nearly 60% of leakage volume was found to be explained by less than 10% of the homes.

The authors of the AWWARF study indicated that creating national water use "averages" was not an objective of the study and that the pooled results were presented for summary and comparative purposes alone. Since all but two of the 12 locales in that study are located in the west, the relatively high per capita mean water use of 69.3 gpcd given in that report may be biased with respect to water use for residences in Connecticut served by on-site wastewater renovation systems because of differing climatic conditions and patterns of water use. It should be noted that Linaweaver, et al. (1967) indicated that the per capita inside water use in residences served by septic systems averaged 47 gpcd as compared to 51 gpcd for residences served by public sewers in the east and 67 gpcd for such residences in the west.

However, a significant conclusion of the report was the similarities between the twelve study sites in the amount and types of water fixtures and appliances used. The report states that this information had significant "transfer" value across North America. Thus, the projected savings in water use resulting from use of each type of low flow fixture and appliance, as shown in Table 3, should be applicable to any location in the United States.

If only the water savings resulting from use of toilets, showerheads and faucets conforming to the current code requirements are considered, the results given in Table 3 indicate the following per capita savings would result:

Fixture Measure	Use Rate	Savings in gpcd
Ultra-Low flush toilets	1.6 gpf	10.5
Low flow showerheads	2.5 gpm	2.6
Low Flow Faucets (installed on kitchen sink and bathroom faucets)	2.2 gpm	0.3
Total Savings:		13.4

It should be noted that the savings resulting from use of ultra-low flush (ULF) toilets shown in Table 3 include the effects of occasional double flushing. (This is also true of the amount of water use shown in Table 3 resulting from the non-conservation types of toilets.) Also, the results are relevant even though some of the 1.6gpf ULF toilets reputedly have a flushing volume in excess of 1.6 gallons (LADW&P- 2000), as the results are based on measured water use rather than on fixture rating. Thus, the results shown above are net savings.

Applying these savings to the per capita flow allowance of 75 gpd derived from the residential design flow of 150 gpd per bedroom in the CT Public Health Code (2004) results in reducing the allowance to about 62 gpcd, a reduction of 17 percent. If only the saving from an ultra-low flush toilet is considered, the 75-gpcd allowance would be reduced to about 65 gpcd, a reduction of 13 percent. A number of municipal water agencies have reported savings upwards of 15 percent of indoor water use after retrofitting of customer buildings with low flow and ultra-low flow water fixtures.

For example, Santa Monica, CA has observed water savings averaged 15% after completion of a toilet and showerhead replacement program. Houston, TX found water savings averaged 18% per household after distribution of water conservation kits.

New York City, in a survey of 67 apartment buildings retrofitted with water saving fixtures found an average reduction of 29% of water use. Seattle, WA, estimates that its Commercial (water) Conservation Program could cut commercial-sector water use by 20%. Tampa, FL's toilet replacement program resulted in a 15% reduction in water use.

The information presented herein regarding the reduction in water use resulting from use of water efficient fixtures and appliances is particularly helpful in addressing situations where on-site wastewater disposal systems have failed due to hydraulic overload. Replacing all existing faucets and shower heads with low flow fixtures; replacing existing dishwashers with the more energy efficient types, replacing existing clothes washers with the new energy efficient side loading designs that save from 30 to 40 percent of water used by older top loading washers, and replacing existing toilets with ultra-low-flow (ULF) toilets could effect a very substantial (30% or more) reduction in wastewater flows. Indications are that the combined cost of retrofitting plus the cost of a smaller replacement on-site wastewater renovation system may be less than the cost of constructing a replacement on-site wastewater renovation system sized on the basis of previous water use.

The replacement of clothes washers with new high-efficiency washers is problematic, because of the additional "first cost" involved. However, it is reputed that the high-efficiency front-loading washers use up to 50 percent less energy, can cut water usage by 30 percent or more and get clothes 25 percent cleaner than traditional top loading models (U.S. Water News Online-a). Thus, there is a payback resulting from the use of such washers in a lower electric bill, and where water is also purchased, an additional payback would result. In 1998, a consortium of 16 electric and gas utilities in New England (the Northeast Energy Efficiency Partnership) launched the TumbleWash program to promote awareness and use of high-efficiency, front-loading washing machines (U.S. Water News Online-a). Thus, there should be an increase in the high-efficiency washer penetration of the clothes washer market in years ahead, and further reduction in residential water use can be expected.

With respect to allowing a wastewater flow reduction credit for water efficient plumbing devices, Siegrist (1981) discussed two major considerations that have to be addressed. "Firstly, one must be relatively confident that the use of a given device or system will yield the predicted waste load (flow) reduction. A second major consideration is the necessity that the technique or device utilized be accepted by the present users as well as future users." He went on to state that "(1) the appropriate regulatory authority could allow only those devices whose characteristics and merits indicate the potential for long-term user acceptance; (2) the plumbing system could be installed in such a way as to discourage disconnection or replacement of a device; or (3) periodic inspection by a local inspector within the framework of a sanitary district or the like may serve to identify plumbing alterations." (In other words, consideration must be given to user circumvention or removal of water saving devices.)

In general, passive wastewater modification methods or devices not significantly affected by user habits tend to be more reliable than those that are subject to user habits and require a preconceived active role by the users. For example, a low-flow toilet is a passive device, while a flow-reducing showerhead is an active one. (National Small Flows Clearinghouse -1997)

It would seem that long-term user acceptance is the better approach to use with respect to granting any wastewater flow credit for water-efficient plumbing devices and appliances. In this respect, it would seem that the Ultra-Low Flush toilet is generally accepted by the public and improvements will continue to be made by the manufacturers to allay the public concern, such as it is, for such matters as double-flushing, bowl staining, and noise (for pressure operated types).

Other water savings devices such as the low flow faucets and showerheads are now required by the State Building Code and are generally accepted, although they can be altered relatively easily to provide an increased flow rate. Thus, there is some risk in granting a flow credit for such fixtures.

The use of high-efficiency, front-loading washing machines has not yet been codified, and they can be replaced, although the replacement would represent a significant monetary expenditure. Additional information will have to be developed regarding the acceptance of such machines by the public.

The AWWRF 1999 study indicates that the savings in per capita water use from use of more efficient dishwashers will be small, on the order of 1 gpcd or less, and thus is not a significant factor in considering any credit for water-efficient plumbing devices and appliances.

Based on the information presented above, a reduction of the residential per capita flow allowance inherent in the CT Public Health Code (currently 75 gpcd) to 65 gpcd might appear to be appropriate where ULFTs are proposed. Note that this reduction is based on utilization of ULFT fixtures throughout the residential facility, and further, that no increase in reduction should be allowed because more than one ULFT will be installed per dwelling unit. In the case of commercial and institutional rest rooms, however, the reduction should be on a fixture use basis.

On the other hand, a recent report (NAHB-2002) to the Seattle Public Utilities, Seattle, WA and the East Bay Municipal Utility District, Oakland, CA suggests that such a reduction in flow allowance may be problematic. That report presented the results of performance testing and evaluation of 49 different new models of ULF toilets. The toilets tested included gravity, pressure-assist, and vacuum-assist models as well as a few special models, such a dual-flush, flapperless and air-assist units. The toilets used in the testing are generally available nationwide at large home improvement centers and plumbing supply stores. The results of the testing and evaluation program cast a different light on potential water savings. The study found that "out of the box" flush volumes of nominal 1.6 gallons per flush (gpf) toilets ranged from 1.45 to 1.89 gpf. The average flush volume of those toilets that exceeded 1.6 gpf was 1.68 gpf; this not a very significant difference.

However, of more concern was the finding that "After replacement of the original flapper with a generic flapper[2], the flush volume for the 1.6 gpf fixtures that could be retrofitted with a standard flapper ranged from 1.03 to 4.66 gpf. Twenty-eight of the 33 models that could be retrofitted with a standard flapper used more than 1.6 gpf after flapper

[2] A "universal" replacement available at hardware stores and home centers.

replacement and averaged 2.91 gpf. This is consistent with the results of an earlier study wherein similar flapper replacements were performed (MWDSC-1998*)*. Because flapper valves typically require replacement several times during the useful life of a toilet fixture and the likelihood that the consumer will install a generic replacement flapper, water efficiency of many of the tested models could significantly degrade over time."

Of the 49 ULF toilets tested, 16 could not be retrofitted with generic flappers, as only the original manufacturer's flappers could be installed. Of these 16, the out-of-box flush volume ranged from 0.62 to 1.70 gpf and averaged 1.47 gpf. Ten of these 16 units also had superior flushing performance under the test conditions. Thus, it appears that there are ULF toilets on the market that can effect a considerable saving in toilet water use while providing acceptable performance. However, the following recommendation of the report is worth noting. "The plumbing industry, in cooperation with the water utility industry, should develop a parts identification and distribution system for flush valve flappers that will assure the consumer will purchase the appropriate replacement flapper to maintain the 1.6 gpf that the fixture was designed for." Until such time as that recommendation is universally adopted, it would seem that a reduction in flow allowance for the installation of ULF toilets should be viewed with caution.

It should be noted that reducing wastewater volume most likely would result in an increase in the concentration of the various pollutants since it is unlikely that the mass of pollutants will be changed. The National Small Flows Clearinghouse publication "Water Conservation Treatment Technology Package (NSFC-1997) indicates that monitoring of septic tanks in Indiana and Pennsylvania over several years reinforced the fact that the increase in pollutant concentrations in effluent is proportional to the decrease in flow. On the other hand, some consideration has been given to the possibility that, if wastewater volumes are reduced without changing the volume of the septic tank, the pollutant removal capabilities of the septic tank will be enhanced, and thus there may not be any significant change in the pollutant concentrations discharged to the SWAS.

Even if there is a proportionate increase in pollutant concentrations, it is doubtful if this would have a significant impact on the performance of a single-family dwelling on-site wastewater renovation (OSWR) system. However, this will not be the case where reductions in wastewater flows from large scale OSWR systems serving a number of dwellings or commercial/institutional establishments are being considered because of the use of high-efficiency plumbing devices and appliances. In that case, where wastewater "strength" is apt to be much higher than residential wastewater, any increase in strength caused by water conservation may have a significant effect on wastewater characteristics.

The following fact should also be borne in mind when comparing unit wastewater flow data from buildings served by on-site systems with similar data obtained from flow measurements in sewered areas. There is a significant difference between the unit flows based on metered water use in individual residential, commercial or institutional buildings and the unit wastewater flow data usually reported for "domestic" wastewater based on flow measurements in collection sewers or at wastewater treatment plants. The latter data may be biased by the inclusion of contributions from commercial and institutional sources, and sometimes by small industrial sources, and is also biased by the effect of inflow and infiltration into the sewer system. The result is that the unit flows derived from sewer measurements are apt to be larger than those derived from flow measurements obtained from individual building water use data. (This is also a significant consideration when comparing concentrations of wastewater constituents.)

E. Published Information on Residential Wastewater Flows

Loomis and Dow (1998) reported on an on-site wastewater demonstration project funded by the State of Rhode Island, involving 12 single-family residences. The mean wastewater flows, based on records from water meters installed on drainfield pressure lines, for the period from August to October 1997, were as follows:

Table R-5
12 Single Family Residences - Wastewater Generated per Household

Persons per Household	Wastewater Generated per Household (gal/d)	gpcd
2 adults, 3 children	195	38.8
2 adults, 3 children	234	46.8
2 adults	29.9	15.0
5 adults	346	69.2
2 adults, 2 children	134	33.4
2 adults, 3 children	142	28.3
2 adults, 1 child	126	41.8
2 adults, 1 child	120	39.8
1 adult, 3 children	115	28.6
2 adults, 2 children	278	69.4
2 adults, 1 child	110	36.5
2 adults, 4 children	179	29.9
Mean:	167	39.8

It should be noted that all of these residences were located on small lots; sizes ranged from 2,250 square ft. to 20,000 sq. ft in area, with all but 3 lots being less than 10,000 sq. ft. in area. The small lot sizes, together with the fact that these sites had failed septic systems prior to their replacement with new systems, may have had an impact on the amounts of wastewater generated, compared to the amounts that might have been generated had there not previously been a history of failed systems. (Many homeowners with failed systems will try to reduce normal water use in such situations, and this may have carried over even after the new systems were installed.)

U.S. EPA (2002) reviewed the results of recent studies on residential water use and indicated that an estimated average daily wastewater flow of approximately 50 to 70 gpcd would be typical for residential dwellings built before 1994 (the year that the U.S. Energy Policy and Conservation Act standards went into effect), and 40-60 gpcd for residences built after 1994.

F. Data on Residential Water Use from Department Files

Table R-6

ELDERLY HOUSING DEVELOPMENT
(Fairfield County)

Metered Water Use for Period 7/12/00 to 2/6/02

No. Bedrooms Served	No. Persons Served	No. Persons per BR	Mean Water Use/BR	Mean Water Use/Capita
111	152	1.4	87 gpd	63 gpcd

Table R-7

CLUSTER SYSTEM DESIGNED TO SERVE EIGHT SINGLE FAMILY HOMES
(Middlesex County)

Period of Time	ADF GPD	No. BR. Served	Flow/BR GPD
11/12/98 - 2/18/99	2,049	23	89
2/19/99 - 5/28/99	2,118	23	92
5/29/99 - 8/31/99	1,701	23	74
9/1/99 - 11/30/99	1,619	23	70
12/01/00 -2/25/00	1,759	23	76
2/26/00 - 5/26/00	1,675	23	73
5/26/99 - 8/31/00	1,716	23	75
9/1/00 - 11/27/00	1,555	23	68
11/28/00 - 2/15/01	1,707	23	74
2/16/01 - 5/30/01	1,557	23	67
6/1/01 - 8/30/01	1,567	27	58
8/31/01 - 11/27/01	1,687	27	63

Mean, 6/1/01 -11/27/01 for 7 dwellings* with a total of 27 BR = 73 gpd/BR

* (Six, 4 BR Dwellings and one - 3BR Dwelling.)

TABLE RC-1

ELDERLY RETIREMENT COMMUNITY
(Middlesex County)

90 residential apartments (54 one-bedroom and 36 two-bedroom dwelling units), containing a total of 126 bedrooms and a commons building containing a central kitchen-dining room for serving meals to the residents and their guests.

AVERAGE DAILY METERED WATER USE PER RESIDENT

Month & Year	Total Water Use, Gallons	Avg. Water Use, Gallons per Day	Resident Population	Gals. per Day Per Resident
Jan. '97 (33)*	273,768	8,296	113	73.4
Feb. '97 (28)	245,344	8,762	113	77.5
Mar. '97 (31)	267,784	8,638	110	78.5
Apr. '97 (30)	297,704	9,923	110	90.2
May '97 (30)	323,884	10,796	113	95.5
June '97 (31)	345,576	11,148	112	99.5
July '97 (31)	378,488	12,209	111	110.0
Aug. '97 (31)	365,024	11,775	107	110.0
Sept. '97 (31)	330,616	10,665	109	97.8
Oct. '97 (31)	309,672	9,989	108	92.5
Nov. '97 (31)	316,404	10,207	109	93.6
Dec. '97 (28)	270,776	9,671	109	88.7
Jan. '98 (32)	282,744	8,835	106	83.4
Feb. '98 (28)	246,840	8,816	110	80.1
Mar. '98 (31)	285,736	9,217	102	90.4
Apr. '98 (31)	299,200	9,652	108	89.4
Mean:		9,912 gpd	109	90.7 gpcd
Mean, most recent 12 months		10,248	109	94.2

* Actual Number of Days included in billing period.

Table No. RC-2 provides information on the average daily water use per apartment. Analysis of apartment occupancy data for the 1997 calendar year indicated that approximately 70% of the occupied apartments were occupied by one resident, approximately 59 % of the two bedroom apartments were occupied by one resident, and the ratio of residents to occupied apartments averaged 1.29.

TABLE RC-2

ELDERLY RETIREMENT COMMUNITY
AVERAGE DAILY WATER USE PER APARTMENT

Month & Year	Avg. Water Use Gals. per Day	Apartments Occupied No.	%	Gal. per Day Per Apartment
Jan. '97	8,296	86	95.6	96.5
Feb. '97	8,762	87	96.7	100.7
Mar. '97	8,638	85	94.4	101.6
Apr. '97	9,923	86	95.6	115.4
May '97	10,796	87	96.7	124.1
June '97	11,148	86	95.6	129.6
July '97	12,209	86	95.6	142.0
Aug.'97	11,775	82	91.1	143.6
Sept.'97	10,665	84	93.3	127.0
Oct. '97	9,989	83	92.2	120.3
Nov.'97	10,207	85	94.4	120.1
Dec. '97	9,671	85	94.4	113.8
Jan. '98	8,835	80	88.9	110.4
Feb. '98	8,816	83	92.2	106.2
Mar. '98	9,217	78	86.7	118.2
Apr. '98	9,652	81	90.0	119.2
Mean :	9,914	84	93.6	118.0
Mean, most recent 12 months:	10,248	83	92.6	122.9

Table No. RC-3

Life Care Retirement Community
Middlesex County, CT

189 residential apartments, 45 convalescent beds, and a commons building containing a central kitchen-dining room for serving meals to the residents and their guests.

	Water Use over 12 Month Period Min. Day	Avg. Day	Max. Day	Max:Avg.Day
Mean: gpd	15,783	21,271	27,425	1.29

G. Published Information on Commercial and Institutional Water Use

1. Effect of efficient plumbing fixtures and appliances

The effect of new water efficient plumbing fixtures and appliances is apt to be more pronounced on commercial sources, since the wastewater contributions from bathroom fixtures are usually a much higher percentage of the total wastewater discharged from such sources. Thus, one can expect a lower per capita or per fixture wastewater discharge and a high concentration of wastewater pollutants than found in historical data that does not include the effects of the new water efficient plumbing fixtures. The effect on institutional wastewater flows may or may not be pronounced, depending upon the nature of water use at such institutions. It will therefore be important to carefully evaluate historic water use (wastewater discharge) data in the context of the number and types of plumbing fixtures and appliances that may have been in use when that data was generated.

A major Ultra Low Flow Toilet (ULFT) study looking at toilet retrofits was conducted for the California Urban Water Conservation Council between 1992 and 1996 (Hagler Bailly Services- 1997). The project evaluated the effect of ULFTs for 12 categories of establishments served by 10 California water agencies. The study estimated the following savings per installed ULFT (AWWARF- 2000):

Category	Savings, gpd
Food Stores	32
Health Care Facilities	21
Hotel/Motel	16
Offices	20
Religious Facilities	28
Restaurants	47
Retail Stores	37
Manufacturing	23

In Tampa, Florida, retrofitting a junior high school with ULFTs was found to have reduced water use by 32% (AWWARF- ibid.).

Bamezai and Chestnut (1994) reported the results of a retrofit program by the San Diego, CA, Water Utilities Department. Evaluation of results from 70 sites retrofitted with ULFTs showed that water savings varied across categories within the public sector. The number of users, number of toilets per facility and the nature of the facility were some of the factors effecting water savings in these public facilities. The least savings occurred in police stations (20.5 gallons per toilet per day (gtd), and the most savings occurred in recreation centers, senior centers, and pools, with an average of 116.8 gtd. (AWWARF- ibid.).

2. Commercial and Institutional Water Use

A significant study of commercial water use was conducted by The Johns Hopkins University in 1966 (Wolff, Linaweaver and Geyer-1966). In addition to obtaining and analyzing water use data from recording devices installed on water meters of commercial and institutional consumers, the literature was reviewed to obtain data from prior work by others on commercial and institutional water use. While the results of this study could prove helpful in designing water distribution systems serving commercial and institutional facilities, they are not helpful for estimating wastewater flows because the total water use was not disaggregated into indoor use (assumed equivalent to wastewater discharge), outdoor use and continuous uses such as air conditioning and leakage.

The most recent comprehensive information published on commercial and institutional water use is the report sponsored by the American Water Works Association Research Foundation (AWWARF, 2000) entitled "Commercial and Institutional End Uses of Water". This report summarizes and interprets the existing knowledge base of utility-supplied potable water in urban areas. The public utilities who participated in this study were:

1. Los Angeles Department of Water and Power , California
2. Irvine Ranch Water District, California
3. City of San Diego Water Utilities Department, California
4. City of Santa Monica, California
5. City of Phoenix Water Services, Arizona.

It is important, when reviewing the data in this report, that it is biased both with respect to the source of the data (urban locations served by water utilities) and the location of the agencies providing the data (western U.S.). Nevertheless, it is a definitive study of commercial and institutional water use and may be of use in judging the value of data obtained from other sources.

The following five commercial and institutional (CI) categories were selected for detailed analysis: Schools, Hotels/Motels, Office Buildings, Restaurants, and Food Stores. Field data were obtained from data loggers installed on water meters, and from sub-meters installed where practical to do so. Sub metering proved impracticable for all but a few facilities, because of the layout of the internal water piping.

Each data logger was fitted with a magnetic sensor that was strapped to the water meter at each site. As water was used, it flowed through the water meter causing the internal magnets of the water meter to spin. The sensor picked up each magnetic pulse as water flowed through the meter and the logger counted the number of pulses detected and stored the total every 10 seconds. Using the physical characteristics of each specific brand and model of water meter, the magnetic pulse data from the data logger was transformed into an average flow rate for each 10-second interval. This flow trace is precise enough to detect the individual flow signatures of water using equipment and appliances and plumbing fixtures in the building and that of any irrigation system. The data obtained from the data loggers was used for flow tracing analyses using custom signal processing software to disaggregate the flows into identifiable component end uses. In the few cases where sub-metering proved practical, the information from these meters was also used to disaggregate flows.

The field data obtained was disaggregated into three basic categories; indoor use, outdoor use, and continuous water use. Indoor use included all domestic sanitary, process, mechanical equipment, cleaning uses and periodic leaks. Outdoor use included irrigation, pool filling, driveway/patio washing, etc. Continuous use included leakage and cooling water demand. In many cases, the indoor water use was further disaggregated into subcategories that varied depending upon the CI category of the facility. After the flow traces from an individual site were analyzed, daily estimates were made for all of the identifiable categories during the logging period. These daily estimates were used in conjunction with the billing data for each facility supplied by the utilities and other information collected during site surveys to create estimates of average annual use for each CI category.

Because the indoor water use was determined, it is possible to use this data judicially for estimating wastewater flows. A summary of the indoor water use at the various CI facilities investigated in the field is given below.

a. Office Buildings

Detailed water use data were determined for five office buildings in the manner previously described. The size and occupancy of these five buildings were as follows:

Location:	Irvine	Los Angeles	Phoenix	San Diego	Santa Monica
Use	Commercial	Commercial	Clinic	Gov. Agency	Commercial
Size (sq. ft.)	57,785	176,500	10,000	8,800	186,000

The average in-door water use was given in terms of gallons/sf/year. Dividing this data by 250 days/year (assuming a 5-day work week and 10 vacation days) yields the following data:

Use	Irvine	Los Angeles	Phoenix	San Diego	Santa Monica
Toilet	0.021		0.032	0.105	0.010
Faucets	0.002		0.019	0.020	
Other/Misc.	0.004		0.001	0.026	0.005
Total Use- g/sf/d	0.027	0.088	0.052	0.151	0.015

Based on an audit of metered water billings for 50 office buildings in Arizona, California, Colorado, and Florida, the following percentiles were given for indoor use:

Office Building Water Use

Percentiles	10%	25%	50%	75%	90%
Indoor Use, gpd/sf	0.011	0.026	0.039	0.069	0.125

b. Restaurants

Direct field measurement studies were made at five restaurants. All were family style, sit-down establishments, as opposed to fine dining or fast food restaurants. The restaurants ranged in size from 73 to 253 seats and served from 190 to 800 meals per day. All had on-site dish washing. The average in-door water use per meal served (g/meal) was as follows:

Use		Irvine	Los Angeles	Phoenix	San Diego	Santa Monica
Dishwashing		0.9		1.4		1.1
Toilets/Urinals		0.4		0.5		0.5
All Other		1.4		3.5		1.8
Total	g/meal	2.7	10.5	5.4	16.2	3.4

Based on an audit of metered water billings for 87 restaurants in California, Florida, and Colorado, the following percentiles were given for restaurant indoor water use:

Percentiles	10%	25%	50%	75%	90%
Gal/meal	5.8	7.0	11.2	18.7	35.5

c. Supermarkets

Detailed water use data were determined for five supermarkets in the manner previously described. All were large, full service stores with produce, meat, deli, and bakery departments. Each supermarket had some form of hot food service. The size of these five buildings were as follows:

Location:	Irvine	Los Angeles	Phoenix	San Diego	Santa Monica
Size (sq. ft.)	38,000	50,000	48,000	66,000	45,000

The average in-door water use was given in terms of gallons/sq. ft./year. Dividing this data by 365 days/year yields the following data, in gpd/sq ft.

Use	Irvine	Los Angeles	Phoenix	San Diego	Santa Monica
Toilets/Urinals	0.02	0.02	0.02	0.01	002
Other Misc.	0.09	0.08	0.05	0.05	0.06
Total Indoor, gpd/sf	0.11	0.10	0.07	0.06	0.08

Based on an audit of metered water billings for 33 supermarkets in California and Arizona, the following percentiles were given for indoor use:

Percentiles	10%	25%	50%	75%	90%
gpd/sq. ft	0.047	0.065	0.091	0.126	0.174

d. Hotels and Motels

Detailed water use data were determined for five hotels in the manner previously described. The number of rooms at these five hotels were as follows:

Location:	Irvine	Los Angeles	Phoenix	San Diego	Santa Monica
No. of Rooms	148	297	140	209	168

The hotels at Irvine, Phoenix and San Diego were economy/budget franchises. The Santa Monica facility was a combination economy travel lodge and beach resort. The Los Angeles facility was a large luxury class hotel and was the only one with restaurant and banquet facilities.

The average indoor use was given in gallons per day per room. These values do not include ice-making use, since such usage was considered negligible with respect to wastewater discharges.

Use	Irvine	Los Angeles	Phoenix	San Diego	Santa Monica
Bathtub	0	6.4	2.7	0	0
Faucets	6.0	17.3	7.4	7.6	6.8
Showers	28.0	88.9	37.6	34.1	30.6
Toilet	26.0	76.8	32.6	32.8	29.5
Leaks	21.9	14.7	6.2	1.3	1.2
Total In-Room	81.9	204.1	86.5	75.8	68.1
Laundry	16.6	0	17.5	31.6	33.0
Other/Misc.	2.6	22.7	3.1	27.3	12.5
Total, gpd/room	101.1	226.8	107.1	134.7	113.6

It is interesting to note that for all but the luxury hotel in Los Angeles, the in-room water use values do not vary greatly, ranging from 68.1 to 86.5 gal/room with an average of 78.1 gal/room .

Based on an audit of metered water billings for 100 hotels and motels in Arizona, California, Florida, and Colorado, the following percentiles were given for indoor use:

Percentiles	10%	25%	50%	75%	90%
Gal/room/day	55	85.1	116.8	145.4	187.9

e. Public High Schools

Detailed water use data were determined for four public high schools in the manner previously described. The number of students/staff, annual operating days at each school, and building footprint area were as follows:

Location	Irvine	Los Angeles	Phoenix	Santa Monica
No. Students/staff	2640	3850	2186	3065
Annual Operating Days	180	340	180	340
Building Footprint (sf)	224,652	253,357	325,000	220,000

Two of the high schools operated on a traditional school year calendar and the other two followed a year-round calendar. The number of students/staff at these schools was probably larger than what would be found at high schools in Connecticut served by on-site wastewater renovation systems. The indoor water use per person (student/staff), based on the annual operating days indicated above for each school, was as follows:

Use	Irvine	Los Angeles	Phoenix	Santa Monica
Toilets	1.51			1.15
Urinals	0.59			0.55
Faucets	0.48			0.48
Showers	0.24			0.14
Kitchen	0.32			0.21
Misc.	0.00			0.20
Total Use, gpcd	3.14	3.73	6.69	2.17

Based on an audit of metered water billings for 136 schools in Arizona, California, Colorado, and Florida, the following percentiles were given for indoor use:

School Water Use (Includes grade schools, middle schools and high schools)

Percentiles	10%	25%	50%	75%	90%
G/Student/School Day	5.9	8.1	11.5	16.2	24.3

f. Offices

Behling and Bartillucci (1992) analyzed metered water records covering a 3-year period for each of 23 office complexes located on Long Island, NY. All of these office buildings were equipped with plumbing fixtures conforming to the 1980 New York State plumbing code, which required 3.5 gal/flush toilets, 1.5 gal/flush urinals, and 3.0 gpm lavatory faucets. To eliminate water use due to outdoor irrigation and cooling water (air conditioning), the data were averaged for the fall-winter months (October through March). Thus, the water use data, assumed to be equivalent to wastewater discharge, includes water used for rest room facilities, drinking water fountains, building maintenance and accessory non-office amenities such as snack bars, restaurants and shops.

The daily water use for the fall-winter period was calculated on the basis of a five-day workweek. Building areas ranged from 45,000 sq. ft. to 2,000,000 sq. ft. and the average occupancy rate was reported to range between 85 and 90%. The average water use was calculated to be 0.045 gpd/sq. ft., and ranged from 0.014 to 0.084 gpd/sq. ft.)

Behling and Bartillucci (ibid.) also developed a method of estimating office indoor water use on the basis of frequency of fixture use and water use per fixture. Their method assumes the following:

Population Density - 250 sq. ft. per person
Gender Mix (% men and women occupying office building)
Frequency of fixture use
    Women - 3 toilet uses /day and 3 lavatory uses/day
    Men - 1 toilet use/day, 2 urinal uses/day, and 3 lavatory uses/day
Lavatory Use - 10 seconds/use (hand washing)
Service Sink Water Use - 100 gpd
    Building Maintenance - 250 gpd
Allowance for non-office use amenities, transient (non-occupant) restroom usage, and leaking fixtures = 20% of the total inside-building water use.

H. Commercial and Institutional Water Use Data from Department Files

TABLE SC-1
SHOPPING CENTER
(159,939 Sq. Ft. of Retail Space Available)

Month, 1991	Avg. GPD	Sq. Ft. Occupied	GPD/SF
March	8,400	149,282	0.056
April	9,066	149,282	0.060
May	7800	149,282	0.052
June	11,700	149,283	0.078
July	7,645	146,628	0.052
August	8,484	149,282	0.057
September	7,900	146,658	0.053
October	7,516	146,658	0.051
		Mean:	0.057

TABLE T-1
THEATERS

Source	No. Seats	Length of Record, Qtrs,	High Qtr. Water Use GPD/Seat
Theaters w/1.6 Gal./Flush Toilets			
Theater A	3080	6	1.37
Theater B	3574	5	1.14
Theaters w/3.5 Gal/Flush Toilets			
Theater C	2,344	6	3.09
Theater D	2,000	5	3.10
Theater E	2,540	4	2.02
Theater F	1,233	2	2.22

Theater B had 1.6 gal/flush toilets, 1.0 gal/use urinals, and sinks with 0.5 gpm automatic shut-off faucets. Theater E had 3.5 gal/flush toilets, 1.0 gal/use urinals, and sinks with 0.5 gpm automatic shut-off faucets.

TABLE OEC-1
OUTDOOR EDUCATION CENTER
(Recreational Facility for day and overnight groups)

Period of Record	Source	Avg. GPD	Max. GPD
1/7/86-2/17/86	Resident Camper	67.5	89

TABLE SCH-1
SCHOOLS

Source	GPCD	Comments
Elementary School	3.3	Seven day average use, 575 students, limited dishwashing, no showers.
Elementary School	3.2	weekday average use, 106 students Limited dishwashing, no showers.
Elementary School	3.8	Average school day use, period from 8/23/79 - 5/28/87 with range of 265-304 students & Staff. Limited dishwashing, no Showers.
Elementary School	6.2	424 Students, dishwashing, Gym Peak water use = 6.6 GPCD
High School	8.5	Seven day average use, 1,600 students, full dishwashing and Gym showers.
High School	8.5	Seven day average use, 876 Students, limited dishwashing, Gym showers.
High School	5.7	Seven day average use, 1,500 Students, limited dishwashing, Gym showers.
High School	8.0	Seven day average use, 1,200 Students, full dishwashing, Gym showers.

TABLE RC-4
LIFE CARE RETIREMENT COMMUNITIES

(Note: The data in this table was taken from a Concept Design Report for a large scale OWRS in Connecticut. That report provided information for similar facilities in other states for comparative purposes.)

	Facility Location					
Parameter	MN	OH	MI	OH	CT	MA
Number of Apartments	321	173	253	307	199	341
Avg. Number of Apt. Residents	385	219	316	359	228	445
Avg. Number of Residents/Apt.	1.19	1.27	1.25	1.17	1.15	1.30
Number of Health Care (H.C.) Beds	66	60	57	90	60	60
Avg. Number of Health Care Patients	63	58	54	87	55	55
Ratio of Apts. To H.C. Beds	4.86	2.88	4.44	3.41	3.27	5.68
Ratio of Apt. Residents to H.C. Patients	6.11	3.78	5.85	4.13	4.15	8.09
Seasonally Adjusted Avg. Water Use, based on Apt. Residents only, GPCD*	92	69	84	117	150**	67
Seasonally Adjusted Avg. Water Use based on Avg. Number of Apt. residents plus health care patients. GPCD*	79	55	72	94	122**	59

* Based on metered water use from Sept. 11, 1985 to Nov. 21, 1985. Represents indoor water use only.

Seasonally Adjusted Avg. Water Use based on Avg. Number of Apt. residents plus health care patients. GPCD*	79	55	72	94	122**	59

* Based on metered water use from Sept. 11, 1985 to Nov. 21, 1985. Represents indoor water use only.

** The Connecticut facility was a high rise building, and the building plumbing was such that residents in the upper floors had to run their hot water faucets and showers for approximately 10 minutes in order to obtain hot water. Therefore, these results are biased.

Note: An architect with considerable experience in design of health care facilities advised that the historic value for life care facility apartment occupancy was 1.4 persons during the initial period after a facility was opened and that this value declined to an average of 1.2 persons over a period of years due to the deaths of one resident of the apartments initially occupied by couples.

TABLE HC-1
HEALTH CARE FACILITIES (CONVALESCENT HOMES)
Middlesex, New Haven and Hartford Counties

(Metered Water Use Data)

Facility No.	No. Beds	Gal./Day/Bed* Range	Gal./Day/Bed* Average	Wastewater Discharged To
1	30	------	72	On-Site System
2	41	72-82	78	On-Site System
3	90	------	68	On-Site System
4	120	102-111	106	On-Site System
5	60	104-141	129	Municipal Sewer
6	360	114-155	128	Municipal Sewer
7	120	149-195	169	Municipal Sewer

* Includes inside and outside water use.

Note: This data is presented to indicate the difference in water use by facilities served by on-site systems vs. those served by municipal sewers. On-site systems appear to constrain water use, probably because of concern with hydraulically overloading the on-site systems.

TABLE SM-1
SUPERMARKET
New Haven County

(64,000 sq. ft.)

Period Covered	Average Daily Use	gpd/sq. ft.
11 months in 2001-02	2432 gals.	0.038

TABLE R-1
RESTAURANT
Middlesex County

125 seats
(Serves Breakfast, Lunch and Dinner)

Year	Average Daily Use	Gal/Seat
1992	2396 gals.	19.2
1993	2254 gals.	18.0

Note: These data may be biased because the restaurant had been experiencing problems with the on-site system during the years indicated.

I. Predicting Wastewater Flows

1. General

As stated in the introduction to this section, one of the first tasks that need to be completed before beginning actual design of an on-site wastewater renovation system (OWRS) is predicting the wastewater flow that will be generated by the facilities to be served by the system. In this respect, one must not only be concerned with prediction of the quantity of flow, but also its temporal distribution. The most important temporal distribution characteristics are the annual average day and maximum day (the highest annual average day) flow rates and peak hourly flow rates. In certain circumstances, the minimum daily and hourly flow rates can also be important for design of enhanced pretreatment facilities.

Flow rates can be predicted from published information, including not only that available from the literature but that contained in the Connecticut Public Health Code. Flow rates can also be predicted from the results of field measurements of metered water use, or wastewater flows, at similar facilities

The published data on wastewater flows contained herein, or found elsewhere in the literature, may be used for guidance. However, the extreme variability of the circumstances under which such data were gathered, as well as the natural variability of such data, precludes its unquestioned use. This is especially true with respect to wastewater flows generated by commercial and institutional facilities, as the variance in water usage among individual establishments in the same category can be considerable. Such flows vary widely, depending upon mode of operation, number of water using fixtures, hours of operation, occupancy ratios, etc. While there are considerable data available on residential wastewater flows, similar data on commercial and institutional facilities are generally not as extensive. Therefore, it behooves the designer of an OWRS to locate and investigate several facilities similar to that for which he is designing an OWRS and determine either the water use or wastewater flow rate.

2. Field Measurement of Water Use or Wastewater Flows.

When selecting similar facilities to obtain data on wastewater flows or metered water use, it is important to be able to segregate water used for indoor domestic purposes from other water use, such as water used for lawn and garden irrigation and for cooling purposes. It is also important to determine if such data could be biased due either to problems with the wastewater system or with the water supply system serving a facility. A facility that is being served by a failing OWRS, or by restrictions on water use due to an inadequate source of water supply, will probably be using water or discharging wastewater at a rate less than it would absent such problems. Such facilities should not be selected for flow monitoring.

It is also important to survey the types and numbers of water using fixtures, the population using such fixtures, the hours of operation and mode of operation of the facility. It may also be necessary to determine the number of dwelling units, number of bedrooms, the total floor area(s) served, and similar data.

Other factors that should be considered are leakage from water using fixtures or on-site water distribution facilities located downstream from the metering point. Leakage from water using fixtures (i.e. leaking toilets, faucets, etc.) can have a significant effect on measured wastewater discharges. For example, one toilet leaking at the rate of one gallon per minute will waste 1,440 gallons (5,450 L) per day. Water leaking from water distribution facilities can result in the metered water use overstating the actual water use.

Where water use data are based on existing water meter readings, the metering accuracy should be determined. Such accuracy should preferably be equivalent to that required by the American Water Works Association specifications for the size and type of existing meter and the meter installation (setting) should meet minimum standards of the AWWA and the meter manufacturer. If the meter is owned by a municipal or public water utility, the utility should be requested to verify the accuracy of the meter. Where a meter is installed for the purpose of monitoring water use, that meter should conform to the same requirements.

Where municipal or public utility water use billings are used to obtain the water use data, at least three years of such data should be obtained and such data should preferably be based on monthly water meter readings. In such cases, the public utility should be asked to identify those monthly water billings that were based on estimates instead of meter readings. Water meter billing records for the non-irrigation seasons (late fall, winter, and early spring) should be used to determine indoor water use.

Where a facility has maintained daily water meter readings, the facility management should be asked to identify any days when peak water use had been influenced by filling of swimming pools, backwashing of pool filters, fire suppression activities, construction activities, irrigation of vegetation, and similar uses of water that would not result in wastewater discharges.

Where gauging of wastewater flows is conducted, it is important to insure that wastewater flows generated from all inside sources be included. Thus, flow gauging should be conducted at terminal manholes on the wastewater conveyance system, or at the outlet of all septic tanks receiving wastewater discharges. This will require a thorough knowledge of the sanitary drainage piping system(s) in the establishment(s) at which such flow gauging will be conducted. It is also important to determine the same information discussed above with respect to field measurement of metered water use. In addition to leakage into the building sanitary drainage piping due to ground water infiltration or leaking water fixtures, the possibility of leakage out of such piping should also be investigated, as the occurrence of such leakage could result in understating the actual volume of wastewater being discharged. It is also necessary to check for the possible presence of clean cooling water, drainage from ice-making equipment, and other such sources of water that may but should not be discharged to the building sanitary drainage piping.

3. Factors of Safety

Factors of safety should always be included in calculations made for predicting wastewater flows because all of the factors that influence these flows that can not be quantified easily or economically. The magnitude of the safety factor to be used will depend upon the confidence that can be placed upon the available data.

Safety factors are also needed to account for changes in use and occupancy over the design period, which may extend upwards of 20 years. For example, a review of the U.S. 2000 census data indicates that the family size in Connecticut presently averages about 3.08 persons, approximately the same as the overall U.S. average family size of 3.14 persons. This data also indicates that the average household population in the State averages 2.53 persons, again approximately the same as the U.S. average household size of 2.59 persons. These values are significantly lower than those recorded in the census data from past decades. However, it is difficult to estimate what the trend in family or household size will be in the future.

An interesting finding by Linaweaver and Wolfe (1963) was that "there is an inverse relationship between the number of persons in a dwelling and the average daily per capita use, varying from 84 gpcd when there are two persons per dwelling to 47 gpcd for five persons per dwelling. This relationship appears to be fairly constant for different strata and for different seasons of the year." Orndorff (1966) also stated that, as found in previous studies, average water use per dwelling increases with increasing family size, but because the incremental change is smaller with each increasing unit of family size, the average per capita use decreases with increasing family size. While the per capita flow values may well have changed in the intervening years, the relationship should still hold.

Thus, to properly analyze residential water use reported in the literature, it would be helpful to know the dwelling population statistics. Unfortunately, such information is largely lacking from published information. However, when developing a dwelling unit flow allowance based on the number of bedrooms, an occupancy of two persons per bedroom, and a high end constant value of per capita water use, the result will be a dwelling unit flow allowance that includes a large safety factor.

For example, let us assume a three bedroom dwelling housing 3 persons with a per capita design flow contribution that is reduced from 75 gpd to 65 gpd due to the use of ultra low flow toilets. In this case, the design wastewater flow would be 195 gpd. On the other hand, using the design rate of 75 gpcd and assuming two persons occupy each bedroom, the design flow for the dwelling would be 450 gpd. This indicates a design safety factor of 2.3. The safety factor increases substantially as the number of bedrooms is increased. For example, many new dwellings are being constructed with four or more bedrooms, even though the family size may average about 3 persons. Using the design rate of 75 gpcd and assuming two persons occupy each of four bedrooms, the total design flow would be 600 gpd. This indicates a design safety factor of about 3.1 with respect to the design wastewater flow calculated on the basis of 65 gpcd and 3 persons per dwelling.

Likewise, when developing an estimate of wastewater flow for multiple dwelling unit developments, the per capita flow selected should perhaps reflect the dampening effect of multiple dwellings. The greater the number of dwellings to be served, the more the per capita flow allowance will tend toward the average per capita flow.

It is also interesting to note that wastewater discharges from existing office buildings may decrease because of the growing tendency of workers to be based at home rather than in the office. Thus, the application of water or wastewater unit flow allowances based on the square feet of existing office space may become questionable and a per capita allowance may be more appropriate.

The applicant's engineer should consult with the Department regarding the factors of safety to be used.

4. Peak Flow Ratios

a. Maximum Daily Flows

The best prediction of maximum day flow ratios (Maximum Day/Average Day) can be made from analyzing data from similar facilities where daily water use information is available for a period of at least 365 consecutive calendar days at full occupancy of the facilities. Where such data is not available, the following maximum day flow ratios should be considered:

Facility Type	Max. Day Flow Ratio
1. dwelling unit developments (clusters of single family dwellings, retirement and elderly housing units, etc.)	Not less than 1.5
2. commercial and institutional facilities	Not less than 2.0

These maximum day flow ratios should be applied to the design average daily flows acceptable to the Department. The applicant's engineer should consult with the Department regarding the flow ratios to be used in predicting maximum day wastewater flows.

b. Peak Hourly Flows

The prediction of peak hourly flows is difficult because it depends to a great degree upon the number of water using fixtures, their water using characteristics, the frequency of their use and the temporal distribution of such use where a large number of fixtures are involved. Existing peak hourly flows can be determined only from continuous recording of metered water use or wastewater discharges over a significant period of time. Unfortunately, such data is hard to come by because of the time and expense involved. Therefore, in most cases, prediction of peak hourly flows must be based on published values. The applicant's engineer should consult with the Department regarding the flow ratios to be used in predicting peak hour wastewater flows.

5. Infiltration and Inflow

Where a conventional wastewater collection system of pipes and manholes is to be used, allowance must be made for ground water infiltration and surface water inflow. While it is possible to construct such systems with much less infiltration and inflow (i.e. ≤ 50 gallons per inch of sewer diameter per mile of pipe (gpid/mile), experience has indicated that over time, infiltration and inflow increases as the systems age. Therefore, an allowance of not less than 200 gallons per inch of sewer diameter per mile of collection system piping would be appropriate.

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