# CHANGING WATER USAGE

UNIVERSITY OF MINNESOTA
ONSITE
SEWAGE
TREATMENT
PROGRAM

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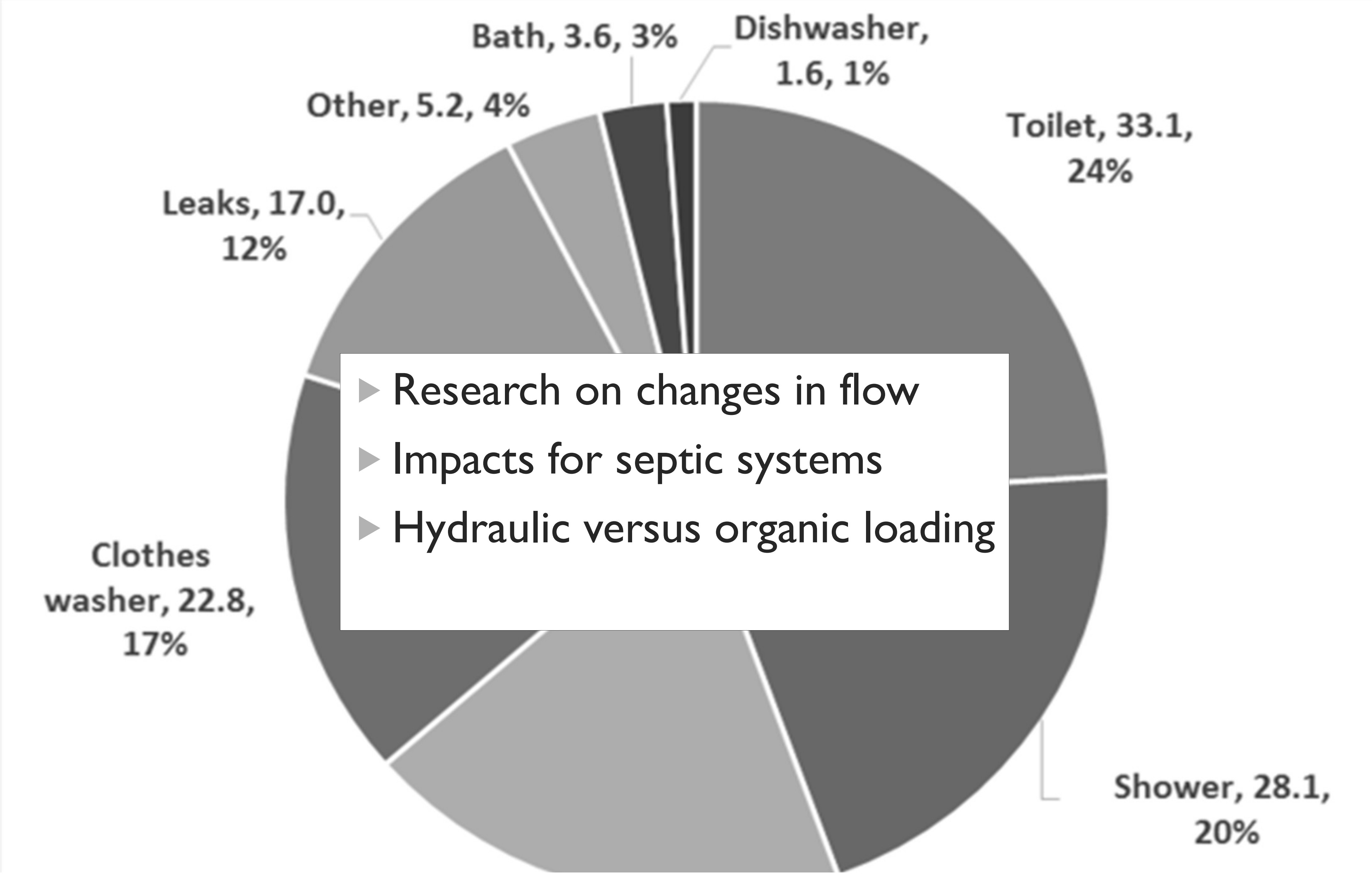
GRANITE STATE
DESIGNERS & INSTALLERS
New Hampshires Association of Septic System Professionals

# UNIVERSITY OF MINNESOTA ONSITE PROGRAM

- Water Resource Center, Onsite Sewage Treatment Program (OSTP)
  - Education for Professionals started in 1974
  - Education for Homeowners & Small Communities started in early 1990s
  - Ongoing research and demonstration supporting educational efforts

# PRESENTATION OVERVIEW




- Research on changes in flow
- Impacts for septic systems
- Hydraulic versus organic loading

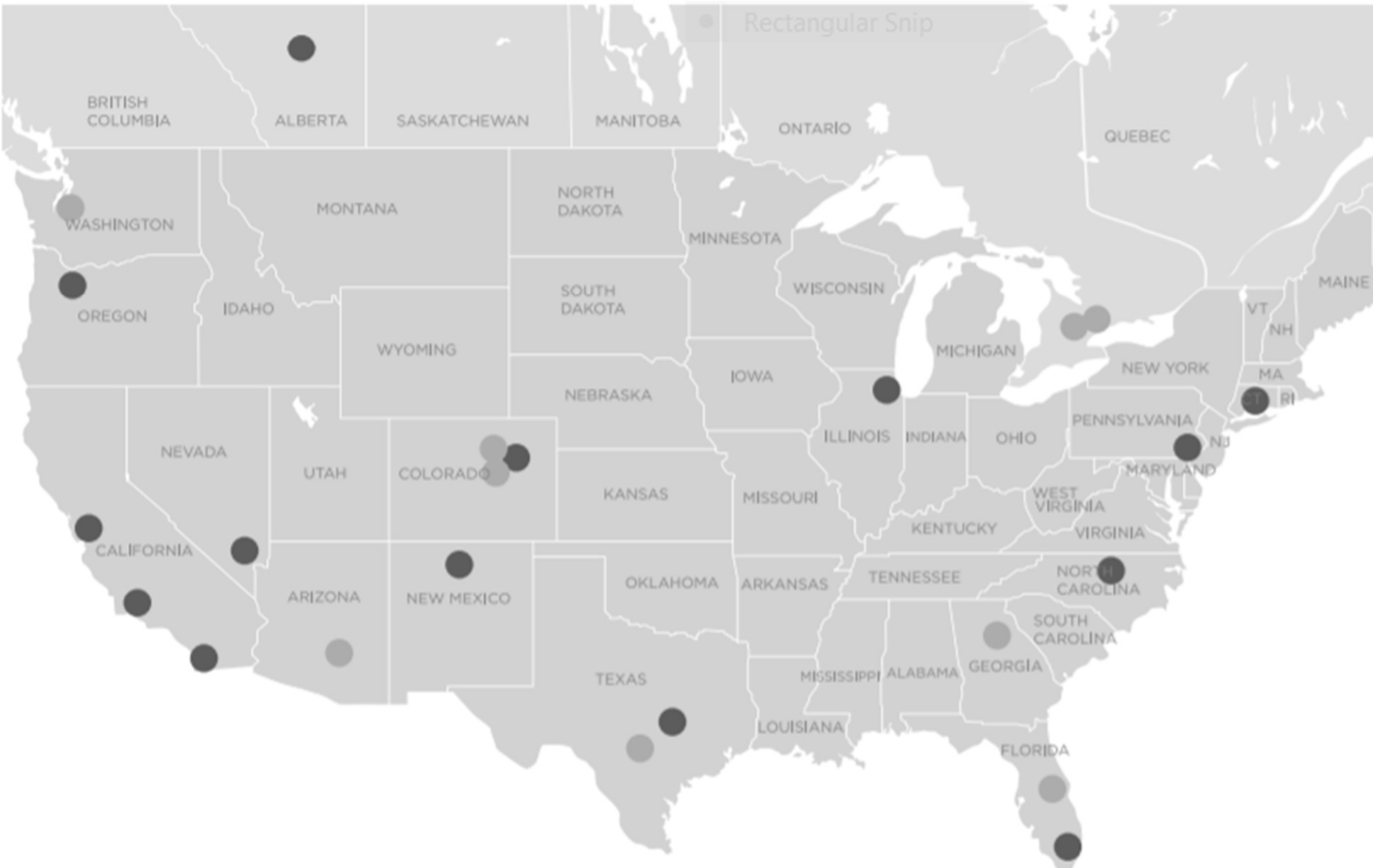
# 2016 RESIDENTIAL END USES OF WATER

***William B. DeOreo, Peter Mayer, Benedykt Dziegielewski, Jack Kiefer***

# STUDY OBJECTIVES

- Collect and analyze current data on the indoor end uses of water in single-family residential settings across North America
- Evaluate changes in water use patterns over a 15-year period (compared to Mayer, et al, 1999)
- Identify variations in water used by each fixture or appliance
- Evaluate conservation potential
- Determine the factors influencing residential water use and evaluate their relative impact

# LOCATION OF END USE STUDY SITES



# STUDY METHODS

- Random representative selection of single-family customers consumption
  - highly detailed information on water use
  - demographics
  - attitudes
  - physical nature of the houses and landscapes
- Data collected from 2010 through 2013 from 23 utilities
  - billing data with surveys ~ 2,000 homes
  - end use monitoring 762 homes
  - hot water use 94 homes

# MAGNETIC SENSOR TO THE SIDE OF THE WATER METER

# DATA LOGGERS PROVIDE HIGH RESOLUTION FLOW TRACE FROM METER

- Brainard Meter Master 100 EL

# THE SENSOR PICKS UP THE MOTION OF THE INTERNAL MAGNETS IN THE METERS

# THE SECRET IS IN THE FLOW PROFILES AND TRACE WIZARD ANALYSIS TOOL

This is a toilet flush:

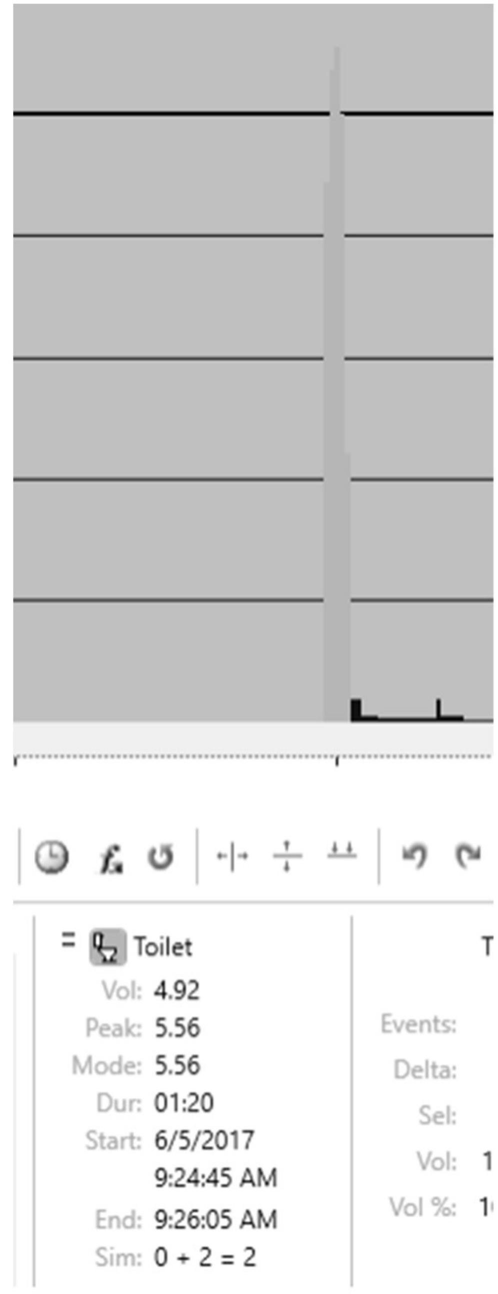
Note the parameters used by Trace Wizard to identify this and all similar events during the logging period.

Volume: 4.92 gallons per flush

Peak Flow: 5.56 gpm

Duration: 1 minute 20 seconds

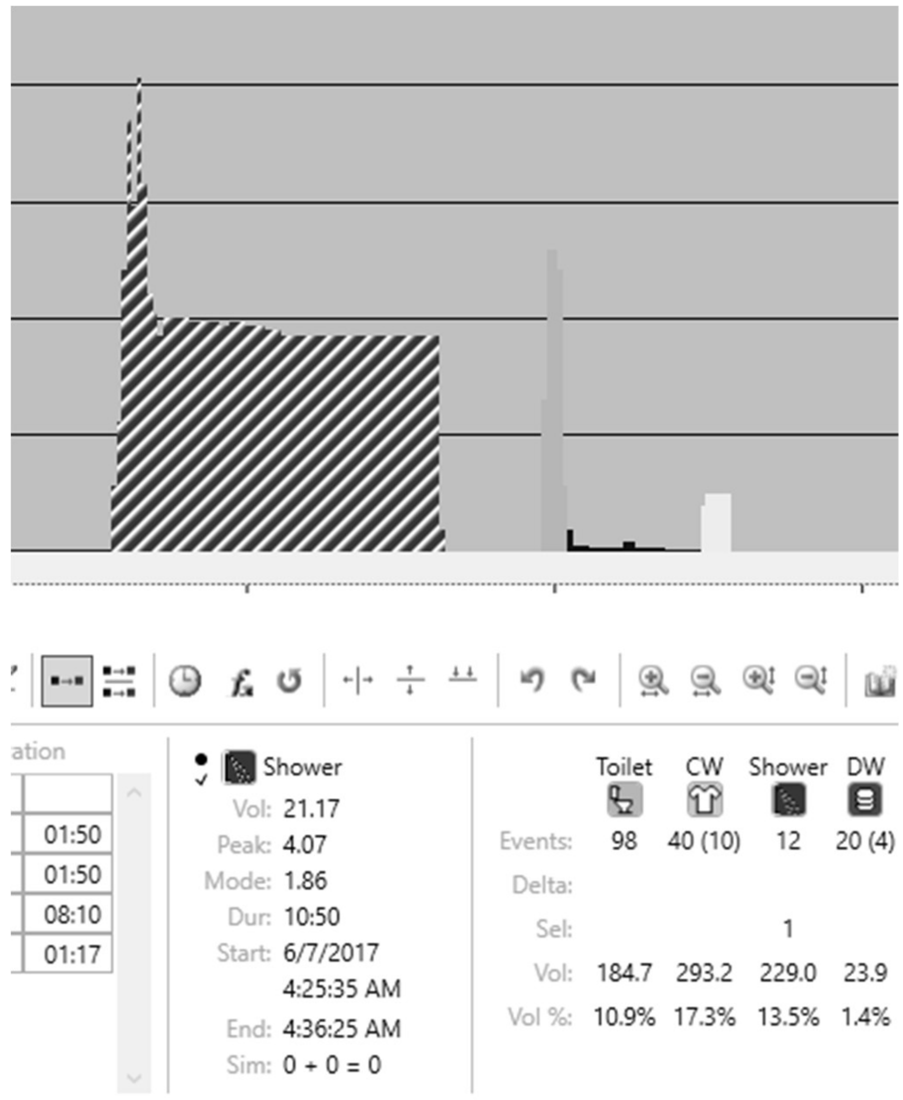
Mode flow, start time, end time and other similar events are also listed.



# TYPICAL BATHROOM SEQUENCE: SHOWER, TOILET, FAUCET

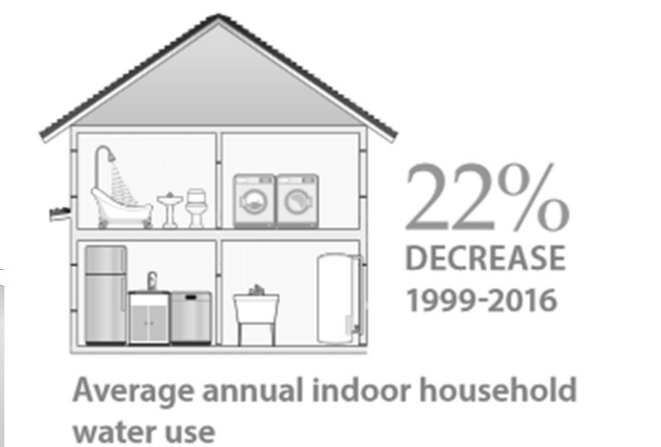
A shower is followed by a toilet flush (with a bit of leakage) and a faucet use.

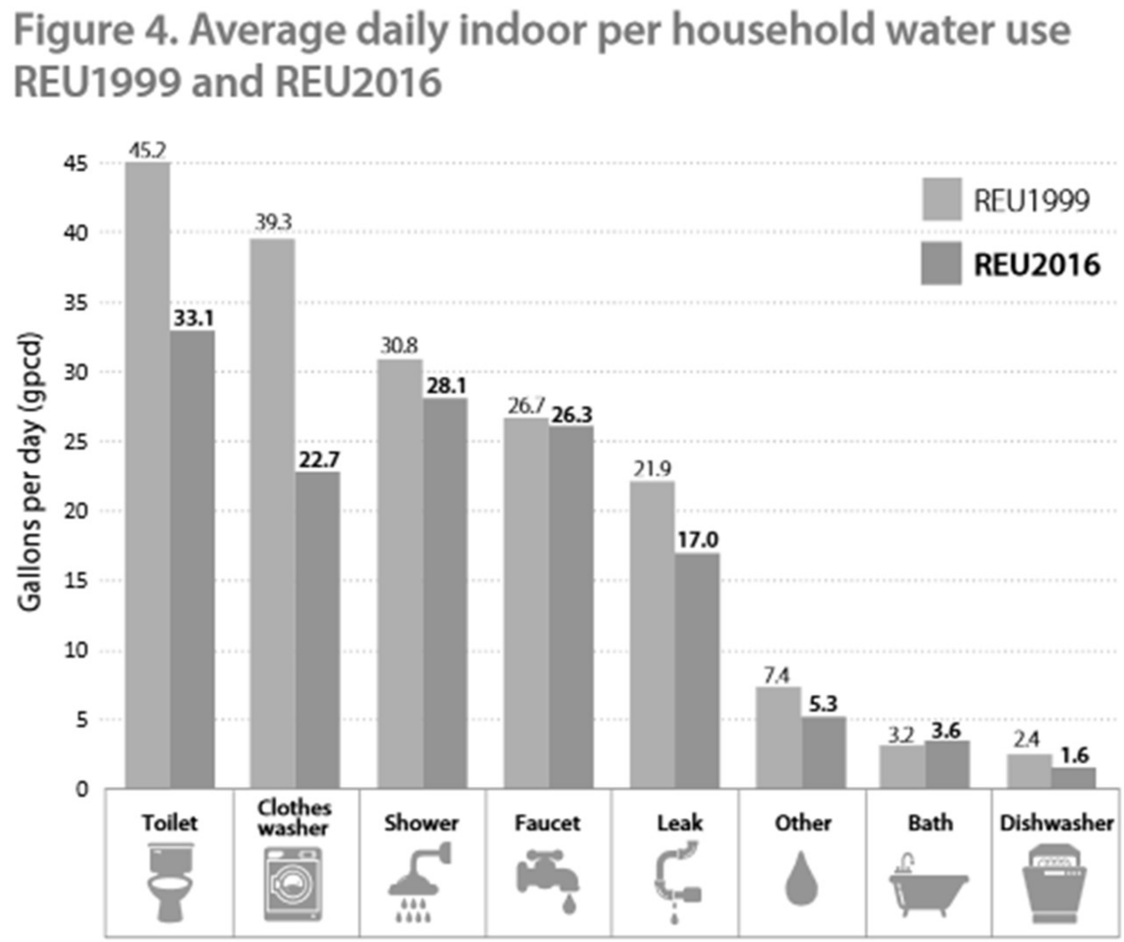
This is a very typical combination



# TYPICAL HOUSEHOLD

- 1999
  - 177 gphd
- 2016
  - 138 gphd



# TYPICAL PER CAPITA

- 1999
  - 69 gpcd
- 2016
  - 59 gpcd

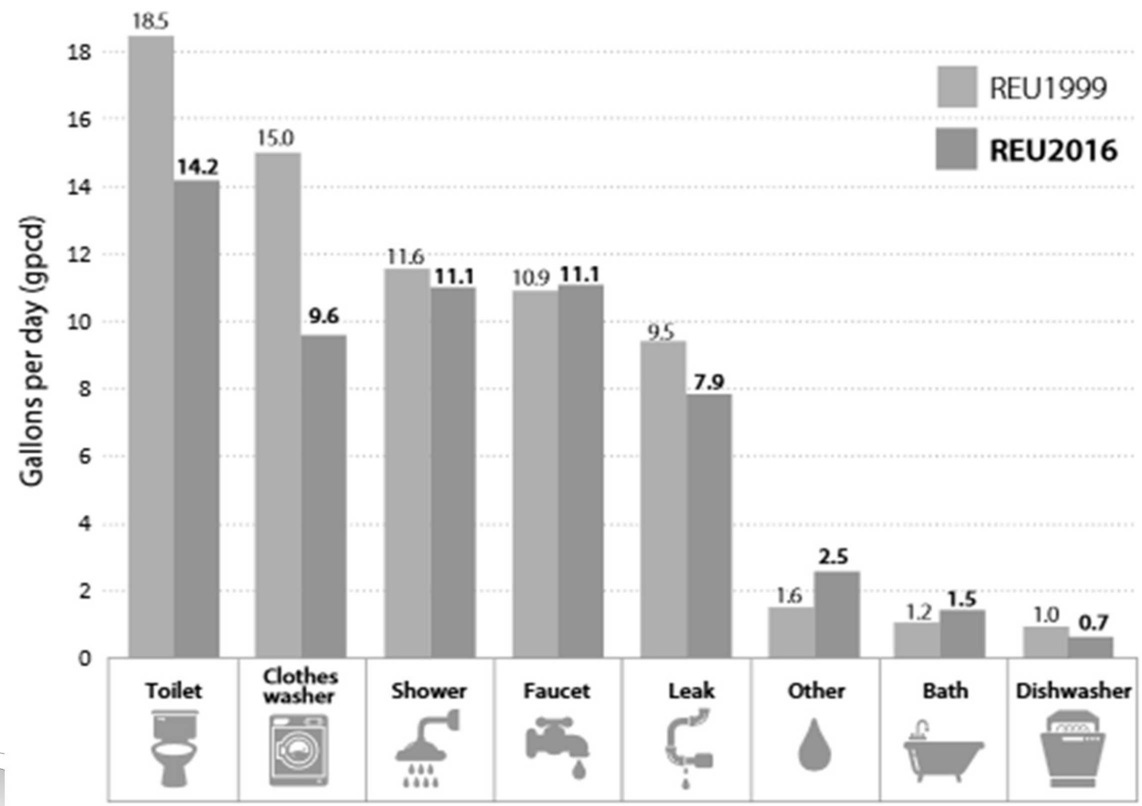



Figure 5. Average daily indoor per capita water use REU1999 and REU2016

15%
DECREASE
PER CAPITA
DAILY WATER USE
1999 TO 2016

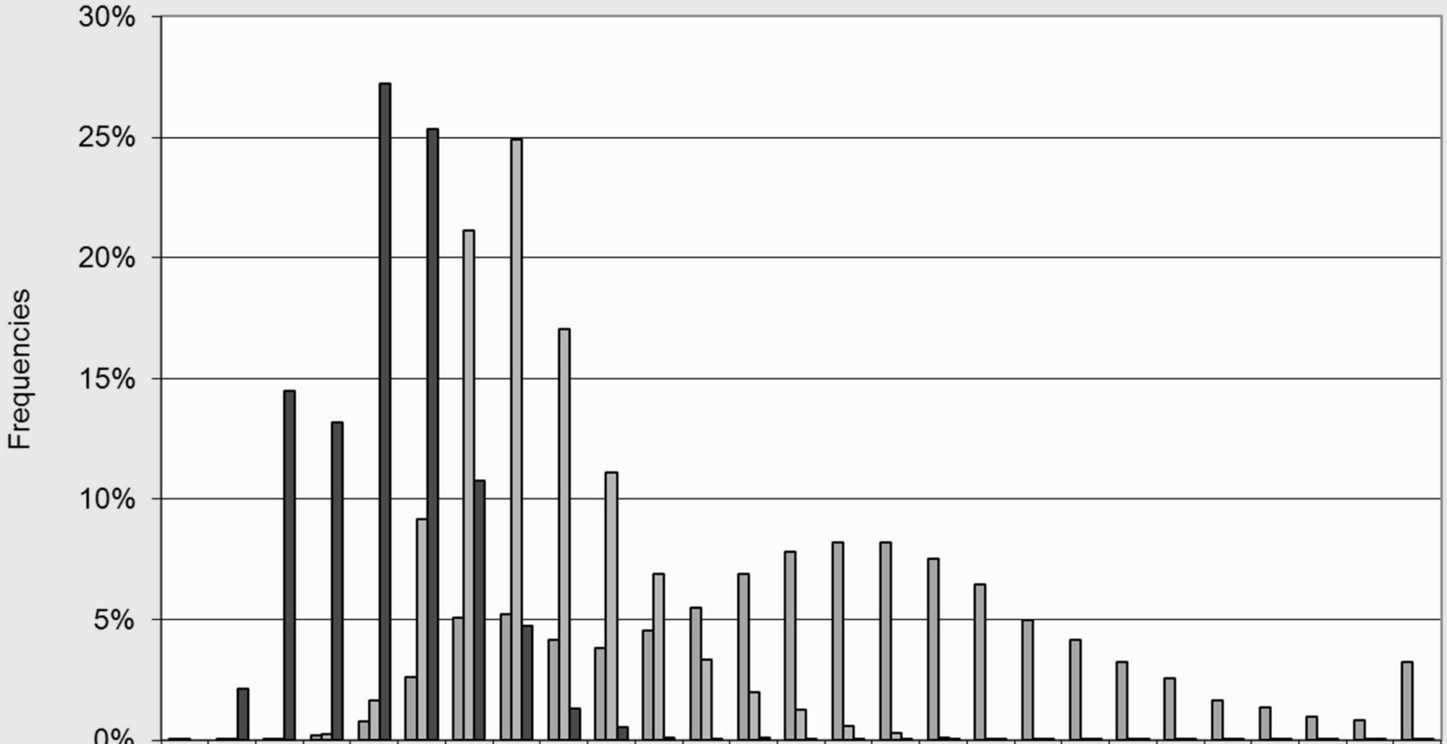
# CLOTHES WASHERS FROM 1999 TO 2016

- The biggest reduction - clothes washer category fell by 36%
  - 15.0 → 9.6 gpcd
- Use of a high efficiency clothes washer
  - 2% → 67%
- Average of 41 → 31 gallons per load
- Average number of loads washed per day and per person per day has remained the same between the two studies

# TOILET FLUSHING FROM 1999 TO 2016

- Toilet use fell by 23.2%
  - 18.5 to 14.2 gpcd
- Average toilet flush volume of less than 2.0 gal/flush
  - 8.5% → 37%
- Average toilet flush volume decreased from 3.7 → 2.6 gal/flush
- Flushing frequency was unchanged at 5.0 flushes per person per day

# DECLINING FLUSH VOLUMES




| | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 3.00 | 3.25 | 3.50 | 3.75 | 4.00 | 4.25 | 4.50 | 4.75 | 5.00 | 5.25 | 5.50 | 5.75 | 6.00 | 6.25 | 6.50 | 6.75 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| REUWS | 0% | 0% | 0% | 0% | 1% | 3% | 5% | 5% | 4% | 4% | 5% | 6% | 7% | 8% | 8% | 8% | 8% | 6% | 5% | 4% | 3% | 3% | 2% | 1% | 1% | 1% | 3% |
| Std NEW | 0% | 0% | 0% | 0% | 2% | 9% | 21% | 25% | 17% | 11% | 7% | 3% | 2% | 1% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| HE New | 0 | 2% | 14% | 13% | 27% | 25% | 11% | 5% | 1% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |

Gallons per Flush

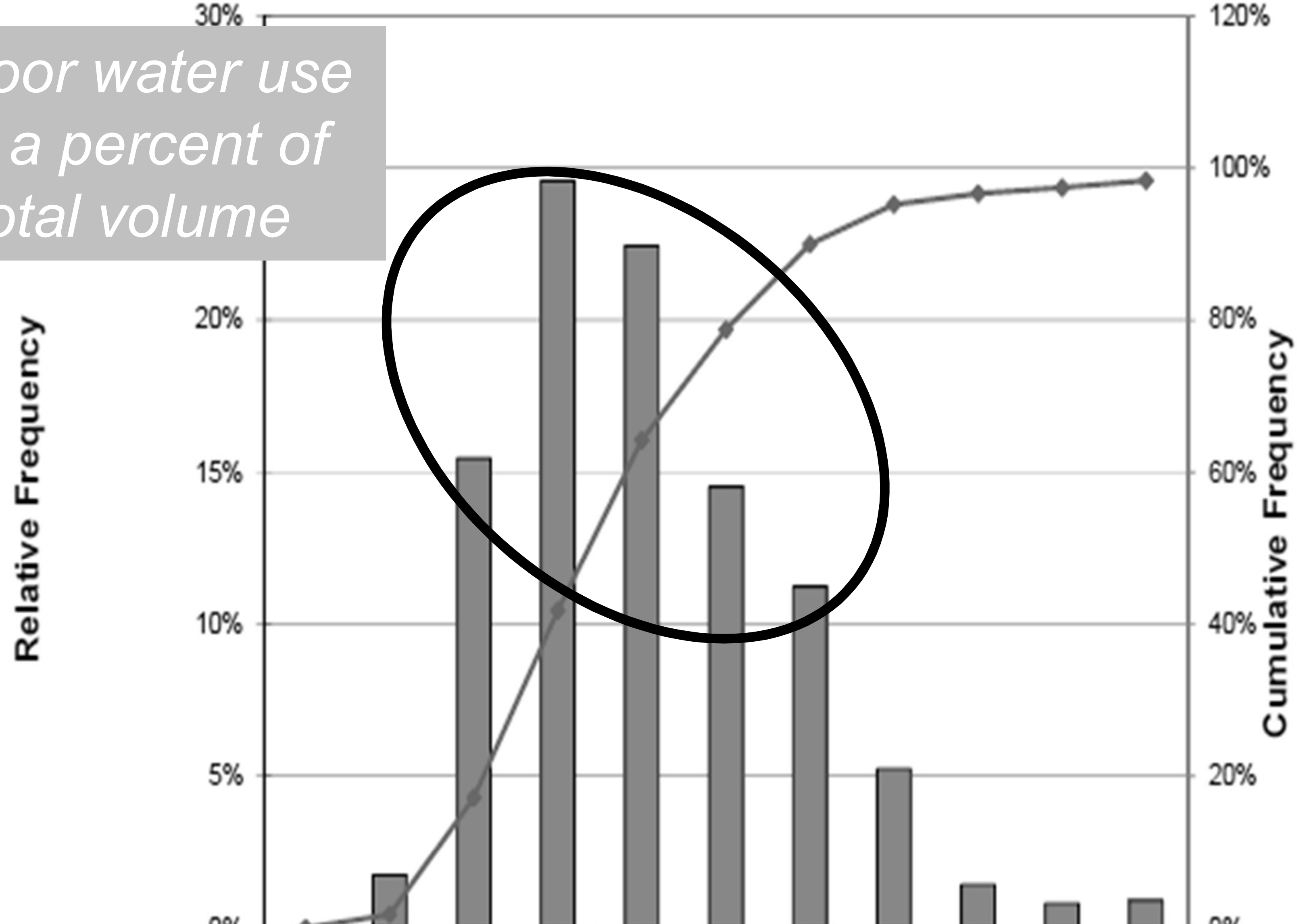
# WATER SAVING DEVICES

- Decrease water quantity
- No change in mass load
- Wastewater strength increases

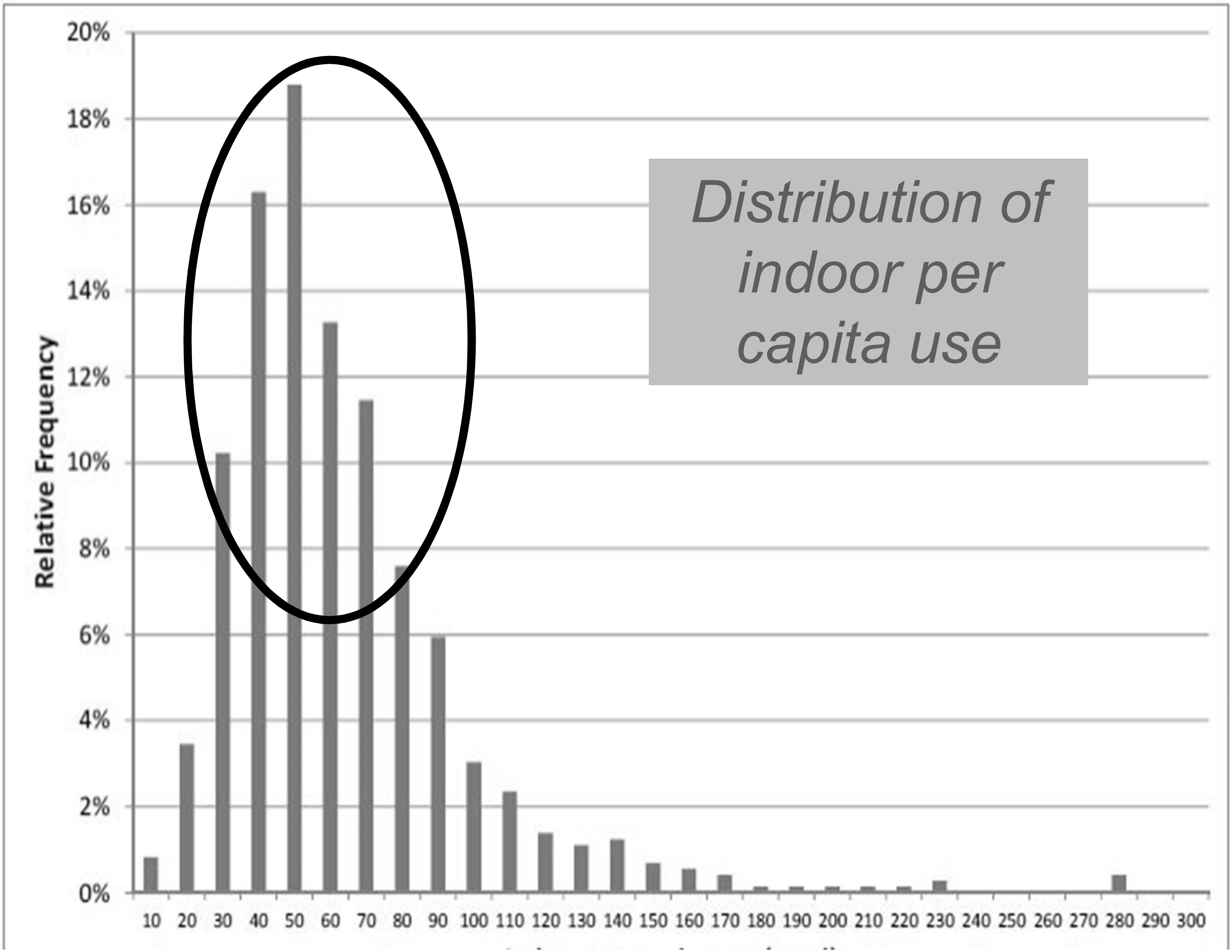
# LEAKS

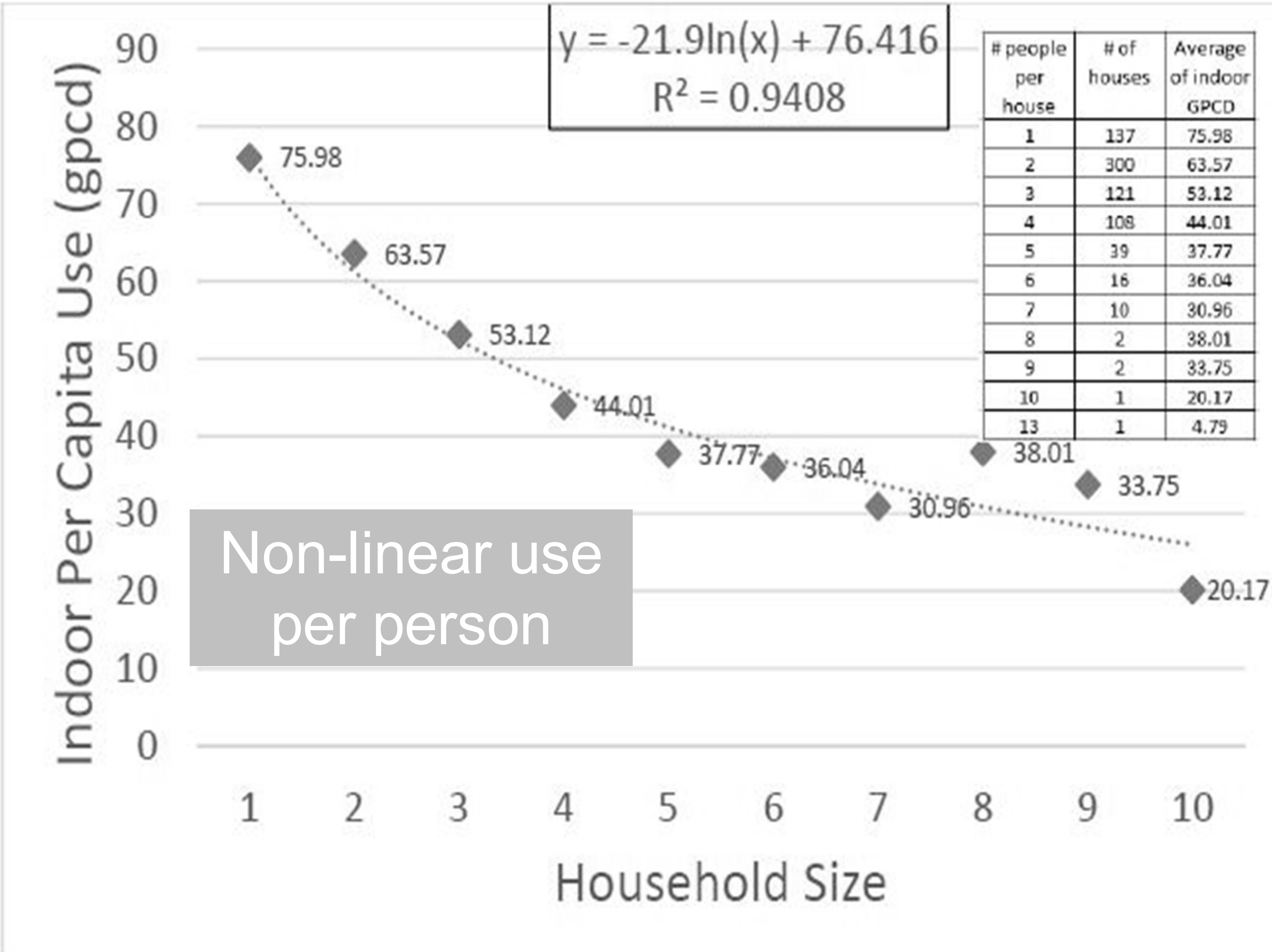
- 5% of the study homes had no leakage at all during the data collection period
- 63% of the homes leaked some amount, but less than 10 gphd
- The other 32% of homes had higher leakage rates, as high as 600 gphd
- Only 7% of homes leaking > 100 gpd
  - They account for > 40% of all leakage

*Indoor water use as a percent of total volume*




| | 25 | 50 | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % of Total Vol. | 0% | 2% | 15% | 25% | 22% | 15% | 11% | 5% | 1% | 1% | 1% |
| Cum % of Indoor Vol | 0% | 2% | 17% | 42% | 64% | 79% | 90% | 95% | 97% | 97% | 98% |


Distribution of indoor per capita use
Relative Frequency
20%
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300




| # people per house | # of houses | Average of indoor GPCD |
|---|---|---|
| 1 | 137 | 75.98 |
| 2 | 300 | 63.57 |
| 3 | 121 | 53.12 |
| 4 | 108 | 44.01 |
| 5 | 39 | 37.77 |
| 6 | 16 | 36.04 |
| 7 | 10 | 30.96 |
| 8 | 2 | 38.01 |
| 9 | 2 | 33.75 |
| 10 | 1 | 20.17 |
| 13 | 1 | 4.79 |

# KEY FINDINGS

- 66.8% of the indoor per household use was for cold water and 33.2% was for hot water
- Reductions in use are largely due to more efficient fixtures and appliances
  - Not the result of changes in either occupancy or behavior
- Significant reductions seen in off-the-shelf new homes
- The best reductions seen in high efficiency homes (retrofit homes and high efficiency new homes)
- This trend should continue into the future and should be used for future planning

# IMPACTS ON SEPTIC SYSTEMS

# SYSTEM SIZING AND SEPTIC IMPACT

Septic are designed for peak flow and maximum capacity

- Annual estimates of actual use
  - Per person per year (@76 gpc) = 28,000 gal
  - Typical home ~ 3 persons (@53 gpc) =58,000gal/yr
  - 250 homes around a lake= 15 million gallons/year

- Septic codes assume 2 people per bedroom
- Must account for mass loading which remains unchanged

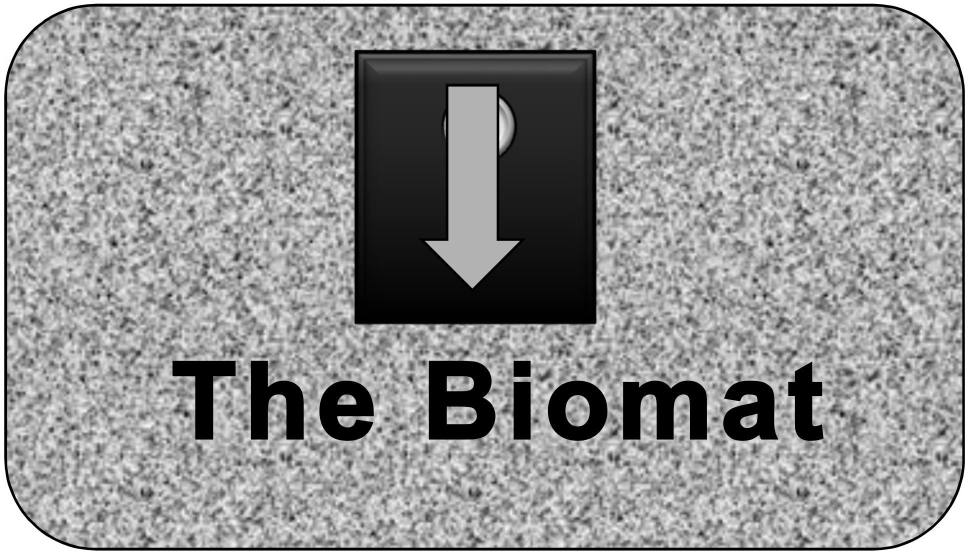
Peak Flow
=
Safety Factor

# LOADING RATES - THE THOUGHT PROCESS

- For long term performance we chose a loading rate based on the soil characteristics to assure we will have:
  - Acceptance
  - Treatment
- Key variables
  - Pore size
    - Oxygen availability
    - Water movement
    - Groundwater mounding
  - Oxygen demand

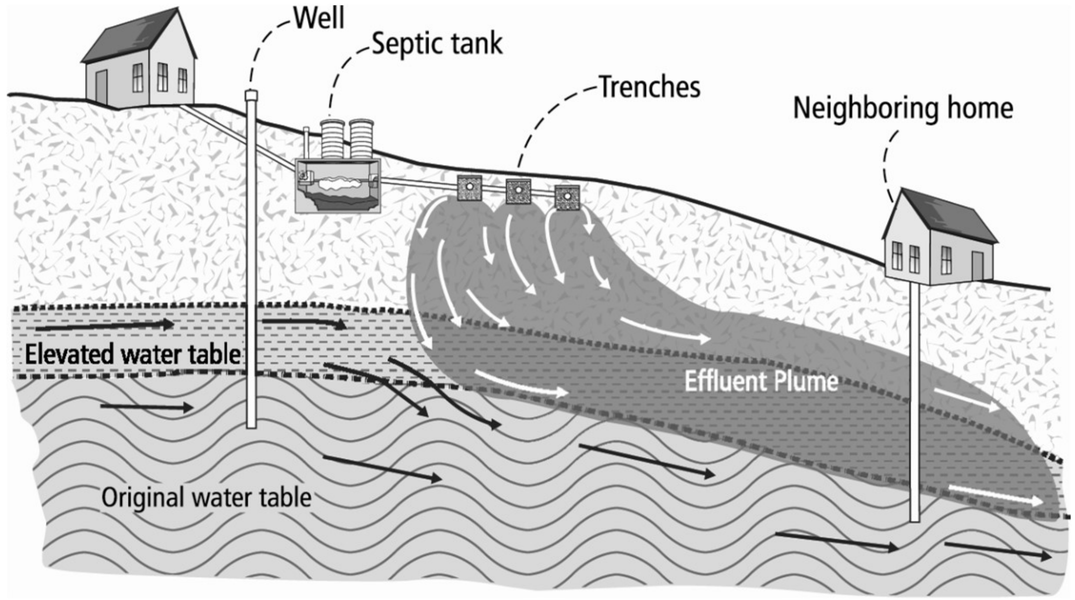
# BIOMAT INFLUENCES

- System: Food
  - Hydraulic loading
  - Organic loading
- Site: Oxygen
  - Soil type
    - Texture
    - Structure
  - Separation
  - Depth
  - Resting
    - Pressurization
  - Geometry [Width]



# *ALL SYSTEMS HAVE TWO VALUES*

- Hydraulic Flow
- Organic Loading




# HYDRAULIC FLOW

# WASTEWATER LOADING

- Wastewater quantity
  - Hydraulic loading
  - Residential Design/Peak values are 100-200 gallons per bedroom
  - Typically residential average values are less then1/2 of Peak
- Commercial facilities are very different

# IMPORTANCE OF HYDRAULIC LOAD

- The daily flow must not exceed the system's hydraulic capability
  - Hydraulic detention time (HDT)
    - Example: solids are not able to settle in a septic tank if the water moves through too quickly.
  - Hydraulic overload of the soil
    - Effluent surfacing
  - Reduces in water use WILL increase retention times

# TOO MUCH USE

- Clean water
  - Groundwater drainage
    - Footing drain
  - Treated water
  - Water conditioning backwash
- Too much use
  - Over use
  - Wash day
  - Cleaning service
  - Change in use
    - In home business
    - Added water using devices

# INFILTRATIVE SURFACE

- Sized by the loading rate in $gpd/ft^2$
- Loading rate determined by
  - Natural soil properties
  - Separation distance
  - Natural site conditions
  - Oxygen demand of the wastewater

# ORGANIC LOADING

# DOMESTIC EFFLUENT CONSTITUENT CONCENTRATIONS

| Source | Oxygen Demand $BOD_5$, (mg/L) | Total Suspended Solids, TSS (mg/L) | Nitrogen Total N (mg/L) | Fecal Coliform (org. /100 mL) |
|---|---|---|---|---|
| Septic Tank | 140-200 | 50-100 | 40-100 | $10^6$-$10^8$ |
| Aerobic Treatment Unit | 5-50 | 5-100 | 25-60 | $10^3$-$10^4$ |
| Sand Filter | 2-15 | 5-20 | 10-50 | $10^1$-$10^3$ |
| Foam or Textile Filter | 5-15 | 5-10 | 30-60 | $10^1$-$10^3$ |

# COMMERCIAL WASTEWATER

- Strength
  - Usually greater than residential
  - Operation based
    - Food preparation
    - Restrooms
    - Laundry


# HIGH STRENGTH WASTEWATER

- National glossary definition

1) Effluent from a septic tank or other pretreatment component that has:
   - $BOD_5$ > 170 mg/L,
   - and/or TSS > 60 mg/L,
   - and/or (FOG) > 25 mg/L and is applied to an infiltrative surface

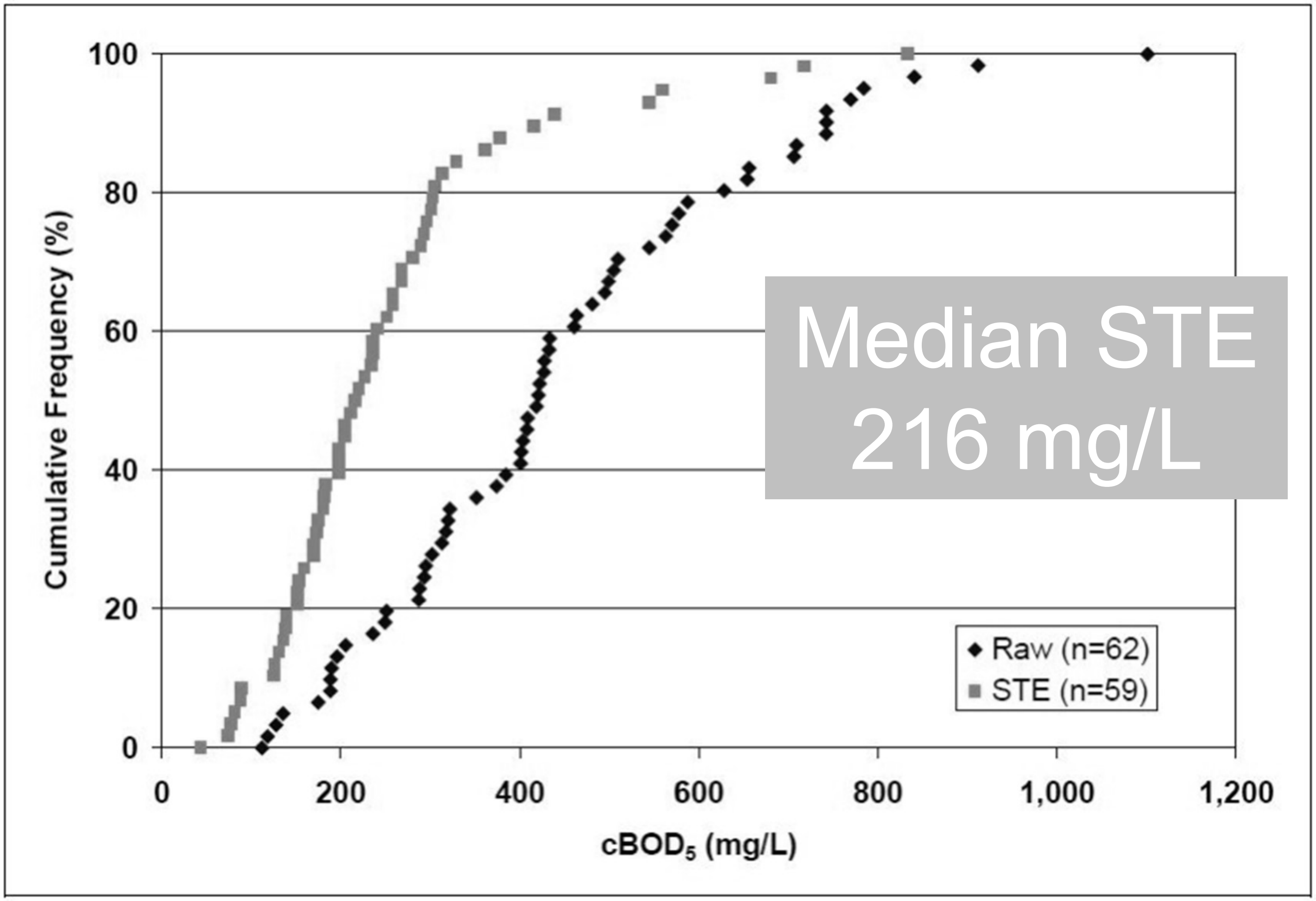
- Nitrogen - concentrations are on the rise

# *2009 INFLUENT CONSTITUENT CHARACTERISTICS OF THE MODERN WASTE STREAM FROM SINGLE SOURCES*

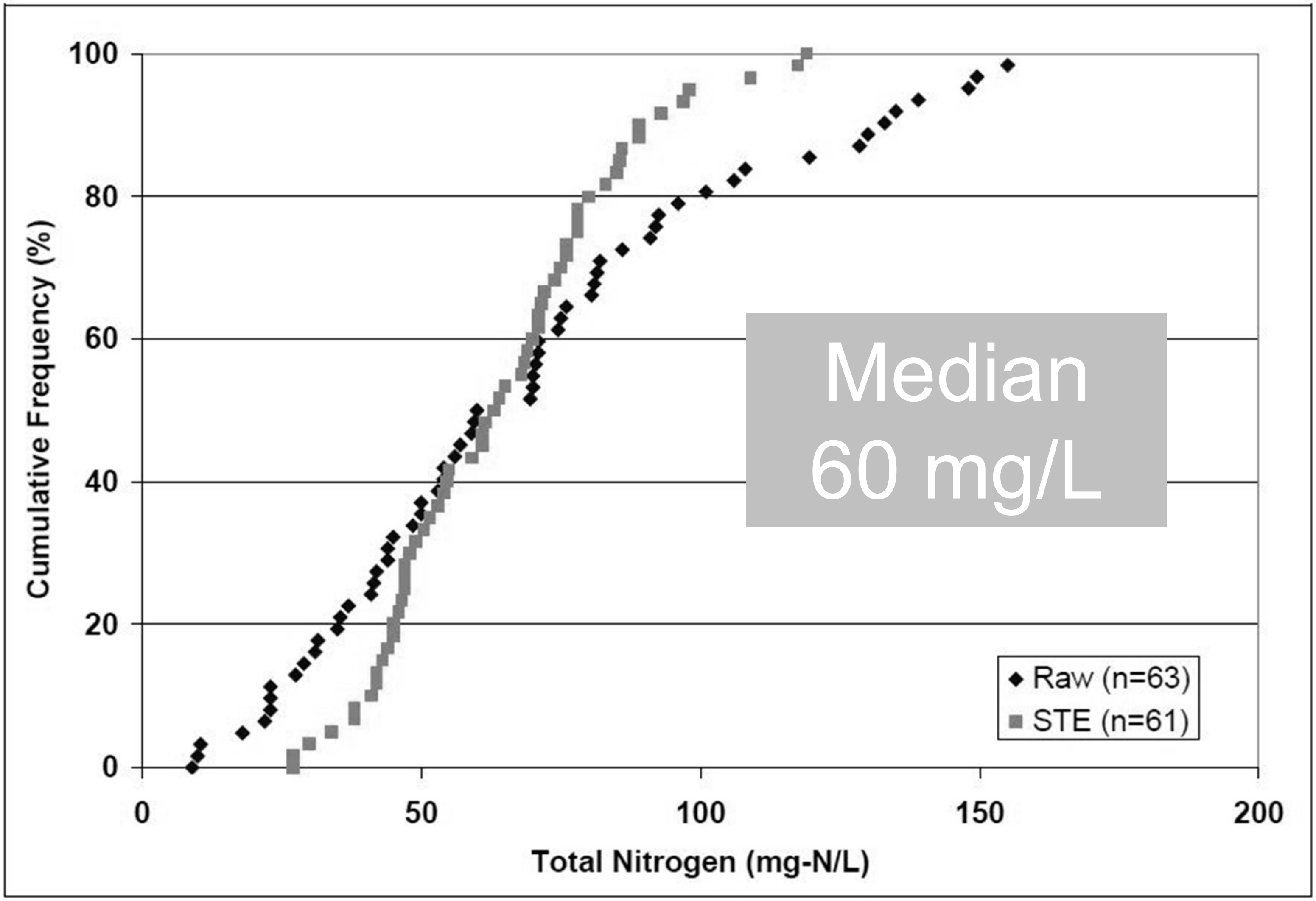
Water Environment Research Foundation
Collaboration. Innovation. Results.

**Kathryn S. Lowe, Maria B. Tucholke, Jill M.B. Tomaras**
**Kathleen Conn, Christiane Hoppe, Jörg E. Drewes**
**John E. McCray, Junko Munakata-Marr**

# BOD IN RAW AND SEPTIC TANK EFFLUENT (STE)



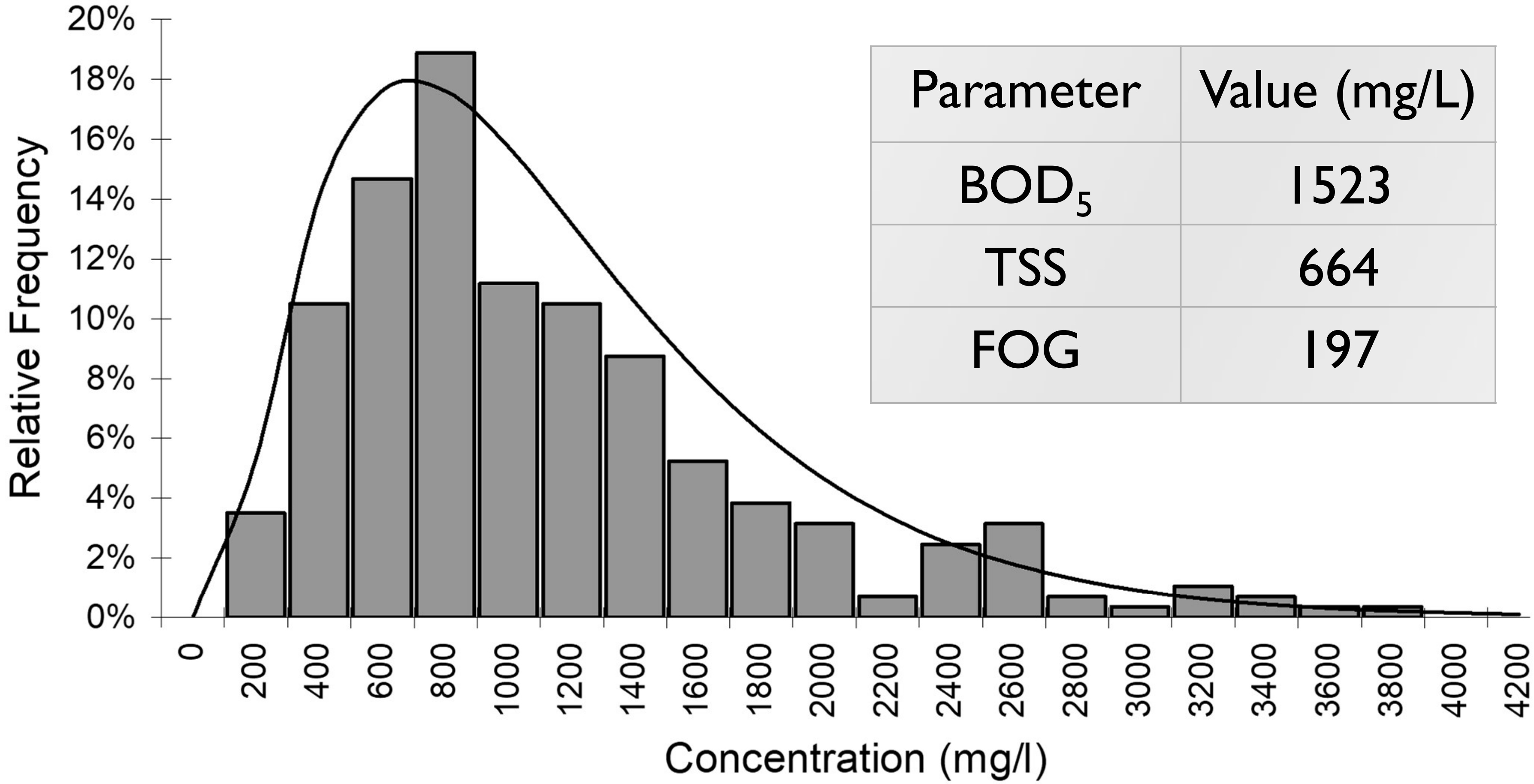
# TOTAL NITROGEN IN RAW AND SEPTIC TANK EFFLUENT



# RESTAURANT DATA

- 28 restaurants located in Texas
- Sampled during June, July, and August 2002
- 12 samples per restaurant and 336 total observations

# GEOMETRIC MEAN PLUS ONE STD. DEV.




| Parameter | Value (mg/L) |
|---|---|
| $BOD_5$ | 1523 |
| TSS | 664 |
| FOG | 197 |

Lesikar et. al (2006)

# MASS LOADING

# MASS LOADING

- Calculate mass loading to a system
  - Concentration of constituent in the wastewater
  - Mass loading based on number of people
- Mass (lb) = C (mg/l) x Q (gpd) x 0.00000834
- Mass (lb) = P (# of people) x $O_L$ (lbs per capita- day)

# MASS LOADING CALCULATION

**Residential strength**

- Calculate mass loading to a system
  - Concentration in wastewater
  - Volume of wastewater
- Mass (lb) = 140(mg/l) x 200(gpd) x 0.00000834
- Mass (lb) = 0.23 lbs per day

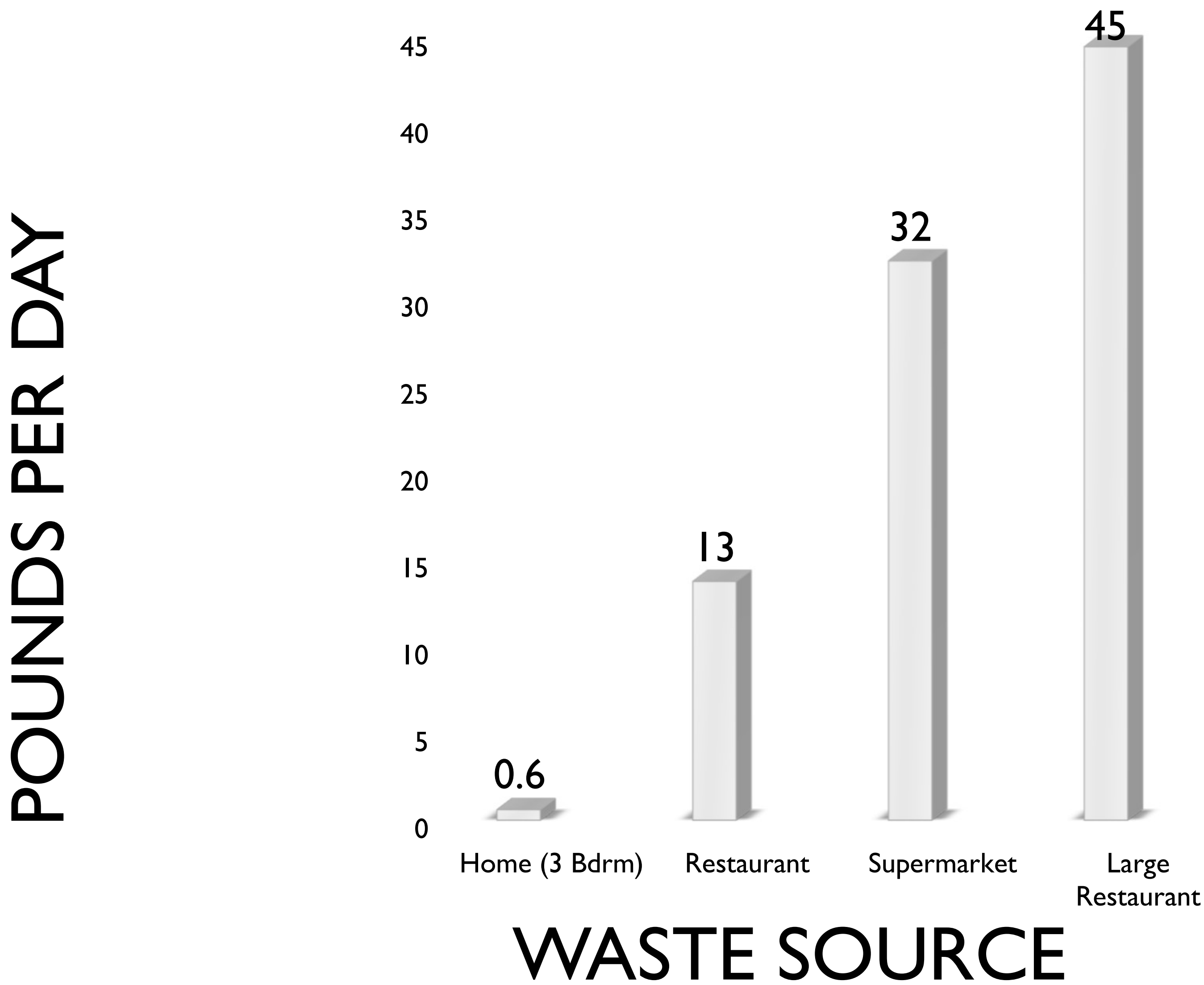
**Commercial strength**

- Mass (lb) = C (mg/l) x Q (gpd) x 0.00000834
- Mass (lb) = 500(mg/l) x 600(gpd) x 0.00000834
- Mass (lb) = 2.5 lbs per day

# MASS LOADING

- Calculate mass loading to a system
  - Number of people
  - Organic loading rate
- **Mass (lb) = P (# of people) x $O_L$ (lbs per capita- day)**
- **Mass (lb) = 5 (# of people) x 0.17 (lbs per capita- day)**
- Mass (lb) = 0.85 lbs per day

# COMPARATIVE BIOLOGICAL LOADS ($BOD_5$)



# WATER SAVING DEVICE EXAMPLE

- A 4 person household produces 0.56 lbs/day TSS without water saving devices (75 gpd/person)
- Then that family switches to water savings devices, and so they only use 60 gpd/person
- What is the change in TSS concentration after water saving devices are installed?

# EXAMPLE CONT.

TSS Concentration (before) =

$$\frac{0.56 \text{ lbs/day}}{300 \text{ gal} \times 0.00000834} = 224 \frac{\text{mg}}{\text{L}}$$

TSS Concentration (after) =

$$\frac{0.56 \text{ lbs/day}}{240 \text{ gal} \times 0.00000834} = 280 \frac{\text{mg}}{\text{L}}$$

# RESIDENTIAL SOIL TREATMENT AREA

- Soil absorption area based on hydraulic loading
  - A = Q / Loading Rate (soil hydraulic)
- Soil absorption area based on organic loading
  - A= organic loading/loading rate (soil organic)

# ORGANIC LOADING TO SOIL (MN VALUES)

| **Soil Texture Group** | **Loading Rate gpd/ft$^2$** | **lbs of $BOD_5$/ ft$^2$/day** | **lbs of TSS/ ft$^2$/day** | **lbs of O&G/ ft$^2$/day** |
|---|---|---|---|---|
| **Sands** | 1.2 | 0.0017 | 0.00065 | 0.00025 |
| **Fine sands** | 0.6 | 0.00087 | 0.00033 | 0.00013 |
| **Sandy loam** | 0.78 | 0.0011 | 0.00042 | 0.00016 |
| **Loam** | 0.6 | 0.0007 | 0.00027 | 0.0001 |
| **Silt loam** | 0.5 | 0.0006 | 0.00024 | 0.00009 |
| **Clay loam, clay** | 0.45 | 0.00035 | 0.00013 | 0.00005 |

# EXAMPLE FOR A REST AREA DESIGN

Size a soil trench system in silt loam soils for a system that is treating 400 gpd with $BOD_5$ effluent of 400 mg/L

Based on hydraulic loading

Ra = 0.50 gal / $ft^2$-day

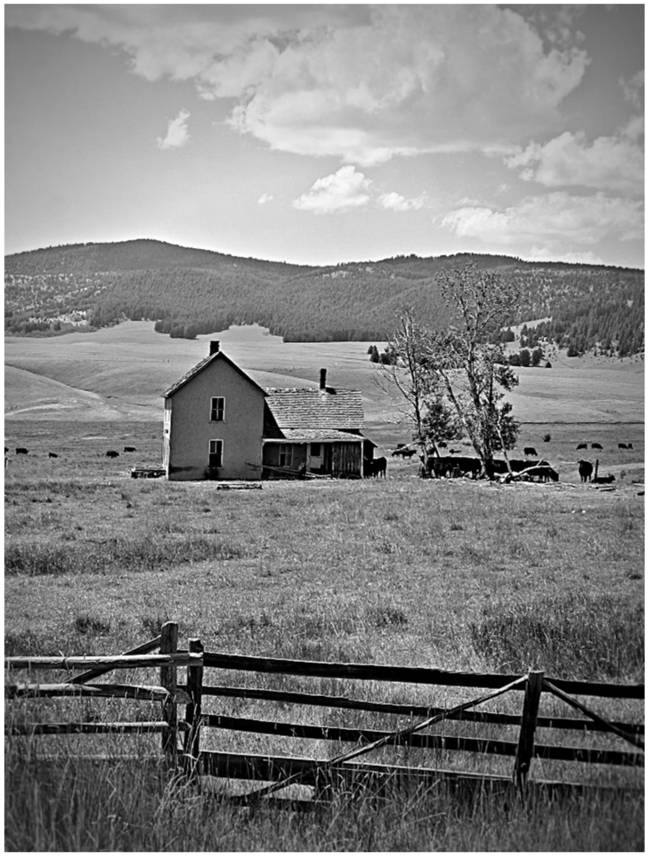
$$\text{Drainfield} = \frac{400 \text{ gal/day}}{0.50 \text{ gal/ft}^2\text{-day}} = \mathbf{800\ ft^2}$$

Based on organic loading

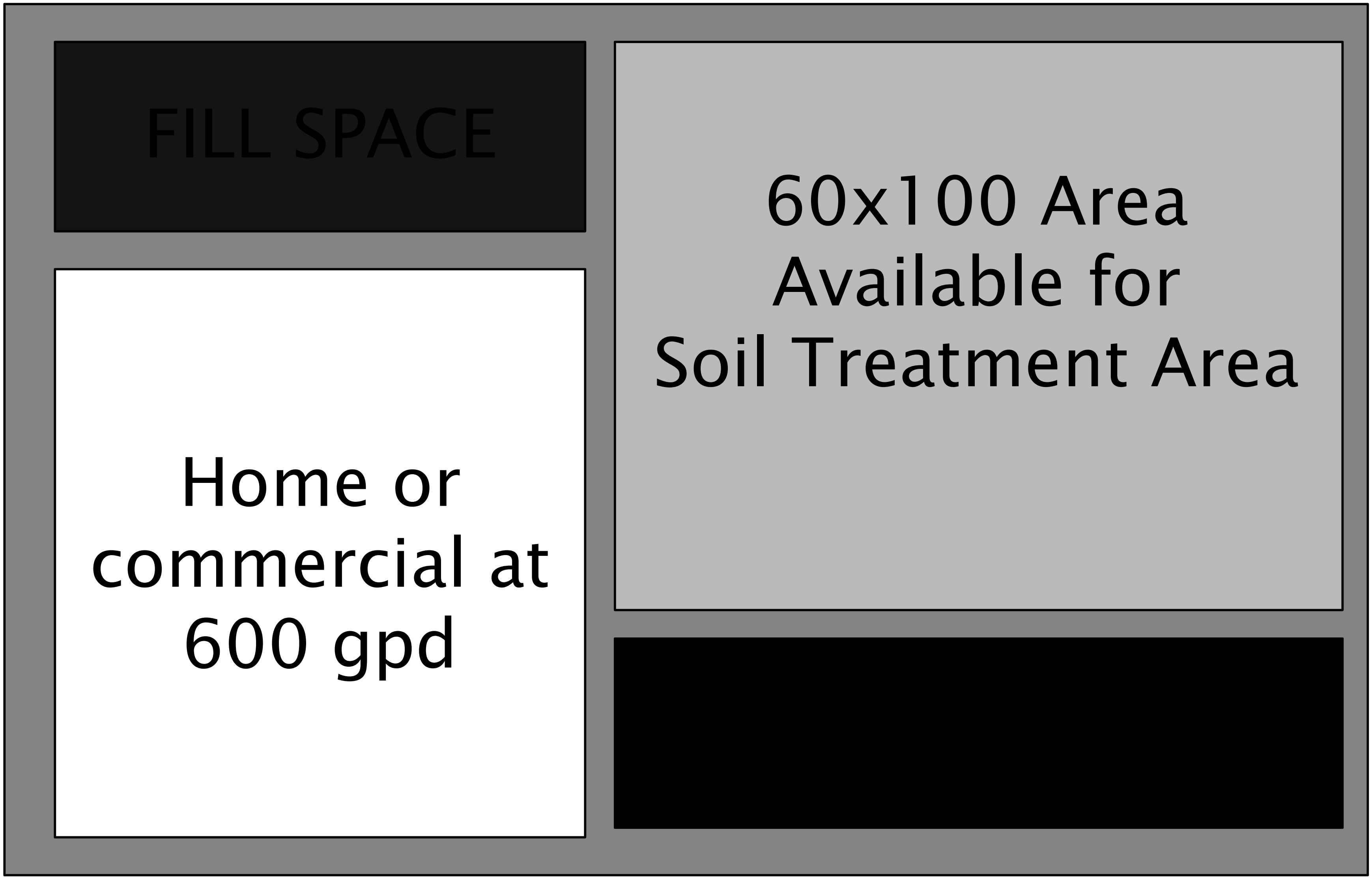
$R_{OL}$ = 0.0006 lbs/$ft^2$- day

$BOD_5$ lbs/d = 400 mg/L x 400 gal/d x 0.00000834 = 1.33 lbs/d

$$\text{Drainfield} = \frac{1.33 \text{ lbs/day}}{0.0006 \text{ lbs/ft}^2\text{-day}} = \mathbf{2217\ ft^2}$$




# RESIDENTIAL VS RESTAURANT DESIGN


FILL SPACE
60x100 Area
Available for
Soil Treatment Area
Home or
commercial at
600 gpd

# *DOMESTIC*

600 GPD X 170 mg/L BOD X 0.00000834 = 0.9 lbs/d

200 GPD X 140 mg/L BOD X 0.00000834 = 0.23 lbs/d

# *COMMERCIAL*

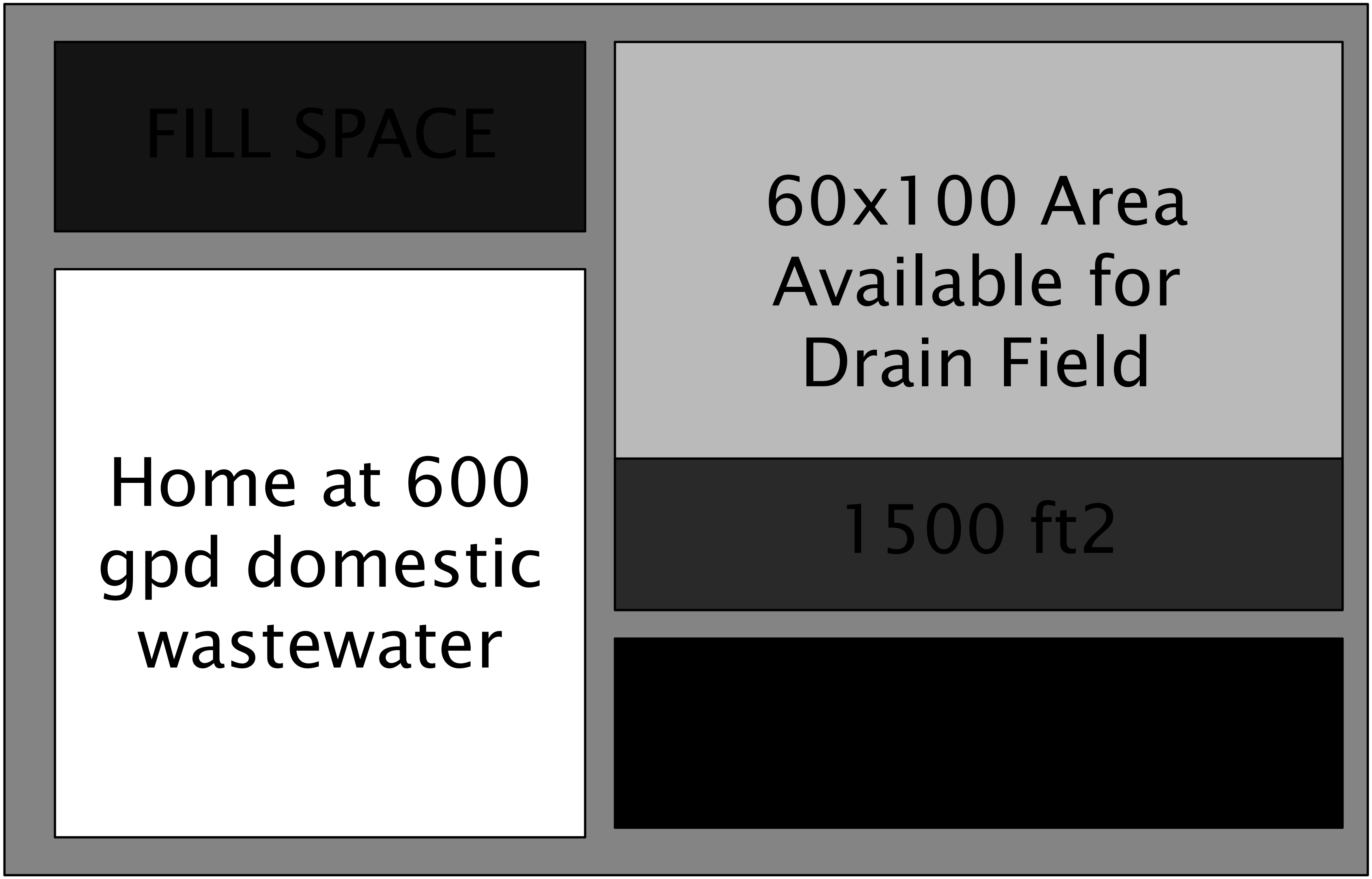
600 GPD X 1200 mg/L BOD X 0.00000834 = 6 lbs/d

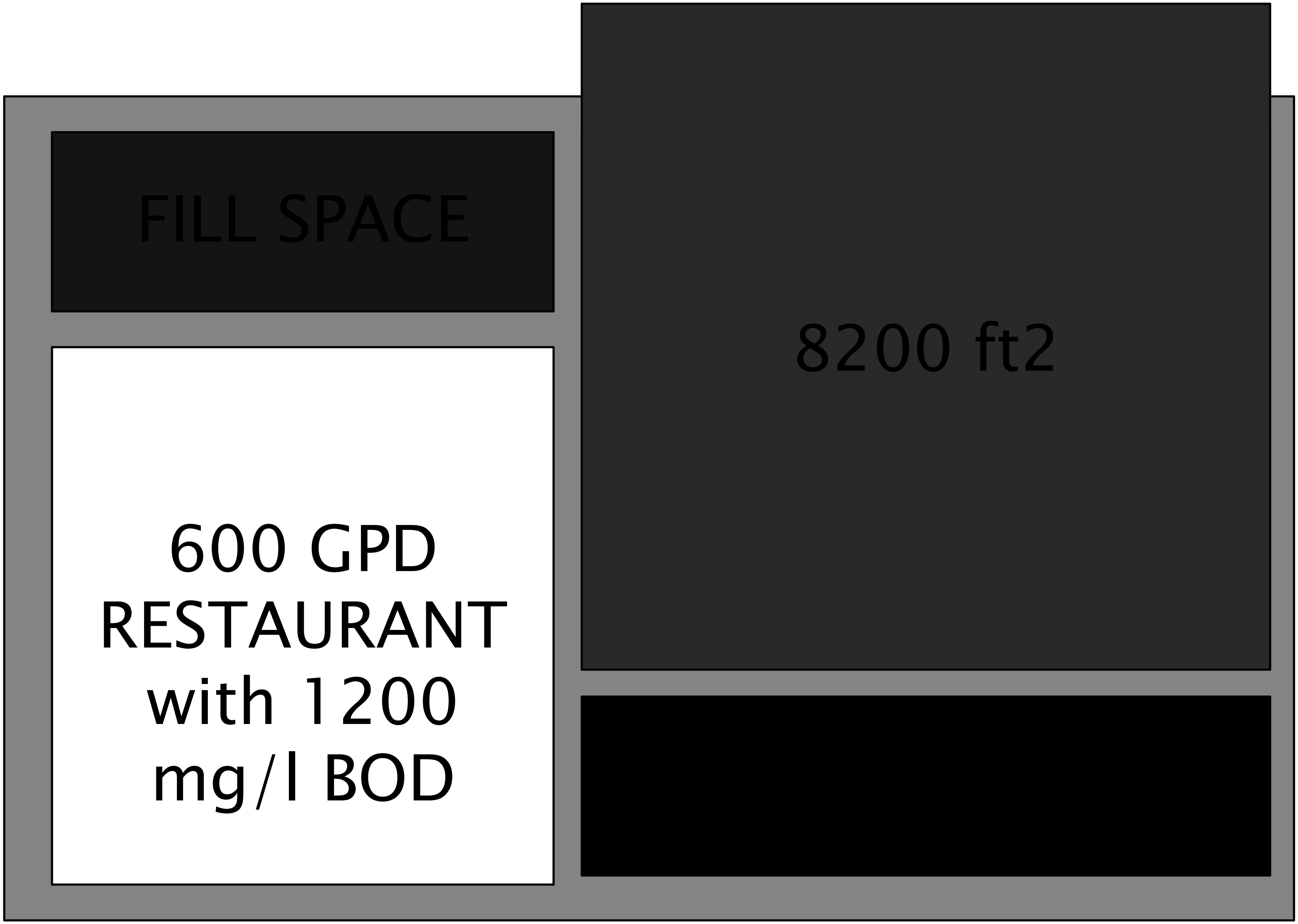
# Drainfield Sizing

ORGANICS

| Residential Strength Waste | | High Strength Waste | |
|---|---|---|---|
| 4 bedroom home= | 600gpd | RESTAURANT= | 600gpd |
| Sandy Loam= | 0.4 g/ft2 | Sandy Loam= | 0.4 g/ft2 |
| Residential BOD= | 170 mg/L | High Strength BOD= | 1200mg/L |
| LBS of BOD/Day= | 0.9 #of BOD | LBS of BOD/Day= | 6 #of BOD |
| Area Needed= | 1500 ft2 | Area Needed= | 8,220 ft2 |
| # of BOD/ft2= | .00073 | # of BOD/ft2= | .00073 |

SIZING DRAINFIELDS FOR ORGANIC LOADS


FILL SPACE
60x100 Area
Available for
Drain Field
1500 ft2
Home at 600
gpd domestic
wastewater


FILL SPACE
8200 ft2
600 GPD
RESTAURANT
with 1200
mg/l BOD

# Drainfield Sizing

ORGANICS

## Residential Strength Waste

| | |
|---|---|
| 4 bedroom home= | 600gpd |
| Sandy Loam= | .4 g/ft2 |
| Residential BOD= | 170 mg/L |
| LBS of BOD/Day= | 0.9 #of BOD |
| Area Needed= | 1500 ft2 |
| # of BOD/ft2= | .00073 |

## High Strength Waste

| | |
|---|---|
| RESTAURANT= | 600gpd |
| Sandy Loam= | .4 g/ft2 |
| High Strength BOD= | 880mg/L |
| LBS of BOD/Day= | 4.4 #of BOD |
| Area Needed= | 6000 ft2 |
| # of BOD/ft2= | .00073 |

SIZING DRAINFIELDS FOR ORGANIC LOADS


FILL SPACE
6000 ft2
WHAT IS MISSING???
600 GPD
RESTAURANT
at 880 mg/L
BOD

# THE FUTURE

- Hydraulics will continue to reduce 110 gphd and 36.7 gpcd in the coming years through replacement of old toilets and clothes washers
- < 110 gphd can be expected as high-efficiency fixtures and appliances are widely installed
- Concentrations will rise
- Organic versus hydraulic loading will become more important even in residential design

# QUESTIONS & MORE INFORMATION

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