CHANGING WATER USAGE

University of Minnesota
Onsite Sewage Treatment Program

6th Northeast Onsite Wastewater Treatment Short Course and Equipment Exhibition
Technology of the Future TODAY!

April 2-4, 2019
Mystic Marriott Hotel
Groton, Connecticut

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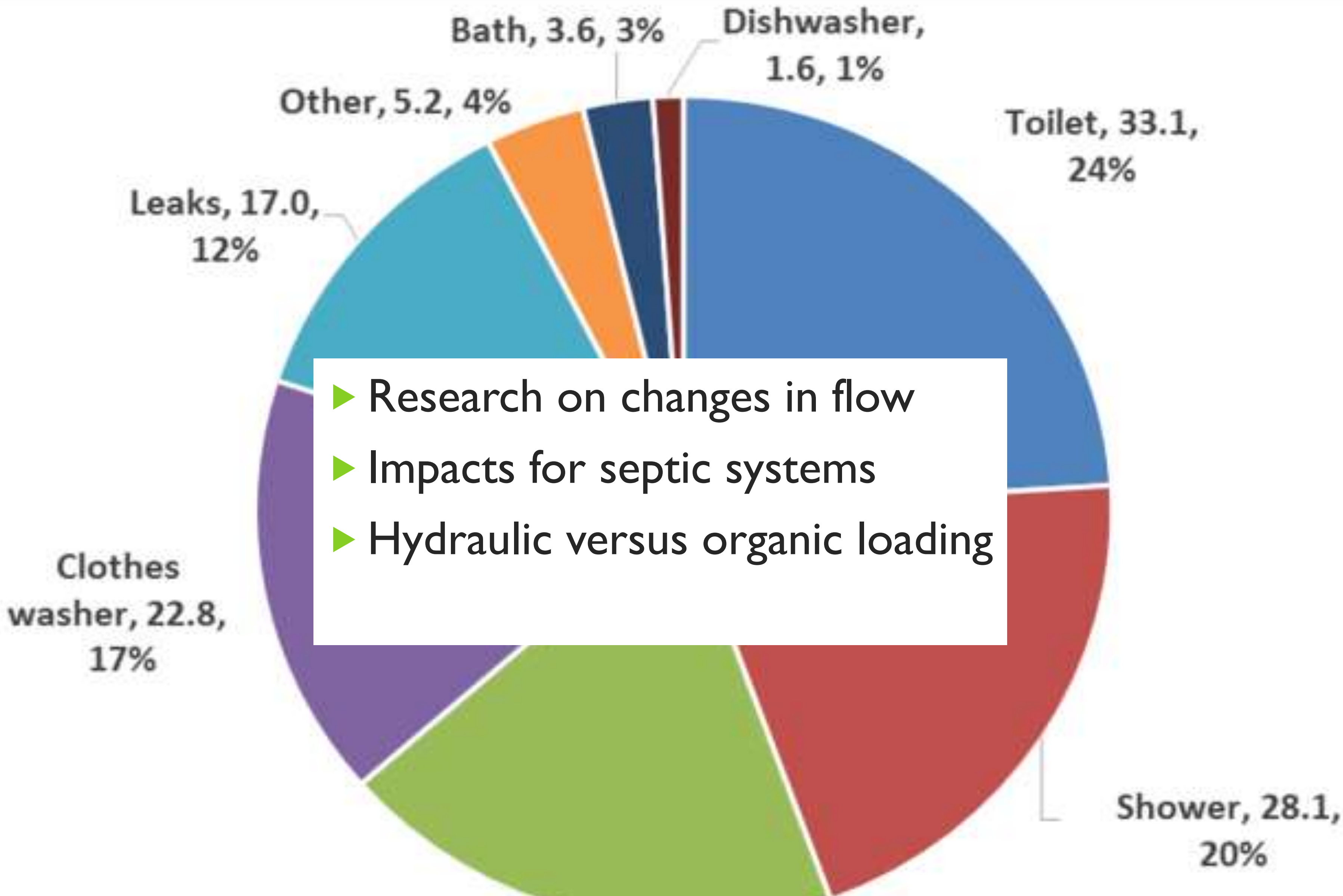
http://septic.umn.edu

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

Water Research Foundation®
advancing the science of water

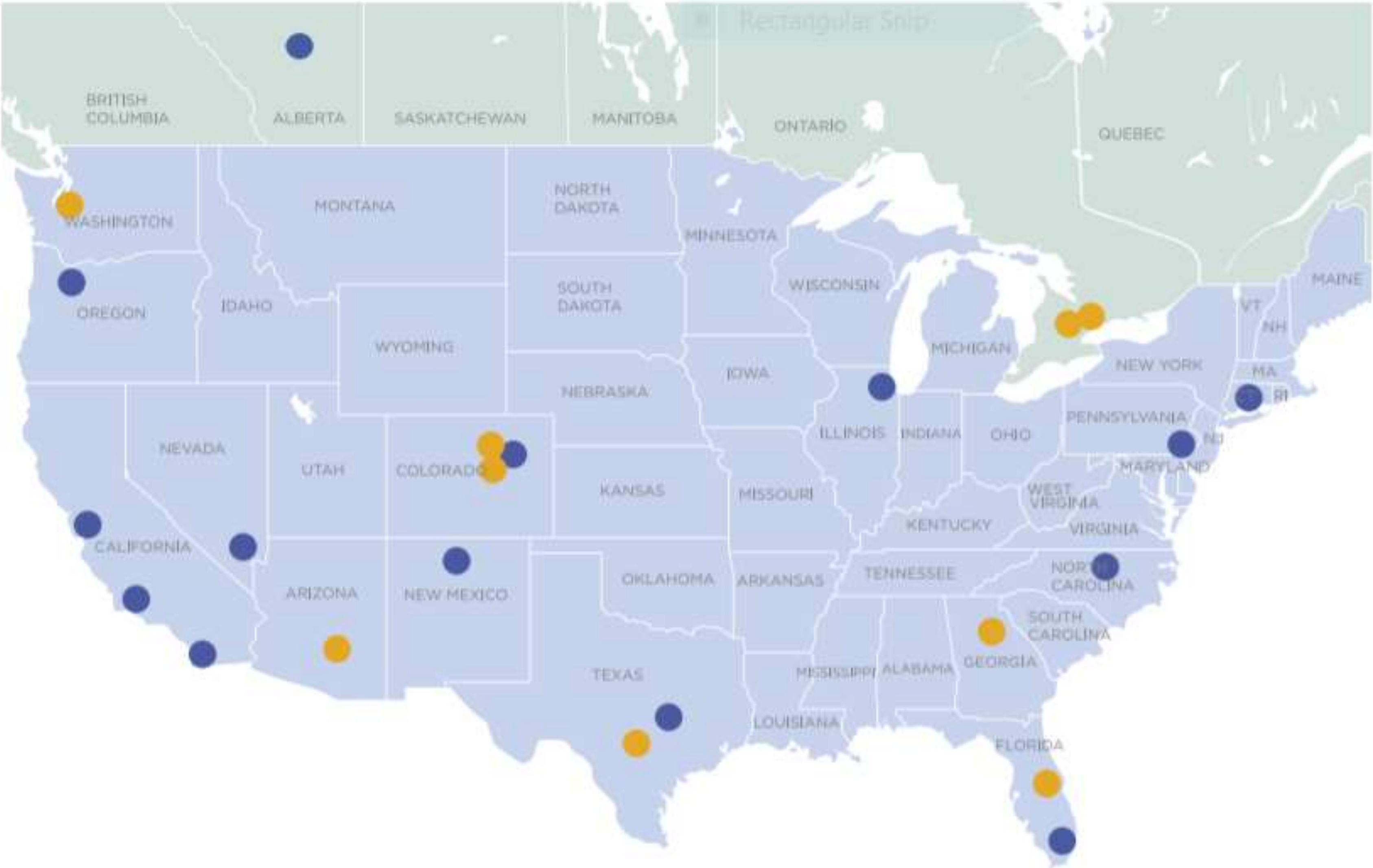
2016 RESIDENTIAL END USES OF WATER

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

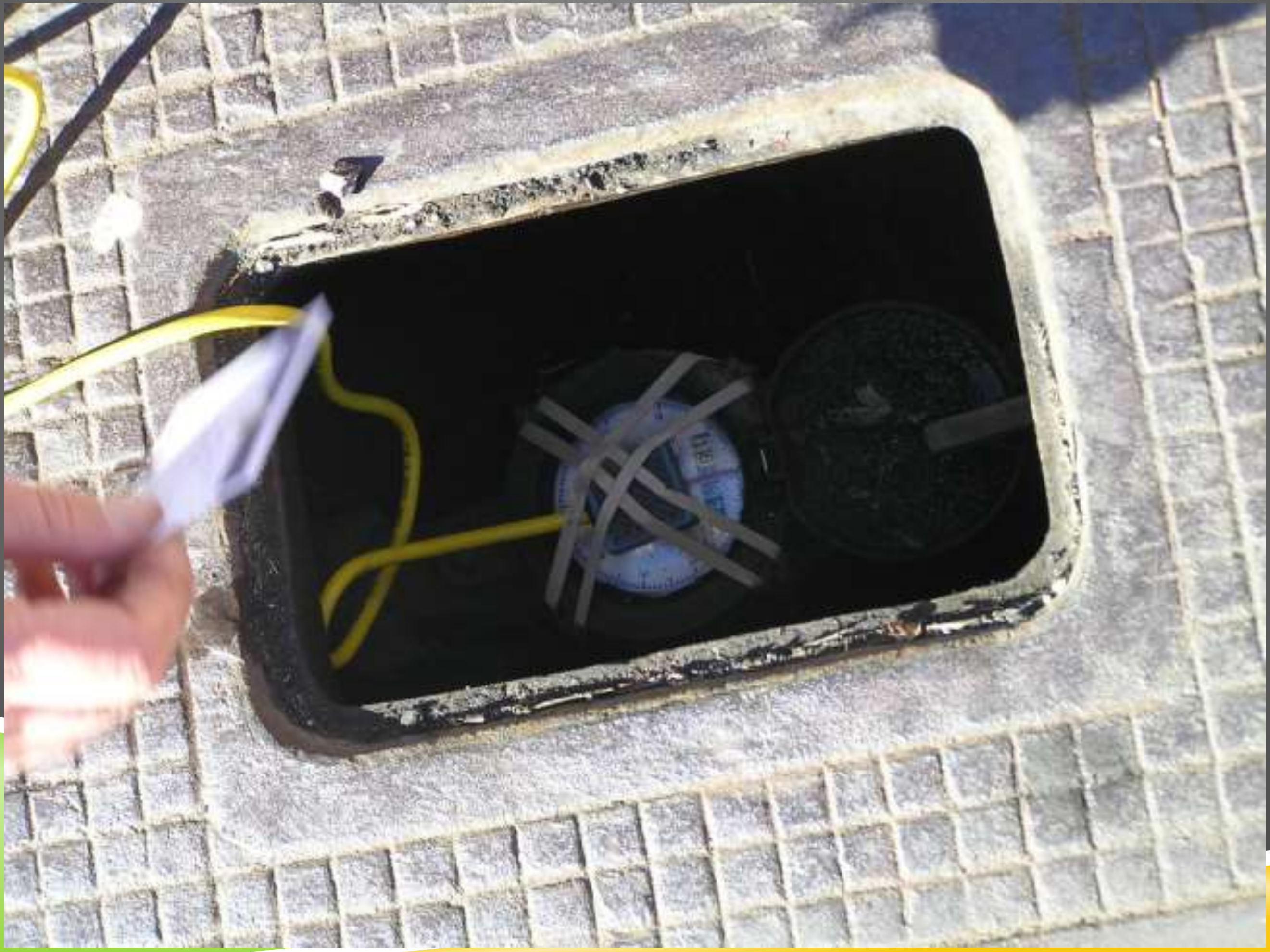
- Random representative selection of single-family customers consumption
  - highly detailed information on water use
  - demographics
  - attitudes
  - physical nature of the houses and landscapes
- Data collected from 2010 through 2013 from 23 utilities
  - billing data with surveys ~ 2,000 homes
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

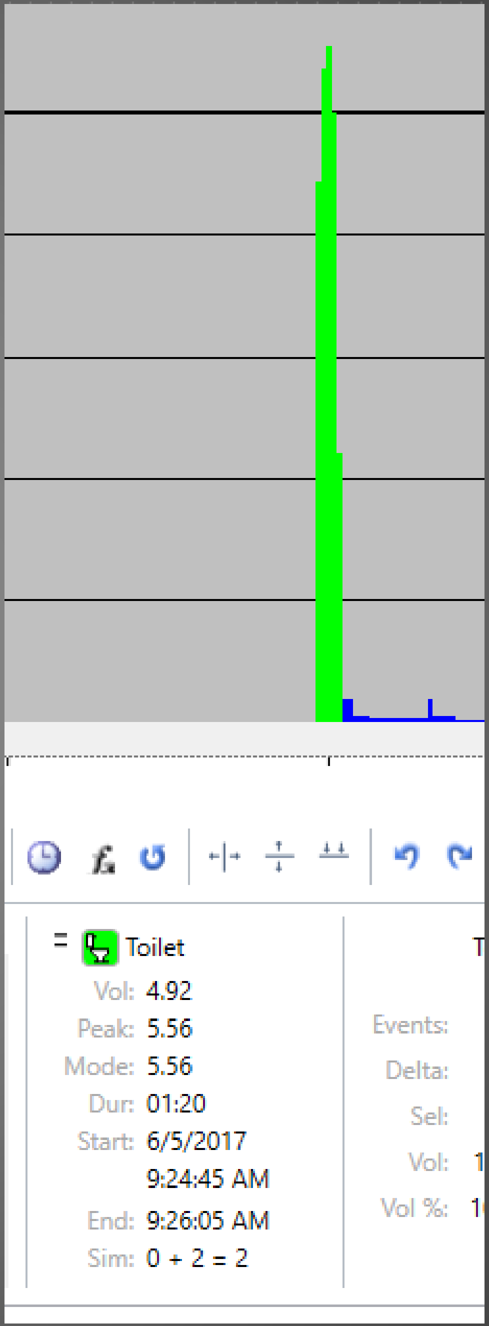
Note the parameters used by Trace Wizard to identify this and all similar events during the logging period.

Volume: 4.92 gallons per flush

Peak Flow: 5.56 gpm

Duration: 1 minute 20 seconds

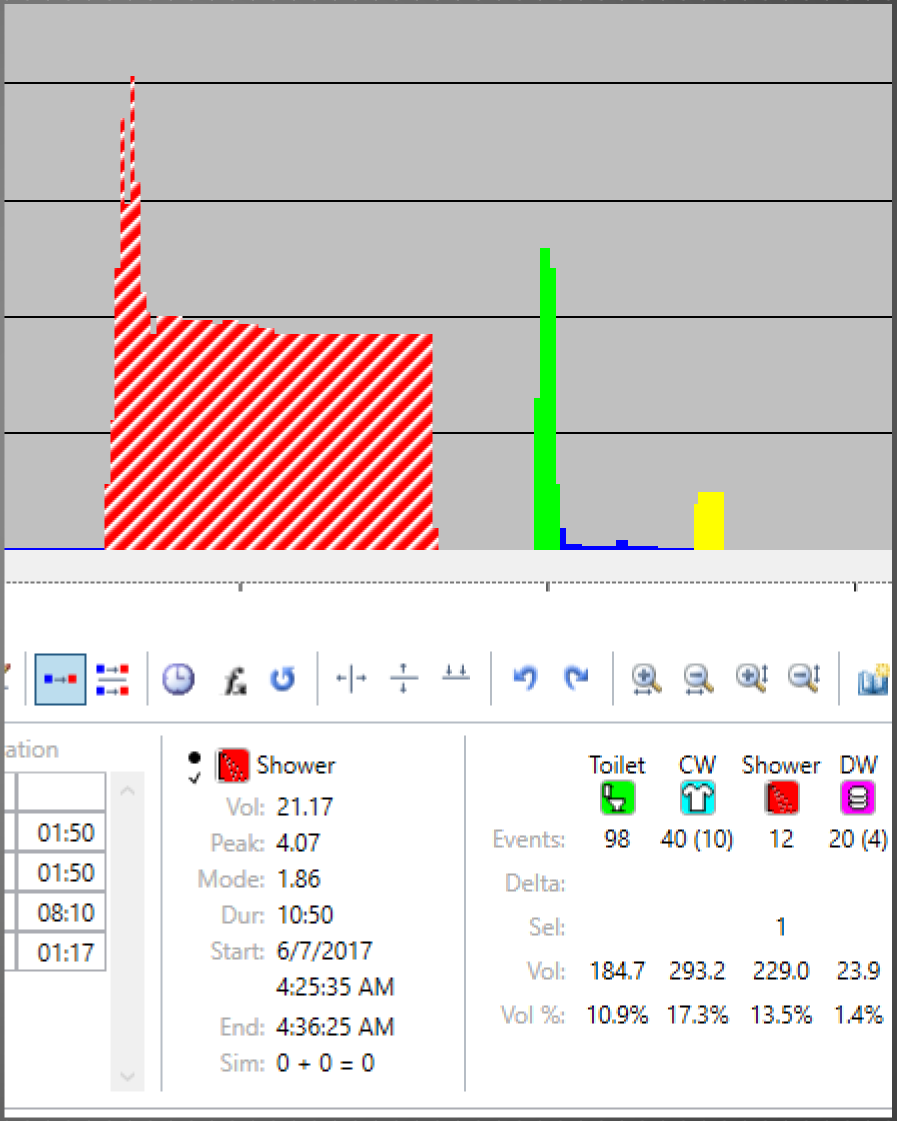
Mode flow, start time, end time and other similar events are also listed.



TYPICAL BATHROOM SEQUENCE: SHOWER, TOILET, FAUCET

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

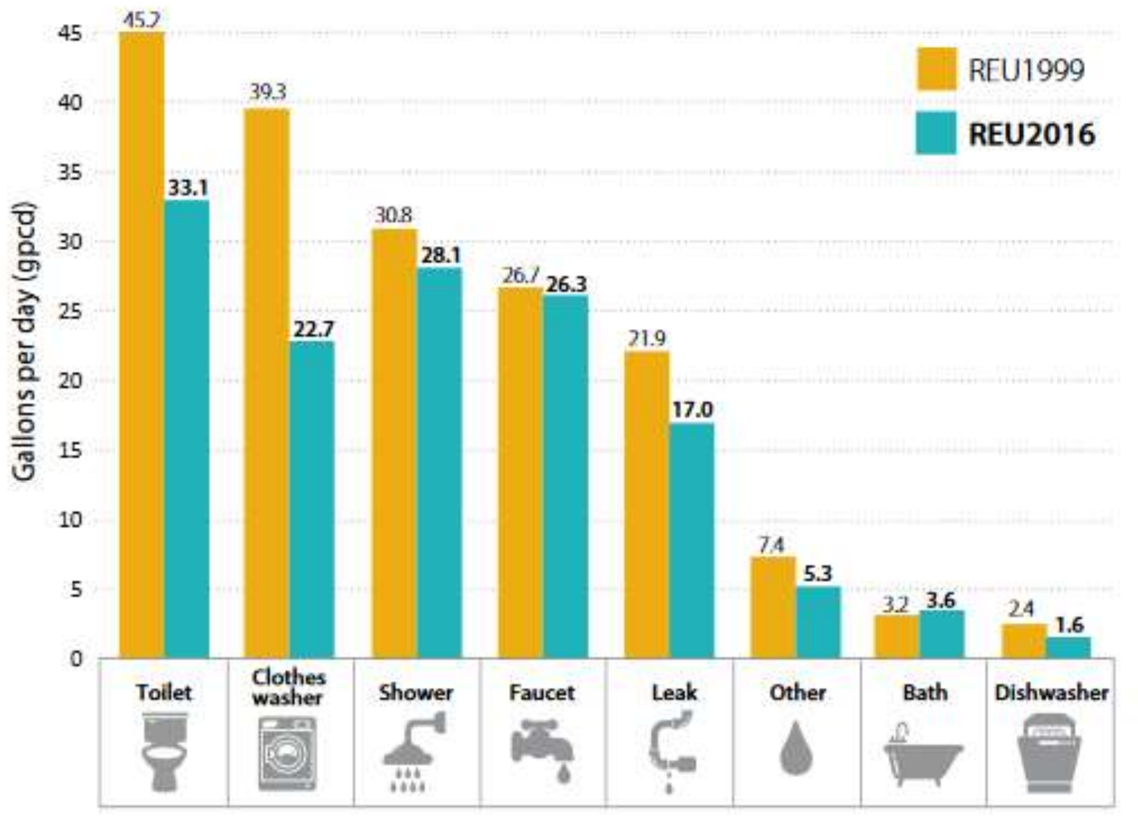
This is a very typical combination



TYPICAL HOUSEHOLD

- 1999
  - 177 gphd
- 2016
  - 138 gphd

Figure 4. Average daily indoor per household water use REU1999 and REU2016

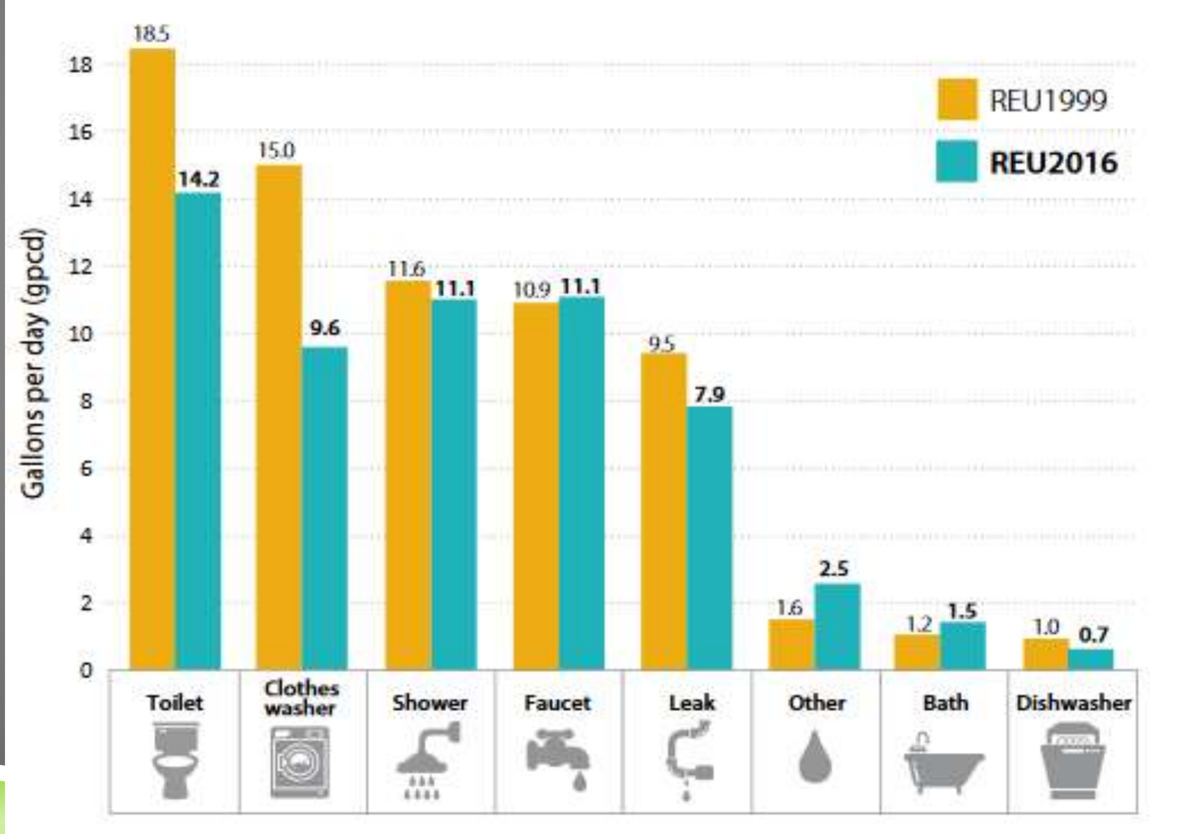


Average annual indoor household water use

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

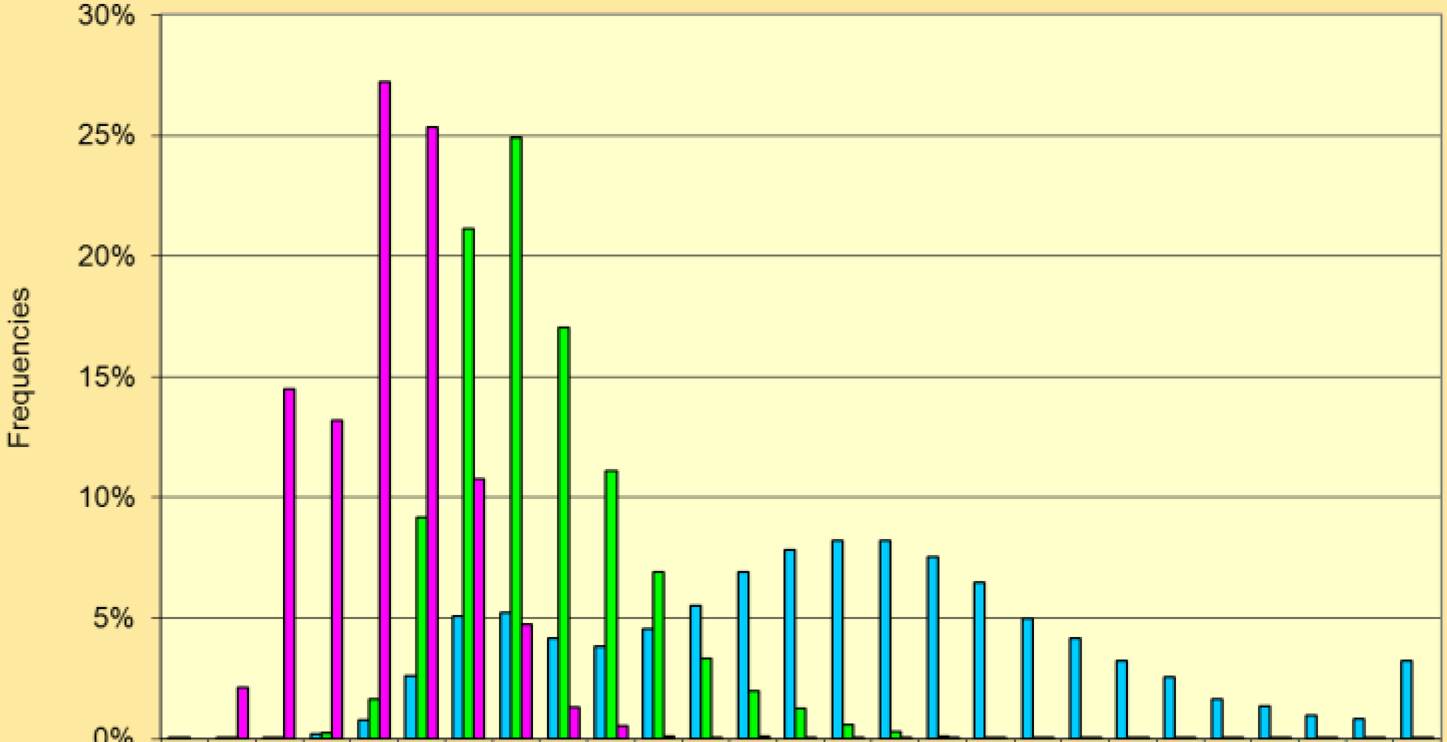
CLOTHES WASHERS FROM 1999 TO 2016

- 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
REUWS	0%	0%	0%	0%	1%	3%	5%	5%	4%	4%	5%	6%	7%
Std NEW	0%	0%	0%	0%	2%	9%	21%	25%	17%	11%	7%	3%	2%
HE New	0	2%	14%	13%	27%	25%	11%	5%	1%	1%	0%	0%	0%

	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	8%	8%	8%	8%	6%	5%	4%	3%	3%	2%	1%	1%	1%	3%
Std NEW	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
HE New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

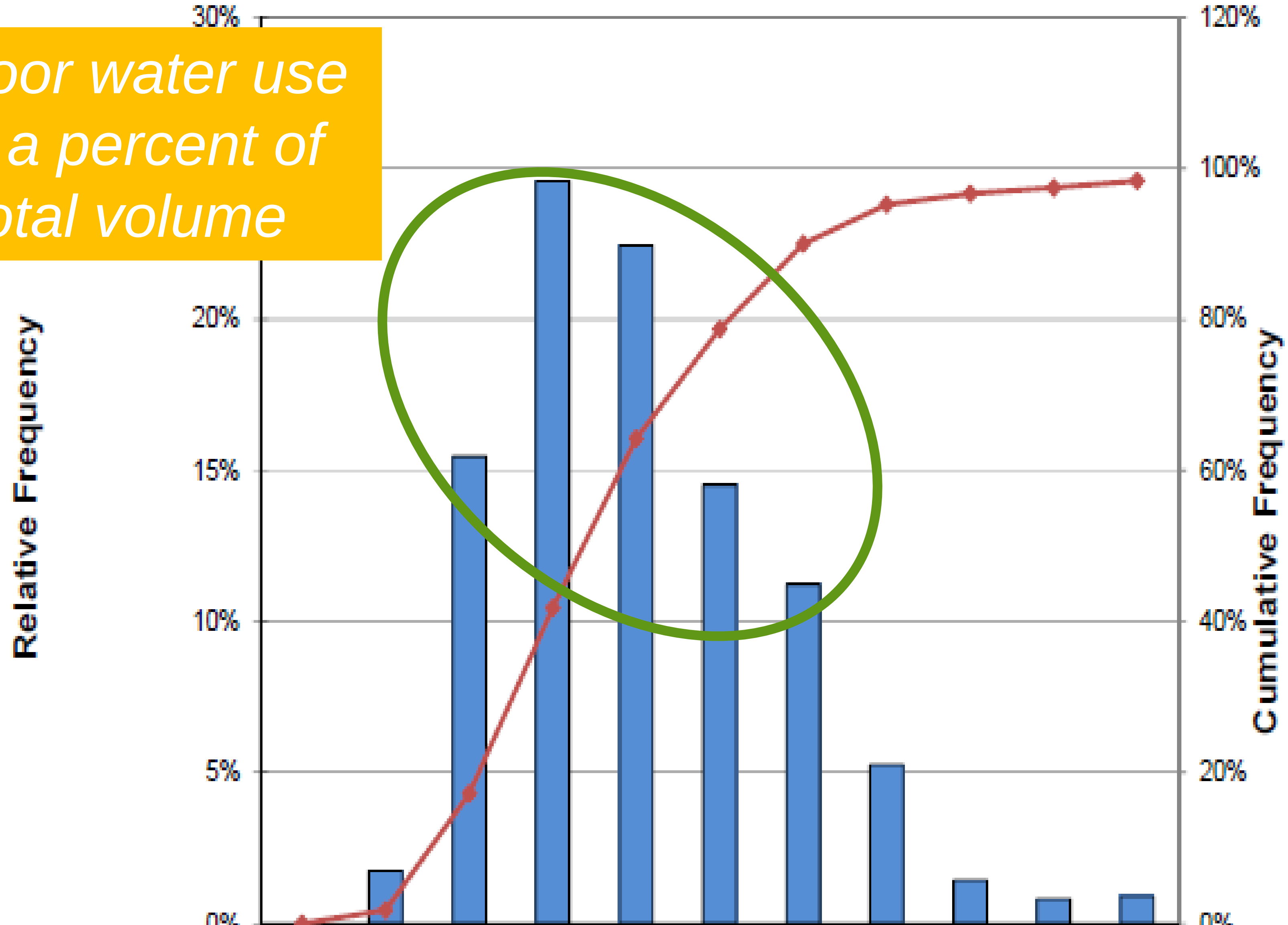
Gallons per Flush

WATER SAVING DEVICES

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

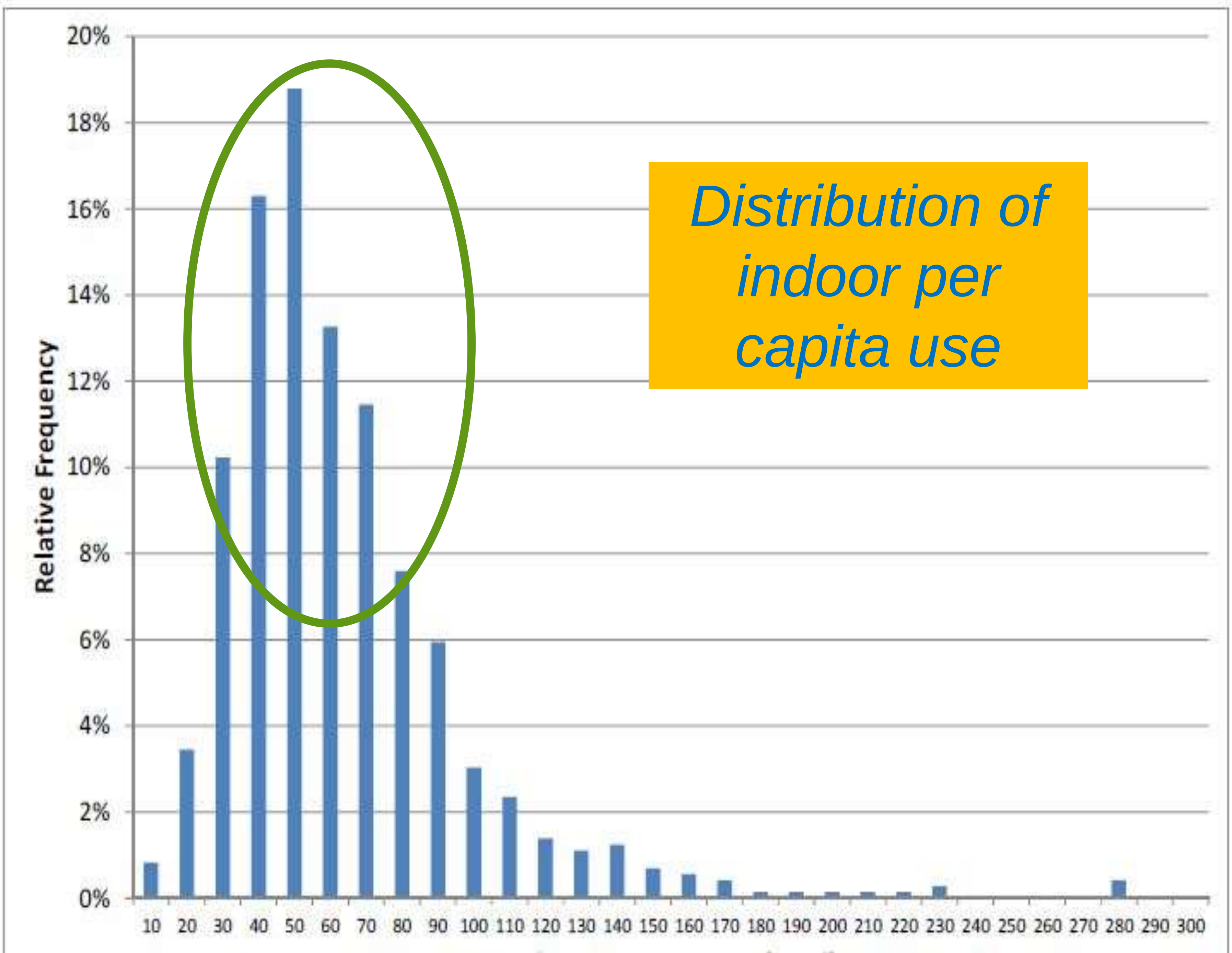
LEAKS

- 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



	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%

Indoor Household Water Use (gphd)


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	4.75

Non-linear use per person

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

=

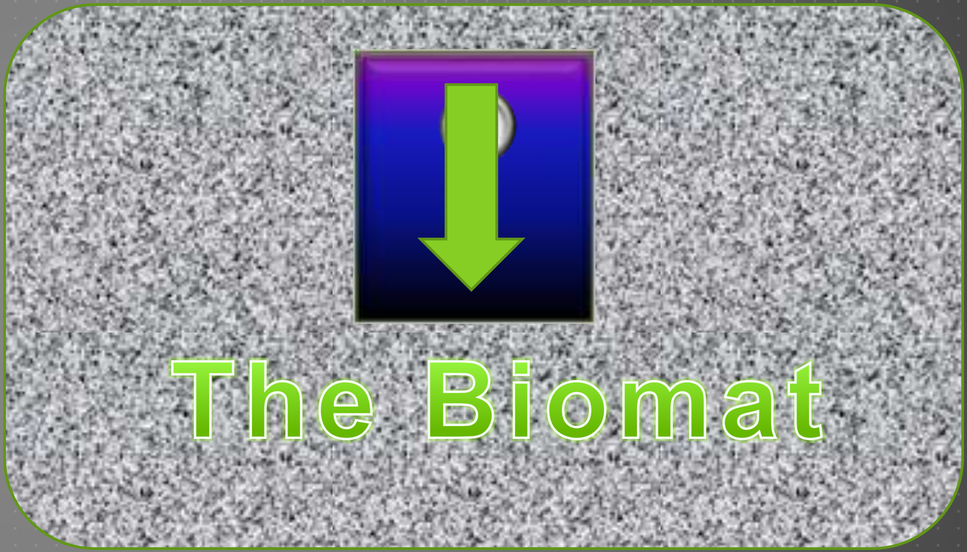
Safety Factor

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

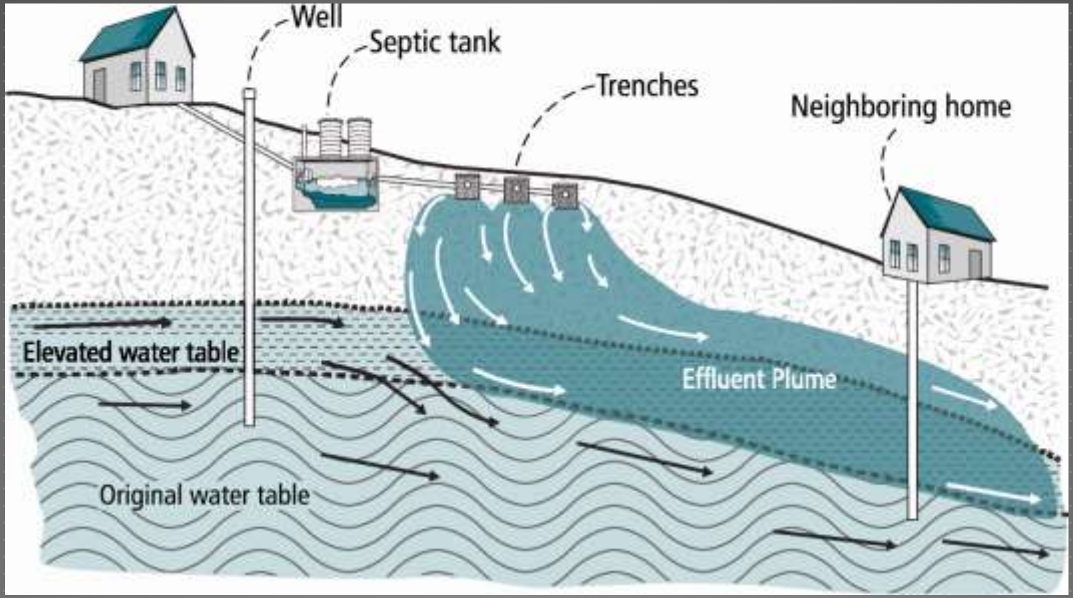
BIOMAT INFLUENCES

- 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

Water Environment Research Foundation
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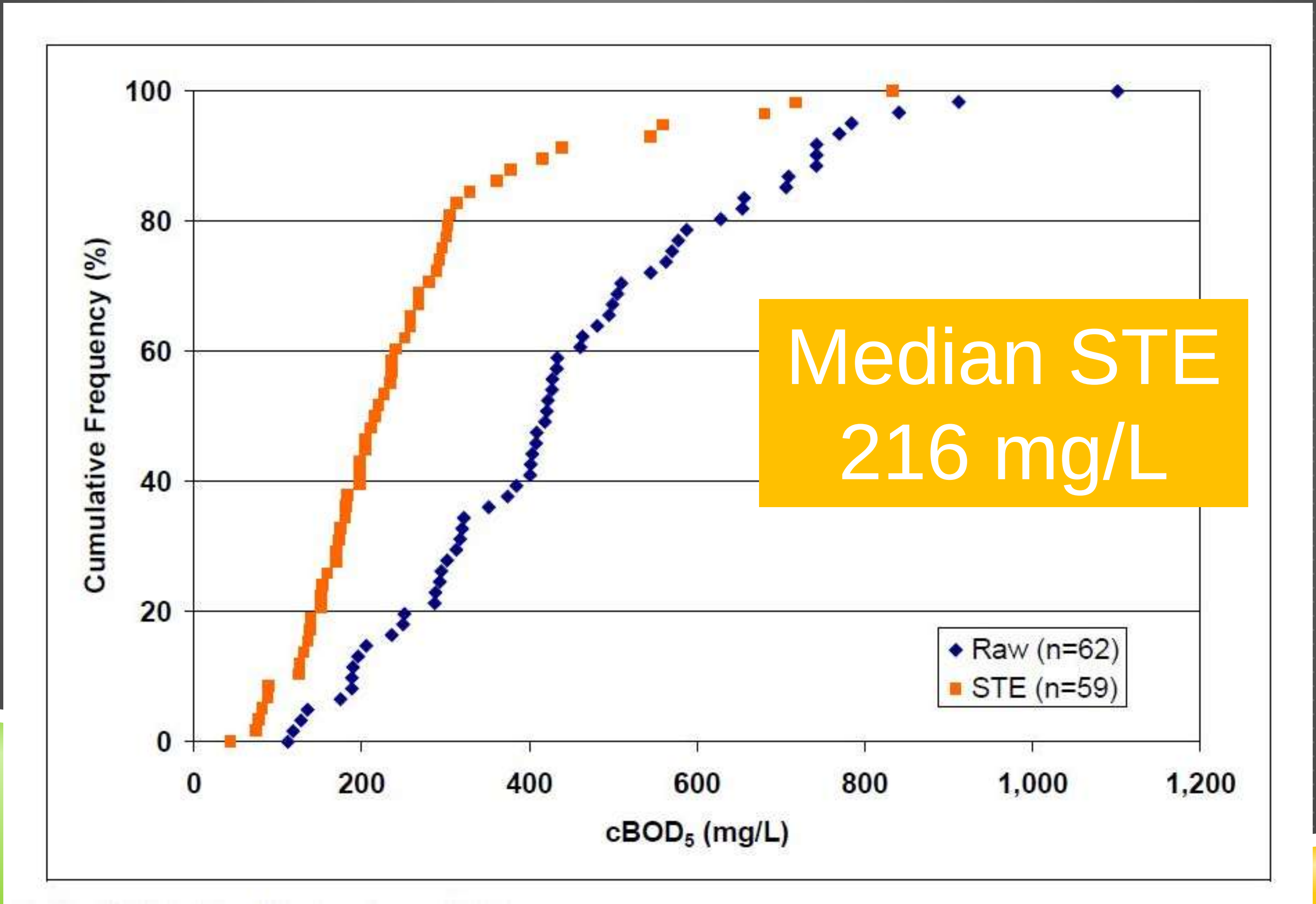
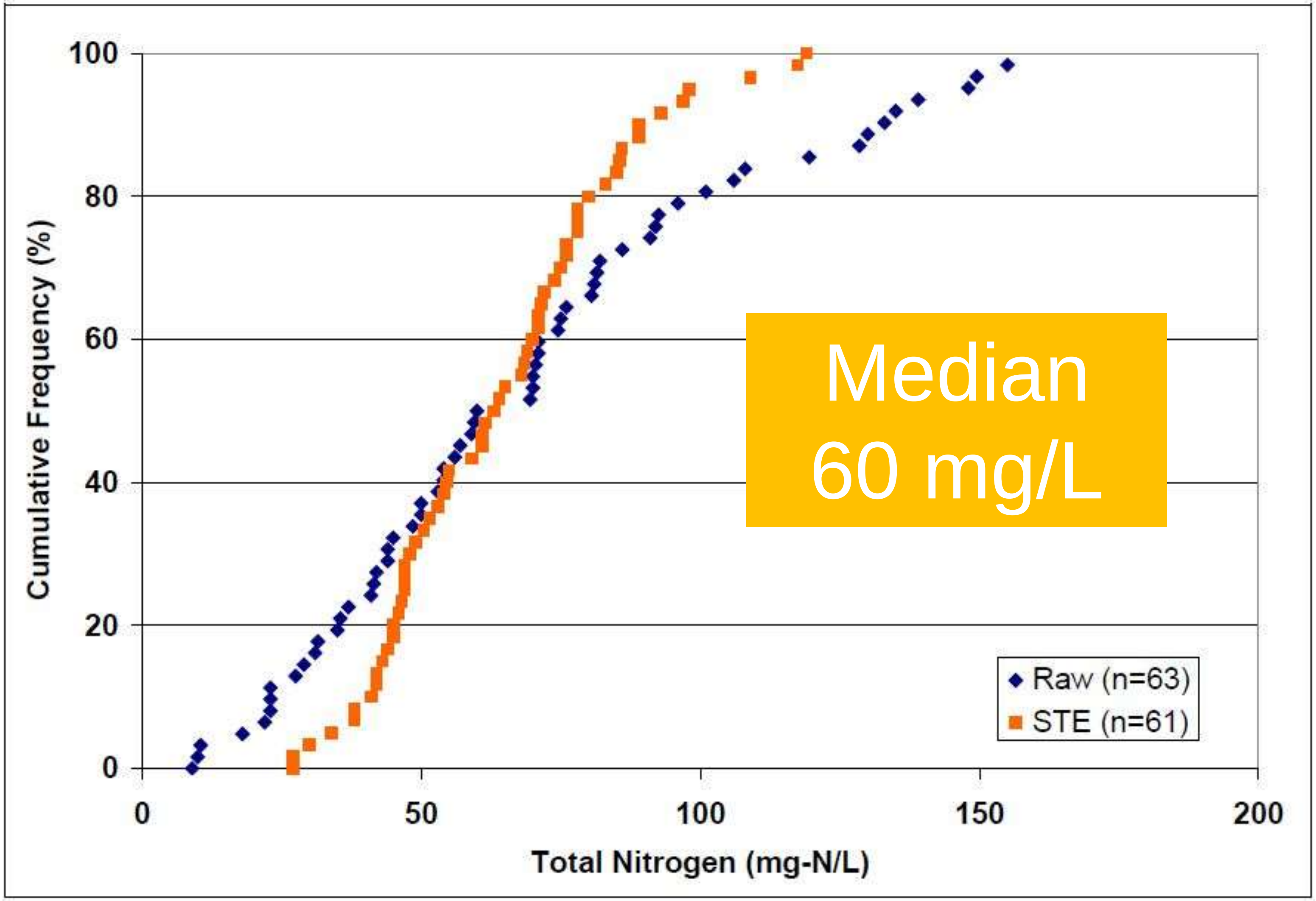
2009 INFLUENT CONSTITUENT CHARACTERISTICS OF THE MODERN WASTE STREAM FROM SINGLE SOURCES

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

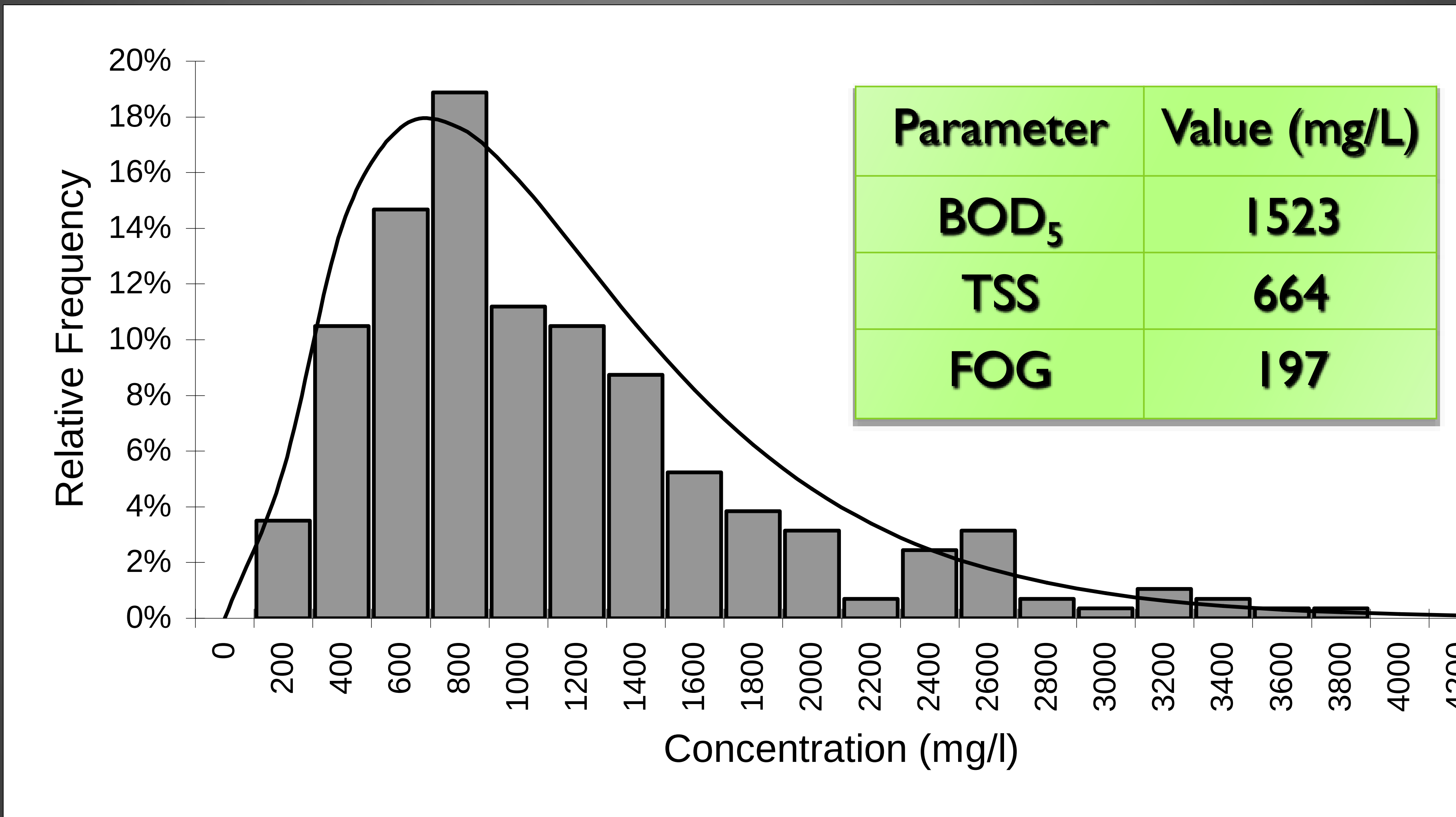


Median
60 mg/L

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

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

$R_a = 0.50$ 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

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

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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