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END-USE BASED BENCHMARKING OF RESIDENTIAL WATER USE

WRF 4309 – Residential End Use Study Update REUWS2

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Metrics and Benchmarks - Definitions

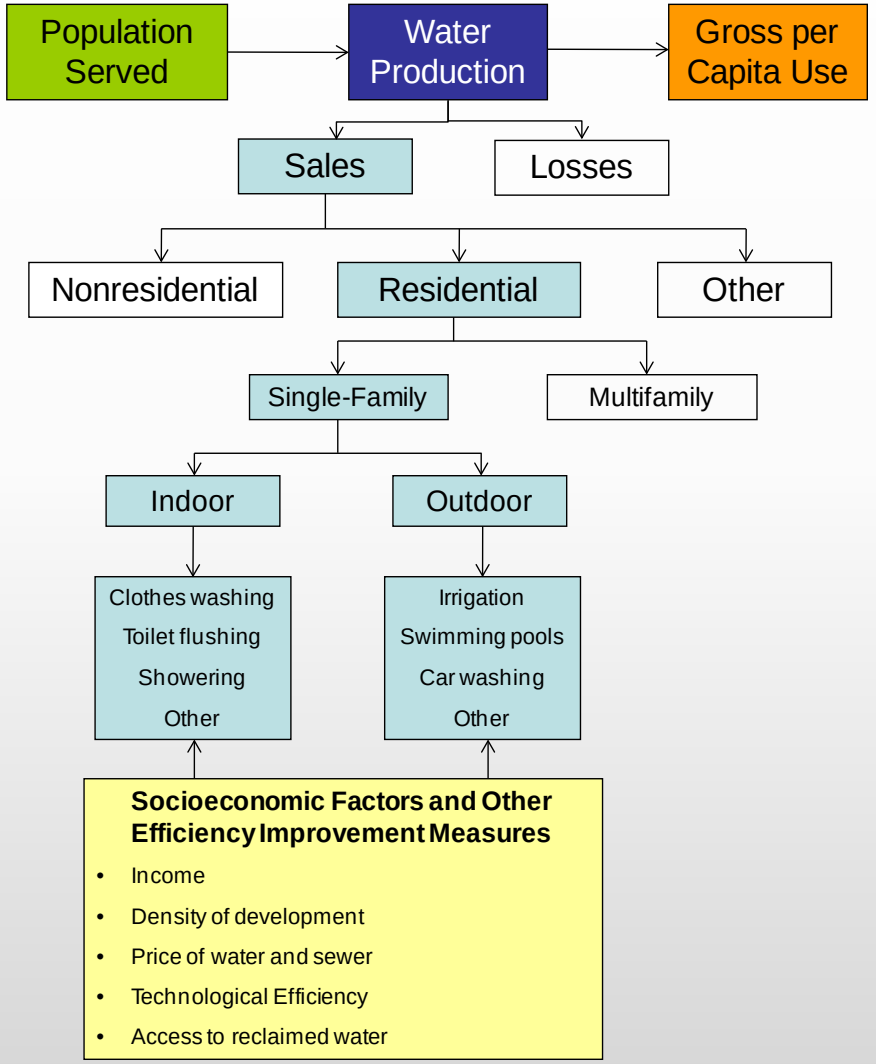
- Allow us to compare measurements of water usage to gage changes over time (or across water utilities)
- A *metric* (or *performance indicator*) is a measure (like a “usage ratio”) that can be applied to water use data to obtain a *numerical value*
- A *benchmark* is a particular (numerical) value of a metric that denotes a specific level of performance, such as a water efficiency target
- Examples of metrics: GPCD, GPAD, GPHD, inches/year

Acronyms

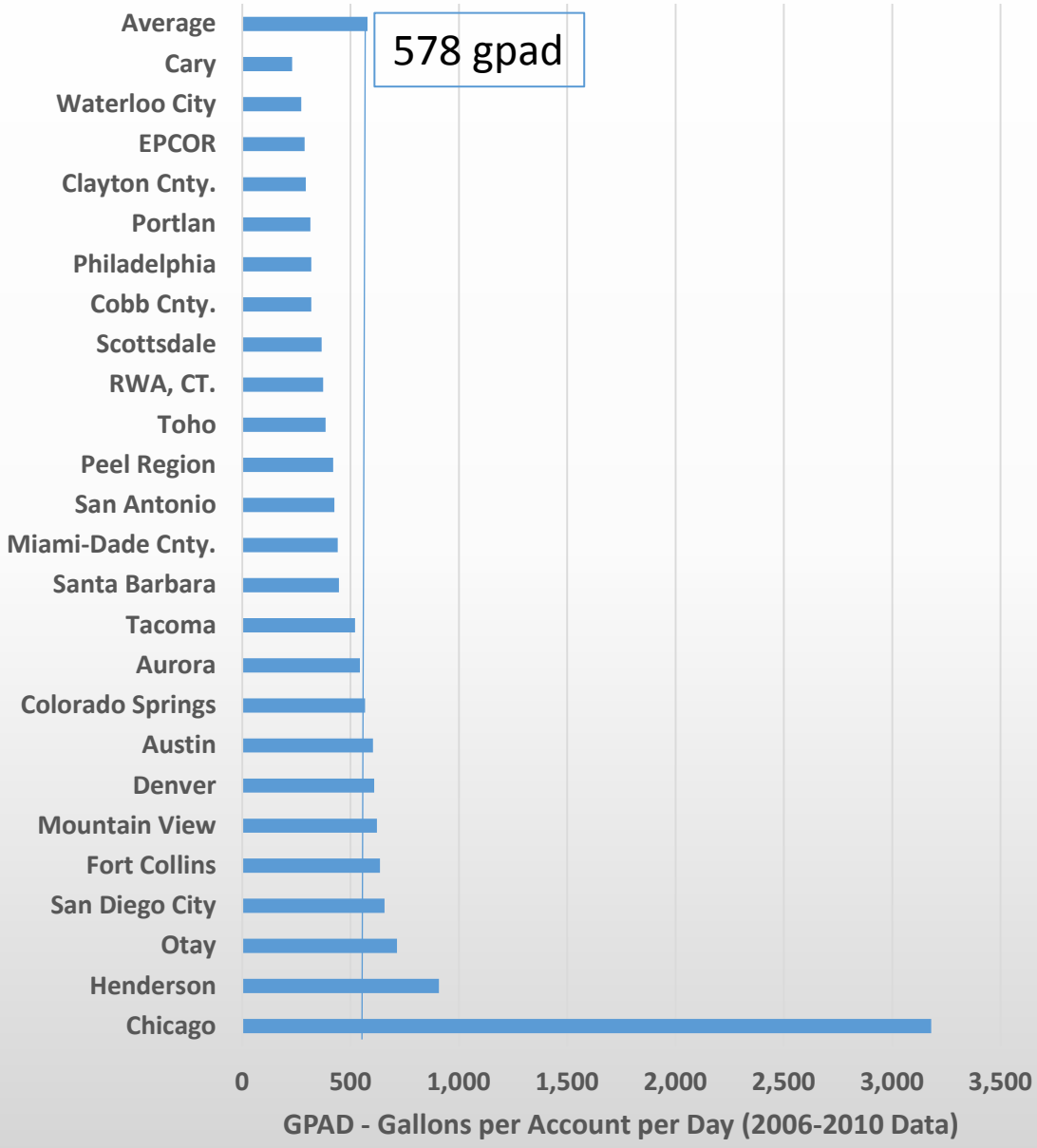
- GPCD = gallons per capita per day
- GPAD = gallons per account (customer) per day
- GPHD = gallons per household per day (SF residential)
- SF = single-family residential
- MF = multifamily residential
- NRES = non-residential
- IRR = irrigation (meters)
- TIR = theoretical irrigation requirement

Metrics of Aggregate Use

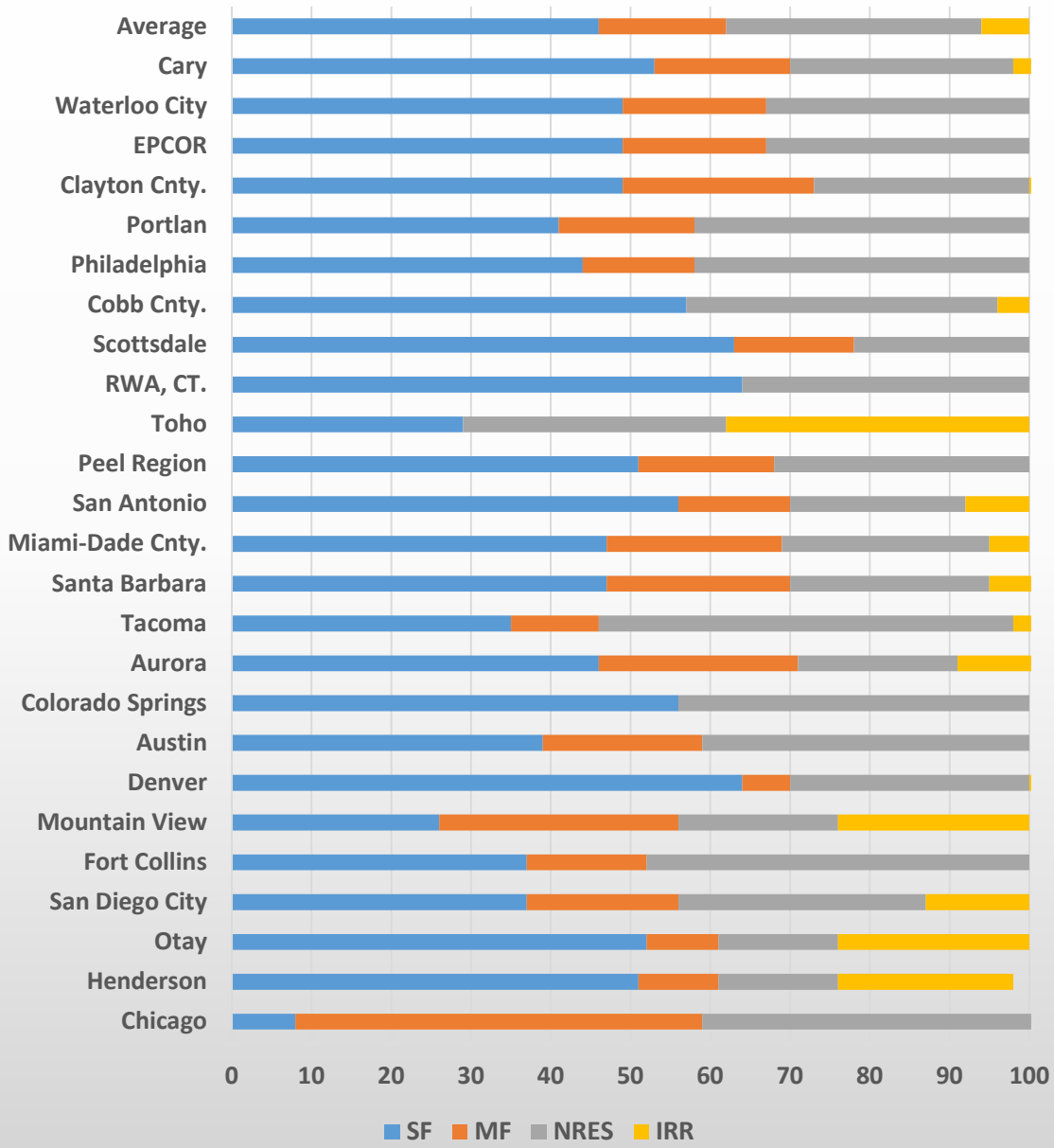
Aggregate metrics capture "other-than-efficiency" effects on the calculated unit quantity of water usage



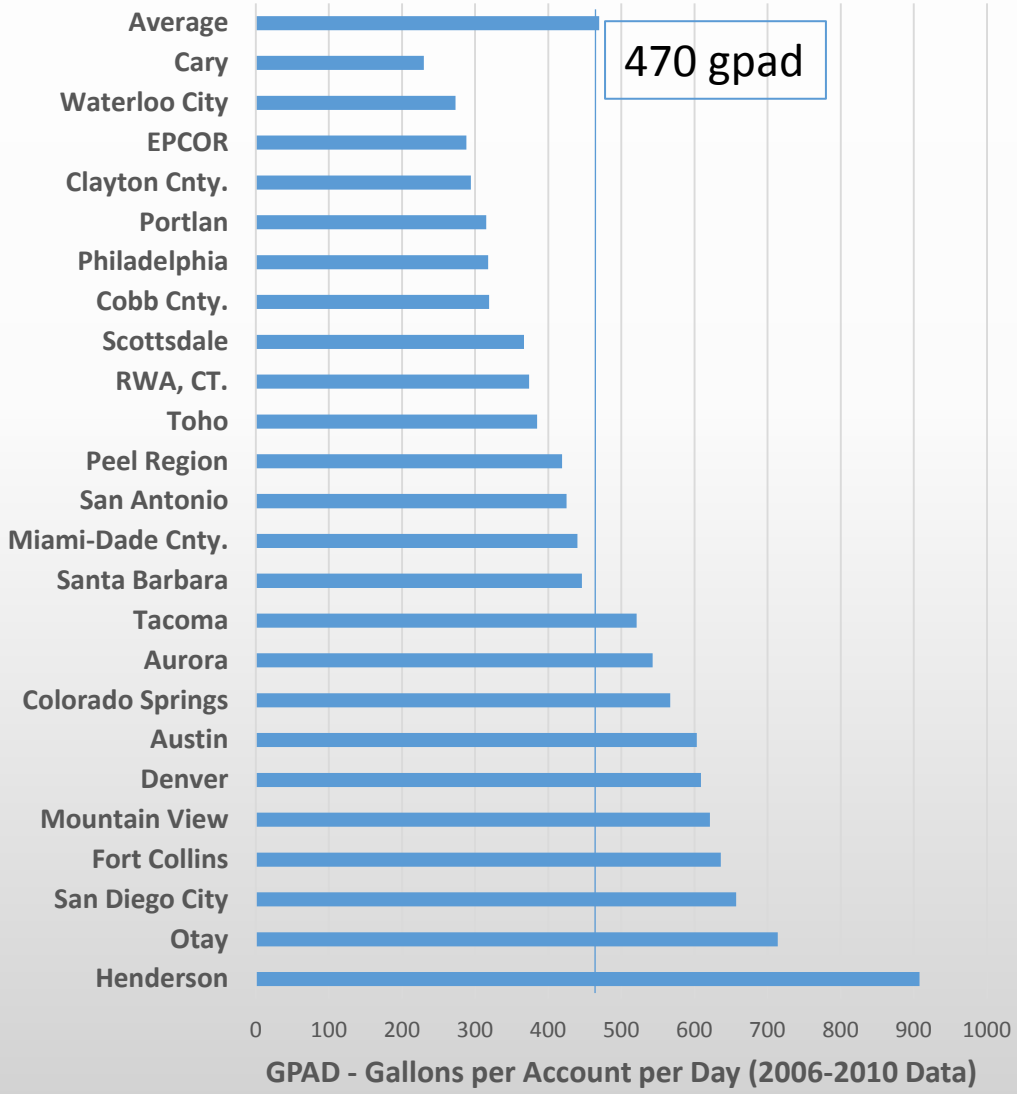
Aggregate GPAD Metric



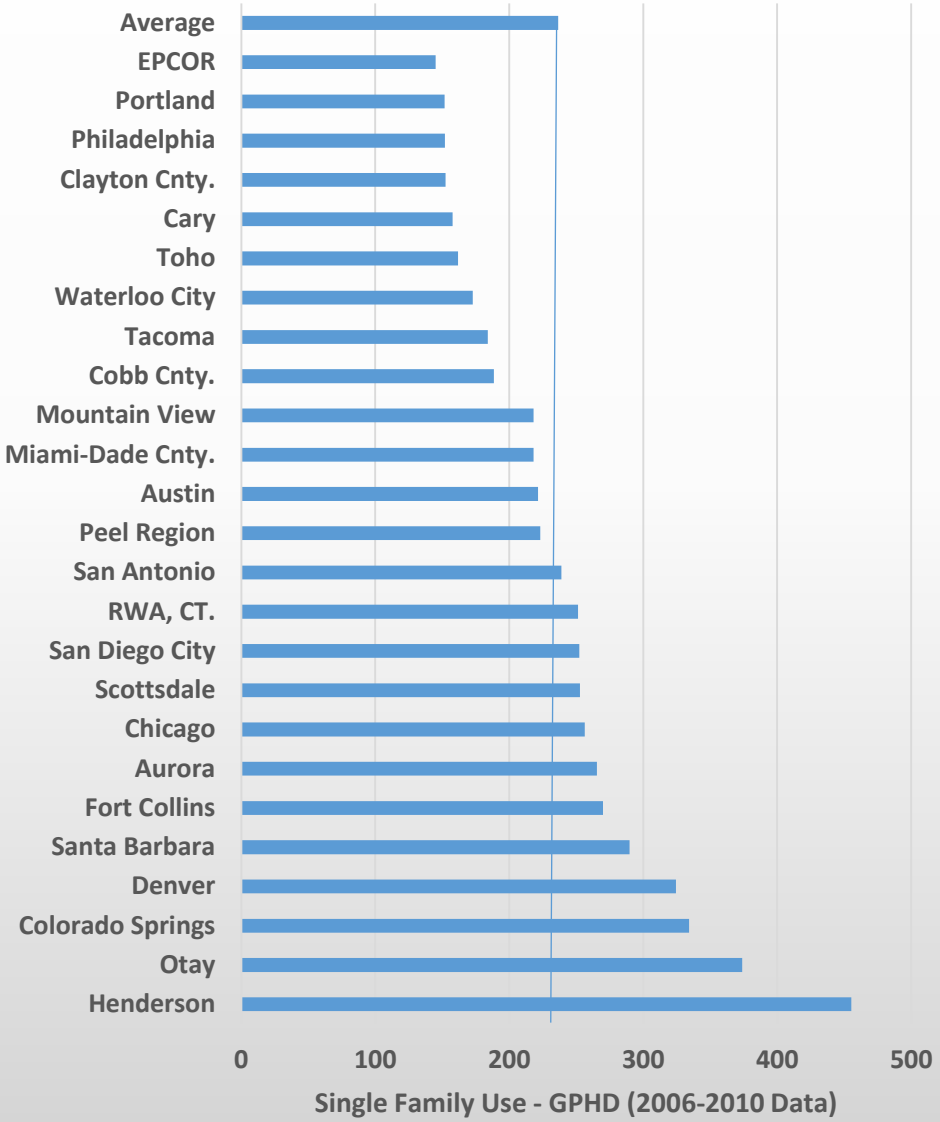
Sectoral Sales, %

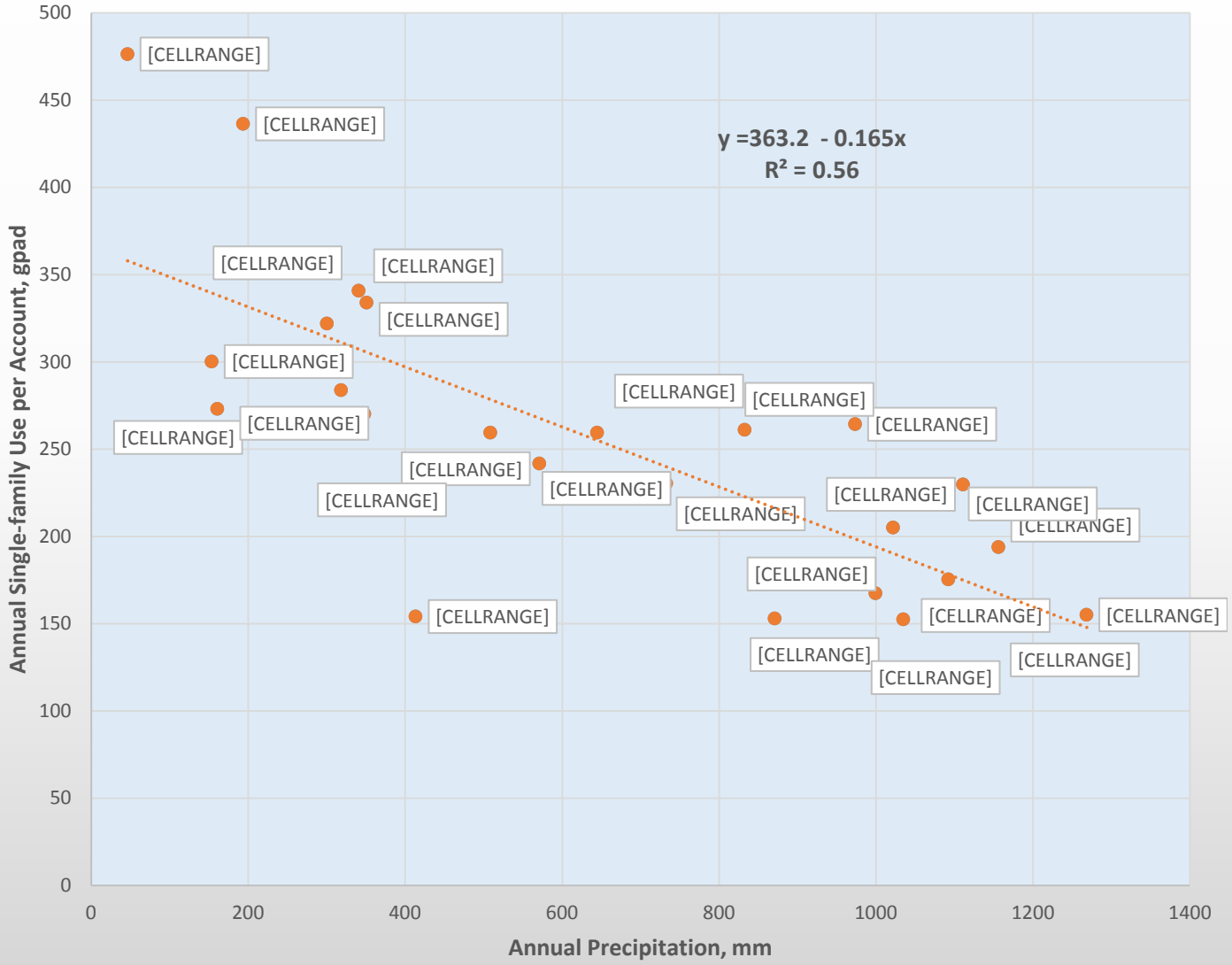


GPAD w/o Chicago

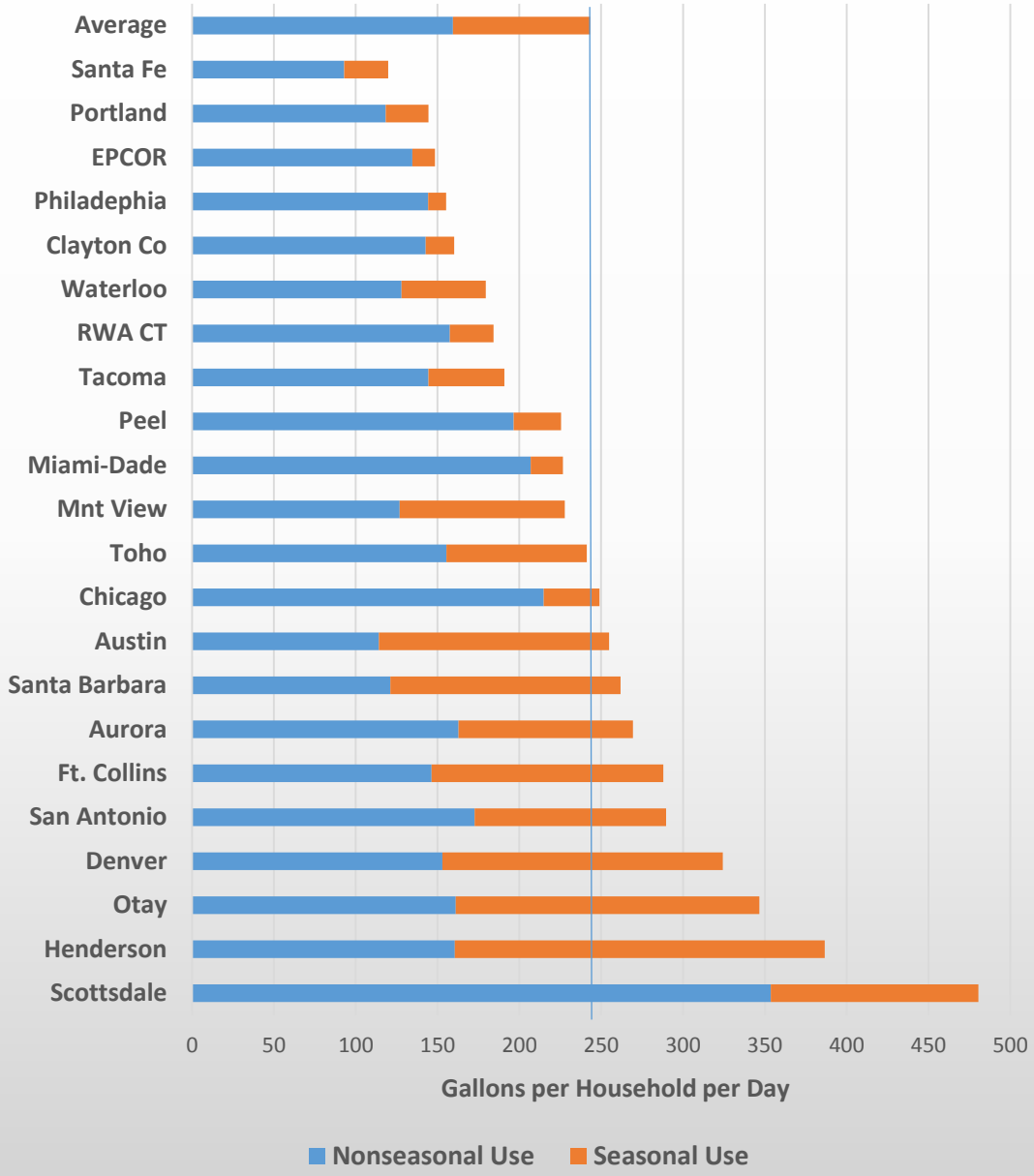


GPHD Metric – Single Family Residential Use

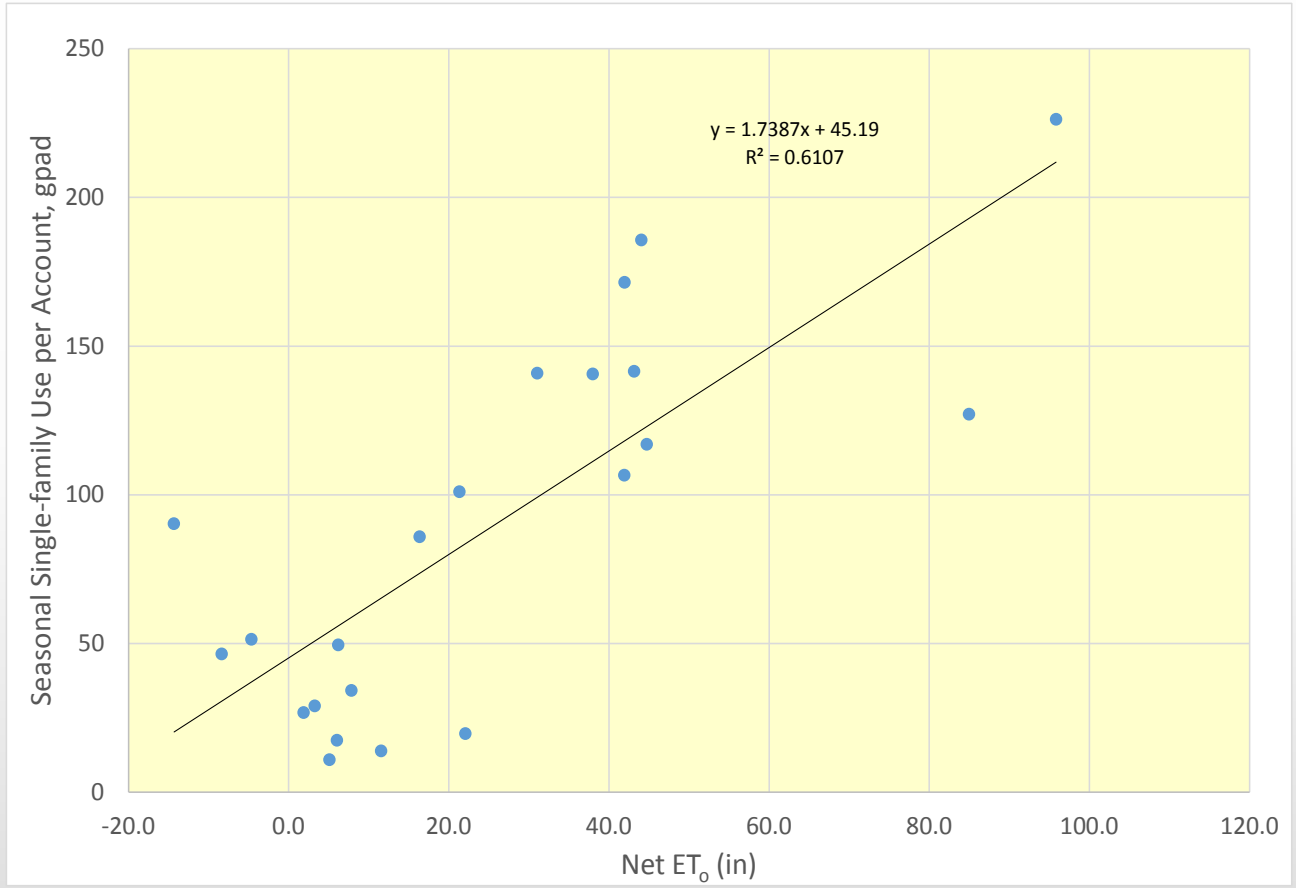




Seasonal and Nonseasonal Water Use, GPHD



(ET_o – Precipitation) vs. Seasonal SF Water Use, GPAD



Metrics from Billing/Sales Data

- Total number of customer accounts or population served do not produce water use metrics that could be used for benchmarking
- Single-family residential per-household metrics are more homogeneous but vary over seasons and across cities
- “Minimum-month method” for estimating seasonal use can under-estimate seasonal use and overestimate non-seasonal use.
- These metrics offer limited opportunity for establishing efficiency benchmarks

Reliable Benchmarks

- Efficiency benchmarks can be derived from the end use logging data
- The logging data enable us to:
  - decompose total metered water use into specific end uses
  - capture technical efficiency of water-using fixtures and appliances
  - capture water-using behaviors of consumers

Use per household vs. per capita use

- Indoor water use is not “strictly proportional” to the total number of residents
- Family size and (age) composition are important because they affect the frequency of end uses
- It is easy to demonstrate that water use of additional resident declines as household size increases:
- Incremental indoor use is:
  - 35.0 gpd for adults
  - 25.0 gpd for teens
  - 20.0 gpd for children

Benchmarks for Indoor Use

- 112 gphd – a logical high-efficiency benchmark for indoor water use with currently available technology as in 247 retrofit study group homes (2.58 pph)

- 108 gphd – adjusted high-efficiency benchmark using REUWS2 end use frequencies in 763 homes (2.62 pph)

- 96 gphd – an ultra-efficiency benchmark with additional savings from EnergyStar & WaterSense standards for CW, showers and toilets

High Efficiency Benchmark – Indoor GPHD

End Use	Observed in Retrofit (gpd)	Events/ day in Retrofit	Gallons/ Event in Retrofit	Events/ day in REUWS2	High Efficiency Benchmark (gpd)	Difference in gallons
Bathtub	6.62	0.28	23.31	0.18	4.20	-2.42
Clothes washer	21.20	0.91	23.25	0.78	18.06	-3.14
Dishwasher	2.25	0.29	7.79	0.26	2.02	-0.23
Faucet	21.45	44.48	0.48	51.35	24.76	3.31
Leaks	11.64	112.79	0.10	117.20	12.10	0.46
Other	1.48	0.25	5.92	0.25	1.48	0.00
Shower	26.27	1.84	14.28	1.77	25.27	-1.00
Toilet	21.08	13.45	1.57	12.90	20.22	-0.86
Total indoor, gpad	**112.00**		--	--	**108.10**	-3.89

Ultra Efficiency Assumptions

- Washing Machines
  - A full-sized EnergyStar certified clothes washer (WF ≤ 8.0 gal/cycle/ft^3) should use on average 15 gallons of water per load (EPA)
  - One fourth of homes in the REUWS2 and Retrofit samples used less than 20 gallons per load with the average volume of 15 gallons per load
- Showerheads
  - 50% of REUWS2 homes and 75% of retrofitted homes had modal shower flows less than 2.0 gpm and the average flow for these homes was 1.6 gpm
- Toilets
  - Ultra-efficiency benchmark = the goal of achieving the average flush volume of 1.28 gallons (set at the EPA WaterSense standard)

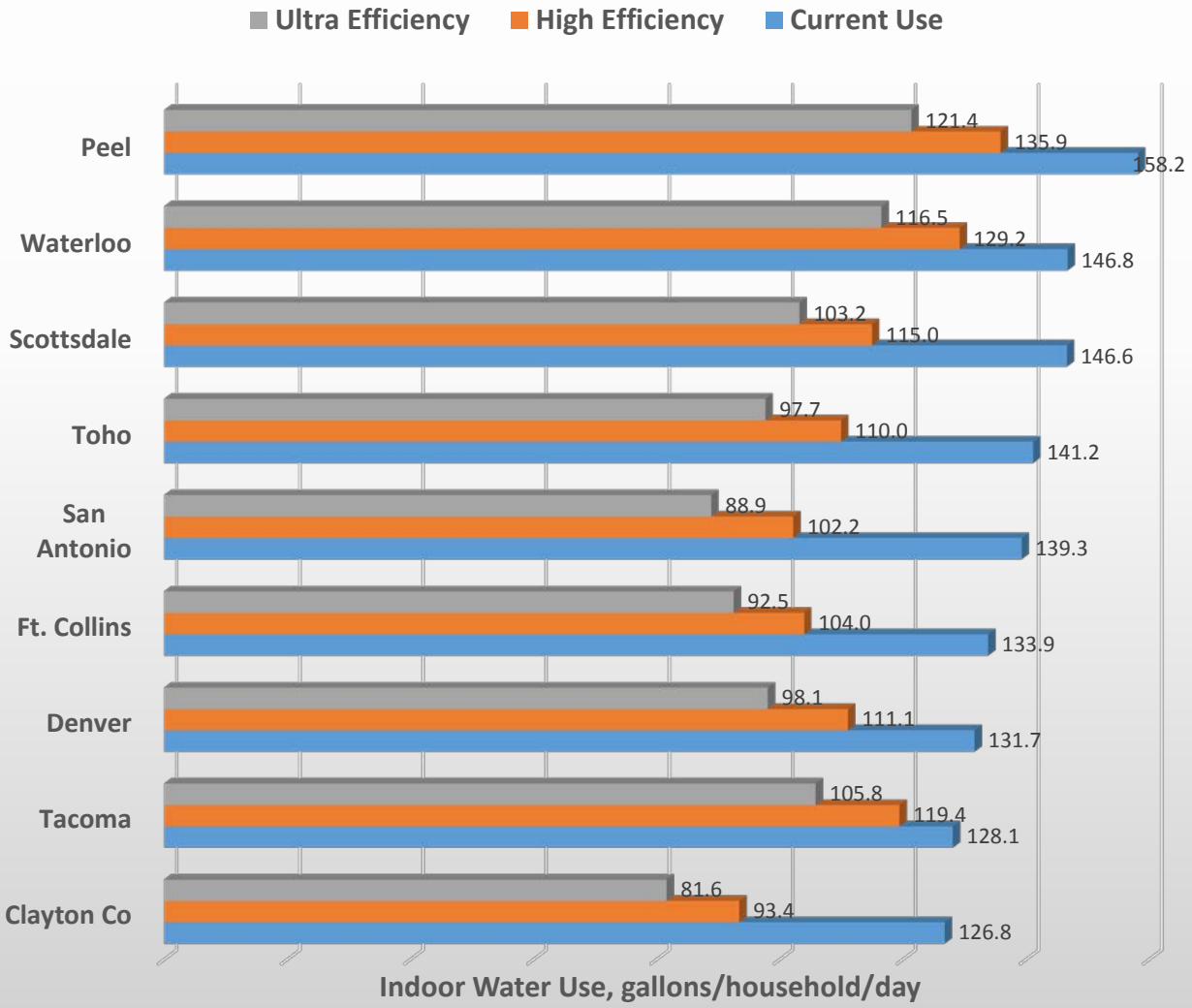
Ultra Efficiency Benchmark – Indoor GPHD

Indoor End Use	GPHD in Retrofit (adj.)	Events/ Day in REUWS2 Sample	Assumed Gallons/ Event	Ultra-Efficiency Benchmark GPHD	Difference in gallons per Day	Difference in Percent
Bathtub	4.20	0.18	23.31	4.20	0.00	0
Clothes washer	18.06	0.78	15.00	11.66	-6.41	-35.5
Dishwasher	2.02	0.26	7.79	2.02	0.00	0
Faucet	24.76	51.35	0.48	24.76	0.00	0
Leaks	12.10	117.2	0.10	12.10	0.00	0
Other	1.48	0.25	5.92	1.48	0.00	0
Shower	25.27	1.77	13.17	23.31	-1.96	-7.8
Toilet	20.22	12.90	1.28	16.51	-3.71	-18.3
Total indoor, gphd	**108.1**		--	**96.0**	-12.1	-11.2

Approximate Savings by Household Size

Sample Homes	Demand for Family of 4 (gphd)	Savings Potential relative to H.E. Homes (gphd)
REUWS1	227.5	103.3
REUWS2	166.5	42.3
High Efficiency	124.2	0

Efficiency Benchmarks are Site-Specific



Site (Persons/household)	Low Savings (gpad)	High Savings (gpad)
Clayton Co (2.84)	33.4	45.2
Tacoma (2.44)	8.7	22.3
Denver (2.37)	20.6	33.6
Ft. Collins (2.38)	29.9	41.3
San Antonio (2.53)	37.1	50.4
Toho (2.77)	31.2	43.5
Scottsdale (2.25)	31.7	43.4
Waterloo (3.15)	17.5	30.2
Peel (3.52)	22.3	36.8
Average (gpad) (2.60)	25.8	38.5
Annual (kgal/yr)	9.4	14.1

Landscape Irrigation - Theoretical Irrigation Requirement (TIR)

$$TIR = 0.624 \times ET_{O\,net} \times \sum_{i=1}^{n} \left[\frac{A_i}{Eff_i} \times K_{zi} \right]$$

Where:

0.624=	converts from inches of ET_o net (net ET_o) to gallons per square foot
ET_o net =	reference ET_o (inches) minus effective rainfall (inches)
n=	number of zones in the landscape
i=	individual zone
A_i=	area of individual zone (sf)
Eff_i =	irrigation efficiency allowance of individual zone
K_{zi}=	zone coefficient for individual zone = $k_{species}$ x k_{densit}y x $k_{microclimate}$

Landscape Irrigation – vs. TIR

Site	Total N	Below TIR Irrigators, N_d	Deficit Below TIR, %	Above TIR Irrigators, N_e	Excess Above TIR, %	Excess/ Outdoor, %
San Antonio	98	90	-64	8	48	**6**
Scottsdale	111	63	-47	46	77	**29**
Clayton Co	103	99	-87	3	15	**0.3**
Waterloo	72	67	-89	5	50	**15**
Peel	69	48	-68	21	78	**27**
Toho	90	75	-83	15	31	**10**
Tacoma	101	85	-73	16	74	**21**
Denver	95	69	-45	26	63	**17**
Ft. Collins	88	88	-68	0	0	**0.0**
ALL	838	693	-70	142	66	**16**

Benchmarks for Landscape Use

- A logical benchmark is at “zero” excess irrigation above TIR
- Irrigators applying water below TIR could be assumed “efficient” based on “minimum acceptable requirements for turf”
- Savings of 16% of outdoor use – potential savings in the combined study group
- Conservation option – water budgets for outdoor use could include only the irrigators applying more water than TIR

CONCLUSIONS

- Alternative methods/criteria can be used to derive benchmarks – but it's difficult to arrive at plausible assumptions
- Benchmark usage rates (in GPHD) and potential conservation savings differ by study site (different persons/household + other factors)
- Savings in outdoor use depend on actual irrigation rates relative to theoretical irrigation requirement (TIR)