2/3/2017

Guidance Document for Water Budget Calculation

Table of Contents

1. Purpose and Applicability

1.1. Purpose

The primary purpose of this document is to provide procedural and design guidelines for estimating water budget for human occupied buildings. Document enlists all the possible indoor and outdoor usage rates necessary to calculate total water demand for a building. The goal of the water budget is to show the home/facility owner how much water is used in the building.

1.2. Applicability

The enlisted guidelines can be applicable to various buildings for estimating water budget. Some example showing the applicability of this document are provided in Table 1.

Table 1. Guidance document applicability

Building Types	Applicability
General Office building	✓
Shopping Mall	✓
Hostels	✓
Warehouses	✓
Schools	✓
Nuclear Plants	×
Libraries	✓
Hospitals	×

2. General Guidelines

A suitable building (enlisted in Table-1.2) should be selected with following known basic parameters.

- Number of occupants in the building
- Flow rates and average daily use of the fixtures
- Type of Grass laid in the lawns
- Lawn Area
- Weather Conditions of the area

First, calculate indoor and outdoor water demands, then incorporate amount of rain water available for reuse in your calculation and then estimate net water budget for the building using table 6.4.

3. Indoor Water Budget Calculation

The indoor budget is calculated using three factors:

- Flowrates of the fixtures installed in the building
- The average daily usage rate of the fixtures
- The number of people in the household

Generally, flowrates can be found in the fixture description manual/literature or obtained from the builder. The average daily usage rates are estimated numbers of use of that fixture per day. And number of people occupying the building can be obtained from facility managing authorities.

Table-2 presents different types of indoor usages and their average rates. Formula used for calculating net indoor demand is also given below.

Indoor Water Demand per Capita (gpd/capita) = (Flow Rate x Duration x Ave Daily Use)

Indoor Water Demand (gpd) = Indoor Water Demand per Capita (gpd/capita) x No. of Occupants

Table 2. Indoor water demand calculation

Usage Types (Daily Use)	Flow Rate	Unit	Duration (4)	Unit	Ave Daily Use (4)	Indoor Water Demand (gpd/capita)
Showerhead (1)	2	gpm	8.2	min	0.65	10.66
Bathroom Faucet (2)	1.3	gpm	1.5	min	1.00	1.95
Bath (2)	25	gal/bath	1	bath	0.10	2.50
Washing Machine (3)	36.9	gal/cycle	1		0.31	11.44
Urinals	0.5	gpf	1	flush	1.74	0.87
Toilet (Water Closet) (1)	1.28	gpf	1	flush	4.75	6.08
Kitchen Faucet (1)	1.8	gpm	7.82	min	1.00	14.08
Drinking Use	0.5	gpd	1		1.00	0.50
Dishwasher (3)	11.15	gal/cycle	1		0.04	0.45
TOTAL						**48.52**

Notes:
(1) Flow rate based on maximum flow rate prescribed by 2011 SF Green Building Requirements (Table 13C.5.303.2.3).
(2) Flow rate from SFPUC 2011 Urban Water Management Plan (UWMP) Retail Demand Model for New Multi-Family Residential Water Use.
(3) Flow rate based on 2010 rate used in the 2010 UWMP Conservation Model.
(4) Flow rate from SFPUC 2010 Urban Water Management Plan (UWMP) Retail Demand Model for New Multi-Family Residential Water Use.
Ave Daily Use for faucets are represented by total average usage per person per day (min/person/day)

4. Outdoor Water Budget Calculation

The outdoor budget is calculated using three factors:

- Daily localized weather data
- Irrigated area
- Grass type factor

The calculation method given in this manual is for lawn (sunny turf) areas only. Soil type can also affect water demand. If no lawn is present and there is a maintained landscape, use water

requirements provided by the nursery or landscape designer. This method presented here is SLIDE (Simplified Landscape Irrigation Demand Estimation) equation method, which will give a general indication of outdoor demand only.

The basic SLIDE equation uses only the Plant Factors, given in Table 3 to adjust reference ET and follows simple calculations to produce an estimate of the water required by a landscape area for a given period. The basic SLIDE equation is:

Landscape Water Demand (gal.) = ETo × PF × LA × 0.623

where,

- ETo is inches of historical average or real-time reference evapotranspiration data in inches for the period of interest.
- PF is the Plant Factor from Table 3.
- LA is the landscape area, in square feet.
- 0.623 is the factor to convert inches of water to gallons; omit this factor if the estimated water demand is desired in inches.

Table 3. Plant factor values for outdoor water demand calculations

Plant Type	Plant Factor
Tree, Shrubs, Vines, Groundcovers (woody plants)	0.5
Herbaceous Perennials	0.5
Desert Adapted Plants	0.3
Annual Flowers & Bedding Plants	0.8
General Turfgrass Lawns, cool-season (tall fescue, Ky. bluegrass, rye, bent)	0.8
General Turfgrass Lawns, warm-season (bermuda, zoysia, St, Augustine, buffalo)	0.6
Home Fruit Crops, Deciduous	0.8
Home Fruit Crops, Evergreen	1
Home Vegetable Crops	1
Mixed Plantings	*PF of the planting is that of the plant type present with the highest PF*

5. Precipitation Calculation

These calculations are only necessary for buildings furnished to store and reuse rainwater. Following steps should be followed in order to estimate for rainwater harvesting for a building

- Calculate daily precipitation falling on the building
- Calculate the daily evaporation losses or initial abstraction and apply runoff co-efficient
- Calculate the net rainfall falling on the building
- Multiply the net rainfall with the roof area of the building to get net volume of water available

- Based on the design of harvesting technology, this amount can be used for indoor or outdoor reuse.

6. *Case Study (Boys Hostel at Mehran University of Engineering and Technology, Jamshoro)*

This section estimate step by step water budget for hostel facility at Boys Hostel at Mehran University of Engineering and Technology, Jamshoro.

6.1. Indoor Water Budget Calculations for MUET Hostel

- First, we will get total number of students living at the hostel facility i.e. 167 students.
- Then we need to check fixture flow rates, if rates are not compatible with table 2, we need to update this table.
- Finally, we will add number of students and multiply them with total consumption rates to get net water demand.

Table 4. Indoor water demand calculation for Jatoi Hostel, MUET Jamshoro

Fixture Type (Daily Use)	Flow Rate	Unit	Duration	Unit	Ave Daily Use	Water Demand (gpd/person)	No. of occupants/ Students	Net Indoor Demand (gpd)
Showerhead	2	gpm	8.2	min	0.65	10.66	200	1780
Bathroom Faucet	1.3	gpm	1.5	min	1	1.95	200	325
Bath	25	gal/bath	1	bath	0.1	2.50	200	417
Washing Machine	36.9	gal/cycle	1		0.31	11.44	200	1910
Urinals	0.5	gpf	1	flush	1.74	0.87	200	145
Toilet	1.28	gpf	1	flush	4.75	6.08	200	1015
Kitchen Faucet	1.8	gpm	7.82	min	1	14.08	200	2350
Drinking Use	0.5	gpd	1		1	0.50	200	83
Dishwasher	11.15	gal/cycle	1		0.04	0.45	200	74
TOTAL						**48.52**		**8,103**

- Graph of net indoor daily demand is attached in appendix II as Figure A1.
- From net indoor water demand per day, we can estimate monthly demand by multiplying number of days of that month. Similarly, we can easily convert monthly demand into annual demand.
- A bar chart showing net indoor monthly demand is attached in appendix II as Figure A2.

Table 5. Monthly indoor demand variation in Jatoi Hostel

Months	Net Indoor Monthly Demand (gpm)
January	251,193
February	226,884
March	251,193
April	243,090
May	251,193
June	243,090
July	251,193
August	251,193
September	243,090
October	251,193
November	243,090
December	251,193
TOTAL	**2,957,598**

6.2. Outdoor Water Budget Calculations for MUET Hostel

For outdoor water budget, we will use following equation.

Landscape Water Demand (gal.) = ETo × PF × LA × 0.623

where,

- ETo is inches of historical average evapotranspiration in inches for the period of interest. For this case, monthly average ET value are available and given in the table 6.2.
- PF is the Plant Factor from Table 3. In this case, PF = 0.6 for General Lawn Turf grass, warm season.
- LA is the landscape area, in square feet. In this case, LA = 25,000 sq. ft
- 0.623 is the factor to convert inches of water to gallons; omit this factor if the estimated water demand is desired in inches

Graph representing monthly outdoor demand is attached in appendix II as Figure A3.

Table 6. Monthly outdoor water requirement for Jatoi Hostel

Months	Monthly Average ET Estimates (inches)	Plant Factor	Landscape Area (sq.ft)	Landscape/Outdoor Water Demand (gmpl)
January	0.31	0.6	25,000	2,897
February	0.49	0.6	25,000	4,579
March	1.17	0.6	25,000	10,934
April	2.21	0.6	25,000	20,652
May	3.58	0.6	25,000	33,455
June	4.05	0.6	25,000	37,847
July	4.45	0.6	25,000	41,585
August	3.8	0.6	25,000	35,511
September	2.47	0.6	25,000	23,082
October	1.37	0.6	25,000	12,803
November	0.57	0.6	25,000	5,327
December	0.3	0.6	25,000	2,804
Total Yearly Demand				**231,476**

6.3. Precipitation Calculations for MUET Hostel

For this part, it is assumed that hostel building has ability to temporary store rain water and then use it for outdoor demand only. The formula used in this scenario is

Net volume of water available (gal) = (Rainfall – losses) inches/12 feet * Runoff Coefficient*Roof area in sq.ft*7.48

- In our case, monthly rainfall data is available, as shown in second column of table 7
- Runoff co-efficient in our case is 0.95 (based on roof type)
- Building area in our case is 20,000 sq.ft

Table 7. Annual rainwater harvesting potential

Months	Monthly Average Precipitation (inches)	Runoff Co-efficient	Building Area (sq.ft)	Net Available Rain Water (gal)
January	0.02	0.95	20,000	189
February	0.02	0.95	20,000	189
March	0.00	0.95	20,000	0
April	0.00	0.95	20,000	0
May	0.00	0.95	20,000	0
June	2.81	0.95	20,000	33,303
July	0.59	0.95	20,000	7,011
August	1.50	0.95	20,000	17,812
September	0.66	0.95	20,000	7,817
October	0.00	0.95	20,000	0
November	0.10	0.95	20,000	1,232
December	0.00	0.95	20,000	0
Total Yearly Demand				**67,554**

In above table, months where monthly average losses are greater than monthly average precipitation values, net effective precipitation is taken as zero.

6.4. Overall Water Demand for MUET Hostel

The overall summary of monthly water demand for MUET hostel is given in the below table. A combo graph representing water budget summary is also given in the appendix II section as figure A4.

Net Water Demand = Indoor Demand + Outdoor Demand – Available Rain Water

Table 8. Net water demand calculation for Jatoi Hostel

Months	Net Indoor Monthly Demand (gal)	Landscape Water Demand (gal)	Available Rain Water for reuse (gal)	Net Water Demand (gal)
January	251,193	2,897	189	253,901
February	226,884	4,579	189	231,274
March	251,193	10,934	0	262,127
April	243,090	20,652	0	263,743
May	251,193	33,455	0	284,648
June	243,090	37,847	33,303	247,634
July	251,193	41,585	7,011	285,767
August	251,193	35,511	17,812	268,892
September	243,090	23,082	7,817	258,356
October	251,193	12,803	0	263,996
November	243,090	5,327	1,232	247,185
December	251,193	2,804	0	253,997
Yearly Demand	**2,957,598**	**231,476**	**67,554**	**3,121,519**

Appendix II

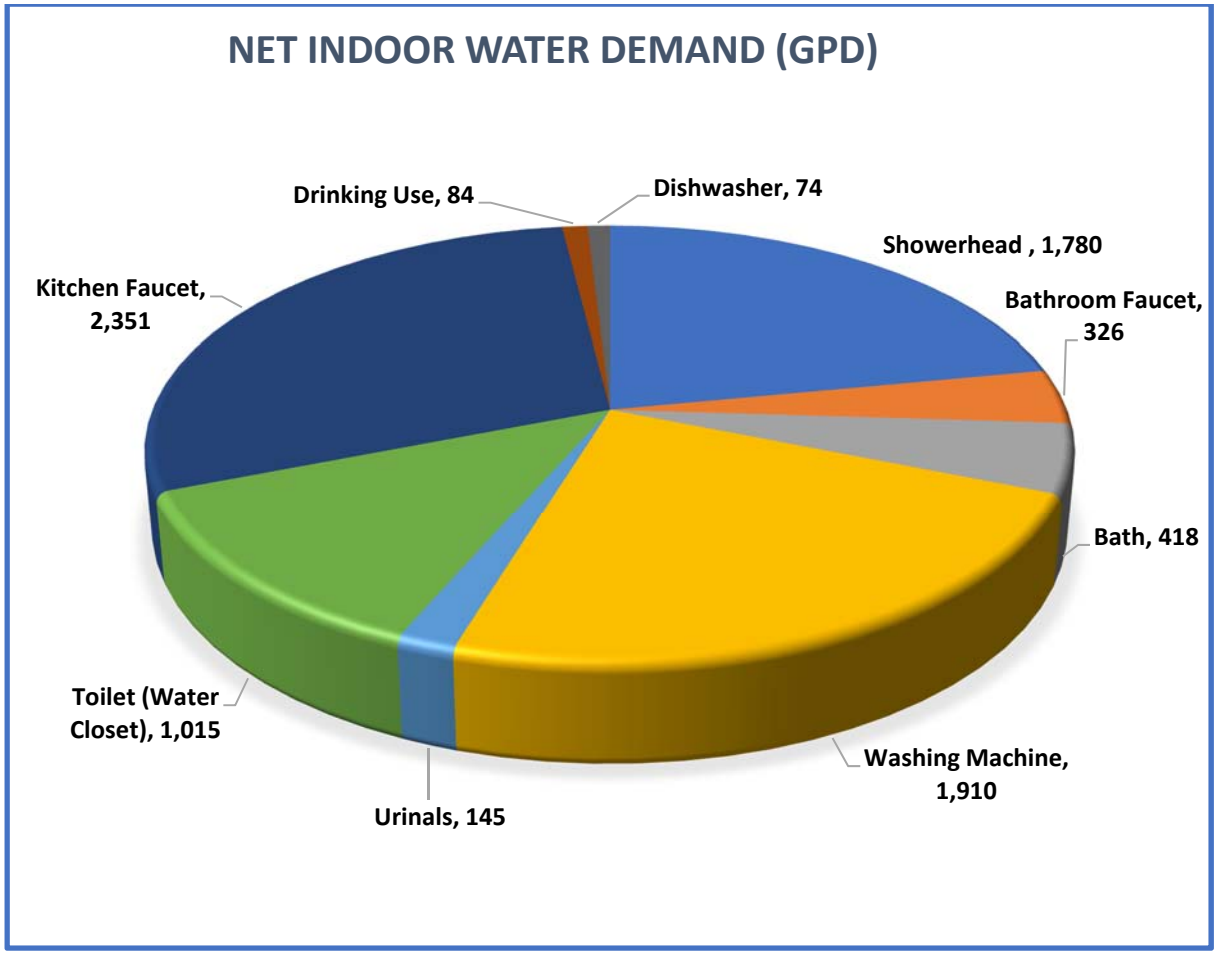

Figure A1. Net indoor water demand for various uses

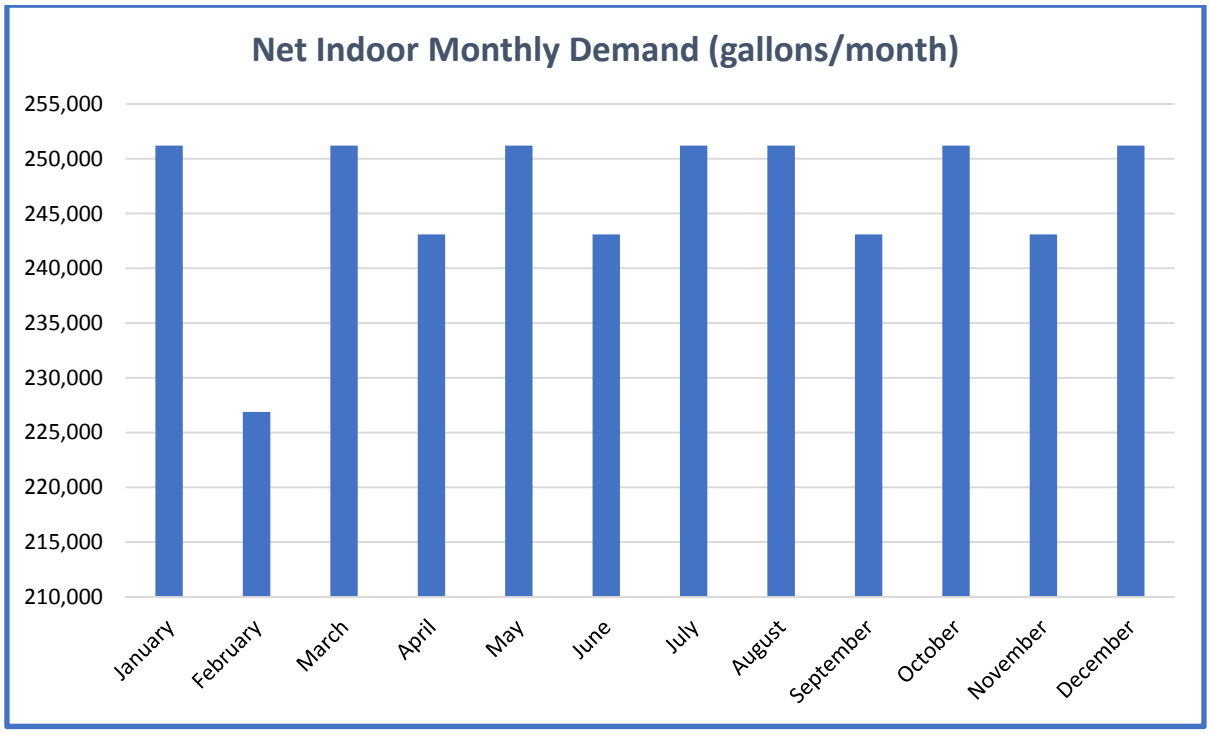

Figure A2. Monthly indoor water demand variation

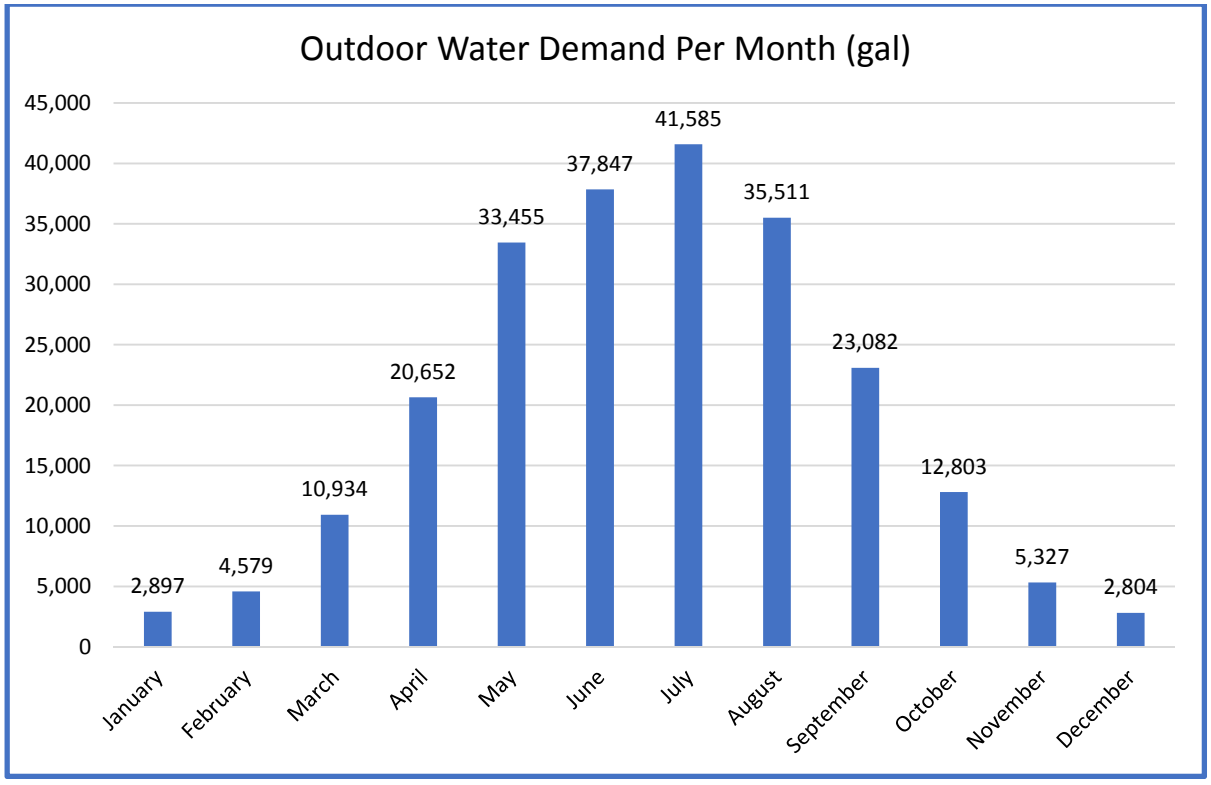

Figure A3. Monthly outdoor water demand variation

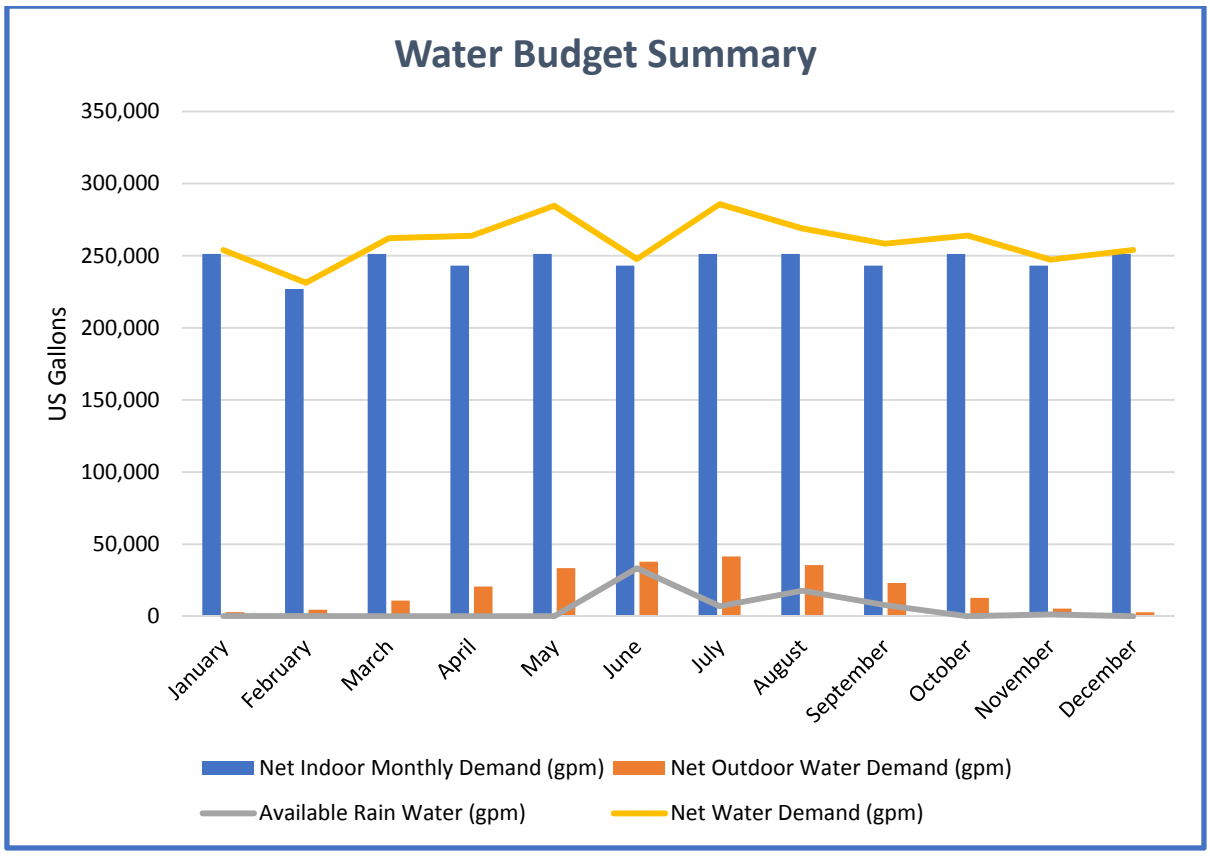

Figure A4. Water budget results