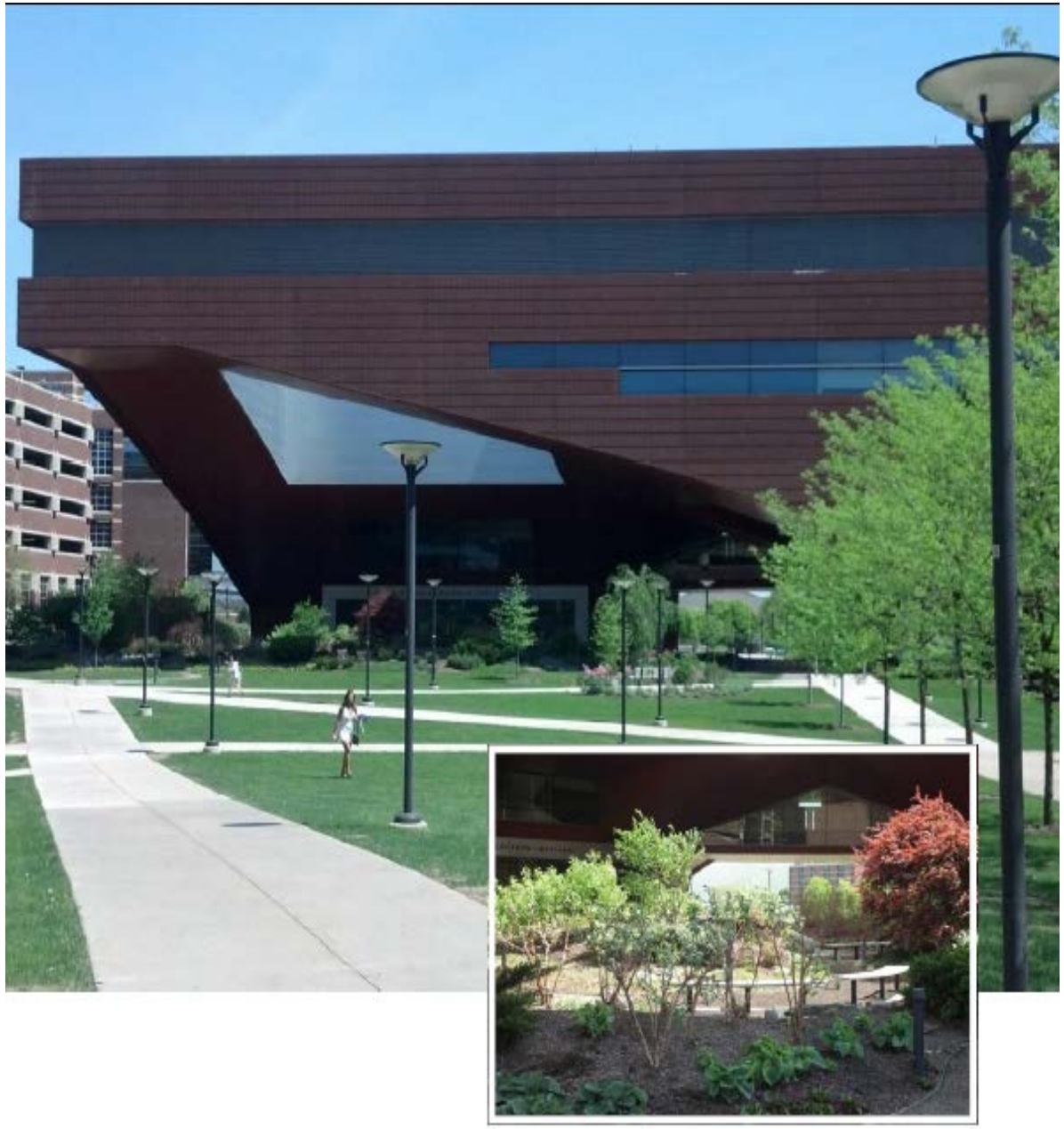


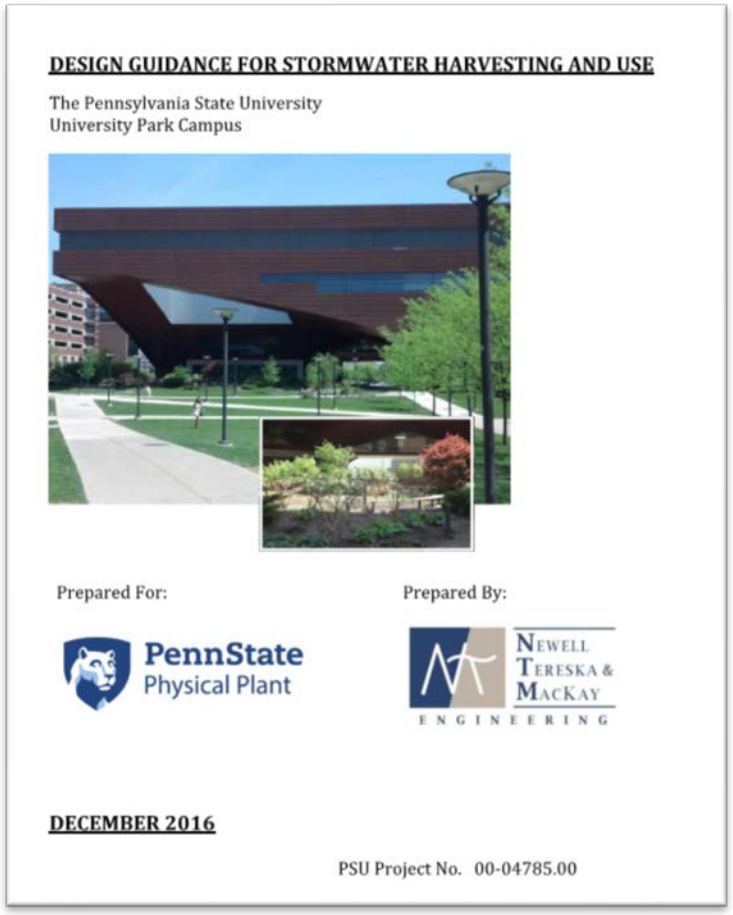
NEWELL TERESKA & MACKAY ENGINEERING

GUIDELINES FOR STORMWATER HARVESTING AND USE

A GUIDANCE DOCUMENT FOR CAMPUS BUILDING PROJECTS AT THE PENNSYLVANIA STATE UNIVERSITY

Scott Brown, PE, D.WRE
Paul DeBarry, PE, PH, GISP, D.WRE

GOAL AND OBJECTIVES


DESIGN GUIDANCE FOR STORMWATER HARVESTING AND USE

The Pennsylvania State University
University Park Campus

Prepared For:

PennState Physical Plant

Prepared By:

Newell Tereska & MacKay ENGINEERING

DECEMBER 2016

PSU Project No. 00-04785.00

https://wikispaces.psu.edu/download/attachments/357077532/SW%20Harvesting%20and%20Use%20Final%20Report%202016-12-02.pdf?api=v2

- **Goal: To bring consistency to the analysis, design, and component specifications for Penn State Stormwater Harvesting and Use Systems.**
- **Objectives:**
  - Research State of Practice
  - Develop a Design Guidance Document for Designers
  - Create Stormwater Use Calculator
  - Outline Process for Assessing Stormwater Harvesting and Use Opportunities
  - Test Procedure on Three Sample Projects

GUIDANCE DOCUMENT OVERVIEW

Source: https://cmlandscapeweb.com/a/2018/02/cm-landscape-irrigation-installation-portland.jpg

Source: http://gardenhoseadviser.com/wp-content/uploads/2017/06/Best-Drip-Irrigation-System-mulch.jpg

- PSU Primary Stormwater Use Opportunities
  - Landscape irrigation
  - Graywater (toilet flushing)

Source: https://c8.alamy.com/comp/a5ye20/man-flushing-toilet-usa-a5ye20.jpg

EXISTING UNIVERSITY HARVESTING AND USE SYSTEMS

- Millennium Science Complex (University Park Campus)
  - 10,000-gallon cistern for planting bed irrigation; planting bed is under building overhang
  - System frequently runs dry; relies heavily on back-up supplemental potable water
- Biobehavioral Health Building (University Park Campus)
  - 12,000-gallon cistern for green roof irrigation
  - System currently functioning as designed. Clover loves this roof

EXISTING UNIVERSITY HARVESTING AND USE SYSTEMS (2015)

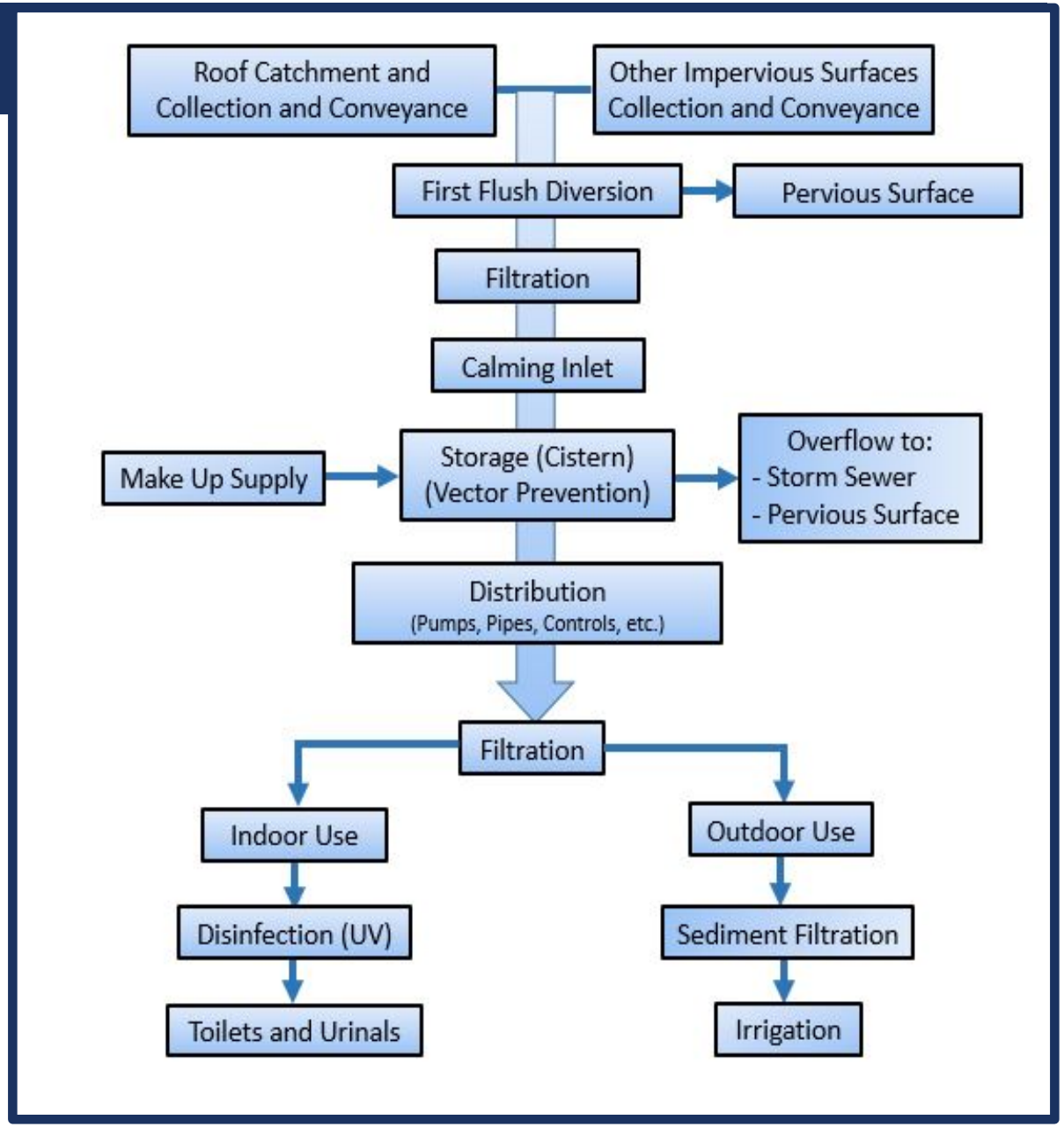
http://www.alexanderbuilding.com/images/LEED_gaige.jpg

- Gaige Technology and Business Innovation Building (Berks Campus)
  - 34,000-gallon cistern supplying 25 toilets and 8 urinals
  - System functioning well with excess supply. System could have served additional facilities

- Child Care Center at Hort Woods
  - 6,000-gallon cistern used to supply graywater for toilet flushing
  - Maintenance costs have been reported to be high

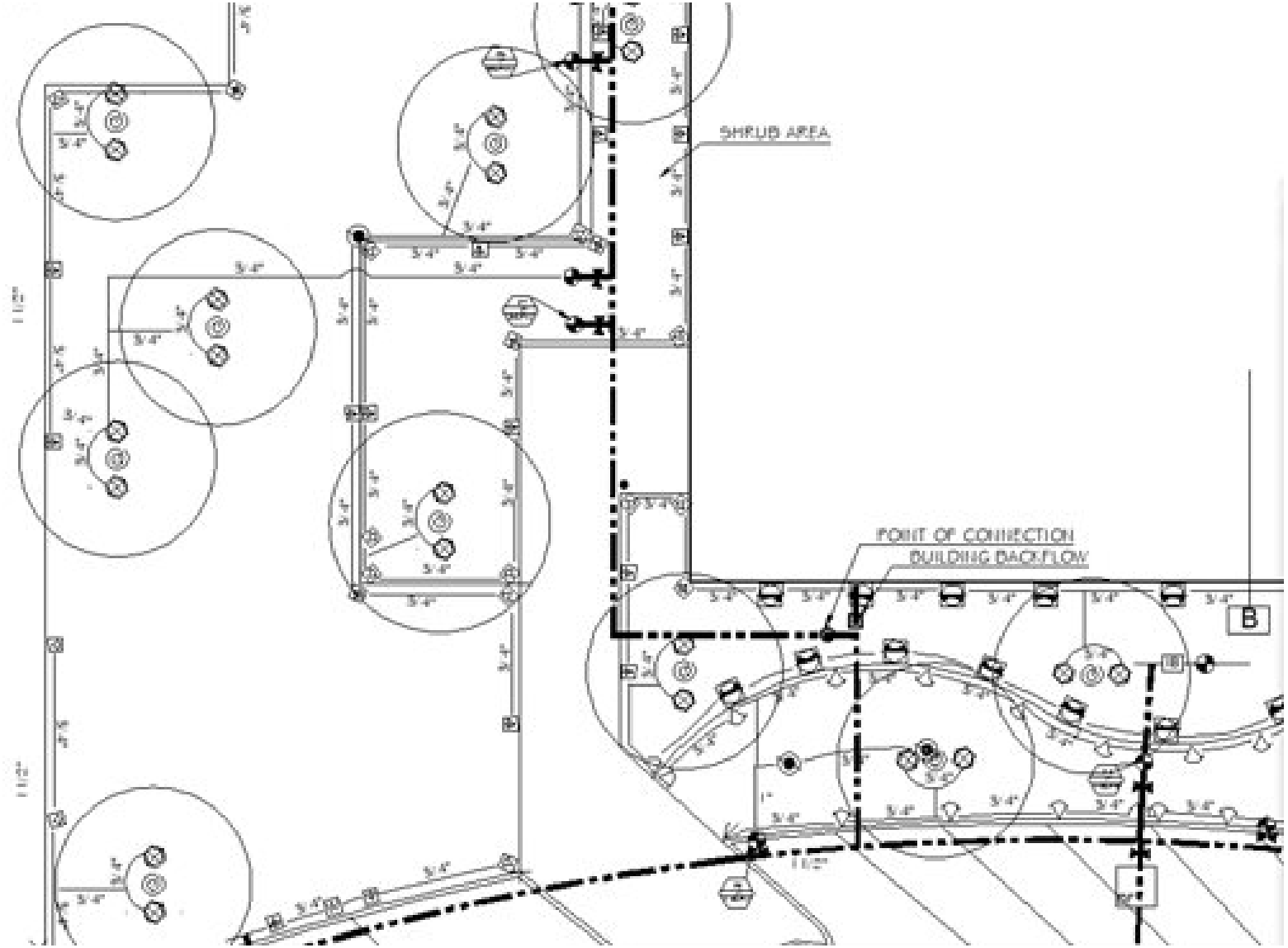
SYSTEM COMPONENTS

- Catchment and Collection (harvesting)
- Pre-treatment and Filtration
- Storage
- Treatment and Disinfection
- Pumps and Controls
- Distribution

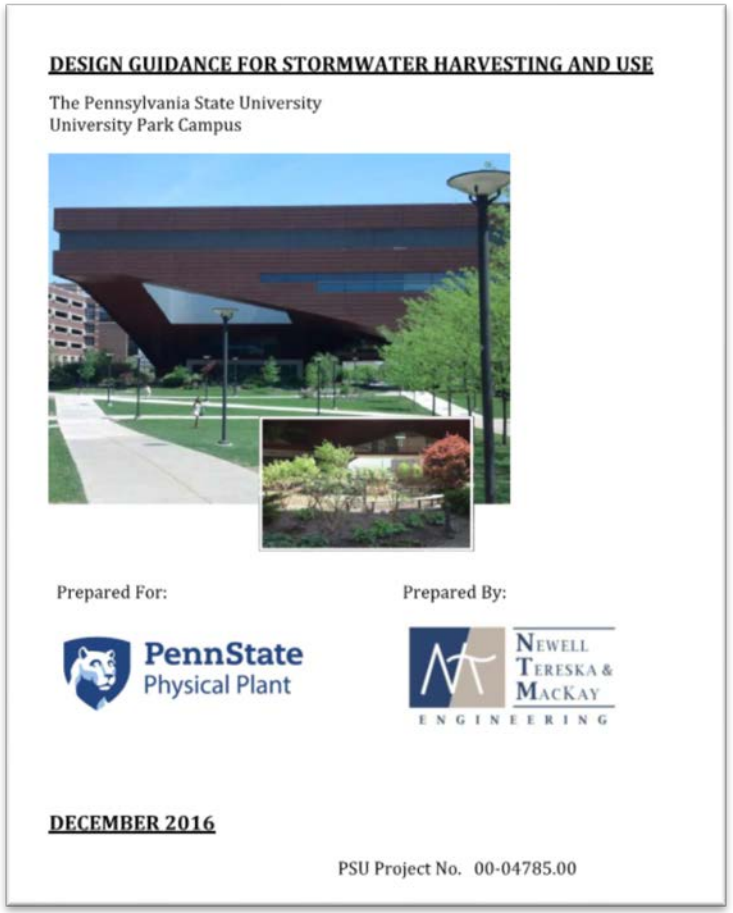


DESIGN GUIDANCE

- Guidelines specific to PSU campuses
- Identifies system components, their function and application, and advantages and disadvantages
- Outlines the design approach and provides design guidelines and plan requirements
- Encourages maximizing educational opportunities
- Identifies operation and maintenance considerations for system components
- Includes cost considerations



TO GET A COPY



Google "Penn State OPP Stormwater Harvesting"

OR

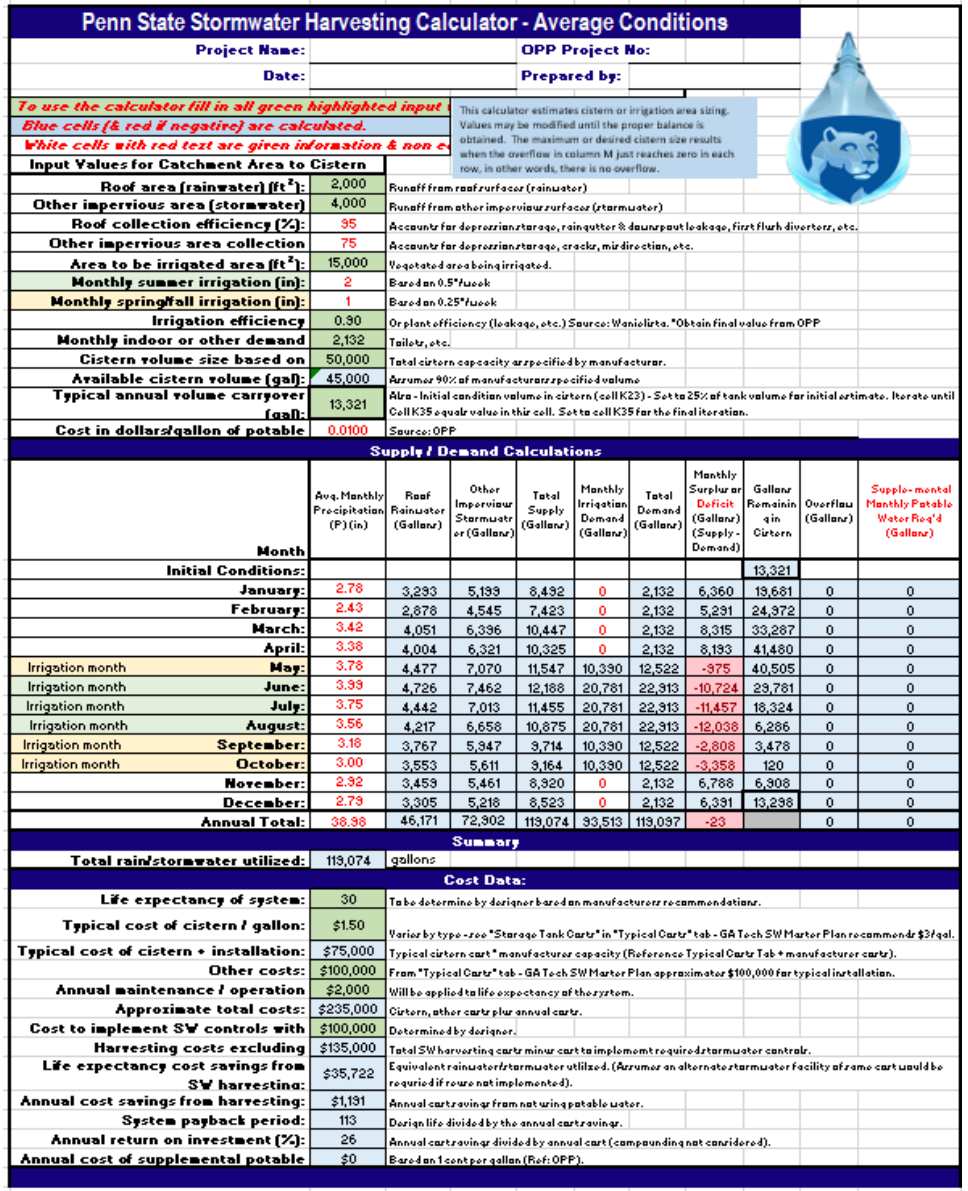
https://opp.psu.edu

Planning/Design/Construction

- **Design and Construction Standards**
  - **Division 33 – Utilities**
    - **3 40 00 Storm Drainage Utilities**
      - **Under related files click on Harvesting and Use Final Rpt.**

OR

https://wikispaces.psu.edu/download/attachments/357077532/SW%20Harvesting%20and%20Use%20Final%20Report%202016-12-02.pdf?api=v2



Penn State Stormwater Harvesting Calculator - Average Conditions

Project Name:		**OPP Project No:**	
Date:		**Prepared by:**	

To use the calculator fill in all green highlighted input
Blue cells (& red if negative) are calculated.
White cells with red text are given information & non e

This calculator estimates cistern or irrigation area sizing. Values may be modified until the proper balance is obtained. The maximum or desired cistern size results when the overflow in column M just reaches zero in each row, in other words, there is no overflow.

Input Values for Catchment Area to Cistern		
Roof area (rainwater) (ft²):	2,000	Runoff from roof surfaces (rainwater)
Other impervious area (stormwater)	4,000	Runoff from other impervious surfaces (stormwater)
Roof collection efficiency (%):	95	Accounts for depression storage, rain gutter & downspout leakage, first flush diverters, etc.
Other impervious area collection	75	Accounts for depression storage, cracks, misdirection, etc.
Area to be irrigated area (ft²):	15,000	Vegetated area being irrigated.
Monthly summer irrigation (in):	2	Based on 0.5"/week
Monthly spring/fall irrigation (in):	1	Based on 0.25"/week
Irrigation efficiency	0.90	Or plant efficiency (leakage, etc.) Source: Waniel ista. *Obtain final value from OPP
Monthly indoor or other demand	2,132	Toilets, etc.
Cistern volume size based on	50,000	Total cistern capacity as specified by manufacturer.
Available cistern volume (gal):	45,000	Assumes 90% of manufacturers specified volume
Typical annual volume carryover (gal):	13,321	Also - Initial condition volume in cistern (cell K23) - Set to 25% of tank volume for initial estimate. Iterate until Cell K35 equals value in this cell. Set to cell K35 for the final iteration.
Cost in dollars/gallon of potable	0.0100	Source: OPP

Supply / Demand Calculations

Month	Avg. Monthly Precipitation (P) (in)	Roof Rainwater (Gallons)	Other Impervious Stormwater (Gallons)	Total Supply (Gallons)	Monthly Irrigation Demand (Gallons)	Total Demand (Gallons)	Monthly Surplus or Deficit (Gallons) (Supply - Demand)	Gallons Remaining in Cistern	Overflow (Gallons)	Supplemental Monthly Potable Water Req'd (Gallons)
Initial Conditions:								13,321		
January:	2.78	3,233	5,199	8,432	0	2,132	6,360	19,681	0	0
February:	2.43	2,878	4,545	7,423	0	2,132	5,291	24,372	0	0
March:	3.42	4,051	6,396	10,447	0	2,132	8,315	33,287	0	0
April:	3.38	4,004	6,321	10,325	0	2,132	8,193	41,480	0	0
Irrigation month May:	3.78	4,477	7,070	11,547	10,390	12,522	-975	40,505	0	0
Irrigation month June:	3.33	4,726	7,462	12,188	20,781	22,313	-10,724	29,781	0	0
Irrigation month July:	3.75	4,442	7,013	11,455	20,781	22,313	-11,457	18,324	0	0
Irrigation month August:	3.56	4,217	6,656	10,875	20,781	22,313	-12,038	6,286	0	0
Irrigation month September:	3.18	3,767	5,947	3,714	10,390	12,522	-2,808	3,478	0	0
Irrigation month October:	3.00	3,553	5,611	3,164	10,390	12,522	-3,358	120	0	0
November:	2.32	3,459	5,461	8,920	0	2,132	6,788	6,908	0	0
December:	2.79	3,305	5,218	8,523	0	2,132	6,391	13,298	0	0
Annual Total:	38.98	46,171	72,902	119,074	93,513	119,097	-23		0	0

Summary

Total rain/stormwater utilized:	119,074	gallons

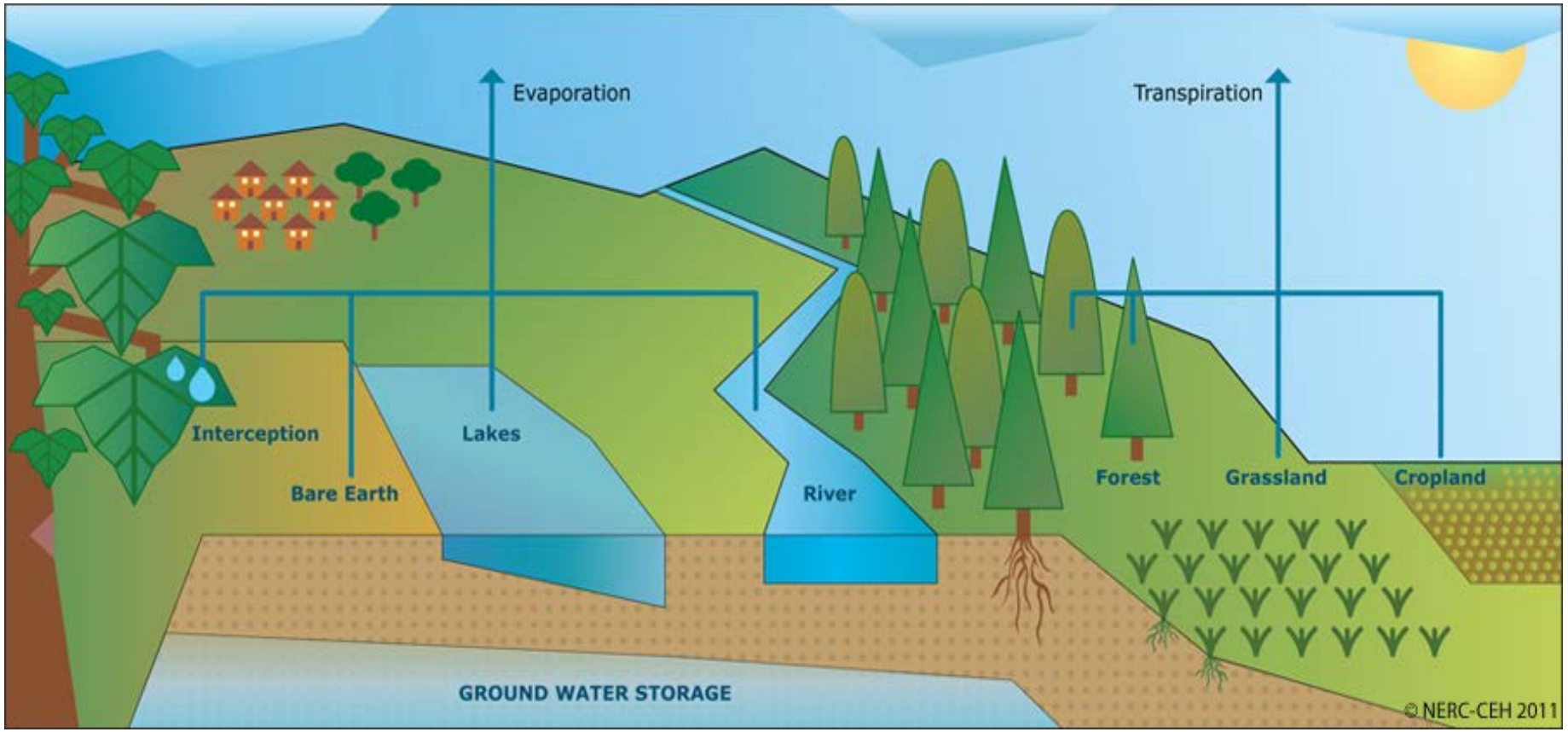
Cost Data:

Life expectancy of system:	30	To be determined by designer based on manufacturers recommendations.
Typical cost of cistern / gallon:	$1.50	Varies by type - see "Storage Tank Costs" in "Typical Costs" tab - GA Tech SW Master Plan recommends $3/gal.
Typical cost of cistern + installation:	$75,000	Typical cistern cost * manufacturer capacity (Reference Typical Costs Tab + manufacturer costs).
Other costs:	$100,000	From "Typical Costs" tab - GA Tech SW Master Plan approximates $100,000 for typical installation.
Annual maintenance / operation	$2,000	Will be applied to life expectancy of the system.
Approximate total costs:	$235,000	Cistern, other costs plus annual costs.
Cost to implement SW controls with	$100,000	Determined by designer.
Harvesting costs excluding	$135,000	Total SW harvesting costs minus cost to implement required stormwater controls.
Life expectancy cost savings from SW harvesting:	$35,722	Equivalent rainwater/stormwater utilized. (Assumes an alternate stormwater facility of same cost would be required if reuse not implemented).
Annual cost savings from harvesting:	$1,191	Annual cost savings from not using potable water.
System payback period:	113	Design life divided by the annual cost savings.
Annual return on investment (%):	26	Annual cost savings divided by annual cost (compounding not considered).
Annual cost of supplemental potable	$0	Based on 1 cent per gallon (Ref: OPP).

WATER HARVESTING CALCULATOR

WATER HARVESTING CALCULATOR

$$P = RO + ET + Use + \Delta S$$



Source: https://www.mckeanweather.com/mwevap.php

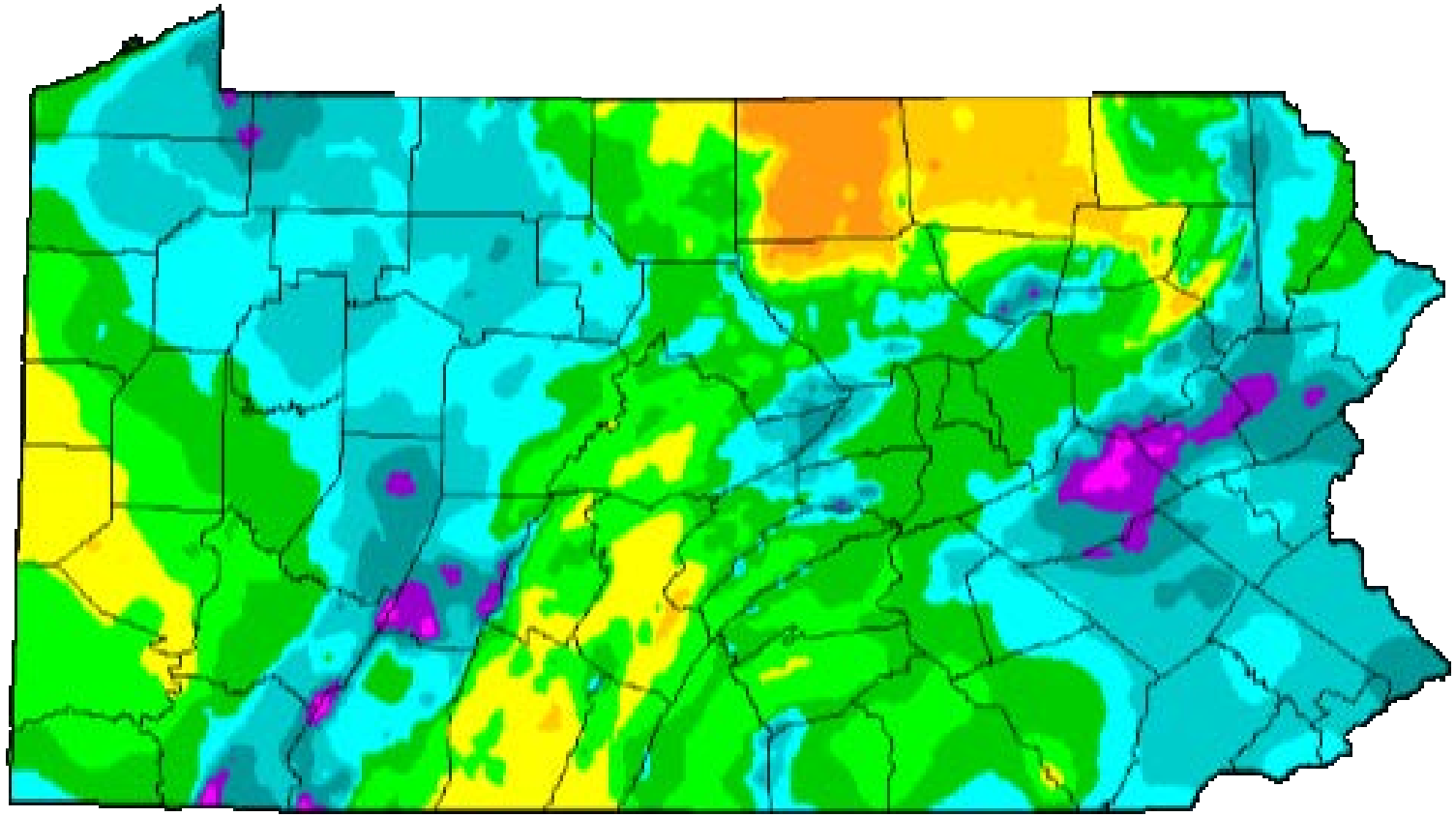
Other input:

- Roof Area
- Other Impervious
- Collection Efficiency
- Area to be Irrigated
- Irrigation Efficiency
- Water Use/Demand
- Cistern size
- Cost

WATER HARVESTING CALCULATOR - PRECIPITATION

P = Precipitation

- **Daily** rainfall records for State College dating back to January 1, 1896 obtained
- Therefore, average daily, weekly, or monthly rainfall averages could be determined

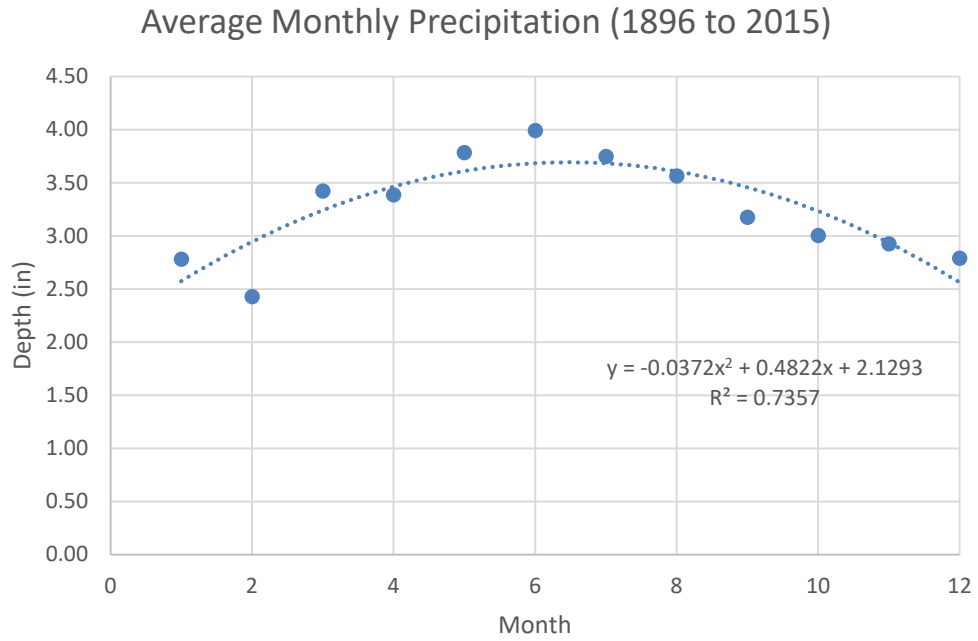


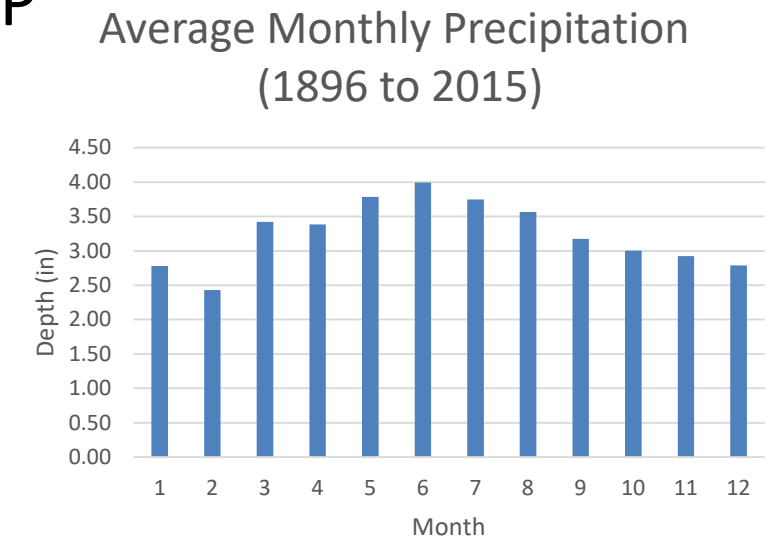
Average Annual Precipitation

WATER HARVESTING CALCULATOR - PRECIPITATION

Monthly Data

- University Weather Station rain gage show that the average annual rainfall in State College is ~39 inches per year
- Lowest average monthly total P occurs in February (2.43 in)
- Highest average monthly total P occurs in June (3.99 in)
- R^2 = .7357



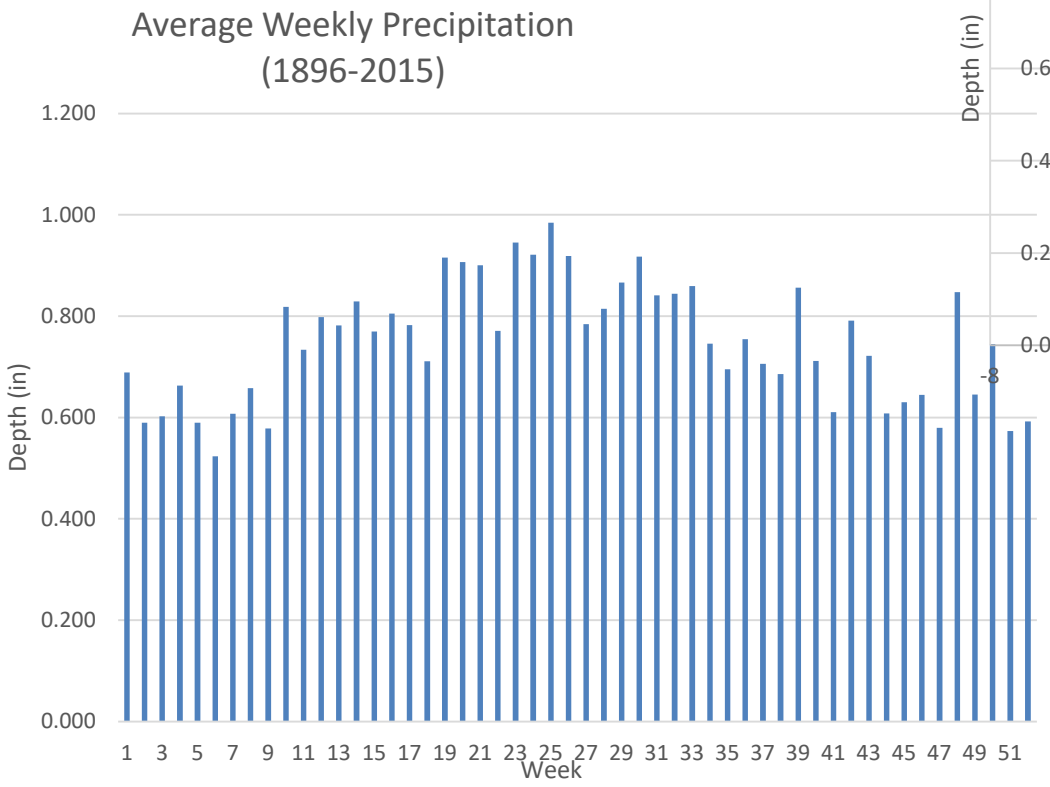


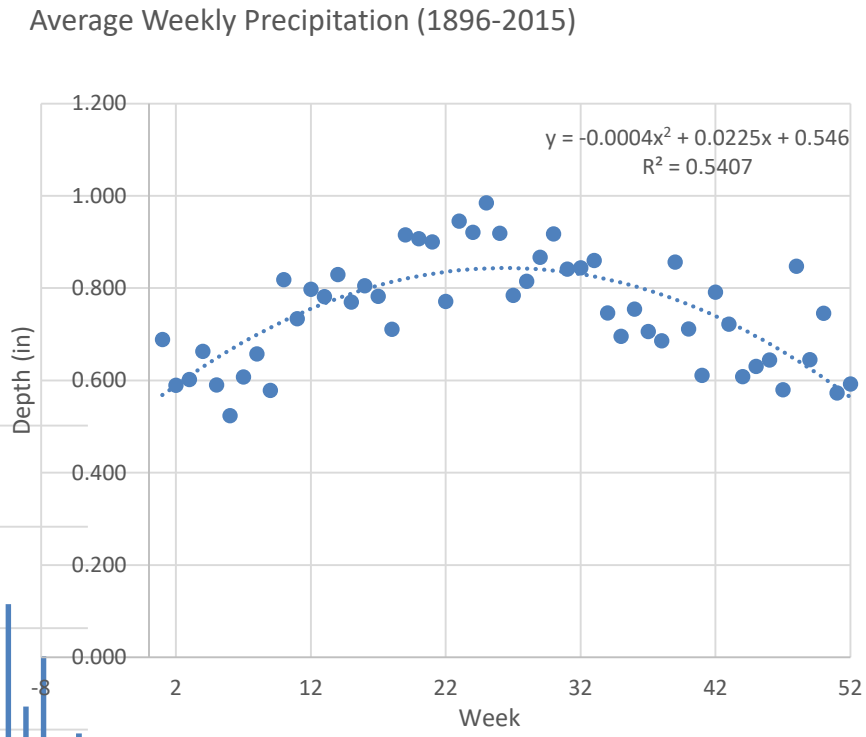
Month	Mo	Average Precipitation
January	1	2.78
February	2	2.43
March	3	3.42
April	4	3.38
May	5	3.78
June	6	3.99
July	7	3.75
August	8	3.56
September	9	3.18
October	10	3.00
November	11	2.92
December	12	2.79
Total		**38.99**

WATER HARVESTING CALCULATOR - PRECIPITATION

Weekly Data

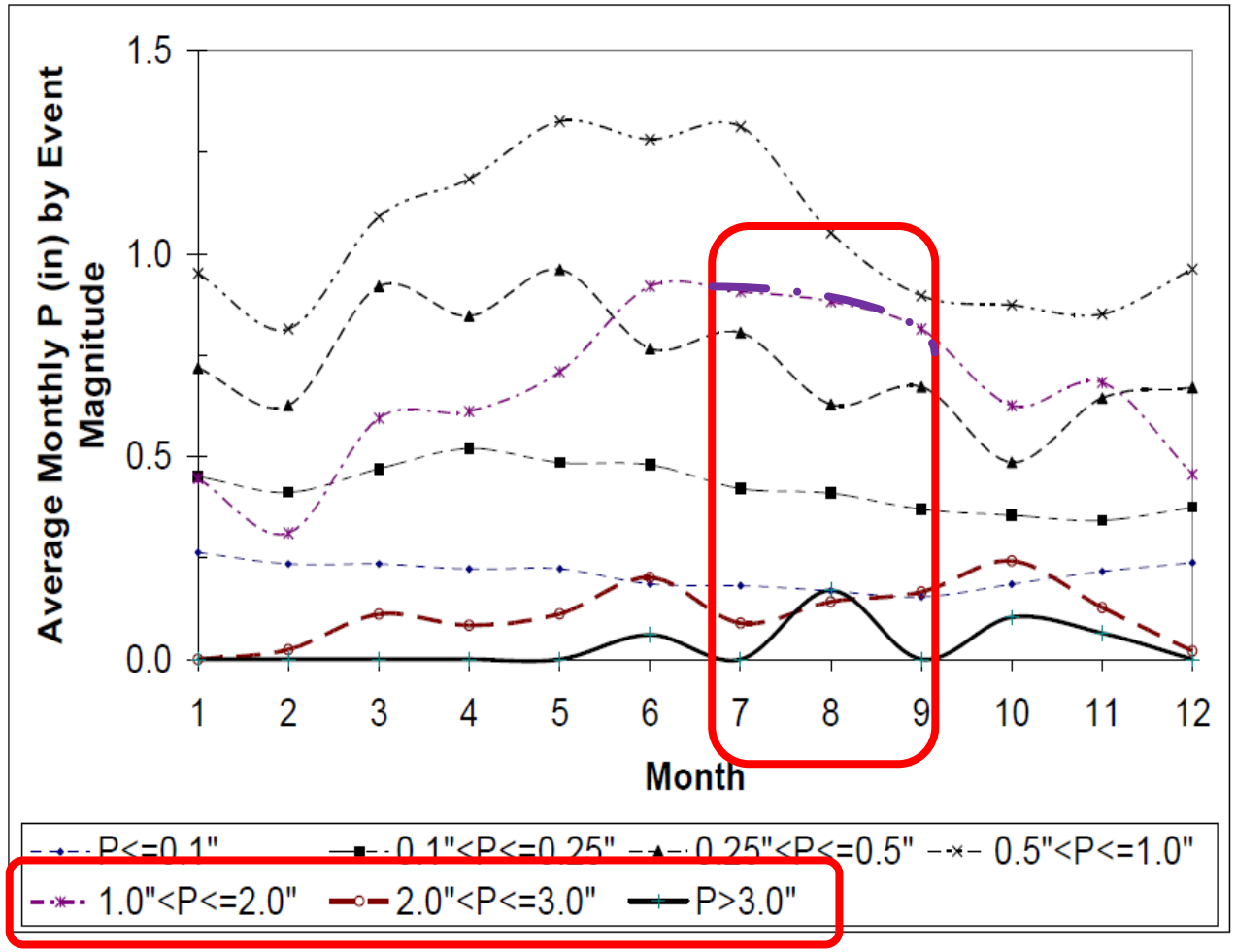
- Generally same pattern as monthly data
- Extreme events will have more of an influence on the results on a weekly basis
- R^2 = .5407





WATER HARVESTING CALCULATOR - PRECIPITATION

Challenges



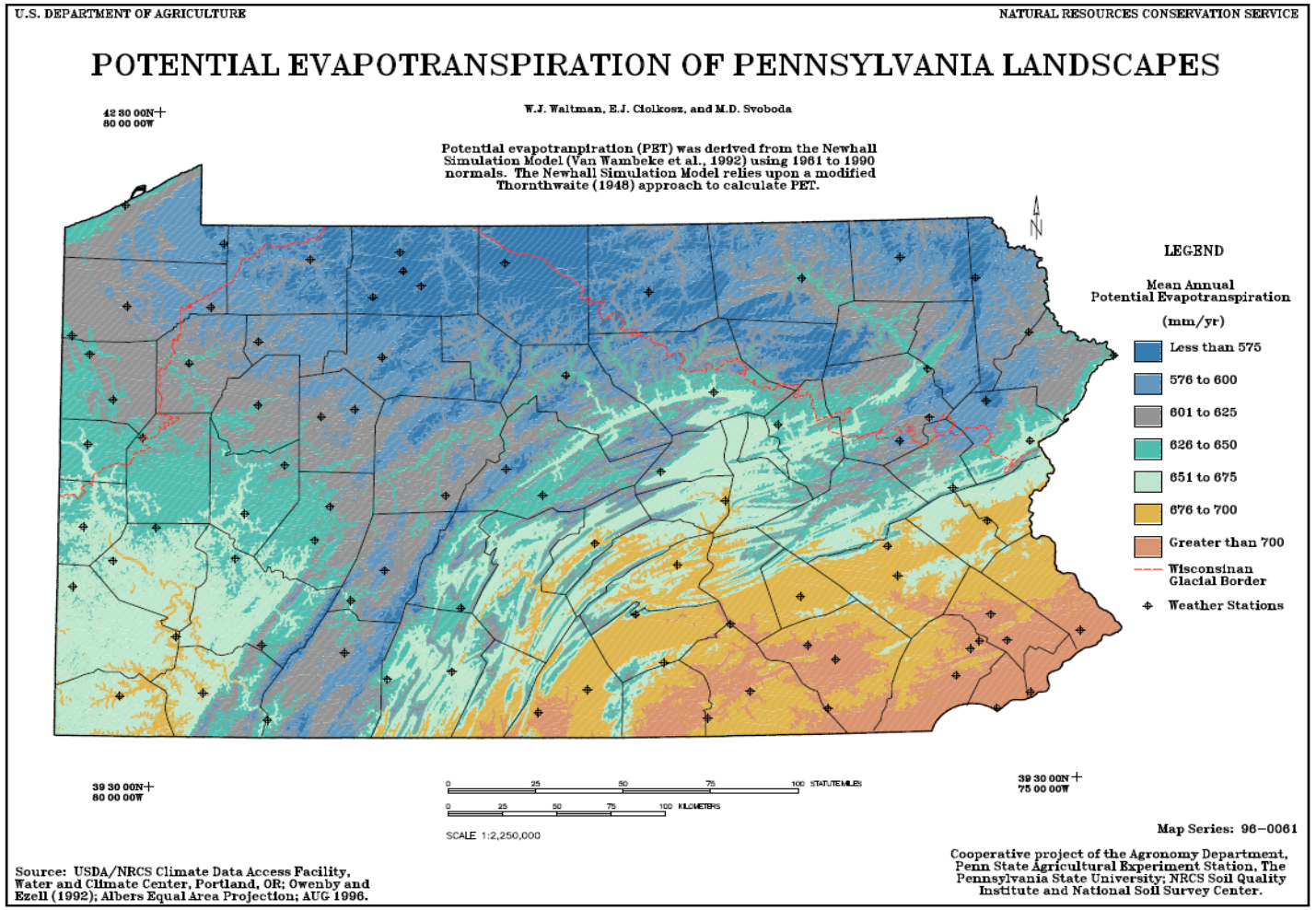
Challenges:

- Highest rainfall in June when irrigation not required
- The majority of the rainfall events (particularly the high intensity events) greater than one inch occur when soil moisture is the most depleted or ET is highest during summer and early fall (July - August) (Fennessey, 2005)
- Ten to twenty percent (10-20%) of the average annual rainfall is comprised of events less than or equal to 0.25 inches which produce very little runoff depending on the season

WATER HARVESTING CALCULATOR - EVAPOTRANSPIRATION

- PET is the ET that occurs when all surface-atmospheric interfaces are wet
- PET usually has a higher value than Actual ET since AET includes ET during dry spells
- Since irrigation is used at PSU, the PET values will be utilized in the guidance document
- PET ranges from 24.6 to 26.2 in/yr depending on source

$P = RO + ET + Use + \Delta S$

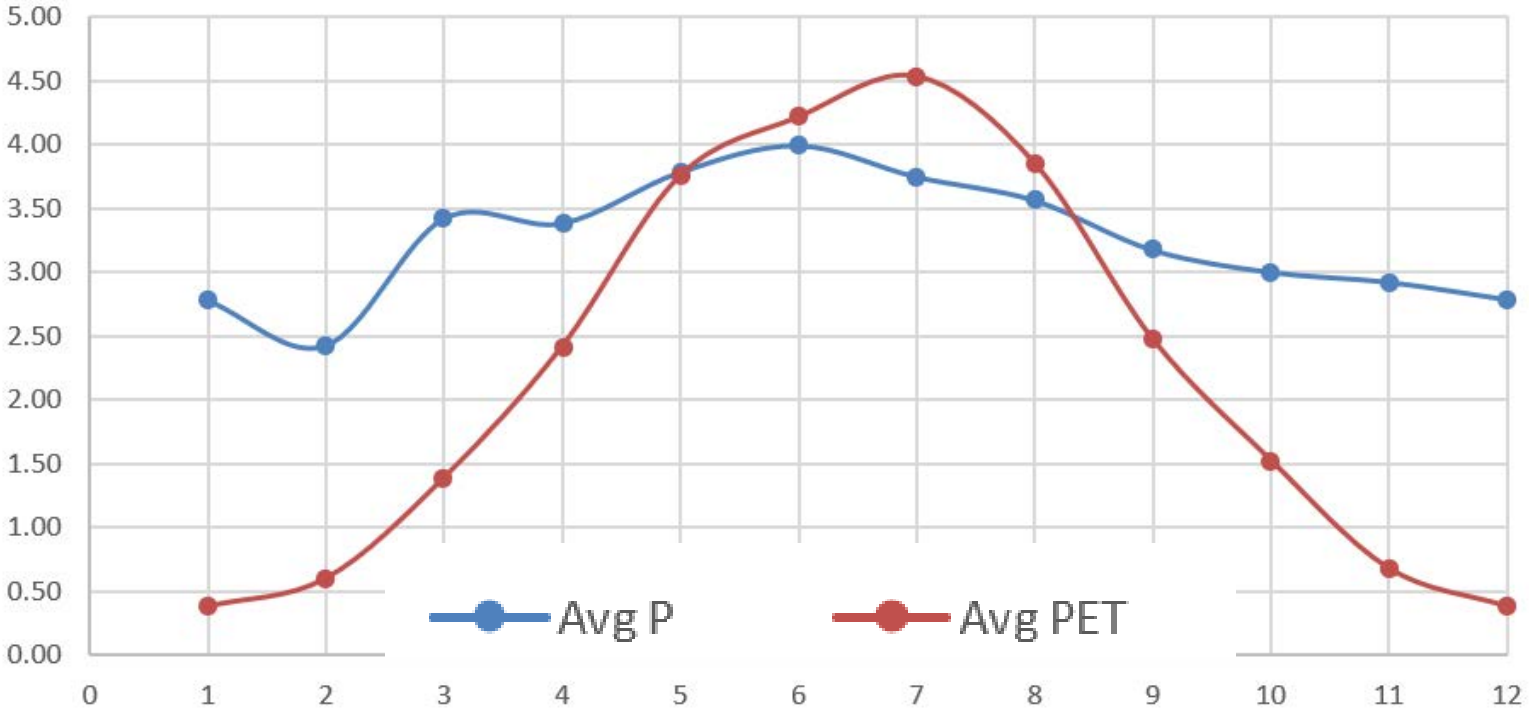


WATER HARVESTING CALCULATOR - EVAPOTRANSPIRATION

$$P = RO + ET + Use + \Delta S$$

ET:

- State College shows a rainfall/ET deficit during the months of June, July, and August.

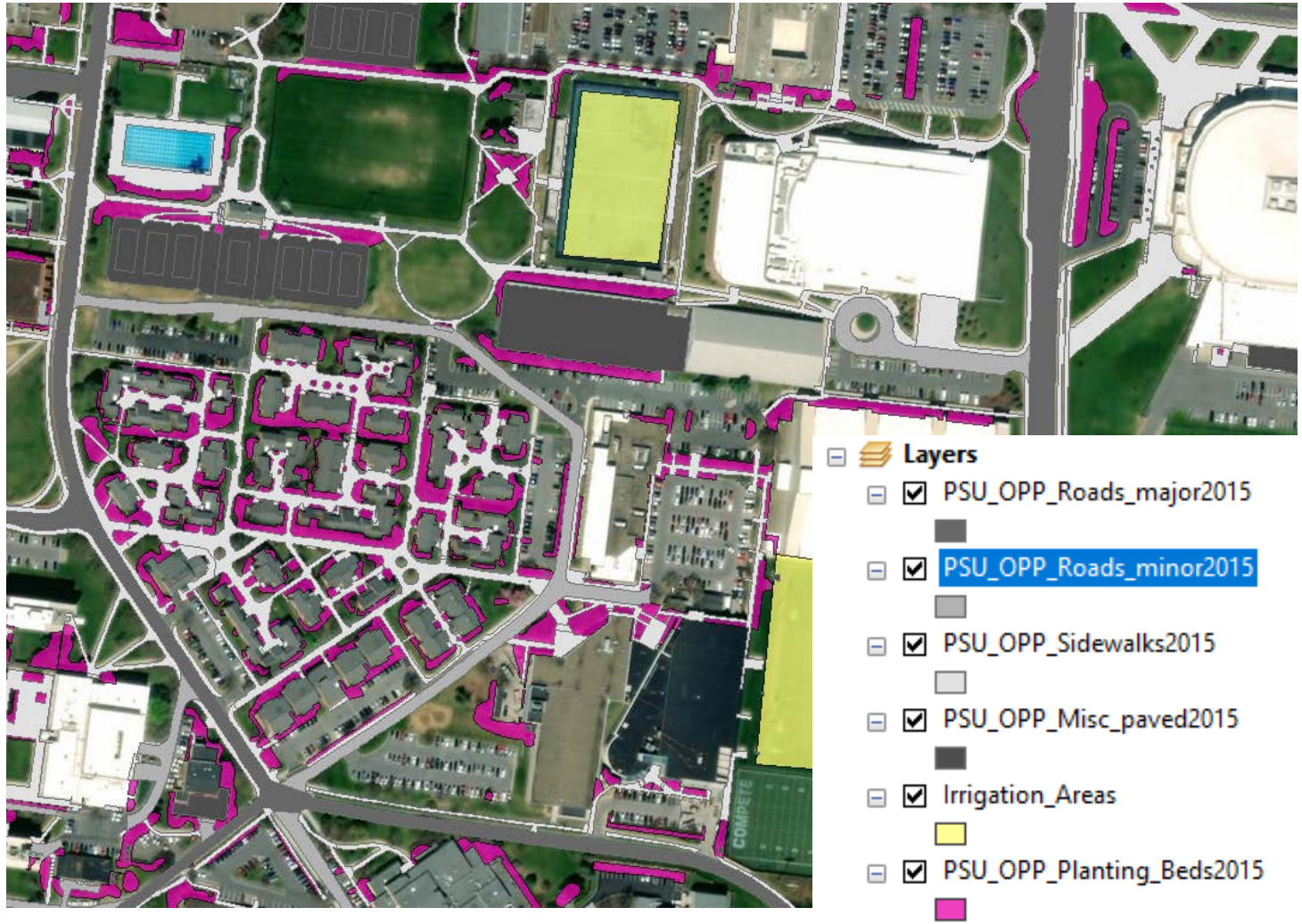


Month	Avg Precip. (in)	Avg PET (in)	Surplus (+) or Deficit (-)
January	2.78	0.38	+2.4
February	2.43	0.60	+1.38
March	3.42	1.39	+2.03
April	3.38	2.42	+0.96
May	3.78	3.76	+0.02
June	3.99	4.22	-0.23
July	3.75	4.54	-0.79
August	3.56	3.86	-0.3
September	3.18	2.48	+0.7
October	3.00	1.53	+1.47
November	2.92	0.68	+2.24
December	2.79	0.38	+2.41
Average Total	38.99	26.24	+12.74

WATER HARVESTING CALCULATOR - RUNOFF

P = RO + ET + Use + ΔS

RO = Roof Area * Efficiency
+ Other Impervious
*** Efficiency**



WATER HARVESTING CALCULATOR - USE

P = RO + ET + Use + ΔS

Use = Area to be Irrigated * Summer Versus Fall Irrigation * Irrigation Efficiency + Indoor or Other Demand

Building Use Sources:

- Branch campus metering
- National databases
- Seasonal occupancy records

Irrigation Use

- U Park records

Table 3. Default Fixture Use adapted from USGBC (2012)

Non-Residential Fixture Use		
Fixture Type	**Full Time Occupant (FTO) Use/Day**	**Transient Occupant (TO) Use/Day**
Toilet Female (high flush)	1	0.1
Toilet Female (low flush)	2	0.4
Toilet Male	1	0.1
Urinal Male	2	0.4
Residential Fixture Use		
Fixture Type	**Full Time Occupant Use/Day**	**NA**
Toilet Female	5	NA
Toilet Male	5	NA

Table 2. Default occupancy numbers by building type (USGBC, 2009).

Type of Building Space	Gross Square Feet Per Occupant	
	Full Time Occupants (FTO)	Transient Occupants (TO)
General Office	250	0
Restaurant	435	95
R&D Laboratory	400	0
Hotel (Dormitory)	1,500	700
Post-Secondary Education	2,100	150

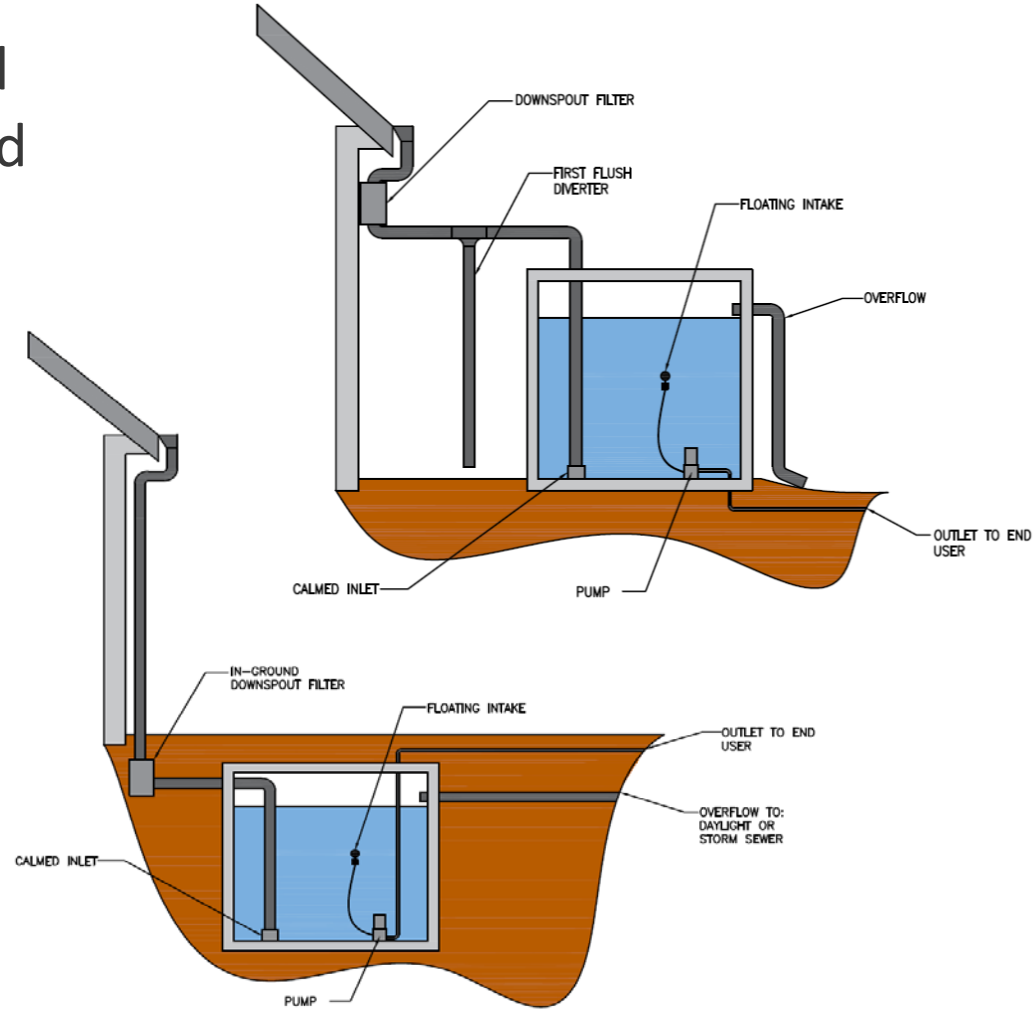
Building	Urinal Uses	Mens Toilet Uses	Womens Toilet Use	Number of Men	Number of Women	Urinal Use/Male-day	Toilet Use/Male-day	Toilet Use/Female-day
Olmstead	7080	1490	2330	1685	1989	0.35	0.07	0.10
S&T	2950	353	887	1685	1989	0.15	0.02	0.04
Swatara	676	198	972	624	968	0.06	0.02	0.06
Susquehanna	--	75	240	624	968	---	0.01	0.02

WATER HARVESTING CALCULATOR - STORAGE

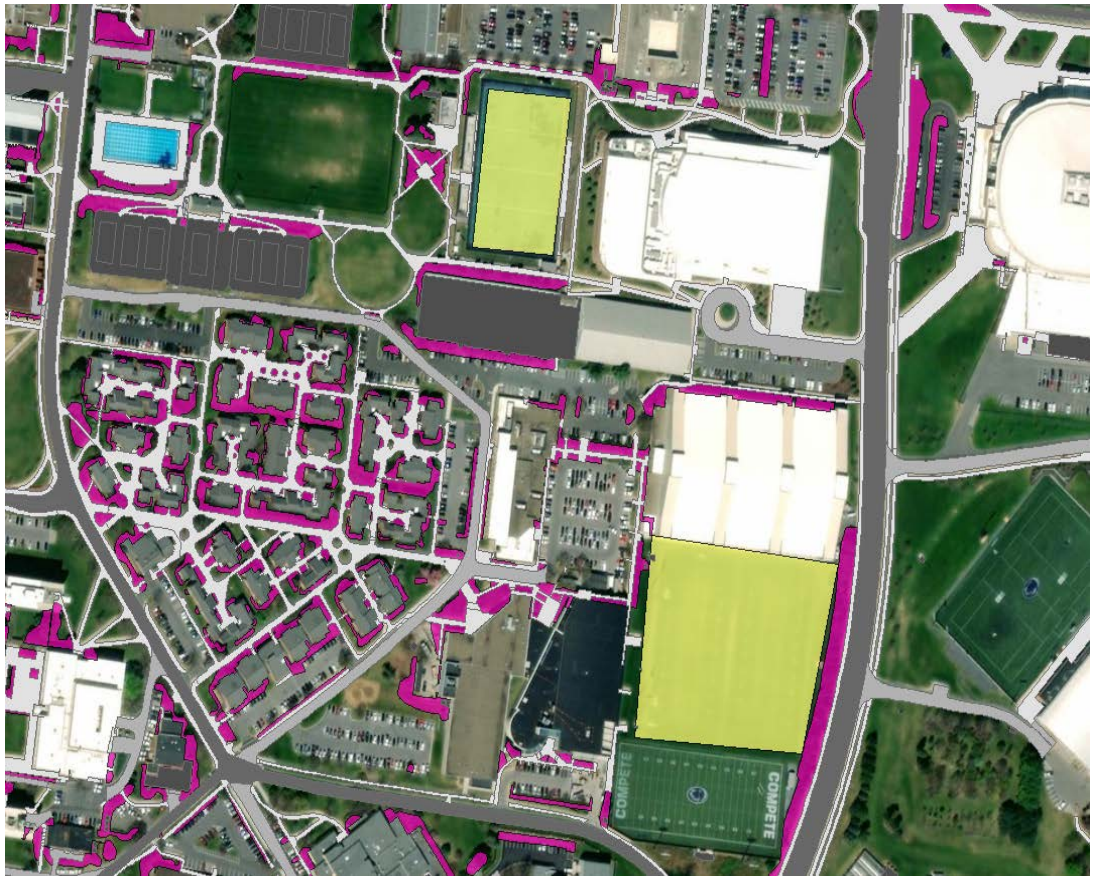
$P = RO + ET + Use + \Delta S$

Storage = Cistern Volume * % Available - % Carryover

- The Calculator developed to determine required cistern storage volume based on local supply and demand, and to establish a consistent design methodology
- Performance for four (4) existing PSU Storage systems analyzed
- Winter months where P ~ 0 due to frozen conditions considered
- Above ground and below ground systems considered
- Overflow



CISTERN DESIGN FLOW DIAGRAM



- Determine Uses of Harvested Water
- Determine Cistern(s) Location
- Determine Drainage Area
- Determine Roof Area
- Determine Other Impervious Area
- Determine Pervious Area
- Calculate Irrigation Area and Demand
- Calculate Indoor Demand
- Estimate Req'd Cistern Volume Using Calculator
- Adjust Cistern Volume or Irrigated Area until Overflow and Supplemental Water Columns = or near 0
- Determine Costs and Cost Savings
- Discuss Results with OPP
- Determine if Economically Feasible

WATER HARVESTING CALCULATOR

- The Calculator can be used for:
  - Determining storage tank size (cistern volume)
  - Determining drainage area required for particular constraints including roof area
  - Determining required irrigation area based on tank size, contributing drainage area, etc.
  - Determining water supply available for toilet flushing or other non-potable uses
  - Determining dry year shortfall or capabilities

- The Calculator is flexible with what parameters are changeable such as:
  - Those parameters above
  - Collection efficiency
  - Irrigation amounts and efficiency
  - Rainfall, ET, costs, etc.

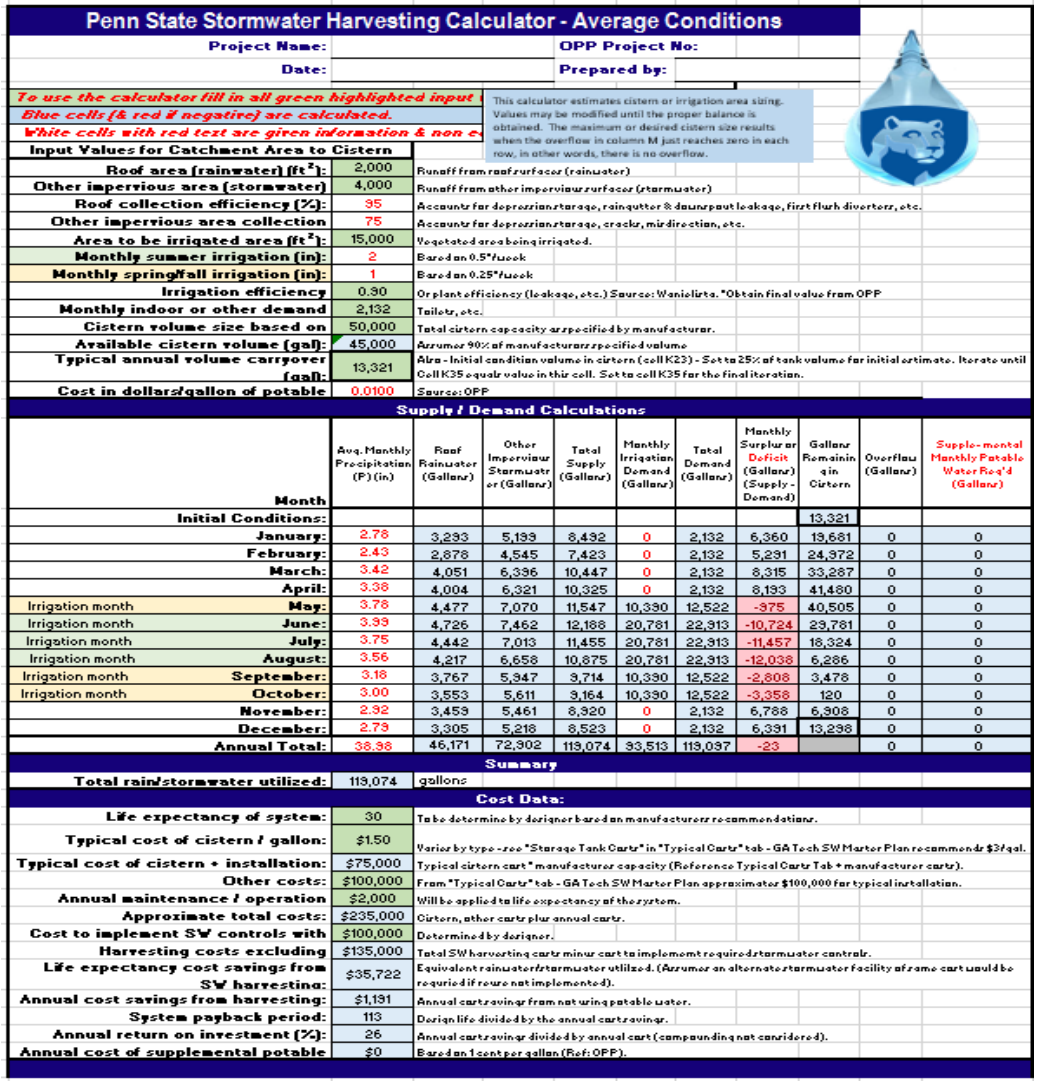
This calculator estimates cistern or irrigation area sizing. Values may be modified until the proper balance is obtained. The maximum or desired cistern size results when the overflow in column M just reaches zero in each row, in other words, there is no overflow.

HARVESTER CALCULATOR - OVERVIEW

Site data →

Monthly supply / demand calculations →

Summary and cost data →



Penn State Stormwater Harvesting Calculator - Average Conditions

Project Name:		OPP Project No:
Date:		Prepared by:

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Cistern volume size based on	50,000	Total cistern capacity as specified by manufacturer.
Available cistern volume (gal):	45,000	Assumes 90% of manufacturers specified volume
Typical annual volume carryover (gal):	13,321	Also - Initial condition volume in cistern (cell K23) - Set to 25% of tank volume for initial estimate. Iterate until Cell K35 equals value in this cell. Set to cell K35 for the final iteration.
Cost in dollars/gallon of potable	0.0100	Source: OPP

Supply / Demand Calculations

Month	Avg. Monthly Precipitation (P) (in.)	Roof Rainwater (Gallons)	Other Impervious Stormwater (Gallons)	Total Supply (Gallons)	Monthly Irrigation Demand (Gallons)	Total Demand (Gallons)	Monthly Surplus or Deficit (Gallons) (Supply - Demand)	Gallons Remaining in Cistern	Overflow (Gallons)	Supplemental Monthly Potable Water Req'd (Gallons)
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Irrigation month August:	3.56	4,217	6,658	10,875	20,781	22,913	-12,038	6,286	0	0
Irrigation month September:	3.18	3,767	5,947	3,714	10,390	12,522	-2,808	3,478	0	0
Irrigation month October:	3.00	3,553	5,611	9,164	10,390	12,522	-3,358	120	0	0
November:	2.32	3,459	5,461	8,920	0	2,132	6,788	6,908	0	0
December:	2.79	3,305	5,218	8,523	0	2,132	6,391	13,298	0	0
Annual Total:	38.38	46,171	72,902	119,074	93,513	119,037	-23		0	0

Summary

Total rain/stormwater utilized:	119,074	gallons

Cost Data:

Life expectancy of system:	30	To be determine by designer based on manufacturers recommendations.
Typical cost of cistern / gallon:	$1.50	Varies by type - see "Storage Tank Costs" in "Typical Costs" tab - GA Tech SW Master Plan recommends $3/gal.
Typical cost of cistern + installation:	$75,000	Typical cistern cost * manufacturer capacity (Reference Typical Costs Tab + manufacturer costs).
Other costs:	$100,000	From "Typical Costs" tab - GA Tech SW Master Plan approximates $100,000 for typical installation.
Annual maintenance / operation	$2,000	Will be applied to life expectancy of the system.
Approximate total costs:	$235,000	Cistern, other costs plus annual costs.
Cost to implement SW controls with	$100,000	Determined by designer.
Harvesting costs excluding	$135,000	Total SW harvesting costs minus cost to implement required stormwater controls.
Life expectancy cost savings from SW harvesting:	$35,722	Equivalent rainwater/stormwater utilized. (Assumes an alternate stormwater facility of same cost would be required if were not implemented).
Annual cost savings from harvesting:	$1,191	Annual cost savings from not using potable water.
System payback period:	113	Design life divided by the annual cost savings.
Annual return on investment (%):	26	Annual cost savings divided by annual cost (compounding not considered).
Annual cost of supplemental potable	$0	Based on 1 cent per gallon (Ref: OPP).

HARVESTER CALCULATOR – GRAPHICAL ANALYZER

Penn State Stormwater Harvesting Calculator - Average Conditions

Project Name:		**OPP Project No:**	
Date:		**Prepared by:**	

To use the calculator fill in all green highlighted input
Blue cells (& red if negative) are calculated.
White cells with red text are given information & non e

This calculator estimates cistern or irrigation area sizing. Values may be modified until the proper balance is obtained. The maximum or desired cistern size results when the overflow in column M just reaches zero in each row, in other words, there is no overflow.

Input Values for Catchment Area to Cistern		
Roof area (rainwater) (ft²):	2,000	Runoff from roof surfaces (rainwater)
Other impervious area (stormwater):	4,000	Runoff from other impervious surfaces (stormwater)
Roof collection efficiency (%):	95	Accounts for depression storage, rain gutter & downspout leakage, first flush diverters, etc.
Other impervious area collection	75	Accounts for depression storage, cracks, misdirection, etc.
Area to be irrigated area (ft²):	15,000	Vegetated area being irrigated.
Monthly summer irrigation (in):	2	Based on 0.5"/week
Monthly spring/fall irrigation (in):	1	Based on 0.25"/week
Irrigation efficiency	0.90	Or plant efficiency (leakage, etc.) Source: Waterlink. *Obtain final value from OPP
Monthly indoor or other demand	2,132	Toilets, etc.
Cistern volume size based on	50,000	Total cistern capacity as specified by manufacturer.
Available cistern volume (gal):	45,000	Assumes 90% of manufacturers specified volume
Typical annual volume carryover (gal):	13,321	Also - Initial condition volume in cistern (cell K23) - Set to 25% of tank volume for initial estimate. Iterate until Cell K35 equals value in this cell. Set to cell K35 for the final iteration.
Cost in dollars/gallon of potable	0.0100	Source: OPP

Supply / Demand Calculations

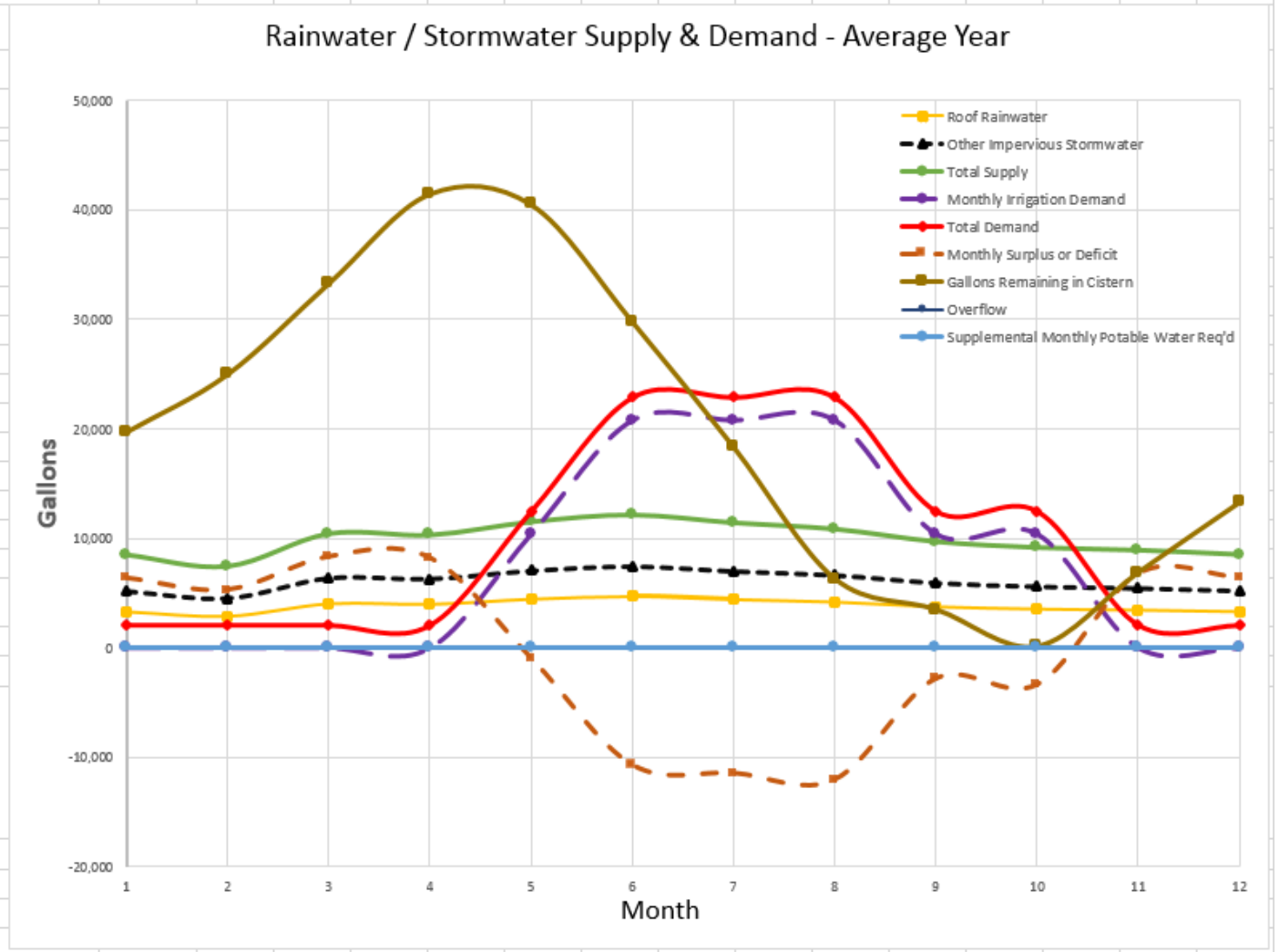
Month		Avg. Monthly Precipitation (P) (in)	Roof Rainwater (Gallons)	Other Impervious Stormwater (Gallons)	Total Supply (Gallons)	Monthly Irrigation Demand (Gallons)	Total Demand (Gallons)	Monthly Surplus or Deficit (Gallons) (Supply - Demand)	Gallons Remaining in Cistern	Overflow (Gallons)	Supplemental Monthly Potable Water Req'd (Gallons)
Initial Conditions:									13,321		
	January:	2.78	3,293	5,199	8,492	0	2,132	6,360	19,681	0	0
	February:	2.43	2,878	4,545	7,423	0	2,132	5,291	24,972	0	0
	March:	3.42	4,051	6,396	10,447	0	2,132	8,315	33,287	0	0
	April:	3.38	4,004	6,321	10,325	0	2,132	8,193	41,480	0	0
Irrigation month	**May:**	3.78	4,477	7,070	11,547	10,330	12,522	-975	40,505	0	0
Irrigation month	**June:**	3.39	4,726	7,462	12,188	20,781	22,913	-10,724	29,781	0	0
Irrigation month	**July:**	3.75	4,442	7,013	11,455	20,781	22,913	-11,457	18,324	0	0
Irrigation month	**August:**	3.56	4,217	6,658	10,875	20,781	22,913	-12,038	6,286	0	0
Irrigation month	**September:**	3.18	3,767	5,947	9,714	10,330	12,522	-2,808	3,478	0	0
Irrigation month	**October:**	3.00	3,553	5,611	9,164	10,330	12,522	-3,358	120	0	0
	November:	2.92	3,459	5,461	8,920	0	2,132	6,788	6,908	0	0
	December:	2.79	3,305	5,218	8,523	0	2,132	6,391	13,298	0	0
	Annual Total:	38.38	46,171	72,302	118,074	93,513	118,037	-23		0	0

Summary

Total rain/stormwater utilized:	118,074	gallons

Cost Data:

Life expectancy of system:	30	To be determined by designer based on manufacturers recommendations.
Typical cost of cistern / gallon:	$1.50	Varies by type - see "Storage Tank Costs" in "Typical Costs" tab - GA Tech SW Master Plan recommends $3/gal.
Typical cost of cistern + installation:	$75,000	Typical cistern cost * manufacturer capacity (Reference Typical Costs Tab + manufacturer costs).
Other costs:	$100,000	From "Typical Costs" tab - GA Tech SW Master Plan approximates $100,000 for typical installation.
Annual maintenance / operation	$2,000	Will be applied to life expectancy of the system.
Approximate total costs:	$235,000	Cistern, other costs plus annual costs.
Cost to implement SW controls with	$100,000	Determined by designer.
Harvesting costs excluding	$135,000	Total SW harvesting costs minus cost to implement required stormwater controls.
Life expectancy cost savings from SW harvesting:	$35,722	Equivalent rainwater/stormwater utilized. (Assumes an alternate stormwater facility of same cost would be required if reuse not implemented).
Annual cost savings from harvesting:	$1,191	Annual cost savings from not using potable water.
System payback period:	113	Design life divided by the annual cost savings.
Annual return on investment (%):	26	Annual cost savings divided by annual cost (compounding not considered).
Annual cost of supplemental potable	$0	Based on 1 cent per gallon (Ref: OPP).



HARVESTER CALCULATOR – INPUT SITE DATA

Penn State Stormwater Harvesting Calculator - Average Conditions

Project Name:		OPP Project No:	
Date:		Prepared by:	

To use the calculator fill in all green highlighted input values.
Blue cells (& red if negative) are calculated.
White cells with red text are given information & non editable

This calculator estimates cistern or irrigation area sizing. Values may be modified until the proper balance is obtained. The maximum or desired cistern size results when the overflow in column M just reaches zero in each row, in other words, there is no overflow.

Input Values for Catchment Area to Cistern		
Roof area (rainwater) (ft^2):	2,000	Runoff from roof surfaces (rainwater)
Other impervious area (stormwater) (ft^2):	4,000	Runoff from other impervious surfaces (stormwater)
Roof collection efficiency (%):	95	Accounts for depression storage, raingutter & downspout leakage, first flush diverters, etc.
Other impervious area collection efficiency (%):	75	Accounts for depression storage, cracks, misdirection, etc.
Area to be irrigated area (ft^2):	15,000	Vegetated area being irrigated.
Monthly summer irrigation (in):	2	Based on 0.5"/week
Monthly spring/fall irrigation (in):	1	Based on 0.25"/week
Irrigation efficiency	0.90	Or plant efficiency (leakage, etc.) Source: Wanielista. "Obtain final value from OPP"
Monthly indoor or other demand (gal):	2,132	Toilets, etc.
Cistern volume size based on specification	50,000	Total cistern capcacity as specified by manufacturor.
Available cistern volume (gal):	45,000	Assumes 90% of manufacturors specified volume
Typical annual volume carryover (gal):	13,321	Also = Initial condition volume in cistern (cell K23) - Set to 25% of tank volume for initial estimate. Iterate until Cell K35 equals value in this cell. Set to cell K35 for the final
Cost in dollars/gallon of potable water:	0.0100	Source: OPP

HARVESTER CALCULATOR – SUPPLY / DEMAND CALCULATIONS

Supply / Demand Calculations												
	Month	Avg. Monthly Precipitation (P) (in)	Avg. PET (in)	Difference	Roof Rainwater (Gallons)	Other Impervious Stormwatrer (Gallons)	Total Supply (Gallons)	Monthly Irrigation Demand (Gallons)	Total Demand (Gallons)	Monthly Surplus or Deficit (Gallons) (Supply - Demand)	Gallons Remaining in Cistern	Overflow (Gallons)	Supplemental Monthly Potable Water Req'd (Gallons)
	Initial Conditions:										13,321		
	January:	2.78	0.4	2.4	3,293	5,199	8,492	0	2,132	6,360	19,681	0	0
	February:	2.43	0.6	1.83	2,878	4,545	7,423	0	2,132	5,291	24,972	0	0
	March:	3.42	1.4	2.03	4,051	6,396	10,447	0	2,132	8,315	33,287	0	0
	April:	3.38	2.4	0.96	4,004	6,321	10,325	0	2,132	8,193	41,480	0	0
Irrigation month	May:	3.78	3.8	0.02	4,477	7,070	11,547	10,390	12,522	-975	40,505	0	0
Irrigation month	June:	3.99	4.2	-0.23	4,726	7,462	12,188	20,781	22,913	-10,724	29,781	0	0
Irrigation month	July:	3.75	4.5	-0.79	4,442	7,013	11,455	20,781	22,913	-11,457	18,324	0	0
Irrigation month	August:	3.56	3.9	-0.3	4,217	6,658	10,875	20,781	22,913	-12,038	6,286	0	0
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	December:	2.79	0.4	2.41	3,305	5,218	8,523	0	2,132	6,391	13,298	0	0
	Annual Total:	38.98	26	12.74	46,171	72,902	119,074	93,513	119,097	-23		0	0

HARVESTER CALCULATOR – GRAPHICAL ANALYZER

Graphical Analyzer

To use the calculator fill in all green highlighted input values.	
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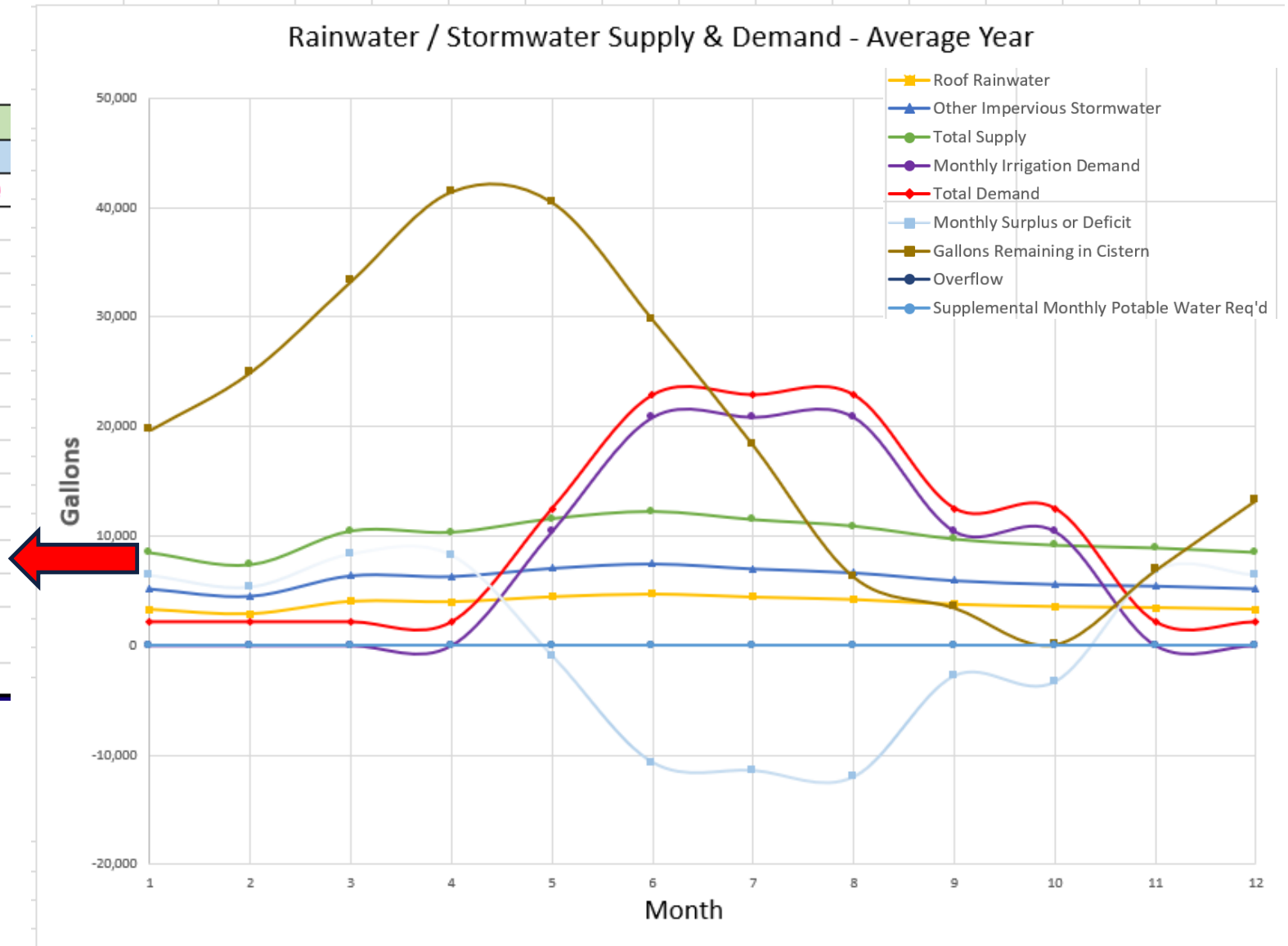
White cells with red text are given information & non editable	
Input Values for Catchment Area to Cistern	
Roof area (rainwater) (ft^2):	2,000
Other impervious area (stormwater) (ft^2):	4,000
Roof collection efficiency (%):	95
Other impervious area collection efficiency (%):	75
Area to be irrigated area (ft^2):	15,000
Monthly summer irrigation (in):	2
Monthly spring/fall irrigation (in):	1
Irrigation efficiency	0.90
Monthly indoor or other demand (gal):	2,132
Cistern volume size based on specification	50,000
Available cistern volume (gal):	45,000
Typical annual volume carryover (gal):	13,321
Cost in dollars/gallon of potable water:	0.0100



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Area to be irrigated area (ft^2):	15,000
Monthly summer irrigation (in):	2
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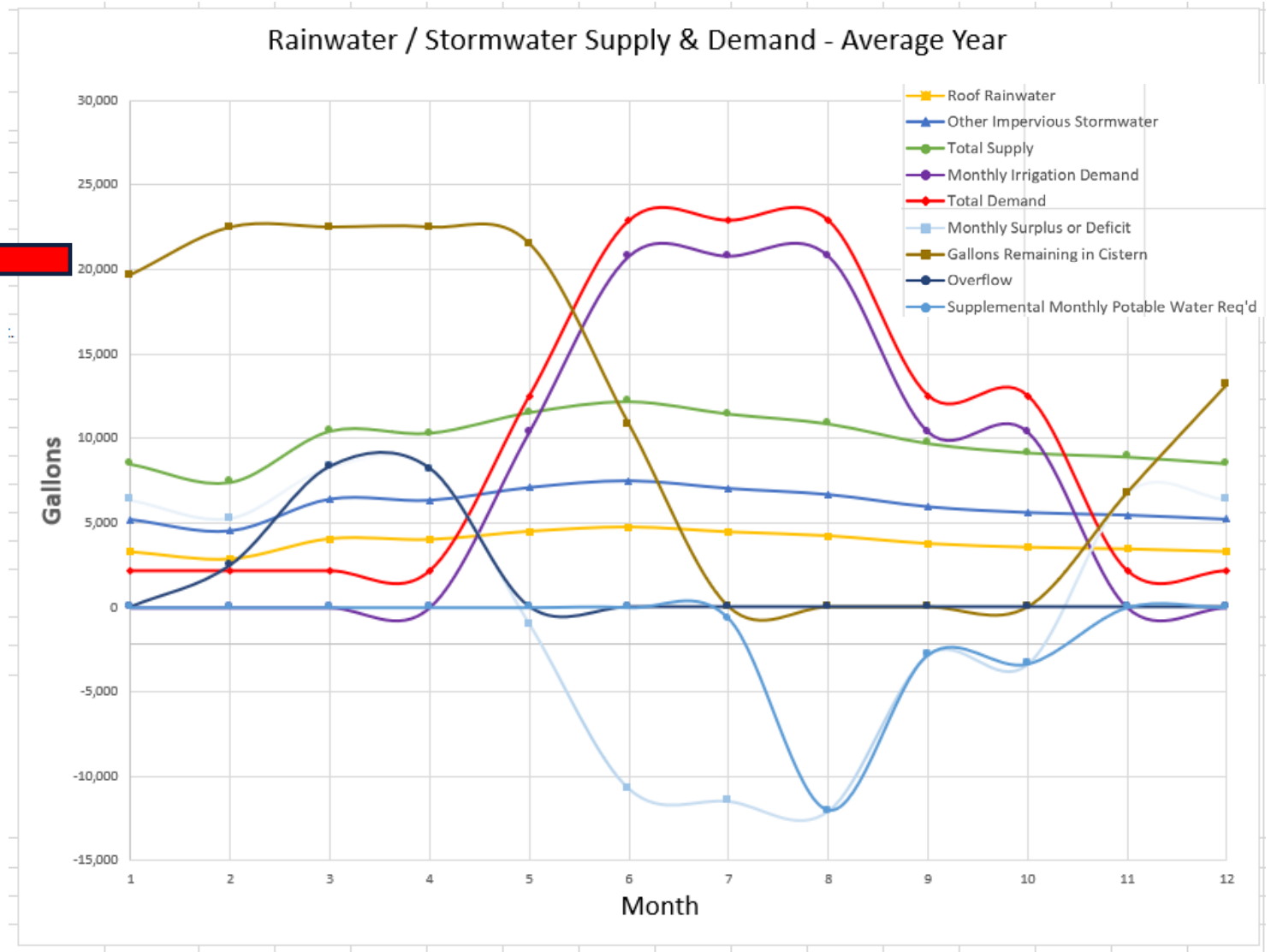
Irrigation efficiency	0.90
Monthly indoor or other demand (gal):	2,132
Cistern volume size based on specification	25,000
Available cistern volume (gal):	22,500
Typical annual volume carryover (gal):	13,321
Cost in dollars/gallon of potable water:	0.0100



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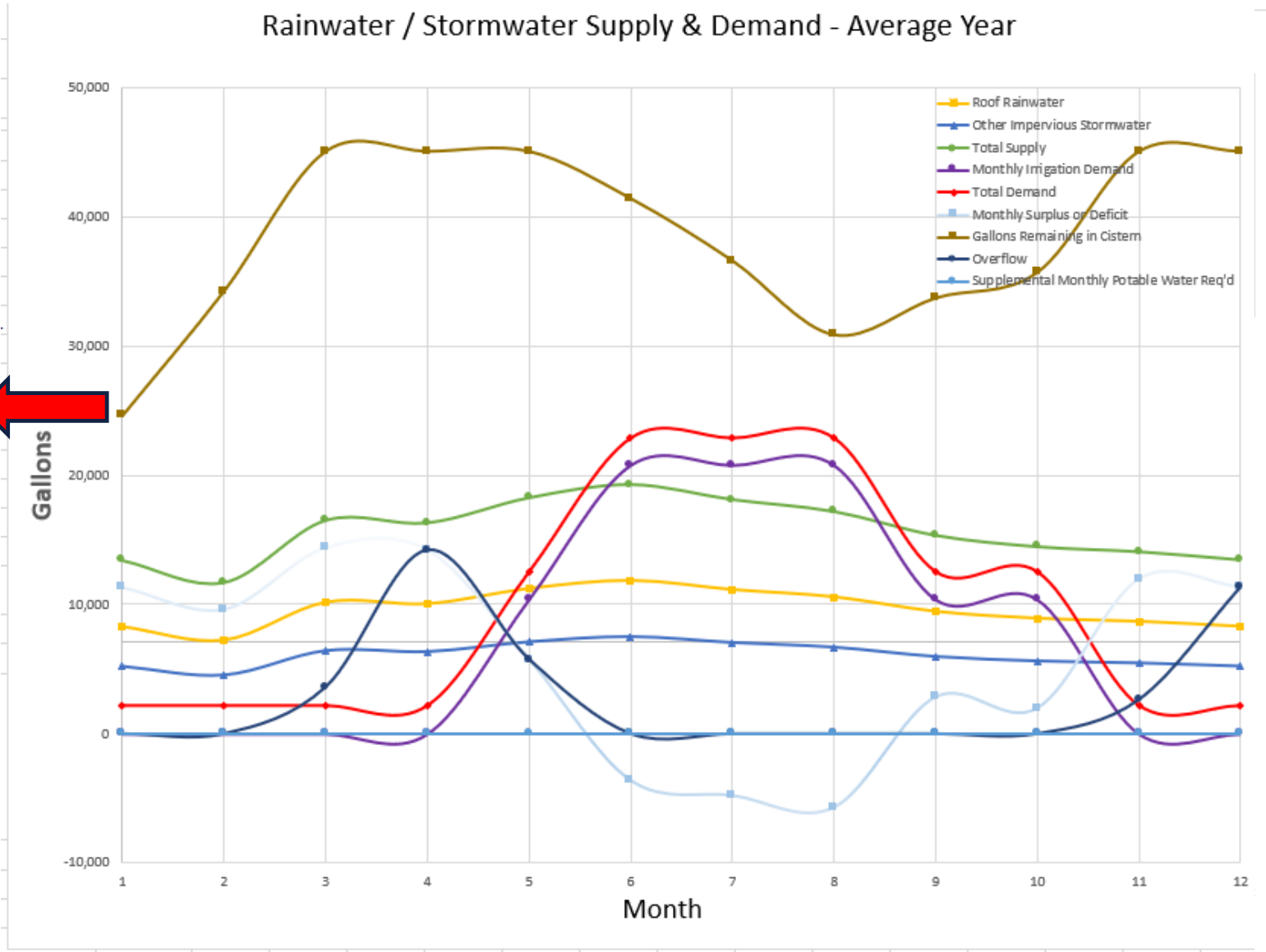

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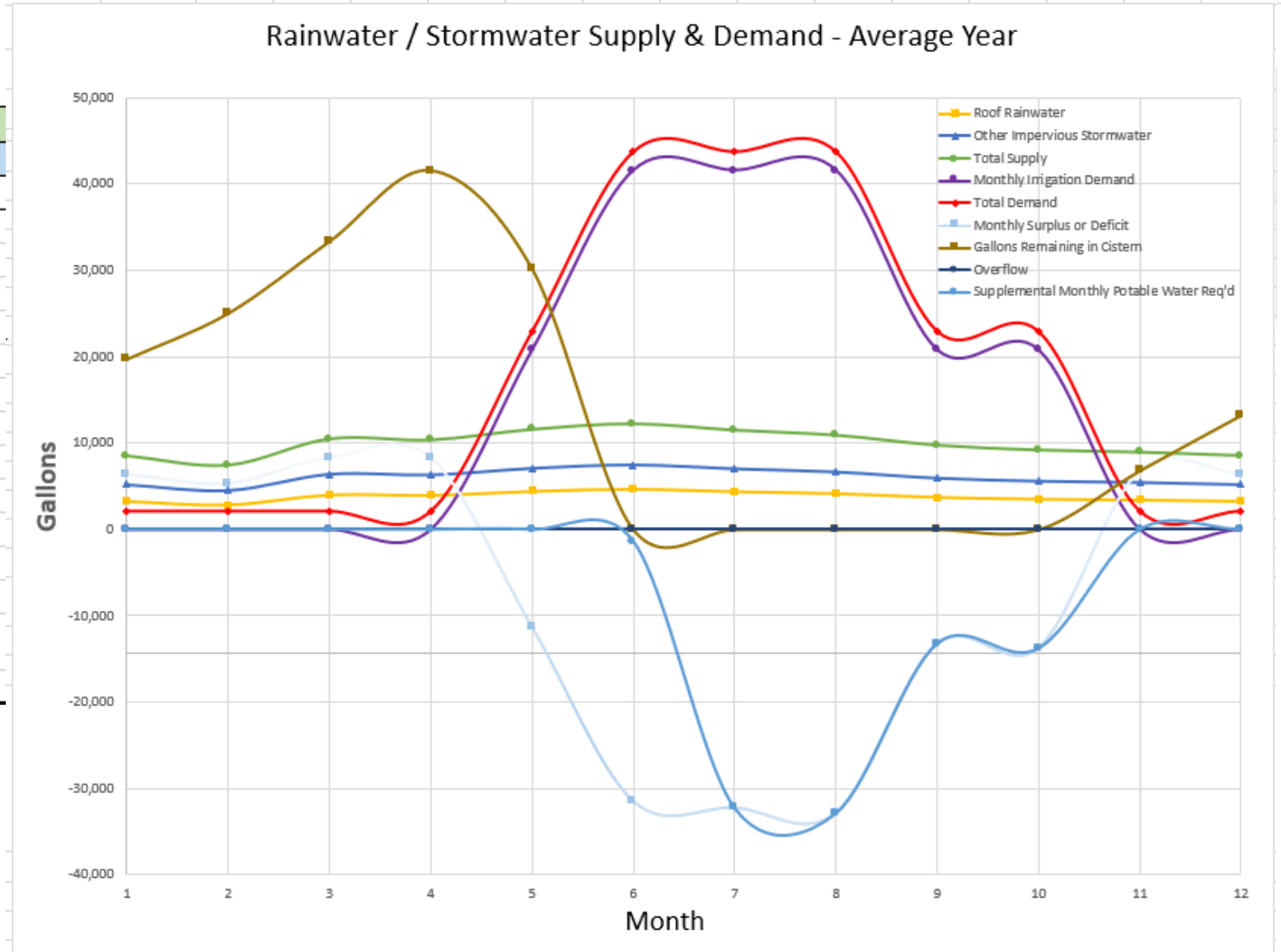

HARVESTER CALCULATOR – SUMMARY & COST DATA

Cost Data:		
Life expectancy of system (Yrs):	30	To be determine by designer based on manufacturers recommendations.
Typical cost of cistern / gallon:	$1.50	Varies by type - see "Storage Tank Costs" in "Typical Costs" tab - GA Tech SW Master Plan recommends $3/gal.
Typical cost of cistern + installation:	$75,000	Typical cistern cost * manufactures capacity (Reference Typical Costs Tab + manufacturer costs).
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Annual maintenance / operation costs:	$2,000	Will be applied to life expectancy of the system.
Approximate total costs:	$235,000	Cistern, other costs plus annual costs.
Cost to implement SW controls with no	$100,000	Determined by designer.
Harvesting costs excluding mandatory SW	$135,000	Total SW harvesting costs minus cost to implememt required stormwater controls.
Life expectancy cost savings from SW harvesting:	$35,722	Equivalent rainwater/stormwater utlilzed. (Assumes an alternate stormwater facility of same cost would be requried if reuse not implemented).
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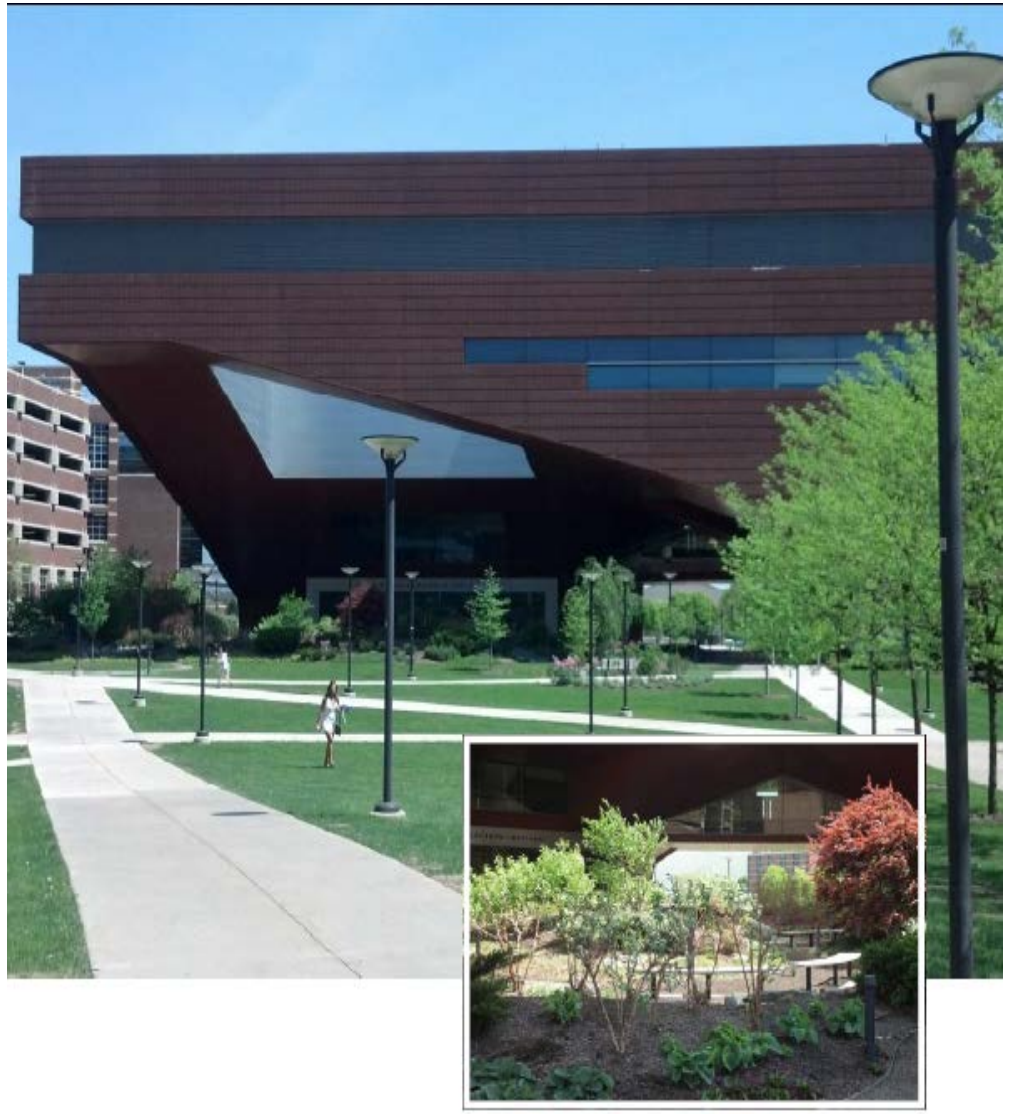
System payback period (Yrs):	113	Design life divided by the annual cost savings.
Annual return on investment (%):	26	Annual cost savings divided by annual cost (compounding not considered).
Annual cost of supplemental potable water:	$0	Based on 1 cent per gallon (Ref: OPP).

SUMMARY



There is a lot to consider when designing Stormwater Harvesting and Use Systems

Questions?