OCTOBER 15, 2013

Summary and User Guide

Integrated Water and Land Management Tool

CALIFORNIA DEPARTMENT OF WATER RESOURCES
AND SONOMA STATE UNIVERSITY

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Department of Water Resources Water Plan

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  "Integrating Water and Land Management: A Suburban Case Study and Locally Adaptable Tool"
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- **The Tool (Excel Spreadsheet)**
  "Integrated Water and Land Management Tool"

Please go to the website for the California Water Plan Update 2013. < http://www.waterplan.water.ca.gov/cwpu2013/index.cfm > Then navigate to Volume 4.

SUMMARY

BACKGROUND

Managing the impacts of development on water resources is an urgent challenge in California. To support more efficient growth with fewer environmental impacts, the California Legislature and governor have adopted policies to better integrate land use and resource management. The Land Use Planning and Management Resource Management Strategy (RMS) located within California's 2009 Water Plan Update calls for Low Impact Development (LID) and Leadership in Energy and Environmental Design (LEED) development approaches to reduce land use impacts on water resources. These strategies are suggested to decrease indoor/outdoor or residential water consumption, improve the quality of stormwater runoff, decrease the quantity and flow rates of stormwater runoff, and protect downstream riparian habitat.

The 2009 RMS set in motion a study to quantify costs and benefits associated with water-smart land use practices. Following this 2009 initiative, the charter for the RMS in the 2013 California Water Plan Update proposed a land use decision tool and demonstration of its application through pilot projects. For the first time since 1957, the Water Plan will also include a land use objective linked to corresponding actions. Consistent with this approach, the California Department of Water Resources partnered with Sonoma State University's (SSU) Center for Sustainable Communities and conducted four case studies of suburban development in Sonoma County. An "Integrated Water and Land Management Tool" was also designed and built as part of this project. **This tool may be downloaded free of charge at the website for the California Water Plan Update 2013. < http://www.waterplan.water.ca.gov/cwpu2013/index.cfm > Then navigate to Volume 4.**

Although existing tools are available to guide practitioners, those that are easy to use generally could not be modified to reflect local conditions. And calculators that could be modified possessed challenging user interfaces that required extensive background knowledge. Thus, the project team determined that a user-friendly calculator with the ability to customize and save local data would be a valuable asset. The case studies were then compared and contrasted using the new tool. This allowed users to specify different residential land cover and infrastructure choices and compare development outcomes, especially at the lot and neighborhood levels.

Guiding principles for the study and creation of the tool were to:

- Create an open, locally modifiable, and user-friendly tool to help guide land use and land cover decisions
- Quantify relationships between land use alternatives and key water management benefits relating to water supply reliability, flood management, water quality, habitat value, and greenhouse gas emissions
- Quantify the monetary costs of implementing LID and traditional development strategies, including long-term costs
- Compare and contrast outputs from different development approaches, as exemplified in four case study sites

The report, "Integrating Water and Land Management: A Suburban Case Study and Locally Adaptable Tool", proceeds in two major parts: developing the tool, and then applying the tool to four residential developments in Sonoma County, California, as a proof of concept. While preliminary conclusions are drawn from the analysis of the case studies, the primary contribution of this research effort is a new, open-source Integrated Water and Land Management Tool, which will further grow and develop over time as additional case studies and applications are completed.

INTENDED USERS

Because of the range of spatial scales the tool addresses, the results will apply to a wide user base. These users may include:

- **Homeowners** interested in testing possible retrofits to their properties, examining costs versus benefits.
- **Residential developers** seeking to evaluate different design strategies.
- **Local agency officials**, including planning and public works staff, and elected and appointed decision-makers, such as council members and planning commissioners. The tool is intended to be useful for evaluating the effectiveness of water conservation measures being considered in a project or by suggested redesign or conditioning. Local agencies may also use the model to help generate standards that would apply to new developments through general plan, zoning, and subdivision regulations; design guidelines; or other planning documents designed to give guidance to private project proponents.
- **Regional agencies and researchers**, seeking to envision cumulative impacts of development or evaluate alternative futures.

TOOL INPUTS AND OUTPUTS

The tool requires two major types of inputs and calculates nine outputs.

TOOL INPUTS

1. Land cover
2. Water infrastructure

Within the Excel workbook, the user selects the tab for the spatial scale of interest. For example, a homeowner might select the "Lot" tab. On the Lot tab, the homeowner specifies the areas of all the land cover types on their lot (in square feet) and answers questions like "Is there an irrigation controller?" At the neighborhood level, it is also necessary to specify data on public infrastructure. The user will input the square footage of asphalt and maintained parks, for example. See the "User Guide" for more information.

TOOL OUTPUTS

From the inputs, the tool calculates nine metrics, four of which relate to water and five to costs:

Water Metrics

1. Percent impervious surfaces
2. Stormwater runoff (from impervious surfaces)
3. Outdoor water requirements
4. Greenhouse gas emissions (from applied outdoor water)

Monetary Metrics

1. Cost of implementation
2. Cost over 10 years
3. Cost over 20 years
4. Cost over 50 years
5. Cost over 100 years

MAJOR CONCLUSIONS

The Integrated Water and Land Management Tool provides a methodology to link land cover and water infrastructure choices with water and monetary metrics. Other major conclusions of the study include the following:

1. The tool effectively demonstrates real differences in consumption at the lot and neighborhood levels when applied to case study sites. The tool is easy to use and locally adaptable. It is most useful for preliminary planning and conceptual design. This tool should not be used in place of a more specific hydrological analysis to calculate volumes of stormwater runoff.
2. Reducing hardscape is a critical component to minimizing water resource impacts. In the context of the suburban case studies, it was possible to minimize costs and impacts while using standard building materials, like concrete. In a more urban context, or when reduced hardscape is not a development option, more expensive porous materials may be a viable alternative. Matching design strategies with development context is a useful future trajectory of the tool.
3. Common building materials can be intelligently sited to further decrease impacts on water resources. For example, if a small concrete driveway is graded to drain into a permeable surface, the impacts will be even less than if it's graded to drain into the street. By minimizing new hardscape and creatively draining and diverting water, it is possible to create a low-cost development that is also low-impact.
4. The tool's output is strongest when evaluating conventional materials. For example, assessing changes in water and cost metrics if turf grass is substituted for a brick patio is reliable because costs and lifespans are well known for these materials. In contrast, comparing the costs and benefits of bioswales is less well documented.
5. In all of the case studies, the environmental and monetary impacts of public infrastructure were sufficiently large that they overwhelmed many of the lot-by-lot choices. Public infrastructure may be the most critical component of a development. With further development of lifecycle cost calculations, it is likely that there will be an increasingly strong case for green infrastructure.
6. Due to the small sample size and site-specific conditions, it is premature to extrapolate major conclusions on stormwater policies. Expansion of the study is needed to evaluate a larger sample of developments and more comprehensively document the relationships between policies and outcomes.

NEXT STEPS

The following next steps are recommended to further expand and refine the tool:

1. Distribute and test the tool at planning, building, water, and public works agencies.
2. Validate results of recorded outdoor water use and cost data in different climates.
3. Conduct case studies of high-density residential and mixed use projects.
4. Conduct case studies at broader spatial levels, including the city, county, and watershed.
5. Improve cost calculations by revising lifecycle costs and folding externalities into per unit valuations.

USER GUIDE

The Integrated Water and Land Management Tool is designed for homeowners and professionals. All users must be familiar with Microsoft Excel to comfortably work with the tool.

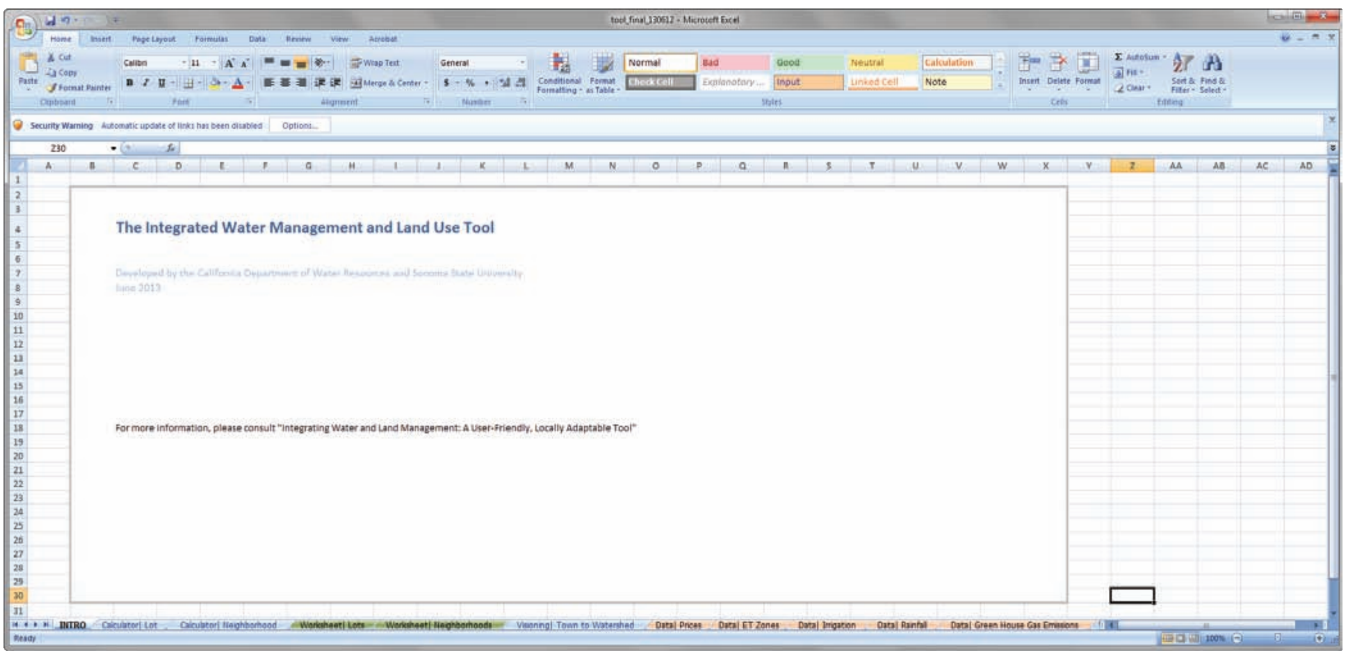
The User Guide progresses through increasingly difficult tasks. The first two tasks, opening the tool and evaluating lots, require basic Excel experience. The next two tasks, evaluating neighborhoods and visioning, require intermediate Excel experience. The last two tasks, editing background data and calculations, require the most Excel experience.

All of the formulas and data within the tool are visible and editable so that the tool is as transparent and accessible as possible. The consequence is that users must be cautious when navigating through the tool. It is possible that a user could unintentionally edit or erase a workbook formula.

For detailed information on development of the tool and the rationale behind the calculations, see Section 2 in the report.

➤ TASK 1. NAVIGATING THE WATER AND LAND MANAGEMENT TOOL

Open the Integrated Water and Land Management Tool with Microsoft Excel.



At the bottom of the workbook are 11 tabs. Each tab performs a different function.

Intro

The first tab, **INTRO**, includes information on the version of the tool and date of the update.

Calculators

The calculators are the workhorses of the tool. **Calculator|Lot** calculates the nine output metrics for lots. **Calculator|Neighborhood** provides additional calculations that are relevant only to neighborhoods.

Worksheets

The worksheets are where the user stores data from the calculators. **Worksheet|Lots** is designed for lot data, and **Worksheet|Neighborhoods** is designed for neighborhood data. Sample data is provided in each of these worksheets.

Visioning

The **Visioning|Town to Watershed** tab is where a user can test how development choices scale across a larger spatial area.

Data

There are five data tabs that store all of the background information used in the calculators.

Data|Prices contains all of the prices for traditional and green construction components in Sonoma County. There is also information on component lifespans. This data is used to calculate the tool's five monetary output metrics.

Data|ET Zones has monthly evapotranspiration data for the state of California by zone.

Data|Irrigation has all the information needed for calculating the water needs of plants, including crop coefficients and data on the efficiency of different irrigation methods. When this is combined with **Data|ET Zones**, the tool can calculate how much water is required by outdoor landscaping.

Data|Rainfall has information on rainfall in Sonoma County, which is used to calculate water runoff volumes.

Data|Greenhouse Gas Emissions contains all of the necessary information to calculate the amount of carbon dioxide emissions embedded in each gallon of water in Sonoma County.

➤ TASK 2. LOT CALCULATIONS

All home-based calculations are executed by the **Calculator|Lot** tab. This task will step through where to enter the necessary input data, how to measure the input data, how to read the output data, and how to store all the data in a worksheet.

Lot

Entering Data

Click the **Calculator|Lot** tab and look at the first three columns in the worksheet: Component, Value, and Unit.

COMPONENT	VALUE	UNIT
Lot land cover		
Asphalt		sq ft
Concrete		sq ft
Pavers, brick or nautral stone		sq ft
Permeable pavement - pavers		sq ft
Permeable pavement - porous asphalt		sq ft
Permeable pavement - porous concrete		sq ft
Permeable pavement - gravel		sq ft
Deck		sq ft
Turf grass		sq ft
Artificial turf grass		sq ft
Cultivated flower or vegetable garden		sq ft
Sparse irrigated vegetation		sq ft
Dense irrigated vegetation		sq ft
Natural/naturalized vegetation		sq ft
Pool		sq ft
Pond		sq ft
Existing trees (canopy)		sq ft
Trees (count)		count
Roof		
Composition Roof		sq ft
Slate Roof		sq ft
Wood Roof		sq ft
Clay Roof		sq ft
Green roof		sq ft
Water Infrastructure		
Rain barrels		gal
Downspout disconnection		percent
French drains		cu ft
Rain garden		sq ft
Grey water system		gal/mo
Irrigation controllers		1= yes 0 = no

The first column, Component, lists common types of land cover and water infrastructure on lots in suburban California. More advanced users can add to this list of components as necessary, while altering background calculations.

The second column, Value, is where the user enters all of the necessary data. This information is based on measurements from the lot.

The third column, Unit, describes the units that the input data must be in. For example, land cover values must be entered in square feet. It is critical to ensure that the input data is in the correct units.

Measuring Data

There are two main methods of collecting the data to enter into the tool. The user can either visit the lot of interest in person and measure land covers, or calculate values by digitizing in a geographic information system (GIS) or Google Earth Pro. After digitizing, it may also be useful to field-verify data.

In general, the more accurate the input data, the more accurate the output will be. Nonetheless, any homeowner should be able to implement the tool after taking some rough measurements with a measuring tape.

Reading Output Data

There are two places in the tool to find output data. Intermediate output values are to the right of the worksheet. Final metrics are at the bottom of the worksheet.

The intermediate values—Cost values and Water Intensity—are used as stepping-stones before deriving the final Cost and Applied Outdoor Water values.

A	B	C	D	E	F	G	H	I
COMPONENT	**VALUE**	**UNIT**	Initial cost	Cost over 10 years	Cost over 20 years	Cost over 50 years	Cost over 100 years	Water Intensity
Lot land cover								
Asphalt		*sq ft*	0	0	0	0	0	
Concrete		*sq ft*	0	0	0	0	0	
Pavers, brick or nautral stone		*sq ft*	0	0	0	0	0	
Permeable pavement - pavers		*sq ft*	0	0	0	0	0	
Permeable pavement - porous asphalt		*sq ft*	0	0	0	0	0	
Permeable pavement - porous concrete		*sq ft*	0	0	0	0	0	
Permeable pavement - gravel		*sq ft*	0	0	0	0	0	
Deck		*sq ft*	0	0	0	0	0	
Turf grass		*sq ft*	0	0	0	0	0	0
Artificial turf grass		*sq ft*	0	0	0	0	0	
Cultivated flower or vegetable garden		*sq ft*	0	0	0	0	0	0
Sparse irrigated vegetation		*sq ft*	0	0	0	0	0	0
Dense irrigated vegetation		*sq ft*	0	0	0	0	0	0
Natural/naturalized vegetation		*sq ft*	0	0	0	0	0	0
Pool		*sq ft*	0	0	0	0	0	0
Pond		*sq ft*	0	0	0	0	0	
Existing trees (canopy)		*sq ft*						0
Trees (count)		*count*	0	0	0	0	0	0
Roof								
Composition Roof		*sq ft*	0	0	0	0	0	
Slate Roof		*sq ft*	0	0	0	0	0	
Wood Roof		*sq ft*	0	0	0	0	0	
Clay Roof		*sq ft*	0	0	0	0	0	
Green roof		*sq ft*	0	0	0	0	0	
Water Infrastructure								
Rain barrels		*gal*	0	0	0	0	0	
Downspout disconnection		*percent*						
French drains		*cu ft*	0	0	0	0	0	
Rain garden		*sq ft*	0	0	0	0	0	
Grey water system		*gal/mo*						
Irrigation controllers		*1= yes 0 = no*	0	0	0	0	0	

The Cost columns show the price of each component over time.

The Water Intensity column indicates which land cover requires the most water. This number is primarily intended to be used as a multiplier when calculating applied outdoor water. It is not a standalone value and should not be reported outside the tool. Users may find the relative measures of each land cover's water consumption interesting, however—it may be possible to see, for example, that a small garden of high-water-use flowers requires more water than a large bed of drought-tolerant plants.

The intermediate outputs, combined with the input values, lead to the final metrics of the tool:

Total lot size	**0**	*sq ft*
Impervious land cover	**0**	*sq ft*
Pct Impervious land cover	**0%**	*percent*
Peak monthly water runoff from impervious cover	**0**	*gal*
Peak monthly applied outdoor water consumption	**0**	*gal*
Peak monthly CO2 emissions (from outdoor water use)	**0.0**	*lbs*
Cost of program		
Initial cost	**$0**	*dollars*
10 year cost	**$0**	*dollars*
20 year cost	**$0**	*dollars*
50 year cost	**$0**	*dollars*
100 year cost	**$0**	*dollars*

The metrics are discussed in detail in Sections 2.3 and 4 of the report.

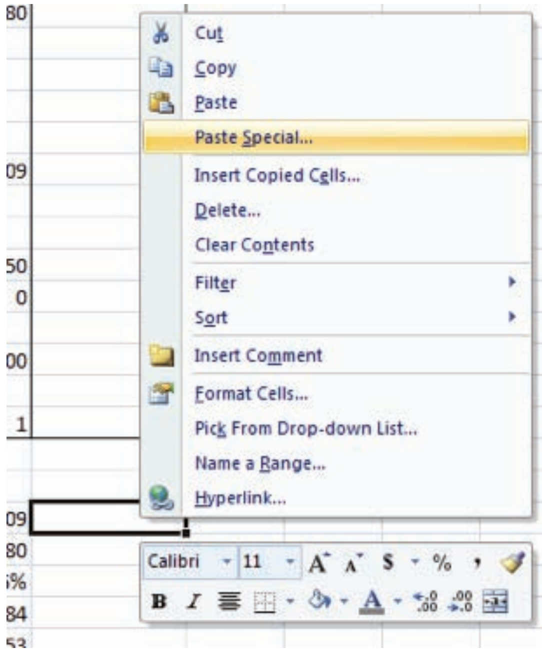
Storing Data

Users can store the input data and final metrics from **Calculator|Lot** in **Worksheet|Lots**. Presently, in **Worksheet|Lots**, information is available from the four case study sites described in the report.

Lot Landcover		Traditional	SUSUMP	Greenpoint	One Planet	Custom
Asphalt	sq ft					
Concrete	sq ft	516	907	330		
Pavers, brick or nautral stone	sq ft					
Permeable pavement - pavers	sq ft				828	
Permeable pavement - porous asphalt	sq ft					
Permeable pavement - porous concrete	sq ft					
Permeable pavement - gravel	sq ft					
Deck	sq ft					
Turf grass	sq ft	598	1125		364	
Artificial turf grass	sq ft					
Cultivated flower or vegetable garden	sq ft				185	
Sparse irrigated vegetation	sq ft	1228		2587	2052	
Dense irrigated vegetation	sq ft	463	354			
Natural/naturalized vegetation	sq ft					
Pool	sq ft					
Pond	sq ft					
Existing trees (canopy)	sq ft	304	495			
Existing trees (count)	count	3	9	4	4	
New trees	count					
Roof						
Composition Roof	sq ft	2480	1831	2001	2080	
Slate Roof	sq ft					
Wood Roof	sq ft					
Clay Roof	sq ft					
Green roof	sq ft					
TOTAL AREA	sq ft	5318	5562	5023	5509	
Lot Water Infrastructure						
Rain barrels	gal				550	
Downspout disconnection	percent	100			0	
French drains	count					
Rain garden	sq ft				200	
Grey water system	gal/day					
Irrigation controllers	1 or 0				1	
Total lot size	sq ft	5589	4712	4918	5509	
Impervious land cover	sq ft	2996	2738	2331	2080	
Pct Impervious land cover	percent	54%	58%	47%	37.76%	
Peak monthly water runoff from impervious cover	gal	13943	12742	10848	8184	
Peak monthly applied outdoor water consumption	gal	3738	4291	1874	2653	
Peak monthly CO2 emissions (from outdoor water use)	lbs	3.8	4.4	1.9	2.7	
Cost of program						
Initial cost	dollars	$23,876	$17,458	$23,716	$41,727	
10 year cost	dollars	$34,916	$22,540	$36,651	$65,134	
20 year cost	dollars	$45,956	$27,622	$50,116	$91,971	
50 year cost	dollars	$92,510	$56,368	$100,233	$193,838	
100 year cost	dollars	$174,578	$108,780	$187,000	$357,169	

The Custom tab is included to encourage users to add their own data. Users can compare their lot against the case studies or delete the case study data and personalize the tool.

Note that when copying and pasting data between sheets, we suggest using the Paste Special command. Right-click on the destination location, choose Paste Special, and then choose "Values and number formats." This will ensure that the cells copy as cleanly as possible, retaining the final output values and formatting without copying over the cell formulas. In general, the Paste Special > Values command is the best way to copy and paste data throughout the tool.



➤ TASK 3. NEIGHBORHOOD CALCULATIONS

The neighborhood calculations require more steps than the lot calculations. Because neighborhoods are composed of both lots and public infrastructure, this task uses **Calculator|Lot** and **Calculator|Neighborhood**, then adds the outputs from both of these calculators together in **Worksheet|Neighborhoods**.

Neighborhood

Lots

The lot calculations for the neighborhood are performed in exactly the same way as the individual lot calculations. For the neighborhood, however, the user should enter aggregated lot data instead of individual lot information. For example, the concrete value should include all of the concrete that exists in lots across the whole neighborhood (it should not include public infrastructure, like sidewalks). This information is most easily derived by digitizing all of the land cover types in the lots and summarizing the values using GIS or Google Earth Pro (see Section 3.3 of the report for more information).

Sample data from the case study sites is available on the **Worksheet|Lots** tab.

		Traditional	SUSUMP	Greenpoint	One Planet	Custom
Total neighborhood size	*sq ft*	2,453,620	752,184	1,304,277	8,712,000	
Total residential area	*acres*				200	
Total number of SF homes	*count*	224	88	138	743	
Total number of MF/apts	*count*		62	24	951	
Lot Landcover						
Asphalt	*sq ft*				0	
Concrete	*sq ft*	261,222	93,909	50,219	0	
Pavers, brick or nautral stone	*sq ft*	29,577	3,047		0	
Permeable pavement - pavers	*sq ft*	22,699	364		165,600	
Permeable pavement - porous asphalt	*sq ft*				0	
Permeable pavement - porous concrete	*sq ft*				0	
Permeable pavement - gravel	*sq ft*				0	
Deck	*sq ft*	16,190			0	
Turf grass	*sq ft*	314,462	64,405	527	72,800	
Artificial turf grass	*sq ft*	425			0	
Cultivated flower or vegetable garden	*sq ft*	3,783			37,000	
Sparse irrigated vegetation	*sq ft*	144,322	50,704	314,172	410,400	
Dense irrigated vegetation	*sq ft*	87,551	54,850		0	
Natural/naturalized vegetation	*sq ft*				0	
Pool/Fountain/Hot Tub	*sq ft*	2,691			0	
Pond	*sq ft*	165			0	
Trees (canopy)	*sq ft*	388,209	6,136	7,081	0	
Trees (count)	*count*	1,587	227	872	800	
Roof						
Composition Roof	*sq ft*	780,087	220,978	259,664	416,000	
Slate Roof	*sq ft*				0	
Wood Roof	*sq ft*				0	
Clay Roof	*sq ft*				0	
Green roof	*sq ft*				0	
Lot Water Infrastructure						
Rain barrels	*gal*				110,000	
Downspout disconnection	*percent*	100%				
French drains	*count*				0	
Rain garden	*sq ft*				40,000	
Grey water system	*gal/day*				0	
Irrigation controllers	*1 or 0*				1	

When creating a custom scenario, after inputting the combined lot data into **Calculator| Lot**, copy and paste the output metrics from the lot tab in the worksheet under ALL LOTS.

ALL LOTS						
Total impervious land cover	*sq ft*	1,071,311	317,934	309,883	416,000	0
Peak monthly water runoff from impervious cover	*gal*	4,984,444	1,479,604	1,442,137	1,636,785	0
Peak monthly outdoor water consumption	*gal*	1,651,472	314,912	237,731	472,306	0
Peak monthly CO2 emissions (from outdoor water use)	*lbs*	1,685	321	243	482	0
Cost of program						
Initial cost	*dollars*	$8,154,374	$2,343,625	$2,952,034	$8,324,894	0
10 year cost	*dollars*	$10,451,211	$3,164,755	$4,523,948	$12,927,888	0
20 year cost	*dollars*	$13,251,123	$3,985,885	$6,095,862	$18,274,882	0
50 year cost	*dollars*	$26,898,059	$8,036,175	$12,192,252	$38,471,064	0
100 year cost	*dollars*	$50,679,814	$15,252,157	$22,813,117	$70,919,234	0

Public infrastructure

For the neighborhood scale, it is also necessary to calculate metrics for public infrastructure. In the sample data in the worksheet, these are found under Neighborhood Transportation Infrastructure and Neighborhood Water Infrastructure.

Neighborhood Transportation Infrastructure						
Street						
Asphalt	*sq ft*	425,993	117,559	186,119	1,651,200	
Concrete	*sq ft*					
Curbs and Gutters - concrete	*sq ft*	24,161	7,395	13,919	31,840	
Sidewalk - concrete	*sq ft*	110,296	54,860	95,219	315,920	
Parking Lot - asphalt	*sq ft*			16,809	90,000	
Neighborhood Water Infrastructure						
Grey infrastructure						
Corrugated Metal Pipe (CMP)						
8 in	*lf*					
10 in	*lf*					
12 in	*lf*					
15 in	*lf*	2,528	551	474		
18 in	*lf*	575	1,220	1,380		
24 in	*lf*		135	291		
30 in	*lf*		250	442		
36 in	*lf*			423		
42 in	*lf*			691		
48 in	*lf*					
60 in	*lf*					
72 in	*lf*					
Reinforced Concrete Pipe (RCP)						
12 in	*lf*					
15 in	*lf*					
18 in	*lf*					
21 in	*lf*	119				
24 in	*lf*	19				
27 in	*lf*	523				
30 in	*lf*	760				
36 in	*lf*	304				
42 in	*lf*					
46 in	*lf*	340				
48 in	*lf*				22,844	
54 in	*lf*	700				
60 in	*lf*					
72 in	*lf*					
84 in	*lf*					
96 in	*lf*			31		
Green Infrastructure						
Vegetated Filter Strips/Bioswales	*sq ft*	9,807	31,103	34,939	813,520	
Neighborhood open space						
Managed open space	*sq ft*	244,967	6,760	145,725	422,532	
Naturalized open space	*sq ft*	38,486	423,555	61,399	766,656	

All of the neighborhood data can be input into **Calculator|Neighborhood** in the same manner as in **Calculator|Lot**. As with the lots, it is critical to enter the values in the appropriate units.

A	B	C	D	E	F	G	H
COMPONENT	VALUE	UNIT	Initial cost	Cost over 10 years	Cost over 20 years	Cost over 50 years	Cost over 100 years
Total Neighborhood size		acres					
Neighborhood transportation infrastructure							
Street							
Asphalt		sq ft	0	0	0	0	0
Concrete		sq ft	0	0	0	0	0
Curbs and Gutters - concrete		lf	0	0	0	0	0
Sidewalk - concrete		sq ft	0	0	0	0	0
Parking Lot - asphalt		sq ft	0	0	0	0	0
Neighborhood water infrastructure							
Grey infrastructure							
Corrugated Metal Pipe (CMP)							
8 in		lf	0	0	0	0	0
10 in		lf	0	0	0	0	0
12 in		lf	0	0	0	0	0
15 in		lf	0	0	0	0	0
18 in		lf	0	0	0	0	0
24 in		lf	0	0	0	0	0
30 in		lf	0	0	0	0	0
36 in		lf	0	0	0	0	0
42 in		lf	0	0	0	0	0
48 in		lf	0	0	0	0	0
60 in		lf	0	0	0	0	0
72 in		lf	0	0	0	0	0
Reinforced Concrete Pipe (RCP)							
12 in		lf	0	0	0	0	0

While the input values for **Calculator|Neighborhood** are different, the outputs are very similar. The exception is that the neighborhood calculator does not have Water Intensity as an intermediary output. For lots, Water Intensity was useful when deriving applied outdoor water because there are many land cover components, each contributing to outdoor water consumption. In neighborhoods, there is only one land cover that uses outdoor water—managed open space. Because this is a simpler calculation, it was not necessary to calculate Water Intensity as an intermediary.

After completing the neighborhood calculations, copy and paste the outputs to **Worksheet|Neighborhoods** under NEIGHBORHOOD INFRASTRUCTURE.

NEIGHBORHOOD INFRASTRUCTURE						
Total impervious land cover	sq ft	613,292	223,522	347351	2250132	0
Peak monthly water runoff from impervious cover	gal	2,780,788	807,576	1355160	4386557	0
Peak monthly outdoor water consumption	gal	1,007,513	27,803	599345	1737812	0
Peak monthly CO2 emissions (from outdoor water use)	lbs	1,028	28	612	1773	0
Cost of program						
Initial cost	dollars	$4,284,573	$1,747,710	$2,856,059	$24,417,333	$0
10 year cost	dollars	$4,676,520	$1,758,526	$3,089,219	$25,093,384	$0
20 year cost	dollars	$5,164,720	$1,851,112	$3,541,453	$28,419,339	$0
50 year cost	dollars	$10,265,631	$3,989,301	$7,371,623	$64,032,781	$0
100 year cost	dollars	$20,220,694	$7,609,756	$14,218,405	$118,151,556	$0

Combining Lots and Infrastructure in the Worksheet

Automatically, the worksheet adds together ALL LOTS and NEIGHBORHOOD INFRASTRUCTURE to create combined neighborhood output metrics. The combined metrics are labeled TOTAL CONSUMPTION.

ALL LOTS						
Total impervious land cover	sq ft	1,071,311	317,934	309,883	416,000	0
Peak monthly water runoff from impervious cover	gal	4,984,444	1,479,604	1,442,137	1,636,785	0
Peak monthly outdoor water consumption	gal	1,651,472	314,912	237,731	472,306	0
Peak monthly CO2 emissions (from outdoor water use)	lbs	1,685	321	243	482	0
Cost of program						
Initial cost	dollars	$8,154,374	$2,343,625	$2,952,034	$8,324,894	0
10 year cost	dollars	$10,451,211	$3,164,755	$4,523,948	$12,927,888	0
20 year cost	dollars	$13,251,123	$3,985,885	$6,095,862	$18,274,882	0
50 year cost	dollars	$26,898,059	$8,036,175	$12,192,252	$38,471,064	0
100 year cost	dollars	$50,679,814	$15,252,157	$22,813,117	$70,919,234	0
NEIGHBORHOOD INFRASTRUCTURE						
Total impervious land cover	sq ft	613,292	223,522	347351	2250132	0
Peak monthly water runoff from impervious cover	gal	2,780,788	807,576	1355160	4386557	0
Peak monthly outdoor water consumption	gal	1,007,513	27,803	599345	1737812	0
Peak monthly CO2 emissions (from outdoor water use)	lbs	1,028	28	612	1773	0
Cost of program						
Initial cost	dollars	$4,284,573	$1,747,710	$2,856,059	$24,417,333	$0
10 year cost	dollars	$4,676,520	$1,758,526	$3,089,219	$25,093,384	$0
20 year cost	dollars	$5,164,720	$1,851,112	$3,541,453	$28,419,339	$0
50 year cost	dollars	$10,265,631	$3,989,301	$7,371,623	$64,032,781	$0
100 year cost	dollars	$20,220,694	$7,609,756	$14,218,405	$118,151,556	$0
TOTAL CONSUMPTION						
Total land area	sq ft	2,453,620	752,184	1,304,277	8,712,000	0
Total impervious land cover (residential + community infrastructure)	sq ft	1,684,603	541,456	657,234	2,666,132	0
Percent impervious land cover (of whole development)	percent	69%	72%	50%	31%	#DIV/0!
Peak monthly water runoff from impervious cover	gal	7,765,232	2,287,181	2,797,296	6,023,342	0
Peak monthly outdoor water consumption	gal	2,658,985	342,715	837,076	2,210,118	0
Peak monthly CO2 emissions (from outdoor water use)	lbs	2,713	350	854	2,255	0
Cost of program						
Initial cost	dollars	$12,438,947	$4,091,335	$5,808,093	$32,742,227	$0
10 year cost	dollars	$15,127,732	$4,923,281	$7,613,167	$38,021,272	$0
20 year cost	dollars	$18,415,843	$5,836,997	$9,637,315	$46,694,221	$0
50 year cost	dollars	$37,163,690	$12,025,476	$19,563,875	$102,503,845	$0
100 year cost	dollars	$70,900,508	$22,861,913	$37,031,521	$189,070,790	$0

Note that the Custom column seems to contain a divide-by-zero error—this formula will calculate if a user enters custom neighborhood data.

In addition to total consumption, this worksheet calculates the output metrics per acre. These data are available under CONSUMPTION PER ACRE.

CONSUMPTION PER ACRE		Traditional	SUSMP	Greenpoint	One Planet	Custom
Percent impervious land cover (of whole development)	acre/acre	0.69	0.72	0.50	0.31	#DIV/0!
Peak monthly water runoff from impervious cover	acre-foot/acre	0.42	0.41	0.29	0.09	#DIV/0!
Peak monthly outdoor water consumption	acre-foot/acre	0.14	0.06	0.09	0.03	#DIV/0!
Peak monthly CO2 emissions (from outdoor water use)	lbs/acre	48.17	20.25	28.53	11.28	#DIV/0!
Cost of program						
Initial cost	dollars/acre	$220,833.12	$236,934.80	$193,977.61	$163,711.13	#DIV/0!
10 year cost	dollars/acre	$268,568.07	$285,113.92	$254,263.13	$190,106.36	#DIV/0!
20 year cost	dollars/acre	$326,943.10	$338,028.46	$321,865.25	$233,471.11	#DIV/0!
50 year cost	dollars/acre	$659,780.39	$696,411.69	$653,390.66	$512,519.23	#DIV/0!
100 year cost	dollars/acre	$1,258,722.27	$1,323,964.52	$1,236,771.84	$945,353.95	#DIV/0!

➤ TASK 4. VISIONING

The **Visioning|Town to Watershed** tab uses the resource consumption per acre (described above) to calculate total consumption over a broader land area. A user can enter acre values for default neighborhood types and examine how the neighborhood metrics would scale. This calculation is a simple extrapolation from the consumption per acre, so it should be approached with caution. More information is available in the report in Section 3.4.

Land Use	Value	Unit
Residential Land		
Tradtional		acres
SUSMP		acres
Greenpoint		acres
Custom		acres
Percent impervious land cover (of whole development)	0	acres
Peak monthly water runoff from impervious cover	0	acre-feet
Peak monthly outdoor water consumption	0	acre-feet
Peak monthly CO2 emissions (from outdoor water use)	0	lbs
Cost of program		
Initial cost	$0	dollars
10 year cost	$0	dollars
20 year cost	$0	dollars
50 year cost	$0	dollars
100 year cost	$0	dollars

More advanced Excel users can add new neighborhood types to **Visioning|Town to Watershed**.

➤ TASK 5. VIEWING AND EDITING THE DATA

Editing the background information is necessary to customize a tool to a new locality. All data and calculations in the tool are currently tailored to Sonoma County.

Some data is more straightforward to update than other data. Crop coefficients and monthly water data are the easiest data sources to alter, requiring no change in formulas in the tool. Price data is slightly more challenging—it is necessary to make sure the costs are in the appropriate units before updating costs per unit. ET Zones and Greenhouse Gases are the most challenging. ET Zones requires changes to the applied outdoor water formulas, while Greenhouse Gases requires the user to perform some research on area-specific multipliers.

Prices

Prices for construction components are based on the best available information for Sonoma County, from June to November 2012. For descriptions of many of the components, please refer to Appendix 5.2. More detail on the price quotes (including sources) is available under "Cost Sources," page 27.

Component	Unit	Cost per unit	Lifespan	Cost per unit for 10 years	Cost per unit for 20 years	Cost per unit for 50 years	Cost per unit for 100 years
Concrete Sidewalk and Driveway	Sq Ft	6.81	30	6.81	6.81	13.62	27.24
Curbs and Gutters	Lf	24.74	30	24.74	24.74	49.48	98.96
Street	Sq Ft	4.775	30	4.775	4.775	9.55	19.1
Parking Lot	Sq Ft	4.1	30	4.1	4.1	8.2	16.4
Conventional Stormwater Conveyance							
Channelized Creeks	acres	11272	999	11272	11272	11272	11272
Corrugated Metal Pipe (CMP)							
8 in	Lf	17.55	20	17.55	35.1	52.65	105.3
10 in	Lf	21.5	20	21.5	43	64.5	129
12 in	Lf	26	20	26	52	78	156
15 in	Lf	30	20	30	60	90	180
18 in	Lf	35.5	20	35.5	71	106.5	213
24 in	Lf	43	20	43	86	129	258
30 in	Lf	64.5	20	64.5	129	193.5	387

ET Zones

Evapotranspiration information is necessary for the applied outdoor water calculations. The tool includes evapotranspiration information for the whole state by month. Currently, the tool relies only on data from Zone 5 (Sonoma County). See Applied Outdoor Water in Section 2.3 of the report for more information.

A	B	C	D	E	F	G	H	I	J	K	L	M
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
1	0.93	1.4	2.48	3.3	4.03	4.5	4.65	4.03	3.3	2.48	1.2	0.62
2	1.24	1.68	3.1	3.9	4.65	5.1	4.96	4.65	3.9	2.79	1.8	1.24
3	1.86	2.24	3.72	4.8	5.27	5.7	5.58	5.27	4.2	3.41	2.4	1.86
4	1.86	2.24	3.72	4.8	5.27	5.7	5.89	5.58	4.5	3.41	2.4	1.86
5	0.93	1.68	2.79	4.2	5.58	6.3	6.51	5.89	4.5	3.1	1.5	0.93
6	1.86	2.24	3.41	4.8	5.58	6.3	6.51	6.2	4.8	3.72	2.4	1.86
7	0.62	1.4	2.48	3.9	5.27	6.3	7.44	6.51	4.8	2.79	1.2	0.62
8	1.24	1.68	3.41	4.8	6.2	6.9	7.44	6.51	5.1	3.41	1.8	0.93
9	2.17	2.8	4.03	5.1	5.89	6.6	7.44	6.82	5.7	4.03	2.7	1.86
10	0.93	1.68	3.1	4.5	5.89	7.2	8.06	7.13	5.1	3.1	1.5	0.93
11	1.55	2.24	3.1	4.5	5.89	7.2	8.06	7.44	5.7	3.72	2.1	1.55
12	1.24	1.96	3.41	5.1	6.82	7.8	8.06	7.13	5.4	3.72	1.8	0.93
13	1.24	1.96	3.1	4.8	6.51	7.8	8.99	7.75	5.7	3.72	1.8	0.93
14	1.55	2.24	3.72	5.1	6.82	7.8	8.68	7.75	5.7	4.03	2.1	1.55
15	1.24	2.24	3.72	5.7	7.44	8.1	8.68	7.75	5.7	4.03	2.1	1.24
16	1.55	2.52	4.03	5.7	7.75	8.7	9.3	8.37	6.3	4.34	2.4	1.55
17	1.86	2.8	4.65	6	8.06	9	9.92	8.68	6.6	4.34	2.7	1.86
18	2.48	3.36	5.27	6.9	8.68	9.6	9.61	8.68	6.9	4.96	3	2.17

Irrigation

The Irrigation tab calculates the relative amount of water required by each landscaping component and includes figures on the efficiency of irrigation equipment. It contains three separate tables that are all needed for Irrigation calculations.

Water Use Multiplier

This multiplier is combined with area and evapotranspiration data in the calculator to determine applied outdoor water. The main objective of this table is to enter Crop Coefficient, Density Coefficient, and Exposure Coefficient multipliers.

Land cover	Crop Coefficient	Density Coefficient	Exposure Coefficient
Turf grass	High	Moderate	Moderate
Cultivated flower or vegetable garden	High	Moderate	Moderate
Sparse irrigated vegetation	Moderate	Low	Moderate
Dense irrigated vegetation	Moderate	High	Moderate
Natural/naturalized vegetation	Very Low	Moderate	Moderate
Trees			
If canopy is specified	Moderate	Moderate	Moderate
If canopy is not specfieid (i.e., trees are immature)	Moderate	Low	Moderate

Updating these variables is valuable and easy, even for novice Excel users. Sensitivity testing in the report determined that the water output metrics are sensitive to changes in local environmental conditions. In order for the tool to give measurements as accurately as possible, it is best to alter the Crop, Density, and Exposure coefficients as is appropriate for the study area. For example, in some places the land cover "sparse irrigated vegetation" may be drought-tolerant vegetation, in which case it would be appropriate to revise the Crop Coefficient from Moderate to Low. Similarly, if a site were located in a hot and sunny microclimate, it would be appropriate to increase the Exposure Coefficient to High. Changes in the coefficients can be made through pop-up menus:

Land cover	Crop Coefficient	Density Coefficient	Exposure Coefficient	C
Turf grass	High	Moderate	Moderate	0
Cultivated flower or vegetable garden	High	Moderate	Moderate	0
Sparse irrigated vegetation	Moderate	w	Moderate	0
Dense irrigated vegetation	Very Low	gh	Moderate	0
Natural/naturalized vegetation	Low Moderate	oderate	Moderate	0
	High			
Trees				
If canopy is specified	Moderate	Moderate	Moderate	0
If canopy is not specfieid (i.e., trees are immature)	Moderate	Low	Moderate	0

The coefficient inputs are used to determine the Water Use Multiplier.

Land cover	Crop Coefficient	Density Coefficient	Exposure Coefficient	Crop Coefficient	Density Coefficient	Exposure Coefficient	Water Use Multiplier
Turf grass	High	Moderate	Moderate	0.9	1	1	0.9
Cultivated flower or vegetable garden	High	Moderate	Moderate	0.9	1	1	0.9
Sparse irrigated vegetation	Moderate	Low	Moderate	0.5	0.5	1	0.25
Dense irrigated vegetation	Moderate	High	Moderate	0.5	1.3	1	0.65
Natural/naturalized vegetation	Very Low	Moderate	Moderate	0.1	1	1	0.1
Trees							
If canopy is specified	Moderate	Moderate	Moderate	0.5	1	1	0.5
If canopy is not specfieid (i.e., trees are immature)	Moderate	Low	Moderate	0.5	0.5	1	0.25

Note that the grayed-out values in the Water Use Multiplier calculations are exact duplicates of the values in the Water Use Coefficients table.

Water Use Coefficients	Very Low	Low	Moderate	High
Crop	0.1	0.2	0.5	0.9
Planting density		0.5	1	1.3
Exposure		0.5	1	1.4

We decided it would be easier for most users to select coefficients with the pop-up menus rather than manipulate water coefficients directly. More advanced gardeners may wish to alter the raw numbers, however. See Applied Outdoor Water in Section 2.3 of the report for more information.

Irrigation Efficiency

Lastly, this worksheet includes data on irrigation efficiency and irrigation controllers. For more information, see Applied Outdoor Water in Section 2.3 of the report.

Irrigation Method	Efficiency
Drip	90%
Sprinkler	50%
DWR default efficiency	71%
Irrigation controller	6.10%

Rainfall

Like most of the other data in the tool, rainfall information is specific to Sonoma County. The tool relies on monthly rainfall data—design storm information is available for reference (the tool could be altered to calculate runoff volumes per design storm). Users can update monthly rainfall data as appropriate.

A	B
By: Design Storm	**Rain (in)**
85th percentile of 24-hour storm event	0.92
By: Month	**Rain (in)**
January	4.05
February	4.78
March	3.83
April	2.18
May	1.62
June	0.43
July	0
August	0
September	0
October	1.79
November	2.19
December	7.47

Greenhouse Gas Emissions

The **Data|Green House Gas Emissions** tab calculates the amount of carbon dioxide embedded in water in Sonoma County. The first column contains the components of Sonoma's water system that consume energy. The tool examines only outdoor water, and some of the components are not relevant to outdoor water. These values are grayed out and available for reference.

A	B	C	D	E
Water system component	**Energy Intensity Ratio (kWh/Mgal)**	**Carbon Dioxide Intensity (lbs/yr)**	**Carbon Dioxide Emissions (lbs/Mgal)**	**Carbon Dioxide Emissions (lbs/gal)**
Groundwater Pumps	1851.5	0.445	823.9175	0.000823918
Booster Pumps	441.5	0.445	196.4675	0.000196468
Wastewater Treatment	3376.5	0.445	1502.5425	0.001502543
Waste Water Pumps	2	0.445	0.89	0.00000089
Recycled Water Pumps	359.5	0.445	159.9775	0.000159978
TOTAL (for Sonoma County)				0.001020385

Each water system component has a reported energy intensity ratio (Column B). Each utility has a carbon dioxide coefficient, which is consistent across all components because it is contingent on the utility's energy portfolio (Column C). Multiplied together, this gives the carbon dioxide emissions per million gallons (Column D). Since the tool calculates gallons of applied outdoor water, however, it is necessary to find the pounds of carbon dioxide per gallon of water (Column E). Summing across the relevant components, the tool calculates the total carbon dioxide per gallon in Sonoma County.

For more information on where to find these figures for another locality, see Greenhouse Gas Emissions from Outdoor Water, Section 2.3. in the report.

➤ TASK 6. ALTERING CALCULATIONS

All calculations take place in either the data sheets or the output value. It is possible for anyone to click on one of these cells, see the formula, and change it.

The primary challenge when changing calculations is ensuring that all of the formulas point to the expected cells. Because some of the formulas refer to data on several different worksheets, it can be difficult to visually ensure that all the cells are correct. Use caution when editing the background data. Reordering components can be particularly difficult.

Before you make any changes, we suggest carefully reading Sections 2.3, 3.2, and 4 in the report.

GLOSSARY OF LID TERMS

Bioswale: A gently sloped drainage canal filled with vegetation, compost, and gravel or rock. Bioswales are similar to rain gardens in that they are designed to reduce runoff volume and remove pollutants from surface runoff. Bioswales are commonly constructed around parking lots or in areas where heavily polluted runoff can be treated before it reaches the watershed or drainage sewer.

Cisterns: Similar to rain barrels, cisterns hold rainwater captured from impervious surfaces, only cisterns are generally much larger. Cisterns are commonly constructed out of concrete, steel, or synthetic material and can be stored above or below ground. Depending on the filtration and water purification system, water collected in cisterns may be used for human consumption.

Cultivated Flower or Vegetable garden: An area of land used for the cultivation of flowers, vegetables, herbs, or fruit.

Deck: An outdoor structure commonly constructed of wood and consisting of a raised floor with surrounding railing and steps leading to ground level.

Downspout Disconnection: Downspouts are a common adaptation to drains, which collect water from rooftop gutters that redistribute water runoff onto pervious surfaces that would otherwise be directed into the sewer system. The existing sewer connection is capped, and the water runoff can be used, collected, or redistributed to water surrounding vegetation.

French Drain: French drains consist of a trench containing a perforated pipe covered with gravel or rock that redirects water runoff away from an area. French drains are commonly constructed around the perimeter of a structure or home in order to prevent ground or surface water from damaging a building's foundation.

Graywater System: A system that captures, filters, and cleans wastewater from bathtubs or sinks and directs it to be used for irrigation purposes.

Green Roof: A green roof, also known as a living roof or eco-roof, is a roof of a building either partially or completely covered with vegetation planted over a waterproofing membrane. Low-profile and lightweight green roofs that consist of mosses, sedums, herbs, and perennials are known as "extensive." Roofs with deeper growth consisting of trees, shrubs, and activity areas are known as "intensive."

Hollywood Driveway: A driveway consisting of mostly vegetated or grassy area and two parallel narrow strips of concrete spaced so that a vehicle's wheels can drive on them.

Native Plants: Plants or vegetation indigenous to a given area.

Permeable Pavement: Permeable or porous pavements are a paving system designed to allow water to percolate through the pavement in order to restore the pre-development hydrologic cycle and reduce water runoff. Permeable pavements include porous asphalt, porous concrete, gravel, and modular pavers.

Planter Box: A box, concrete or wooden, containing a growing medium such as soil or mulch and vegetation. Planter boxes are an effective way to treat water runoff in urban areas while also providing valuable green space and aesthetics.

Pond: A still body of water that is smaller than a lake and is often artificially constructed.

Pool: Also known as a recreational swimming pool, a pool is a small area of still water that sits in an impervious bowl. Pools are usually located in backyards of single-family homes, in a shared multifamily development, or in a publicly shared space.

Rain Barrel: An artificial water reservoir that collects and stores rainwater from downspouts and rooftops to be used for watering surrounding vegetation and lawns. Rain barrels can be constructed in a variety of ways, but all serve the purpose of collecting rainwater and decreasing the amount of runoff from a given property.

Rain Garden: A shallow depression with deep-rooted native plants, grasses, shrubs, and mulch. Rain gardens are usually positioned near a rainwater runoff source such as a parking lot or traffic median. The runoff slowly percolates through the soil, is filtered, and then infiltrates into a surrounding soil medium.

Rain Harvesting System: The process of capturing, filtering, and utilizing rainfall from impervious surfaces such as roofs, driveways, or parking lots.

Soil Amendments: Soil amendments, which include soil conditioners and fertilizers, make soil more suitable for plant growth and increase water retention capabilities. Introducing compost and soil amendments to disturbed and compacted soils changes the physical, chemical, and biological characteristics of the soil, effectively reducing runoff volume and enhancing pollutant removal.

Tree Box Filters: Small bioretention areas consisting of soil, mulch, and drainage systems installed beneath a shrub or tree. Tree box filters effectively collect stormwater runoff directly from impervious surfaces and filter it through vegetation and a soil medium to enhance overall pollutant removal.

Turf (Artificial): An area of synthetic fibers that mimics the aesthetic of natural grass. Artificial turf grass is often used in sports arenas to take advantage of the low maintenance costs and high level of durability.

Turf (Lawn): An area of land planted with grasses that are maintained at a short height and used for aesthetic and recreational purposes. Commonly featured in the front yards and/or backyards of private households, public parks, and assorted sports fields.

Vegetated Filter Strips: Bands of vegetation designed to catch, filter, and slow runoff volumes. Filter strips also enhance the reduction of pollutants found in stormwater runoff through the process of absorption, filtration, and evapotranspiration.