RSMP and UWSCF Payment Rate Structures – Summary of Proposed Changes

The City of Austin is in the process of updating the payment rate structures for the Regional Stormwater Management Program (RSMP) and Urban Watershed Structural Control Fund (UWSCF). The Watershed Protection Department (WPD) recently completed a study to provide recommendations for updates to the payment structures of these two programs, both of which provide payment in lieu of on-site control options for qualifying developments. The payment structures of these two programs were last evaluated and updated in 2002.

Participation in the Programs

The RSMP provides a method of alternative compliance to the code requirement for on-site detention. There are two general options for participating in RSMP: 1) payment in lieu of detention with drainage analysis to show no adverse flooding impact in order to justify participation or 2) construction of drainage improvements that provide a public benefit and do not cause adverse flooding impacts as credit towards the RSMP payment amount.

The UWSCF provides a payment in lieu option for on-site water quality improvement facilities. Participation in the UWSCF is currently restricted to watersheds designated as Urban whereas RSMP participation may be available in any watershed that is within City of Austin full purpose jurisdiction. However, simply being located in a participating watershed does not automatically make a site eligible to participate in either the RSMP or UWSCF.

There are various criteria used by WPD to determine eligibility for participation in these programs. For RSMP, a site must be located in a participating watershed and the proposed development must produce no additional adverse flooding impact to roadways, structures, or other properties. Section 1.2.2(G) of the Drainage Criteria Manual (DCM) For UWSCF, a site must be located in a participating watershed, be less than two acres in size for residential development or less than one acre for commercial development, and have less than 8,000 square feet of total proposed impervious cover (new or redeveloped) per Environmental Criteria Manual (ECM) requirements.

Payment Structure Update Study

The recently completed study evaluated the existing payment structures for both of these programs and provided recommendations for updating the payment methodologies to better keep pace with construction costs and land values in Austin. Each of the programs' payment structures has a construction cost-related component and a land cost-related component. The UWSCF payment also includes a Building Component that was not examined as part of the payment study, but that may ultimately be removed from the calculation. The intent of the payment structures for both is to calculate a comparable amount to what a developer would have to spend to design and construct a storm water control facility on their site.

The study showed that the Construction Cost Component (CCC) of the RSMP and the Site Area Component (SAC) of the UWSCF were lagging behind the actual cost of constructing on-site controls, despite applying an annual adjustment based on the Engineering News Record's (ENR) Construction Cost Index (CCI). The study examined multiple factors to determine whether certain construction cost or site factors impacted the estimated construction cost for on-site controls more than others. Based on these evaluations a similar approach to that followed in the 2002 study was recommended. This approach fits a curve to the collected data for facility construction costs and associated areas of impervious cover and uses this curve to establish the per-acre payment amounts.

For both RSMP and UWSCF the study recommended the pooling of commercial and residential construction cost data for the development of a single cost curve and resultant set of construction cost rates.

Recommended Payment Structure – RSMP Construction Cost Component

WPD staff subsequently determined that, due to the scale of small residential subdivision construction, the proposed combined rate structure for the CCC resulted in a unreasonably large increase in cost for small single-family residential developments. In order to compensate for this, the rate for the first acre of impervious cover under the combined rate structure was adjusted down to provide a discount for single-family residential construction. This is reflected in the summary of construction cost rates in Table 1. Table 1 also compares the new cost per acre of impervious cover rates to the rates from the 2002 study (both the original rates and the rates adjusted based on the ENR CCI). While the adjustment of the rate for the first acre was implemented primarily to provide some relief in the participation payment amount for small SF residential subdivisions, it also provides a small discount to all sizes of SF residential developments.

Table 1: RSMP Construction Cost Component Rates Table

Impervious Acres			Cost per impervious acre					
	From	To	2002 Commercial	2002 Residential	Current Commercial (Adjusted)	Current Residential (Adjusted)	Proposed Commercial	Proposed Residential
A1	0	1	$60,000	$35,000	$101,991	$59,495	$129,000	$103,000
A2	1.01	2	$18,000	$15,000	$30,597	$25,498	$70,000	$70,000
A3	2.01	5	$8,000	$10,000	$13,599	$16,998	$44,000	$44,000
A4	5.01	10	$6,000	$7,000	$10,199	$11,899	$29,000	$29,000
A5	10.01	20	$5,000	$5,000	$8,499	$8,499	$20,000	$20,000
A6	20.01	50	$4,000	$3,000	$6,799	$5,100	$12,000	$12,000
A7	50.01	100	$2,500	$2,000	$4,250	$3,400	$8,000	$8,000
A8	100.01	>	$2,500	$1,500	$4,250	$2,550	$4,000	$4,000

Recommended Payment Structure – UWSCF Construction Cost Component

For the UWSCF, which already used a combined rate structure, the construction cost curve was updated based on the additional data available for the recently completed study. The updated rates are compared to the rates currently in use in Table 2. In order to be consistent with the area breakdown in the RSMP rate structure, an additional acreage range was created through the split of the previous range of 2.01 to 10 acres into two ranges (from 2.01 to 5 acres and from 5.01 to

10 acres). To compare current rates with the proposed rates, the new acreage ranges are used with the current numbers for 2.01 to 10 acres reflected for both of the ranges covered by these acreages (2.01 to 5 and 5.01 to 10).

Table 2: UWSCF Site Impervious Cover Component Rates Table

Impervious Acres			Cost per impervious acre		
	From	To	2002 Commercial/ Residential	Current Commercial/ Residential (Adjusted)	Proposed Commercial/ Residential
A1	0	1	$32,000	$52,614	$114,000
A2	1.01	2	$18,000	$29,595	$58,000
A3	2.01	5	$11,000	$18,086	$34,000
A3/A4	5.01	10	$11,000	$18,086	$21,000
A4/A5	10.01	20	$8,000	$13,153	$14,000
A5/A6	20.01	>	$6,000	$9,865	$8,000

Recommended Payment Structure – Land Cost Components

As part of the final implementation of the payment structures following the 2002 study, static $/acre caps were placed on the land values used to calculate the RSMP Land Cost Component (LCC) and the UWSCF Site Impervious Cover Component (SICC). Because of these static caps on land values, the portions of the participation payments based on land costs have not kept pace with the significant increases in land values that we have experienced in the Austin area since 2002. Thus, the current payment structures produce payment amounts that are steeply discounted relative to the actual land and construction costs for storm water control facilities. As a result, the payment amounts collected are not sufficient for the WPD to construct or implement regional flood risk reduction or water quality solutions commensurate with the actual cost of on-site stormwater controls.

The most significant proposed change to the payment structures is the removal of the static cap on the land value used in the land cost-related components (LCC and SICC). The proposed structure modifies the calculation so that the appraised land value of a site is used rather than a static, capped value dependent only upon type of development. Using the appraised land value makes the calculation site-specific so that areas of town where land has a lower per acre value have a lower land cost-related component than a similar site in an area where the land is more highly valued. The appraised land value in the proposed calculation will be discounted to 80% as a “moving cap”. The 80% discount provides an incentive for developers participate over and above the benefit of not giving up a portion of a site for construction of stormwater controls. The UWSCF SICC will be updated similarly so that the site area and land value of a particular site are used rather than a static $/acre rate depending on development type. The proposed SICC assumes that 3% of the site area would be used for an on-site control and the calculation is modified to reflect this instead of basing the calculation on a static $/acre rate. The RSMP LCC assumes 5% of the site area for construction of an on-site detention pond. This assumption was verified through the examination of the additional construction information collected for the study.

Another modification made to the Land Cost Component of the RSMP payment calculation was the addition of an impervious cover adjustment factor (ICAF). This multiplier was adapted directly from the drainage utility charge and is based on the City-wide weighted average of impervious cover (approximately 52.3%). The equation to determine the ICAF uses the total proposed impervious coverage to adjust the Land Cost Component, providing a slight discount for developments with less than 52.3% proposed impervious coverage (which tend to be mostly single-family residential). For developments with greater than 52.3% proposed impervious coverage, the ICAF will be replaced by a value of one (1). This will ensure that developments with higher impervious coverage are not disincentivized to participate in the RSMP by ICAF adjustment factors greater than one.

A second change is to implement an overall cap on the calculated payment amount per acre based on an the cost of an underground detention vault such as would be utilized on a small urban site with very high (95-100%) impervious cover (and typically a tall building with parking structure) is proposed. The proposed cap, of $440,000/acre, would prevent extremely high land appraisal values from impacting the calculated payment amount of a site so that it is out of proportion with on-site detention. The general payment calculation has a construction cost component that is based on the cost of on-site detention with the assumption that the detention would be an above-ground pond. For urban sites, where the land cost could impact the overall payment amount, the typical on-site detention solution is more likely to be an underground vault given the limited site area and high impervious cover.

Additional Information

The proposed payment structure updates will be a significant change for both programs. If you would like additional information about the changes, a PDF of the stakeholder presentation given on December 19, 2019 along with the handout provided at that presentation are available on the RSMP website. The PowerPoint includes information on changes to the payment structures as well as current and proposed example calculations to illustrate the changes in payment amounts for different types of development and different site areas. The handout includes a list of acronyms and a short section that spells out the steps for each program's proposed payment calculation. The complete payment study report and accompanying technical memorandum can be found on the RSMP website at http://www.austintexas.gov/RSMP. Also available by emailed request is a locked Microsoft Excel spreadsheet with the proposed RSMP payment calculations for single family residential and commercial/multi-family/mixed-use developments so that specific site information can be entered for comparison with the current calculations. Calculation spreadsheets for the current RSMP payment structure can also be requested by emailing RSMP@ausintexas.gov.

Regional Stormwater Management Program Participation Payment and Urban Watersheds Structural Control Fund Payment Methodology Modifications

Prepared for

City of Austin, Texas
Watershed Protection Department

November 2019

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Acronyms and Abbreviations

%	percent
\$/acre	dollar per acre
\$/ft^2	dollar per square foot
2002 Report	CDM, *Regional Stormwater Management Program Payments and Urban Watersheds Structural Control Fund Payments Cost Study,* June 28, 2002
ACS	American Community Survey
AF	adjustment factor
ANOVA	Analysis of variance, a statistical method in which the variation in a set of observations is divided into distinct components
CCC	construction cost component
CH2M	CH2M HILL Engineers, Inc.
City	City of Austin
COA	City of Austin
CoSA	City of San Antonio
CPI-U	Consumer Price Index for all Urban Consumers
DA	drainage area
DET	Detention Pond
DetVol	detention volume
DOEE	Department of Energy & Environment
ENR CCI	Engineering News-Record Construction Cost Index
FILO	fee in lieu of
ft^2	square foot
ft^3	cubic foot/feet
FTE	full-time employees
FY	fiscal year
GI	green infrastructure
IA	impervious area
ICAF	Impervious Cover Adjustment Factor
ILF	in lieu of fee or payment
LCC	land cost component
Louisville MSD	Louisville Metropolitan Sewer District
Offv	off-site retention volume
p-value	probability value

Programs	RSMP and UWSCF Programs
R^2	R Square
RSMP	Regional Stormwater Management Program (City of Austin)
RSWF	Regional Stormwater Facility (City of San Antonio)
RSWMP	Regional Storm Water Management Program (City of San Antonio)
SA	surface area
SAC	site area component
SCM	structural control measure
SICC	site impervious cover component
SRC	Stormwater Retention Credits
SWRv	stormwater retention volume
TCAD	Travis Central Appraisal District
UWSCF	Urban Watersheds Structural Control Fund
WQ	water quality pond
WPD	City of Austin Watershed Protection Department
WQ/DET	water quality/detention pond

Executive Summary

ES.1 Introduction

The City of Austin (City) Watershed Protection Department (WPD) currently provides a payment-in-lieu-of option to land developers as an alternative to providing on-site detention (Regional Stormwater Management Program [RSMP]) or water quality improvement (Urban Watersheds Structural Control Fund [UWSCF]) facilities. The payments are based on the avoided cost associated with the construction of on-site facilities. Revenues are used for the implementation of regional facilities by WPD. The previous update of the respective payment structures occurred in 2002 (CDM, 2002). The effort described in this report resulted in recommendations for updated payment calculations based on current land and construction costs.

The project included two phases: (1) The CH2M HILL Engineers, Inc. (CH2M) project team[1] compiled recent construction cost and land cost data, resulting in recommendations for updated, appropriate payment structures for participation in the RSMP and UWSCF; and (2) The project team conducted a "benchmarking" effort of WPD's RSMP program against similar programs in other cities.

ES.2 Develop Construction Cost/Design Factor Database

For the first task, the project team performed a data collection effort to obtain updated construction cost data for both detention and water quality facilities, collectively called structural control measures (SCMs). The resulting effort was a combination of three data sets, including the following:

- CH2M adjusted the costs associated with projects included in the Regional Stormwater Management Program and Urban Watersheds Structural Control Fund Fee Study (2002 Report) to current (2018) dollars based on the Engineering News-Record Construction Cost Index (ENR CCI) and consistent with the existing payment structure methodology.
- Doucet+Chan provided construction costs for SCM projects based on an average of actual bid prices, some obtained by Doucet+Chan, others provided by WPD.
- WPD identified additional projects to be included; the project team reviewed drawings and bid documents to obtain construction costs and other design parameters.

CH2M compiled the data, including construction costs, resulting increase in impervious area, facility type, and other design parameters, such that each of these components could be evaluated in relation to others.

ES.3 Land Costs and Land Factors

The second data collection effort resulted in recent real estate and land cost data within the areas applicable to the RSMP and UWSCF, as defined in the Environmental and Drainage Criteria Manuals (COA, 2017). Note that WPD is in the process of updating the Criteria Manuals, and the list of participating watersheds currently contained in the Criteria Manuals are inaccurate because the RSMP has been recently expanded to include all watersheds with streams that drain into or through Austin city limits and its extraterritorial jurisdictions. This included actual real estate sales of single-family residential, commercial, and multi-family residential properties.

[1] The project team consists of CH2M, Doucet & Associates, Inc. and Atrium Real Estate Services.

The data collected were used to develop descriptive statistics, define alternatives to the current land cap value employed in the RSMP, and validate (or not) the assumption of 5 percent (%) of total site area required for a detention facility, currently incorporated in the calculation of RSMP payments. The project team was able to validate the 5% assumption for detention facilities. Further, for water quality facilities, an assumption of 3% was justified.

ES.4 Correlate Construction Cost with Design Parameters

One of the two major components of the payment structures is the construction cost; that is found in the construction cost component (CCC) of the RSMP and the Site Impervious Cover Component (SICC) of the UWSCF. The current rate structures are based on the 2002 Report (CDM, 2002), which delineated data by the following land use type: single-family residential, commercial, and multi-family residential properties. Using the addition of impervious area within the contributing drainage area to the SCM and costs (construction, design, and permitting), the 2002 Report employed a best fit cost curve using the Microsoft Excel power trendline ($y=cx^b$). The 2002 Report also applied an adjustment factor (AF) (between 11 and 58 %) to "…satisfy the balance between providing a development participation incentive versus subsidizing development." Additionally, as a result of the 2002 Report, the City elected to use the ENR CCI to escalate the construction cost component to current year dollars.

The project team analyzed the compiled, updated construction cost data and developed XY scatter plots of construction costs versus impervious area to determine functional relationships between the parameters, similar to the relationships developed during the 2002 effort. For consistency with the 2002 Report (and based on the data), Microsoft Excel's power trendline was applied to the XY scatter plots to illustrate the general trend and relationships. A total of 104 SCMs were included in the project team's analysis. SCMs were categorized as detention ponds (DETs) (aligned with the RSMP), water quality ponds (WQ) (aligned with the UWSCF), and combined water quality/detention (WQ/DT) ponds (new category called stacked ponds based on use allowed as of 2013). Data were further categorized by land use type. Table ES-1 summarizes the calculated, updated RSMP CCC rate structure for both land use types, as well as a combined land use, based on the updated data evaluated.

Table ES-1. Updated RSMP (Detention Ponds) CCC Rate Structure

Impervious Area (acres)*		Single-family Residential	Commercial/Mixed-use/Multi-family Residential	Combined
		$y = 124151x^{-0.75}$	$y = 75618x^{-0.436}$	$y = 87{,}068x^{-0.561}$
From	**To**	**n = 13**	**n = 26**	**n = 39**
0	1	$209,000	$103,000	$129,000
1.01	2	$92,000	$64,000	$70,000
2.01	5	$49,000	$44,000	$44,000
5.01	10	$28,000	$32,000	$29,000
10.01	20	$17,000	$24,000	$20,000
20.01	50	$9,000	$17,000	$12,000
50.01	100	$5,000	$12,000	$8,000
100.01	500	$2,000	$7,000	$4,000

Costs expressed in October 2018 dollars
Excludes outlier.
*Calculation of cost per impervious acre based on mid-point. For example, the mid-point between 1.01 and 2 is 1.505.
$ = U.S. dollars

Table ES-1. Updated RSMP (Detention Ponds) CCC Rate Structure

Impervious Area (acres)*		Single-family Residential	Commercial/Mixed-use/Multi-family Residential	Combined
		$y = 124151x^{-0.75}$	$y = 75618x^{-0.436}$	$y = 87{,}068x^{-0.561}$
From	**To**	**n = 13**	**n = 26**	**n = 39**

n = # of case studies

y = construction cost component ($)

Table ES-2 summarizes the calculated, updated UWSCF SICC rate structure for both land use types, as well as a combined land use, based on the updated data evaluated.

Table ES-2. Updated UWSCF (Water Quality Ponds) SICC Rate Structure

Impervious Area (acres)*		Single-family Residential	Commercial/Mixed-use/Multi-family Residential	Combined
		$y = 42948x^{-0.426}$	$y = 89339x^{-0.744}$	$y = 73703x^{-0.626}$
From	**To**	**n = 18**	**n = 23**	**n = 41**
0	1	$58,000	$150,000	$114,000
1.01	2	$37,000	$66,000	$58,000
2.01	5	$26,000	$36,000	$34,000
5.01	10	$19,000	$20,000	$21,000
10.01	20	$14,000	$12,000	$14,000
20.01	50	$10,000	$7,000	$8,000
50.01	100	$7,000	$4,000	$5,000
100.01	500	$4,000	$2,000	$3,000

Costs expressed in October 2018 dollars
Excludes outliers.
*Calculation of cost per impervious acre based on mid-point. For example, the mid-point between 1.01 and 2 is 1.505.

Table ES-3 summarizes the calculated new category (stacked WQ/DET ponds) rate structure related to construction cost for both land use types, as well as a combined land use, based on the updated data evaluated.

Table ES-3. Stacked Water Quality/Detention Pond CCC Rate Structure

Impervious Area (acres)*		Single-family Residential	Commercial/Mixed-use/Multi-family Residential	Combined
		$y = 139187x^{-0.505}$	$y = 814647x^{-1.238}$	$y = 140063x^{-0.525}$
From	**To**	**n = 17**	**n = 3**	**n = 20**
0	1	$198,000	$1,922,000	$202,000
1.01	2	$114,000	$492,000	$114,000
2.01	5	$74,000	$173,000	$73,000

Table ES-3. Stacked Water Quality/Detention Pond CCC Rate Structure

Impervious Area (acres)*		Single-family Residential	Commercial/Mixed-use/Multi-family Residential	Combined
		$y = 139187x^{-0.505}$	$y = 814647x^{-1.238}$	$y = 140063x^{-0.525}$
From	To	n = 17	n = 3	n = 20
5.01	10	$51,000	$68,000	$49,000
10.01	20	$36,000	$29,000	$34,000
20.01	50	$24,000	$10,000	$22,000
50.01	100	$16,000	$4,000	$15,000
100.01	500	$8,000	$1,000	$8,000

Costs expressed in October 2018 dollars
*Calculation of cost per impervious acre based on mid-point. For example, the mid-point between 1.01 and 2 is 1.505.

In addition, the project team identified SCM design parameters to determine if any of the parameters could be statistically correlated with cost using bivariate or multivariate analyses to determine if there are (statistically) better predictive models available, compared to the current methodology. For the SCM projects that were evaluated, the project team considered the following design parameters with the purpose of determining if a bivariate or multivariate regression model could be used in developing an updated construction cost-based formula:

- Impervious Area (estimated based on percent imperviousness of total site area)
- Drainage Area
- Total Site Area
- Surface Area (detention and water quality)
- Detention Volume
- Sedimentation Pond Volume
- Filtration Pond Volume

Note that the first three parameters listed are the parameters that are most easily obtained and do not require calculations. If WPD approves the use of one of the payment in lieu of programs for a development, the avoided facility area and volume may be difficult to estimate.

In the resulting predictive models (including the XY scatter plots), in most cases, the analysis specific to single-family residential or commercial/multi-family residential/mixed-use land use types independently does not produce a statistically reliable model. In these cases, combining the two land use categories ("combined") produced a better result. For the example project sites used, on a percentage of actual costs, the various models predict costs that are 25 to 50% more or less than actual. Some models predict costs at or near the actual amount.

ES.5 Cost Indices

So that WPD does not have to perform this analysis on an annual basis to maintain reasonable payment structures compared to current conditions, the project team evaluated options for different cost indices that may be applied. The project team identified and considered the following three possible indices:

- Consumer Price Index for all Urban Consumers
- Engineering News-Record Construction Cost Index
- Travis Central Appraisal District (annual, overall appraisal roll growth, as a percent change)

ES.6 Results and Recommendations, Updates to RSMP and UWSCF Payment Structure

Based on statistical analysis of construction costs and SCM design parameters, the following predictive models were determined to be significant[2]:

- Power Trendline Fit (Scatter Plot) of total costs per impervious area versus impervious area for DETs (combined land use) with a predictive model of y = 87,068 * IA ^ -0.561 (R^2=0.48).
- Power Trendline Fit (Scatter Plot) of total costs per impervious area versus impervious area for water quality ponds (combined land use) with a predictive model of y = 73,703 * IA ^ -0.626 (R^2=0.34).
- Power Trendline Fit (Scatter Plot) of total costs per impervious area versus impervious area for stacked (WQ/DET) ponds (combined land use) with a predictive model of y = 140,063 * IA ^ -0.525 (R^2=0.38).
- Bivariate regression of total costs versus impervious area for detention ponds (combined land use) with a predictive model of y = 99,462 * IA ^ 0.3735 (R^2=0.31, F(1,38)=17.44, p<0.001).
- Bivariate regression of total costs versus impervious area for water quality ponds (combined land use) with a predictive model of y = 84,435 * IA ^ 0.368 (R^2=0.15, F(1,42)=7.66, p<0.01).
- Bivariate regression of total costs versus impervious area for stacked, or WQ/DET, ponds (combined land use) with a predictive model of y = 140,020 * IA ^ 0.4744 (R^2 =0.33, F(1,18)=8.77, p<0.01).
- Multivariate regression for commercial detention ponds (total costs, detention volume, drainage area [DA], and total site area). y = 56,924 + (2.6495 * DetVol) - (15,461 * DA) + (3,176 * TotalSiteArea)) (R^2 =0.68, F(3,11)=7.8, p<0.01).
- Multivariate regression for commercial water quality ponds (total costs, water quality volume, surface area, and total site area). Predictive model is y = exp(11.53 – (0.085 * WQ Vol) + (2.12 * SA) + (0.045 * Site Area)) (R^2=0.57, F(3,20)=8.85, p<0.001).
- Multivariate regression for residential WQ/DET ponds (total costs, impervious area, water quality volume, detention volume, water quality surface area, detention surface area, and total site area). Predictive model is y = (54,979 * IA) + (1.51 * WQ_vol) - (0.64 * DET_vol) + (93,444 * DET_sa) + (364,020 * WQ_sa) - (15,427 * Total Site Area) (R^2= 0.35, F(1,15)=8.09, p=0.01).

The predictive models resulting from the statistical analyses conducted suggest the following:

1. The models produced during the power trendline fit (scatter plot) using all land use types was statistically better compared to the predictive models produced using the individual land use types (i.e., single-family residential versus commercial/multi-family residential/mixed-use).
2. The models produced for the WQ/DET ponds using commercial/multi-family residential/mixed-use data only are unreasonable due to a low number of data points available.
3. The models produced during the bivariate analyses result in equations that are more precise than the ranges of values resulting from the power trendline fit model.

[2] R^2 refers to a statistical measure that represents the proportion of the variance for a dependent variable that is explained by an independent variable or variables in a regression model. F refers to the F statistic, a value obtained when one runs an ANOVA test (which is an analysis of variance, a statistical method in which the variation in a set of observations is divided into distinct components) or a regression analysis to determine if the means between two populations are significantly different. The variable p refers to the probability value, the level of marginal significance within a statistical hypothesis test representing the probability of the occurrence of a given event.

4. The models produced during the multivariate analyses did not result in statistically significant models for all land use types and SCM types.

Following the analyses, WPD chose to:

- Maintain the use of the power trendline fit due to the complexities associated with applying the models produced using the bivariate analyses (e.g., differing values for each development).
- Use the models produced during the power trendline fit for all land use types ("combined").
- Remove the option of a stacked, or combined, facility because of the lack of data available.

Specific to the land cost component (LCC) of each payment structure, because single-family residential land can vary widely in size, number of lots, and infrastructure needs; the variability in other land use types; and the need to easily update land cost data as the market changes, WPD chose to incorporate current appraised values.

ES.6.1 RSMP Updates

Based on the project team's review of land and construction cost data, and our work with WPD, our recommendation to the City includes the following:

- Apply a land value cap of 80% to either the current, applicable appraisal district value or the value from a certified appraisal (if one is provided by the applicant), then apply a one-time Impervious Cover Adjustment Factor (ICAF) to calculate the necessary LCC.
- Continue use of the assumption of 5% of the site area as the area required for a detention facility (used when calculating the LCC).
- Continue use of the ENR CCI as an annual inflation adjustment to the CCC, with the baseline index set to October 2018.
- Update the CCC structure, as presented in Table ES-4.

The ICAF is intended to result in a lower participation payment associated with developments of a lower impervious cover, and those with a higher impervious cover would have a payment adjusted upwards. This would replace the current component of the methodology that applies a capped value per acre ($40,000 per acre for single-family residential land use and $120,000 per acre for commercial/ mixed-use/multi-family residential land use). The ICAF mimics the AF used in the calculation of the stormwater drainage charge associated with an individual property, which is based on delineation between those properties with impervious cover either greater or less than the weighted average percent of impervious cover for the entire city (52.3%). The ICAF is calculated for each property using this formula: ICAF = (1.5425 x % impervious cover) + 0.1933.

Table ES-4. Recommended RSMP (Detention Ponds) CCC Rate Structure

Impervious Area (acres)*		All Land Use Types $y = 87{,}068x^{-0.561}$
From	**To**	**n = 39**
0	1	$129,000
1.01	2	$70,000
2.01	5	$44,000
5.01	10	$29,000

Table ES-4. Recommended RSMP (Detention Ponds) CCC Rate Structure

Impervious Area (acres)*		All Land Use Types $y = 87{,}068x^{-0.561}$
From	To	n = 39
10.01	20	$20,000
20.01	50	$12,000
50.01	100	$8,000
100.01	500	$4,000

Costs expressed in October 2018 dollars
Excludes outliers
*Calculation of cost per impervious acre based on mid-point. For example, the mid-point between 1.01 and 2 is 1.505.

ES.6.2 UWSCF Updates

Based on the project team's review of land and construction cost data, and our work with WPD, our recommendation to the City includes the following:

- Apply a land value cap of 80% to either the current, applicable appraisal district value or the value from a certified appraisal if one is provided by the applicant.
- Incorporate an assumption of 3%, instead of the assumed 5% of the site area, as the area required for a facility.
- Apply the payment structure presented in Table ES-5 to update the UWSCF SICC.
- Continue use of $0.10 per square foot ($ft^2$) for the Building Component
- Continue use of the ENR CCI as an annual inflation adjustment to the SICC, with the baseline index set to October 2018.

Table ES-5. Recommended UWSCF (Water Quality Ponds) SICC Rate Structure

Impervious Area (acres)*		All Land Use Types $y = 73{,}703x^{-0.626}$
From	To	n = 41
0	1	$114,000
1.01	2	$58,000
2.01	5	$34,000
5.01	10	$21,000
10.01	20	$14,000
20.01	and greater	$8,000

*Calculation of cost per impervious acre based on mid-point. For example, the mid-point between 1.01 and 2 is 1.505. The mid-point used for the final category incorporated the mid-point between 20.01 and 50 acres.

ES.7 Task 2, Comprehensive Evaluation of RSMP Program

The project team conducted a high-level comparison of 10 localities that have RSMPs and offer Payment in Lieu of onsite stormwater management options. Upon review, the project team and WPD collectively selected three of those localities for further, detailed comparison. Following the detailed comparison, the project team determined the RSMP program is structured so similarly to CoSA's, WPD may benefit from peer to peer sharing, both now and following the implementation of CoSA's upcoming payment structure review. One potential option for WPD to consider is the use of a structured development agreement in which a developer identifies, designs, and constructs a project that would achieve project mitigation. Further, similar to the other two entities examined, WPD could consider translating impervious area additions to volumes of runoff that must be mitigated, which may be more tangible for the development community to understand and for the community to support.

Introduction

The City of Austin (City) Watershed Protection Department (WPD) currently provides a payment-in-lieu-of option to land developers as an alternative to providing on-site detention or water quality (WQ) improvement facilities, as required by City Code. The payments are based on the avoided cost associated with the construction of on-site facilities. The payments for the alternative to on-site detention are referred to as Regional Stormwater Management Program (RSMP) participation payments and are based on a set of formulas as illustrated in public web pages accessible from WPD's website (http://www.austintexas.gov/rsmp and associated links). The RSMP is administered by the Watershed Engineering Division of WPD. The payments for the alternative to on-site WQ facilities are referred to as Urban Watersheds Structural Control Fund (UWSCF) payments and are based on a set of formulas as illustrated in Appendix T of the COA Environmental Drainage Criteria Manual (DCM) (COA, 2017). The payment structure for the RSMP payments was originally adopted in 1985, and the payment structure for the UWSCF payments was originally adopted in 1991. Revenues are used for the implementation of regional facilities, by WPD, to provide flood mitigation and improve runoff WQ.

In 2002, CDM developed the *Regional Stormwater Management Program Payments and Urban Watersheds Structural Control Fund Payments Cost Study* (2002 Report) (CDM, 2002), which summarized CDM's efforts to update the methodologies used to estimate appropriate payment structures for participation in the RSMP and UWSCF programs (programs). Since this was the last comprehensive evaluation of the programs, and since land values and construction costs in Austin have changed significantly since 2002, WPD contracted with CH2M HILL Engineers, Inc. to evaluate and update the costs, calculations, and recommendations contained in the CDM document and provide recommendations for updated payment calculations based on current land and construction costs, among other changes (CDM, 2002). This effort is described in the report herein and is referred to as the project.

The following sections provide additional background information specific to each of the programs.

1.1 Regional Stormwater Management Program

Developers must implement provisions to address post-development runoff such that development will not result in additional adverse flooding on other property (as defined in Chapter 25-7 of the Land Development Code, specifically 25-7-61(A)(5)(a)), typically in the form of site-specific detention ponds. If a development meets a number of criteria, WPD may offer an alternative to on-site detention via the RSMP. A participation payment amount is calculated, and then, depending on the applicant, either satisfied through construction of off-site drainage improvements or paid directly. Payments received from projects that participate in the RSMP provide for the planning, design and construction of public, regional drainage improvements. Implemented improvements may include improved conveyance structures, regional detention ponds, channel modifications, or voluntary floodplain buyouts. Currently, the COA DCM provides a list of 26 watersheds in which RSMP participation is available (COA, 2017). However, participation is not limited to those watersheds; RSMP participation has been approved in all watersheds with streams that flow into or through Austin city limits and its extraterritorial jurisdictions.

The payment assessed for participation in the RSMP is non-refundable and is currently based upon the size of the development, the proposed land use, the development intensity, and the value of the land being developed. Payments are allocated to a dedicated fund for the watershed in which a development is located.

1.1.1 RSMP Participation Criteria

Note the following information was taken directly from the DCM, Section 8.2.0, Regional Stormwater Management Program (COA, 2017).

Participation in the RSMP is contingent upon proof that the development will not produce additional, adverse flooding impact to other nearby and downstream properties due to increased runoff. Each potential RSMP applicant must first submit a completed RSMP Participation – Feasibility Meeting Request Form. The intent of the feasibility meeting is to determine if a project is viable for participation and, if so, which method of participation. To participate in the RSMP, the applicant must satisfy the following:

1. The intervening drainage system from the site to the tributary or main branch of the downstream mapped floodplain must have the capacity to provide for the fully developed 100-year storm from the entire drainage area. If the downstream systems are undersized or downstream flooding conditions exist, RSMP participation may be approved if the applicant can verify there will be no additional adverse flooding impact to downstream properties for storm events up to and including the 100-year storm.
2. The applicant must submit an engineering analysis that includes a certified statement by a licensed engineer in the State of Texas stating no additional adverse flooding impacts to other property will occur as a result of the proposed development.
3. The applicant must provide an easement for unconditional conveyance of the fully-developed 100-year flood event from the site to the main branch or tributary of the watershed.

At WPD's discretion, the following special conditions may be allowed:

1. Should a regional detention facility or the intervening public drainage system be committed to its maximum capacity, an applicant may increase the capacity of the regional facility or drainage system through approved modifications. The funding of these modifications may take the place of the RSMP participation payment if:
   a. The cost of the improvements is equal to or greater than the required payment, and
   b. The improvements provide a public benefit
2. If an applicant desires to participate but intends to develop prior to construction of a regional facility or conveyance improvements, the applicant may be allowed to make provisions for temporary, on-site detention until construction of the regional facility or conveyance improvements are completed.
3. WPD may approve removal of existing, on-site ponds if participation in the RSMP is approved.

Participation payments are calculated based on total site area, with certain types of areas deducted, including: dedicated greenbelts, common areas, permanent retention facilities, and areas undevelopable in accordance with City of Austin Ordinances.

1.1.2 RSMP Framework

The existing framework for the RSMP includes a construction cost component (CCC) and land cost component (LCC), and there two rate structures for the CCC that differentiate between commercial/ mixed-use/multi-family residential and single-family residential properties. The following define the individual cost components:

- CCC results in a total cost per impervious acre. This is calculated based on established values associated with specific ranges of impervious area and specific land uses (single-family residential and commercial/mixed-use/multi-family residential), with the total impervious area defined by the maximum allowable impervious acreage as defined by the more restrictive of zoning or watershed ordinance for subdivisions.

Note that the CCC is adjusted annually by using the "Engineering News-Record" construction cost index, with the base construction cost index being referenced to October 2002.

- LCC is calculated by multiplying the following three values:
  1. The land cost per acre, which is the appraised cost per acre or the capped value per acre.
  2. The assumed portion of the site area that would be used for on-site detention, which is 5%.
  3. The land cost area determination for new and redeveloped sites is slightly different, based on the definition of the total site area. For new development, this is the gross site area; for redevelopment, this is the limits of construction. Examples include where a drainage easement traverses a property (described in the DCM [COA, 2017]), and as referenced in the previous section that discusses RSMP participation requirements, part of a property is in a regulated floodplain, or where a large tract of land is being developed but only a small portion will be "disturbed" for the project. It is possible that these two values are equivalent. Developers may then subtract "deductible" areas, those deemed undevelopable, from the total site area.

  Note that the standard calculation for the LCC also allows for a reduction for large lot, low impervious cover developments. This reduction is intended to encourage relatively low impervious cover values since less impervious cover is beneficial to the city as a whole (Table 1-1).

Table 1-1. Land Cost Component Reductions

Lot Size (acres)	Impervious Cover (%)	Reduction
2 to 5	Less than 20	50%
Greater than 5	Less than 20	75%

The total payment is calculated as the sum of the CCC and the LCC.

1.2 Urban Watersheds Structural Control Fund

1.2.1 Urban Watersheds Structural Control Fund Participation Criteria

Note that the following information was taken directly from the Environmental Criteria Manual, Section 1.6.4, Structural Control Standard and Criteria for Fee-in Lieu of Structural Controls in Urban Watersheds.

WPD has selected sedimentation/filtration as the primary structural water quality control to reduce nonpoint source pollution. As such, Section 25-8-211 (Water Quality Control Requirement) of the Land Development Code requires water quality controls, typically in the form of sedimentation/filtration ponds, in Urban, Suburban, Water Supply Suburban and Water Supply Rural Watersheds. However, according to the Environmental Criteria Manual, "The City recognizes that incorporating structural water quality control facilities into some urban watershed land development projects can be difficult." Thus, in an urban watershed, a developer may request participation in the UWSCF; the standards are set forth in the Environmental Criteria Manual. The funds received via this program are used to study, design, implement, and construct urban water quality improvement projects. Note this program is only for development within an urban watershed as defined by Section 25-8-2 of the Land Development Code.

The delineated categories for participation, in order of priority for participation are as follows:

- Type I development features include, but are not limited to, at least one of the following:
  - Commercial development sites of 1 acre or less

  - Single-family development of subdivisions 2 acres or less
  - Development upon which stormwater runoff travels via sheet flow over pervious cover, prior to being concentrated
  - Development that is likely to be treated by an existing or future regional water quality facility

- Type II development features include, but are not limited to, at least one of the following:
  - No, or minimal, existing impervious cover
  - Substantial redevelopment
  - Development adjacent to an open channel stream
  - Development within 500 feet of Town Lake

At WPD's discretion, the following special conditions may be allowed:

- If a regional facility is committed to its maximum capacity, an applicant may increase the capacity through approved, applicant-funded modifications. The funding of any such modifications will be credited toward any required payment.
- WPD may approve removal of existing, on-site water quality facilities if participation in the UWSCF is approved.

1.2.2 UWSCF Framework

The UWSCF framework is similar to the RSMP in that it incorporates site area and impervious cover. The main difference is in the evaluation of redevelopment. The applicant submits information to the City for review via the Request for Payment in Lieu of or Cost Recovery for Water Quality Controls in Urban Watersheds form, including:

- Location of site
- Total site area (acres)
- Type of development
- Total impervious cover (acres), divided into that which is redeveloped versus that which is new
- Size of building (in square feet [ft^2])

The following data inputs are used to calculate the cost components:

- Site Impervious Cover Component (SICC), including Redevelopment Impervious Cover (acres) and New Impervious Cover (acres). This is calculated based on established values associated with specific ranges of impervious area. Unlike the RSMP, these values are the same regardless of land use type.
- Building Component, which is $0.10 per ft^2 of the gross square footage of the building, excluding the area of the ground floor.
- Site Area Component (SAC), which is $6,000 per acre for commercial/mixed-use/multi-family residential and $4,000 per acre for single-family residential

Note that the SICC is adjusted annually by using the *Engineering News-Record* construction cost index, with the base construction cost index being referenced to October 2002. Further, note that if a property drains to a proposed or existing regional facility, the SICC is reduced to account for the "City portion". The City portion is calculated as 75% of the ratio of redeveloped impervious cover to total impervious cover, multiplied by the calculated SICC.

Develop Construction Cost/Design Factor Database

For the first task, the project team[3] performed a data collection effort to obtain updated construction cost data for SCMs. CH2M requested assistance from teaming partner Doucet+Chan because of their experience with designing these types of facilities. Appendix A includes a description of the data they provided. CH2M compiled the data, including construction costs, resulting increase in impervious area, facility type, and other design parameters so that each of these components could be evaluated in relation to others.

After reviewing the construction cost data provided by Doucet+Chan with WPD, the project team determined that the amount of data and the diversity of the data (i.e., differing facility types amongst differing land use types) was less than ideal. WPD requested the analysis include additional SCM projects, including those from the 2002 Report updated to (2018) dollars (CDM, 2002). Note the 2002 data primarily includes cost and increase in impervious area. WPD was able to provide additional design parameter data.

WPD also provided (permitted) design drawings and bid documents for additional, actual SCM projects, and CH2M was able to extract construction cost and design parameter data for these projects, as well.

Without actual design payment data, total project costs include construction costs and an assumed 20% for engineering and design. Appendix B provides a comprehensive list of the three data sets, including:

- CH2M adjusted the costs associated with projects included in the 2002 Report to (2018) dollars based on the Engineering News-Record Construction Cost Index (ENR CCI) and to be consistent with the existing payment structure methodology (CDM, 2002).
- Doucet+Chan provided construction costs for SCM projects based on an average of actual bid prices, some were obtained by Doucet+Chan, others were provided by WPD.
- WPD identified additional projects to be included; the project team reviewed drawings and bid documents to obtain construction costs and other design parameters.

[3] The project team consists of CH2M, Doucet & Associates, Inc. and Atrium Real Estate Services.

SECTION 3

Land Costs and Land Factors

The second data collection effort conducted as part of this project was recent real estate and land cost data obtained within the areas applicable to the RSMP and UWSCF (as defined by the Environmental and DCMs at the time of project initiation) (COA, 2017). Atrium Real Estate Services, a subconsultant to CH2M, researched actual real estate sales of residential (single-family), commercial, and multi-family residential properties (three total land uses) within each of the relevant watershed areas and provided building and lot sizes for developed land where available. Where there was no data differentiating the size of the building versus the lot, the project team applied the average building:land ratio found in Travis Central Appraisal District (TCAD) 2017 data for that specific land use (Appendix C).

The data collected by Atrium Real Estate Services were used to develop descriptive statistics for single-family residential, multi-family residential, and commercial properties within the areas of interest. Appendix C provides a summary of that data. Note that tracts of land designated as single-family residential can vary widely, more so than the other land use types. Single-family residential land includes large developments with 50 or more lots on many acres – including roads and other non-residential infrastructure and amenities to individual lots of less than an acre that are being divided into 2 or 3 lots (typical impervious cover increase from 20% to 45%). This is illustrated in the descriptive statistics provided in Appendix C.

3.1 Land Cost Maximum Value

As part of the 2002 study, a maximum value, or cap, was applied to the land cost value used in RSMP payment calculations: $40,000 per acre for single-family residential and $120,000 per acre for commercial and multi-family residential. Since the methodology implements an assumed 5% of the total land value associated with the SCM, the maximum land cost per acre used in the RSMP calculation is $2,000 and $6,000, respectively. Other than a simple mention of the real estate data collected, there is little rationale for a cap cited in the 2002 Report (CDM, 2002). The factors cited for contributing to variability in land costs are location, topography (i.e., slope), and geology (i.e., soil type) of the land being considered for development. Further, in the 2002 Report, land costs that were less than average were used to develop a payment that seemed equitable and reasonable. Table 3-1 summarizes average land cost (dollar per acre [$/acre]) from the 2002 Report and corresponding cap on the land cost applied in the RSMP LCC calculation.

Table 3-1. Average Land Cost and Land Value “Cap” Developed in the 2002 Report, RSMP LCC

	Single-family Residential	**Commercial and Multi-family Residential**
Average Land Cost ($/acre)	$140,000	$160,000
Rationale for Cap	≤75% of non-outlier data	≤75% of non-outlier data
Land Cost Cap ($/acre)	$40,000	$120,000
Land Cost Cap Adjusted based on ENR CCI (April 2000 to April 2018, factor = 1.77)	$70,800	$212,400
Assumed % of Lot needed for SCM	5%	5%
Land Cost ($/acre) for SCM	$2,000	$6,000

≤ = less than or equal to

Using the real estate and land cost data collected as part of this project (Appendix C), a similar approach would result in the numbers provided in Table 3-2.

Table 3-2. Updated, Average Land Cost and Land Value "Cap" Calculated using 2002 Report Methodology, RSMP LCC

Values	Single-family Residential	Commercial	Multi-family Residential
Average Land Cost ($/acre)	$641,793	$408,549	$272,551
Rationale for Cap	75% of non-outlier data	75% of non-outlier data	75% of non-outlier data
Land Cost Cap ($/acre)	$481,000	$306,000	$204,000
Percent of Lot needed for SCM	5%	5%	5%
Land Cost ($/acre) for SCM	$24,050	$15,300	$10,200

Historically, the UWSCF applies a maximum value of $6,000 for commercial or multi-family residential development or $4,000 for single-family residential and duplex development for the SAC. A sample set of sales data for improved properties were analyzed to calculate the ratio of land value to assessed value, as summarized in Table 3-3. The ratio was applied to sales data for single-family residential, commercial, and multi-family residential properties and the results are summarized in Table 3-4.

Table 3-3. Updated, Average Improved Property Cost and Land Value "Cap" Calculated using 2002 Report Methodology

Values	Commercial	Multi-family Residential	Single-family Residential
Average of Sales Price	$5,068,798	$32,209,441	$461,852
Average of Appraised Value	$4,158,206	$26,622,505	$449,169
Average of Assessed Value	$4,155,880	$26,622,505	$439,946
Average of Land Value	$752,736	$3,707,316	$174,517
Average of Improved Value	$2,417,580	$20,053,166	$212,555
Average of Land to Assessed Value	44.10%	26.21%	43.83%
Average of Improved to Assessed Value	49.64%	70.79%	58.67%

Table 3-4. Updated, Average Improved Property Cost and Land Value "Cap" Calculated using 2002 Report Methodology, UWSCF SAC

Values	Single-family Residential	Commercial	Multi-family Residential
Average Land Cost ($/acre)	$1,013,885	$1,179,473	$1,071,836
Rationale for Cap	75% of non-outlier data	75% of non-outlier data	75% of non-outlier data
Land Cost Cap ($/acre)	$760,000	$885,000	$804,000
Percent of Lot needed for SCM	5%	5%	5%
Land Cost ($/acre) for SCM	$38,000	$44,250	$40,200

Based on review of the 2002 Report, the project team did not find a basis for the land value caps recommended and implemented (CDM, 2002). The project team believes imposing a land value cap underestimates the LCCs of the payment calculations, thus underestimates the avoided cost to the developer. The LCC and SAC are intended to provide WPD with an equivalent amount of money the developer would have used to construct a SCM on a property for a proposed development, for use in watershed-specific regional stormwater management solutions. For a developer to calculate a project-specific RSMP LCC, applying the current methodology, the appraised land value and site size are needed. Table 3-5 provides the results of current LCC calculation methodologies applied to updated, land costs, employing both existing land cost caps and updated land cost caps calculated using the 2002 Report methodology.

Table 3-5. Comparison of Current RSMP LCC Calculation Methodologies Applied to Updated Land Costs, Employing Both Existing Land Cost Caps and Land Cost Caps Calculated Using The 2002 Report Methodology

Item	Land Cost Payment Component	Single-family Residential		Commercial		Multi-family Residential	
		Current Cap	Updated Cap	Current Cap	Updated Cap	Current Cap	Updated Cap
A	Appraised Value	$385,471	$385,471	$1,174,210	$1,174,210	$3,003,541	$3,003,541
B	Lot Size (acres)	2.86	2.86	9.93	9.93	12.90	12.9032
C	Land Cost ($/acre)	$641,793	$641,793	$408,549	$408,549	$272,551	$272,551
D	Capped Land Cost ($/acre)	$40,000	$481,000	$120,000	$306,000	$120,000	$204,000
E	Assumed % of Lot needed for SCM	5%	5%	5%	5%	5%	5%
F	Land Cost for SCM ($/acre) (C*E)	$32,090	$32,090	$20,427	$20,427	$13,628	$13,628
G	Capped Land Cost for SCM ($/acre) (D*E)	$2,000	$24,050	$6,000	$15,300	$6,000	$10,200
H	LCC Payment (Min(F,G)*B)	$5,721	$68,794	$59,553	$151,860	$77,419	$131,613

Items A, B, and C are averages from separate data fields. Item C is calculated for each sample property, and the average is reported.
* indicates “multiplied by”

Because the land value per acre ($/acre) has increased since the land cost cap values were determined in 2002, nearly all projects applying for RSMP participation qualify for using the capped $/acre value. As such, this part of the LCC is relatively important to the payment structures. It is believed that the cap was originally implemented to avoid deterring development; however, with the cap staying static for almost two decades, regional funding for SCMs is limited by the large difference between actual costs and calculated payments. WPD has chosen to incorporate the current appraised values into the updated payment structures for the following reasons:

- Variance in size of single-family residential land (which can vary widely, for example, in number of lots and infrastructure needs)
- Variability in other land use types
- Ease of updating land cost data as the market changes

Further, the 2018 RSMP and UWSCF update will include application of a land value of 80% of either the current, applicable appraisal district value or the value obtained from a certified appraisal, if one is provided by the applicant, and a one-time Impervious Cover Adjustment Factor (ICAF). The ICAF is intended to result in a lower participation payment associated with developments of a lower impervious cover, and those with a higher impervious cover would have a payment adjusted upwards. This would replace the current component of the methodology that applies a capped value per acre ($40,000 per acre for single-family residential land use and $120,000 per acre for commercial/ mixed-use/multi-family residential land use). The ICAF mimics the adjustment factor (AF) used in the calculation of the stormwater drainage charge associated with an individual property, which is based on delineation between those properties with impervious cover either greater or less than the weighted average percent of impervious cover for the entire city (52.3%). It is calculated for each property using this formula: Adjustment Factor = (1.5425 x % impervious cover) + 0.1933.

Additional land value cap options that were considered but not selected include the following:

1. Remove a cap and use the (uncapped) land value obtained from either the applicable appraisal district or a certified appraisal provided by the applicant. This option would result in the highest payment amount of any of the three options. For single-family developments, typically the type of development with the lowest impervious cover, would not be addressed differently than commercial developments. This would be the simplest option to apply. The resulting calculation would not make any distinction based on proposed use or impervious cover. This could put a relatively higher burden on single-family development given the economics involved in single-family development versus commercial and multi-family development. If applied, WPD could retain a reduced payment for low impervious cover, single-family residential development.
2. Apply an adjusted cap to either the applicable appraisal district value or a certified appraisal provided by the applicant. For this option, the current cap values would be replaced with an updated value based on the overall, annual TCAD property valuation increase percentage as reported in the TCAD annual report. The adjusted cap values would then be updated each year based on the latest valuation increase percentage as reported by TCAD. The payment calculation approach in this option is most like the current methodology compared to the other options and would maintain the reduced payment for single-family residential development. The adjustment would be based on a readily available source produced by a reliable organization that uses industry standard methods to determine valuations.

3.2 Land Cost Area Factor

As described previously, to calculate the LCC using current methodology, the applicant incorporates a value of 5% as the assumed portion of the site area required for a detention facility. The project team compared this assumption to the data collected as part of this study. Using the most recent data provided by WPD, the calculated detention pond area as a percent of drainage area was, on average, 5.1%. The calculated detention pond area as a percent of total site area was 5.6%. Therefore, the assumption of 5% is representative of actual data.

For water quality facilities, the calculated water quality facility area as a percent of drainage area was, on average, 3.5%. The calculated water quality facility area as a percent of total site area was 2.6%. Thus, an appropriate assumption for the site area required for a water quality facility is 3% instead of 5%.

Correlate Construction Cost with Design Parameters

The construction cost-related rate structures are based on the 2002 Report (CDM, 2002), which included analysis related to detention and water quality facilities for single-family residential, commercial, and multi-family residential properties. For each property, the addition of impervious area within the contributing drainage area to the SCM and costs (construction, design, and permitting) were evaluated. Based on these parameters, the 2002 Report applied a cost curve using the Microsoft Excel power trendline ($y=cx^b$). The 2002 Report also applied an AF (between 11 and 58 percent) to "…satisfy the balance between providing a development participation incentive versus subsidizing development." Additionally, as a result of the 2002 Report, the City elected to use the ENR CCI to escalate the payment component to current year dollars. The current CCC rate structure is summarized in Table 4-1. Once the total CCC or SICC is calculated in 2002 dollars, the ENR adjustment is applied.

Table 4-1. Current CCC Rate Structure, RSMP

Impervious Area (acres)	Cost per Impervious Acre	
	Single-family Residential (2002 Dollars)	Commercial and Multi-family Residential (2002 Dollars)
0 to 1	$35,000	$60,000
1.01 to 2	$15,000	$18,000
2.01 to 5	$10,000	$8,000
5.01 to 10	$7,000	$6,000
10.01 to 20	$5,000	$5,000
20.01 to 50	$3,000	$4,000
50.01 to 100	$2,000	$2,500
100.01 and greater	$1,500	$2,500

ENR 2002 = 6579 and ENR 2018 = 11183.28, ENR adjustment = ENR 2018 /ENR 2002 = 1.6998

Source: http://www.austintexas.gov/page/regional-storm-water-management-program and http://www.austintexas.gov/page/rsmp-single-family-development-calculator.

The current SICC is provided in Table 4-2.

Table 4-2. Current SICC Rate Structure, UWSCF

Impervious Area (acres)	Cost (2002 Dollars)
0 to 1	$32,000
1.01 to 2	$18,000
2.01 to 10	$11,000
10.01 to 20	$8,000
20.01 and greater	$6,000

Table 4-2. Current SICC Rate Structure, UWSCF

Impervious Area (acres)	Cost (2002 Dollars)

Source: Appendix T, Environmental Criteria Manual.

Note an ENR CCI adjustment similar to the RSMP CCC is applied. However, the CCI for October 2002 listed with the UWSCF instructions is 6597 and should be corrected to 6579.

To update the CCC and SICC rate structures, the project team analyzed the updated construction cost data and developed XY scatter plots using cost versus increase in impervious area for both detention and water quality facilities. For consistency with the 2002 Report (and based on the data), Microsoft Excel's power trendline was applied to the XY scatter plots to illustrate the general trend and relationships. The project team then conducted a detailed statistical analysis to develop regression equations for SCMs in terms of design parameters found statistically significant.

Notes:

- For some of these records, necessary information such as percentage of impervious area and total site area were missing. In these cases, these records were not included because the cost per impervious acre could not be calculated.
- There were some records that resulted in cost per impervious acre that skewed the trendline; these records were deemed outliers and excluded.

4.1 Identification of Design Parameters

The project team identified different SCM design parameters to determine if any of the parameters could be statistically correlated with cost. The intent being, if correlations were found, the project team would determine functional relationships between the parameters, if any exist. For the SCM projects that were evaluated, the project team considered several design parameters to determine whether a bivariate or multivariate regression model could be used in developing an updated construction cost-based formula.

The following list describes the design parameters available for analysis within this data set:

- **Impervious Area**. Impervious surfaces are typically manmade structures that consist of impenetrable materials and reduce (or eliminate) the ability for stormwater runoff to infiltrate. The addition of buildings, parking lots, and other structures all increase the impervious area associated with a site.
- **Drainage Area**. In this case, the drainage area is the amount of land that drains to the SCM for detention or treatment.
- **Total Site Area**. This is the total area that is being developed and includes portions of the site with impervious area, pervious areas, and location of SCMs. Impervious cover percent is limited by City Code based on different land use types. Thus, total site area and allowed impervious cover percent are often used to calculate (allowed) impervious cover in acres.
- **Surface Area**. This is the surface area, essentially the size of the footprint of the SCM.
- **Detention Volume**. This is the total volume of a detention SCM.
- **Sedimentation Pond Volume**. According to the DCM, Section 1.6, water quality controls comprise some portion of sedimentation facility and some portion of filtration facility. This is the volume of the sedimentation portion of a water quality SCM (COA, 2017).

- **Filtration Pond Volume**. Per the Environmental Criteria Manual, Section 1.6, water quality controls comprise some portion of sedimentation facility and some portion of filtration facility. This is the volume of the filtration portion of a water quality SCM (COA, 2017).

Note that the first three parameters listed are the parameters that are most easily obtained and do not require calculations. If WPD approves the use of one of the payment in lieu of programs for a development, the avoided facility area and volume may be difficult to estimate.

4.2 Statistical Analysis

A total of 104 SCMs were included in the project team's analysis. Depending on the type of analysis, outliers were excluded. Note that more than one of these SCMs can be located at one "development" if multiple SCMs were constructed. For purpose of ease, each of the projects evaluated by the project team are classified as a "water quality pond" or a "detention pond." Additionally, based on recent trends, a third category was added due to the use of combined, "stacked" ponds, referred to as "WQ/DET Ponds" in this document, which combine both water quality and detention SCMs into one facility to provide both quantity and quality control/treatment. A detailed list of SCM facilities included in the analysis is provided in Appendix B.

The project team used the construction cost information compiled to develop an XY scatter plot of construction costs versus design parameters to determine functional relationships between the parameters. The project team then conducted bivariate and multivariate statistical analyses between construction costs and the required design parameters related to SCM facilities. Note: When conducting this type of analysis, data can exhibit both economies of scale (i.e., lower unit costs per acre as acreage increases), as well as substantial scatter because of local site conditions; the inherent variability associated with the data can limit the applicability of such analysis.

4.2.1 Scatter Plots

The current RSMP CCC methodology uses cost per impervious acre. Figure 4-1 provides an updated scatter plot of costs per impervious acre and total impervious area for single-family residential detention ponds, which illustrates that the per unit cost decreases as impervious area increases. Figure 4-2 provides a similar updated scatter plot for the collective commercial, multi-family residential and mixed-use development land use type. Table 4-3 summarizes the calculated, updated RSMP CCC rate structure based on the updated data evaluated.

Table 4-3. Updated RSMP (Detention Pond) CCC Rate Structure

Impervious Area (acres)*		Single-family Residential	Commercial/Multi-family Residential/Mixed-use	Combined
		$y = 124{,}151x^{-0.75}$	$y = 75{,}618x^{-0.436}$	$y = 87{,}068x^{-0.561}$
From	**To**	**n = 13**	**n = 26**	**n = 39**
0	1	$209,000	$103,000	$129,000
1.01	2	$92,000	$64,000	$70,000
2.01	5	$49,000	$44,000	$44,000
5.01	10	$28,000	$32,000	$29,000
10.01	20	$17,000	$24,000	$20,000
20.01	50	$9,000	$17,000	$12,000
50.01	100	$5,000	$12,000	$8,000

Table 4-3. Updated RSMP (Detention Pond) CCC Rate Structure

Impervious Area (acres)*		Single-family Residential	Commercial/Multi-family Residential/Mixed-use	Combined
		$y = 124{,}151x^{-0.75}$	**$y = 75{,}618x^{-0.436}$**	**$y = 87{,}068x^{-0.561}$**
From	**To**	**n = 13**	**n = 26**	**n = 39**
100.01	and greater	$2,000	$7,000	$4,000

Costs expressed in October 2018 dollars
Excludes outliers.
*Calculation of cost per impervious acre based on mid-point. For example, the mid-point between 1.01 and 2 is 1.505.

Table 4-4 summarizes the calculated, updated UWSCF SICC rate structure based on the updated data evaluated data presented on Figures 4-3 and 4-4.

Table 4-4. Updated UWSCF (Water Quality Ponds CCC Rate Structure

Impervious Area (acres)*		Single-family Residential	Commercial/Multi-family Residential/Mixed-use	Combined
		$y = 42{,}948x^{-0.426}$	**$y = 89{,}339x^{-0.744}$**	**$y = 73{,}703x^{-0.626}$**
From	**To**	**n = 18**	**n = 23**	**n = 41**
0	1	$58,000	$150,000	$114,000
1.01	2	$37,000	$66,000	$58,000
2.01	5	$26,000	$36,000	$34,000
5.01	10	$19,000	$20,000	$21,000
10.01	20	$14,000	$12,000	$14,000
20.01	50	$10,000	$7,000	$8,000
50.01	100	$7,000	$4,000	$5,000
100.01	500	$4,000	$2,000	$3,000

Costs expressed in October 2018 dollars
Excludes outliers.
*Calculation of cost per impervious acre based on mid-point. For example, the mid-point between 1.01 and 2 is 1.505.

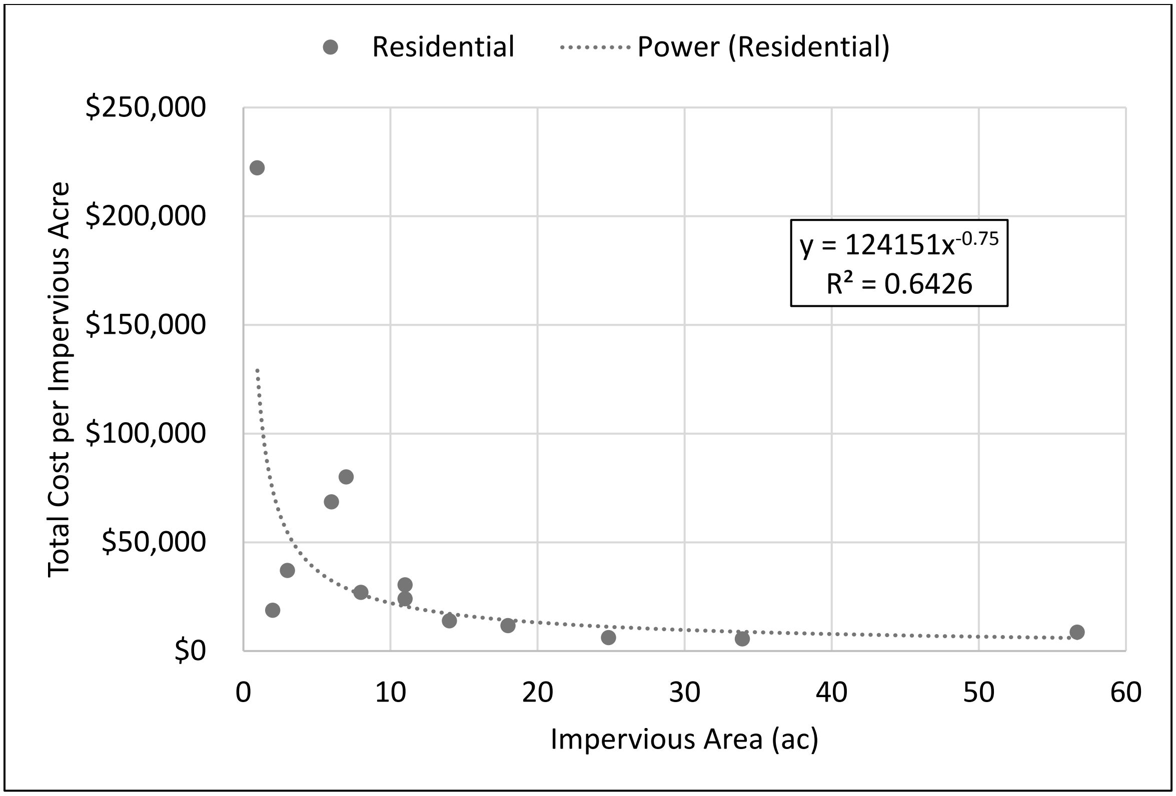

Figure 4-1. Single-family Residential RSMP (Detention Pond) Costs per Impervious Acre vs. Impervious Acre

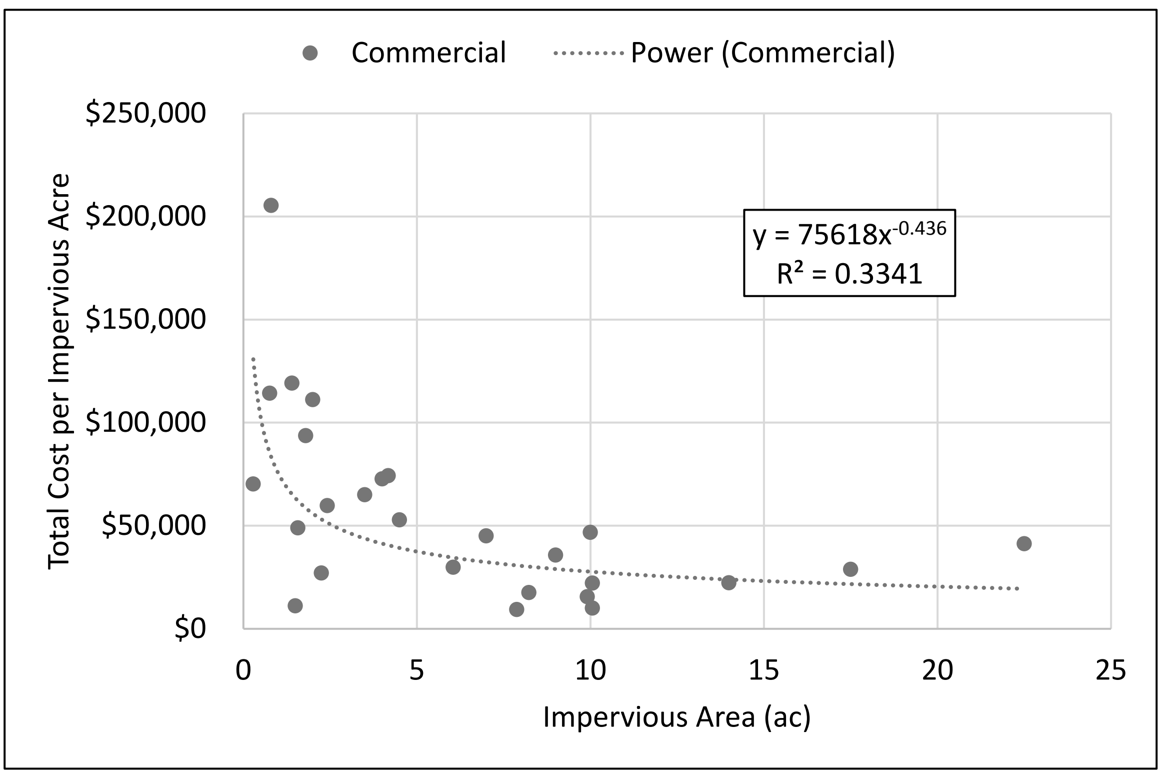

Figure 4-2. Commercial/Multi-family Residential/Mixed-use RSMP (Detention Pond) Costs per Impervious Acre vs. Impervious Acre

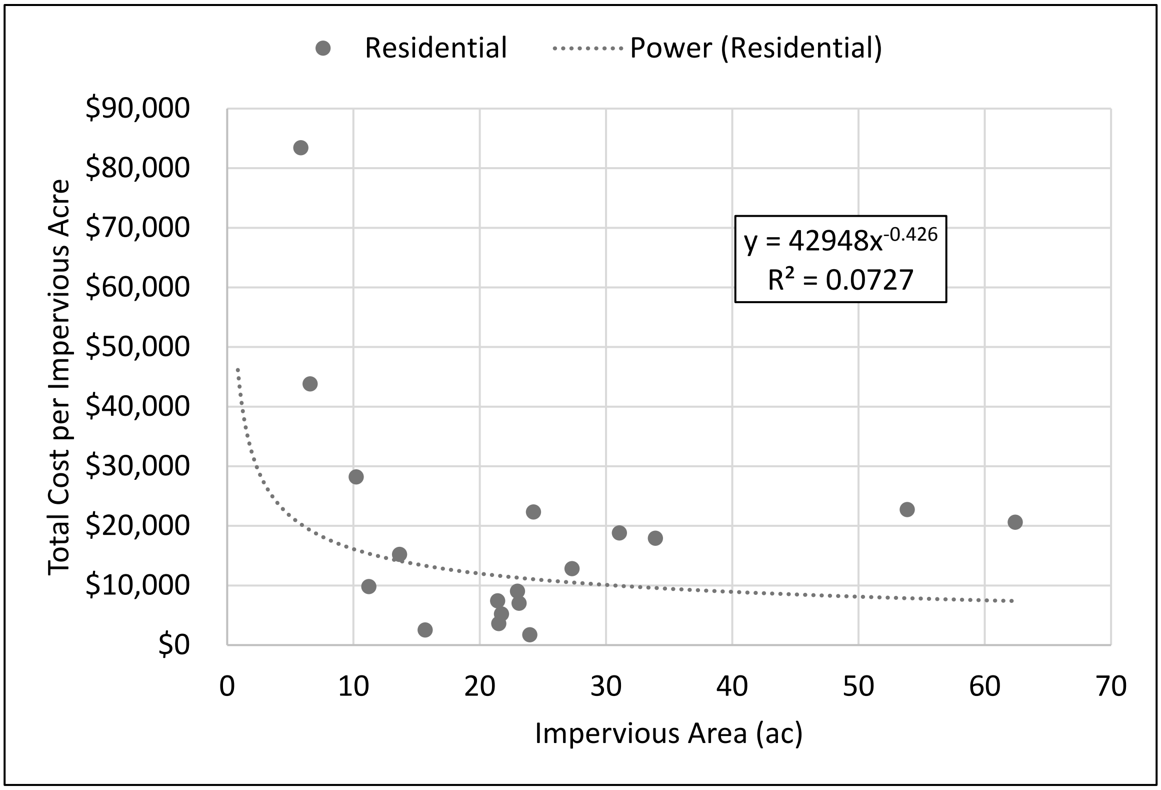

Figure 4-3. Single-family Residential UWSCF (Water Quality Ponds) Costs per Impervious Acre vs. Impervious Acre

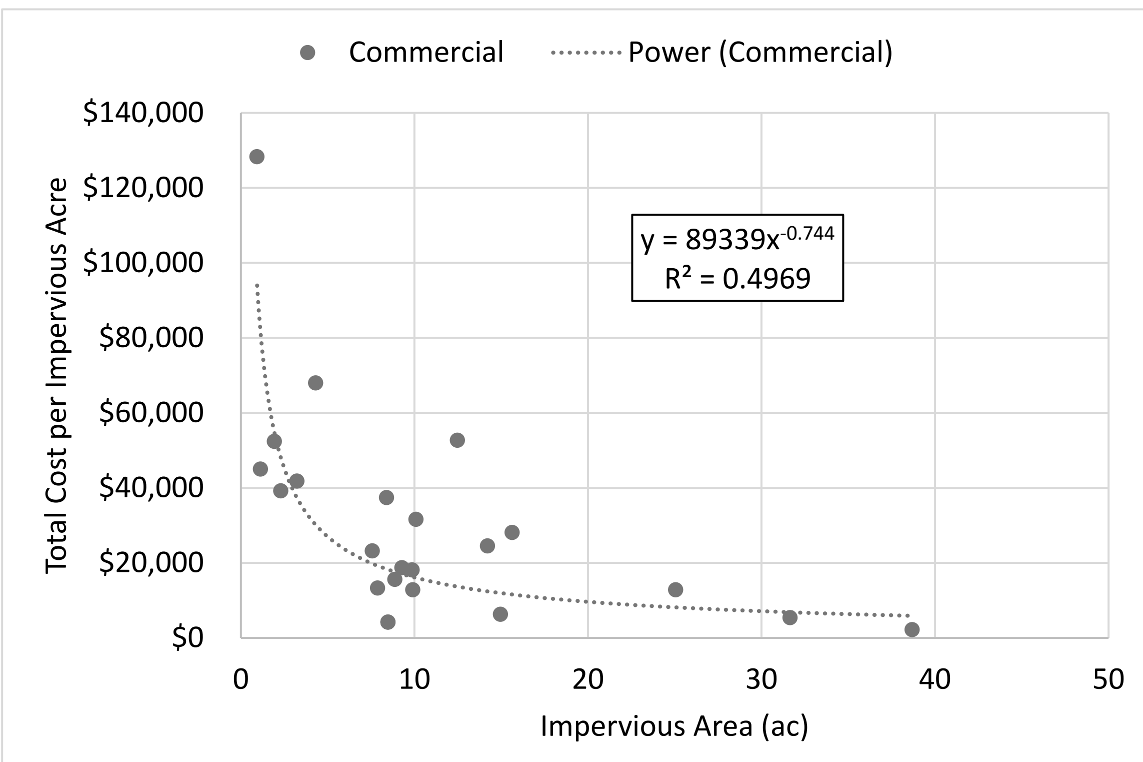

Figure 4-4. Commercial/Multi-family Residential/Mixed-use UWSCF (Water Quality Ponds) – Costs per Impervious Acre vs. Impervious Acre

A new category of SCMs was added to the analysis based on the recent (2013) addition of "stacked" facilities for participation in the Payment in Lieu of Program (referred to as WQ/DET Ponds in this document). These SCMs provide both quantity and quality control in a single facility and were evaluated separately. Table 4-5 provides a proposed construction cost-based rate structure similar to detention and water quality SCMs (independent). Figure 4-5 provides a scatter plot of costs per impervious acre and total impervious area for the new category of single-family residential WQ/DET Ponds. Figure 4-6 provides a scatter plot of costs per impervious acre and total impervious area for the new category of commercial/multi-family residential/mixed-use WQ/DET Ponds.

Table 4-5. Proposed Stacked Ponds CCC Rate Structure

Impervious Area (acres)*		Single-family Residential	Commercial/Multi-family Residential /Mixed-use	Combined
		$y = 139{,}187x^{-0.505}$	$y = 814{,}647x^{-1.238}$	$y = 140{,}063x^{-0.525}$
From	**To**	**n = 17**	**n = 3**	**n = 20**
0	1	$198,000	$1,922,000	$202,000
1.01	2	$114,000	$492,000	$114,000
2.01	5	$74,000	$173,000	$73,000
5.01	10	$51,000	$68,000	$49,000
10.01	20	$36,000	$29,000	$34,000
20.01	50	$24,000	$10,000	$22,000
50.01	100	$16,000	$4,000	$15,000
100.01	500	$8,000	$1,000	$8,000

Costs expressed in October 2018 dollars
Excludes outliers.
*Calculation of cost per impervious acre based on mid-point. For example, the mid-point between 1.01 and 2 is 1.505.

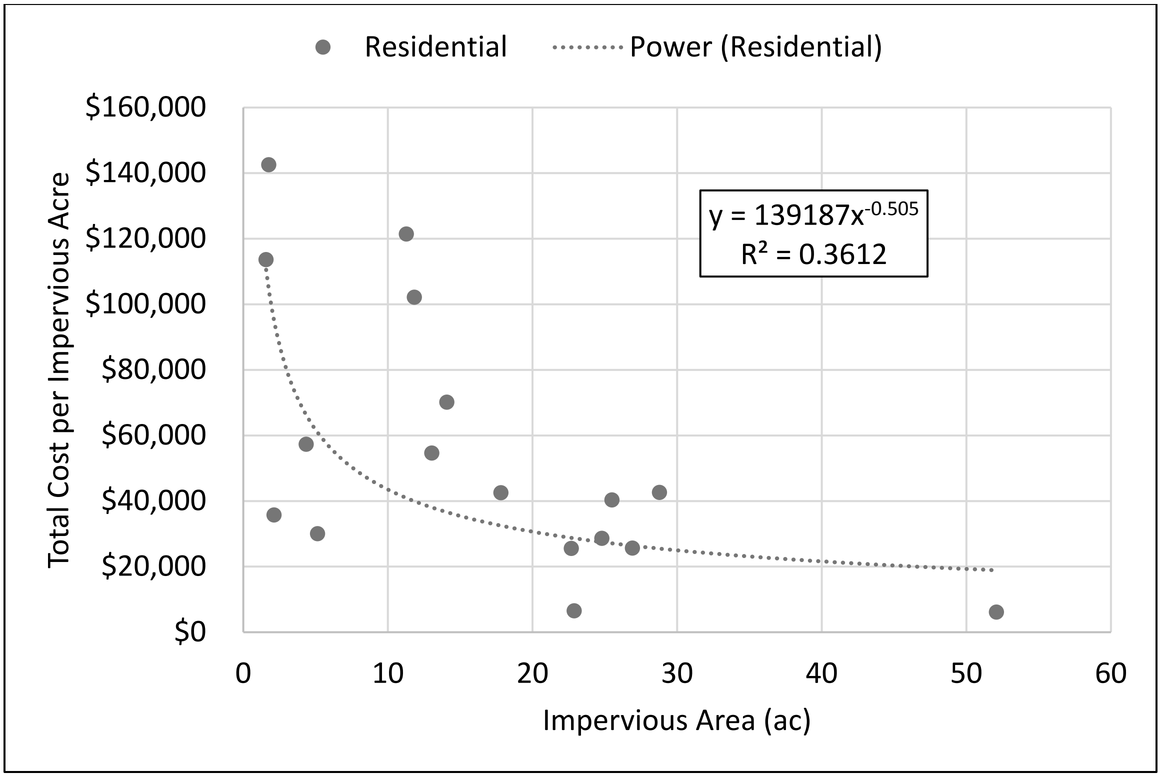

Figure 4-5. Single-family Residential WQ/DET Ponds – Costs per Impervious Acre vs. Impervious Acre

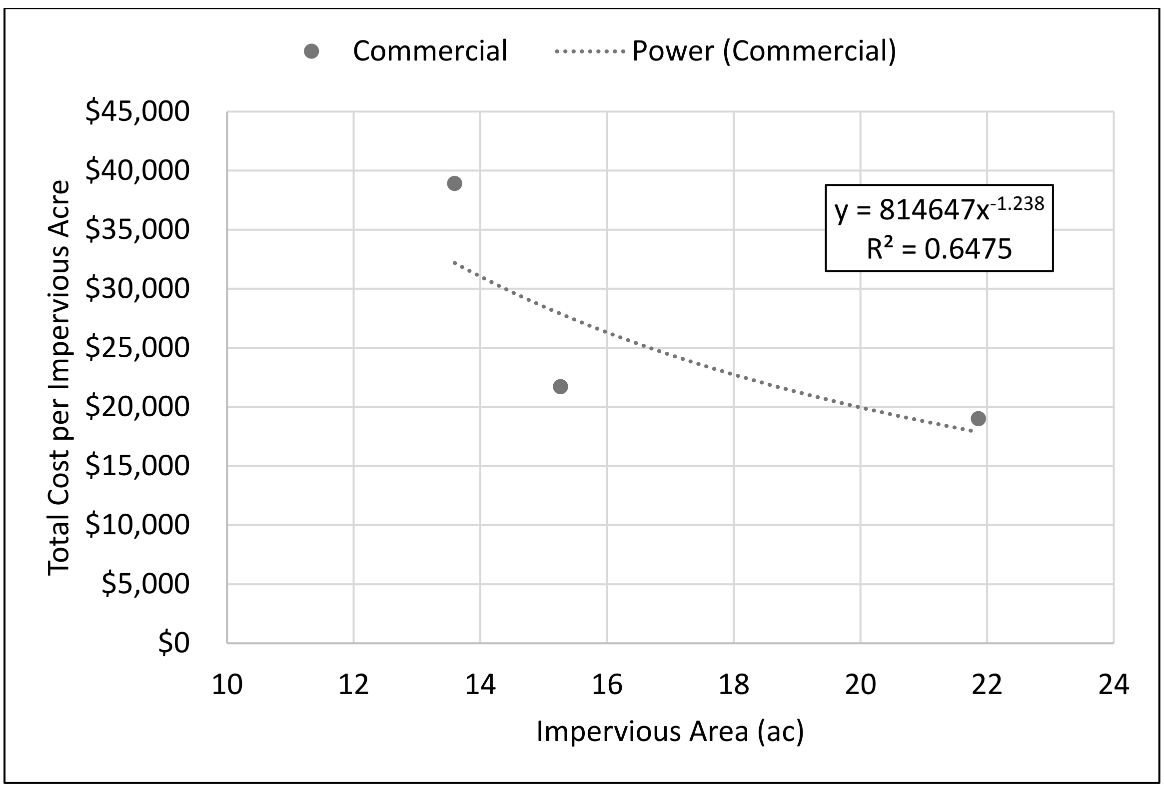

Figure 4-6. Commercial/Multi-family Residential/Mixed-use WQ/DET Ponds – Costs per Impervious Acre vs. Impervious Acre

4.2.2 Histograms

To understand the data distributions of the design parameters, histograms help visually identify data that are not normally distributed. For the regressions presented in later sections, determining if data are normally distributed is necessary. If data are not normally distributed, data transformations must be completed to identify a regression model that is statistically significant. Based on the histograms presented on Figures 4-7 through 4-16, data are skewed to the right and appear not to be normally distributed. This is confirmed in the statistical output presented in Appendix D. Therefore, data transformation is necessary.

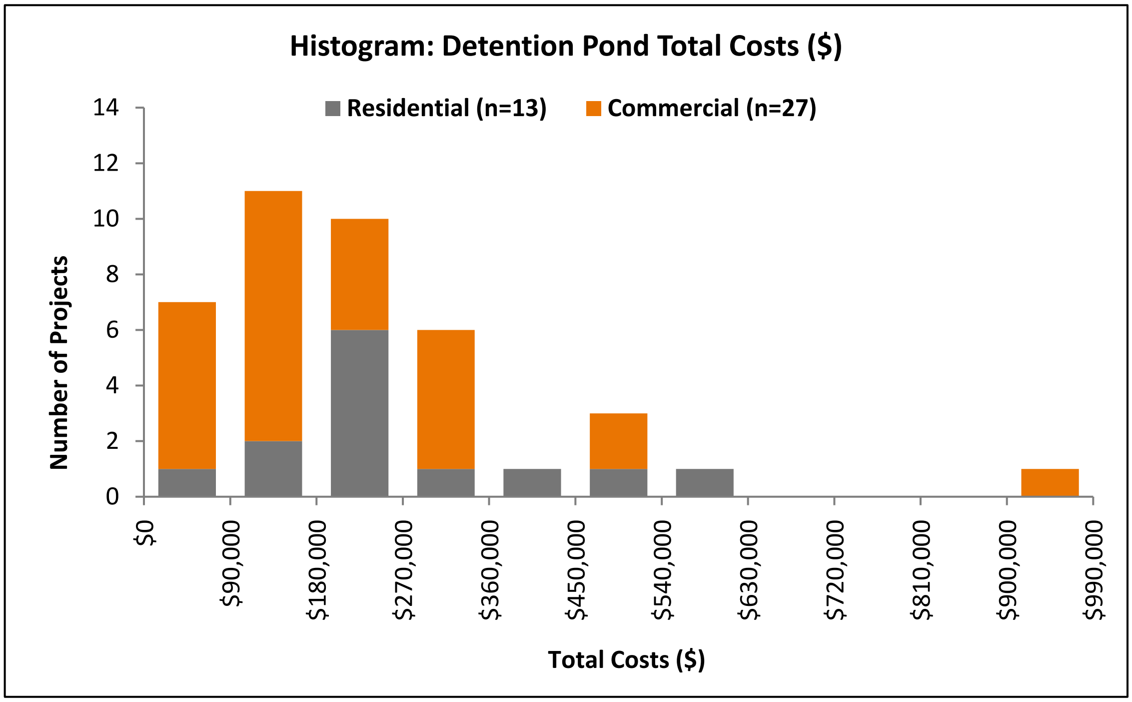

Figure 4-7. Histogram of RSMP Detention Pond Total Costs ($)

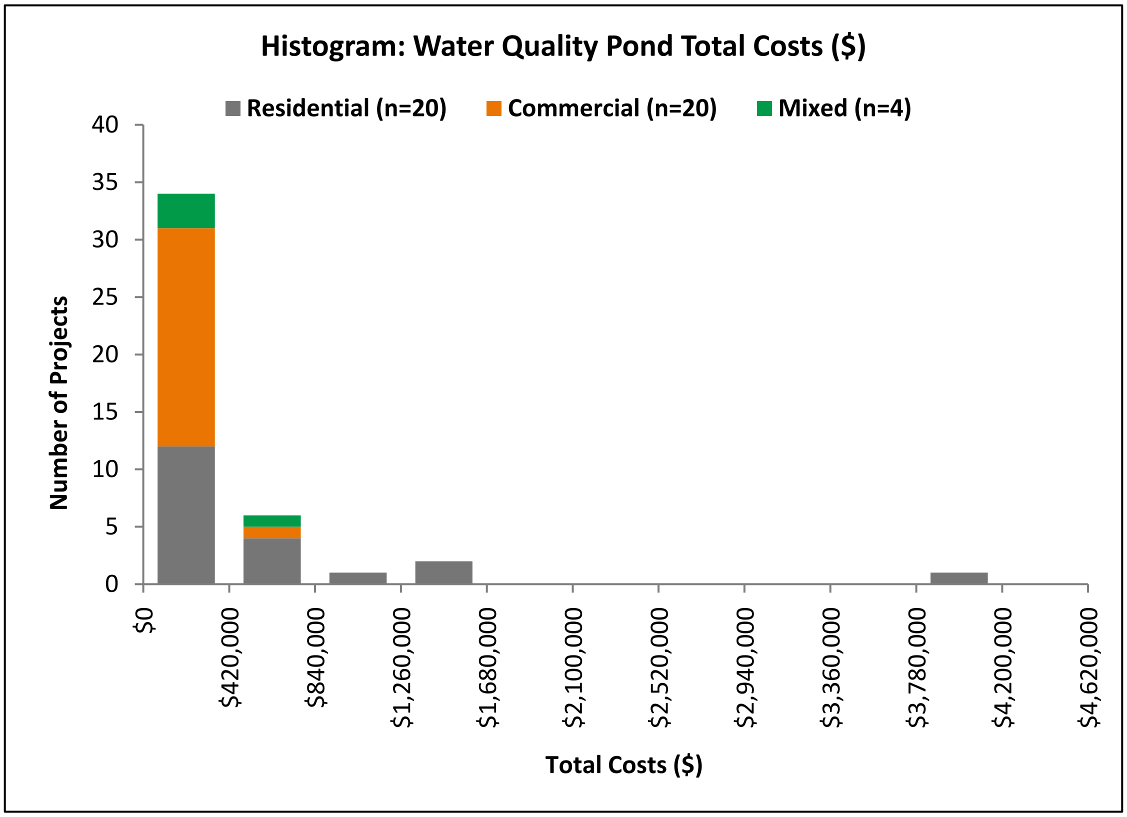

Figure 4-8. Histogram of UWSCF Water Quality Pond Total Costs ($)

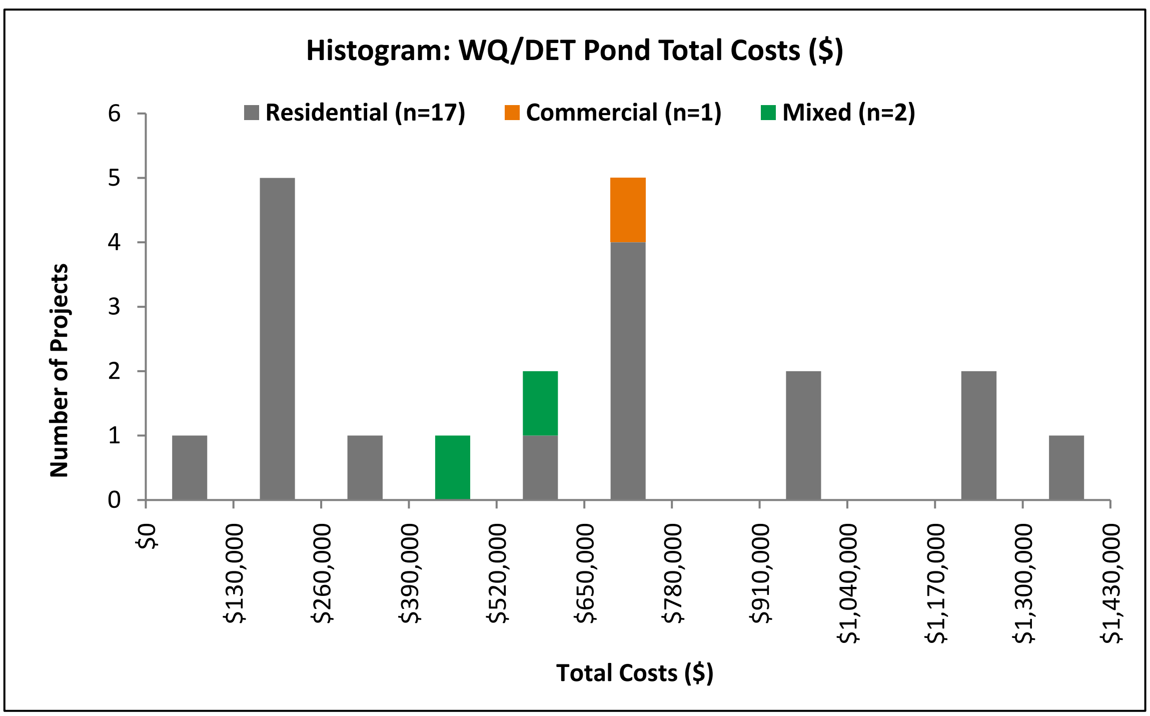

Figure 4-9. Histogram of WQ/DET Pond Total Costs ($)

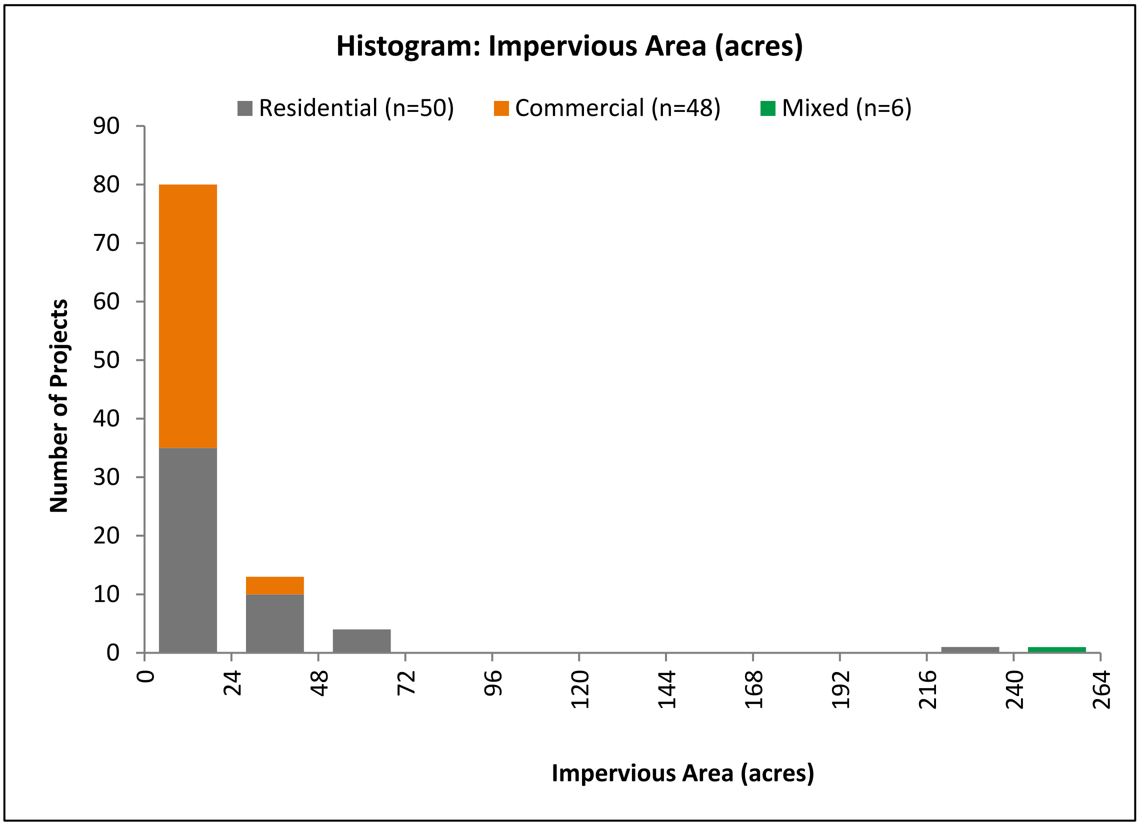

Figure 4-10. Histogram of Impervious Area, All Facilities (acres)

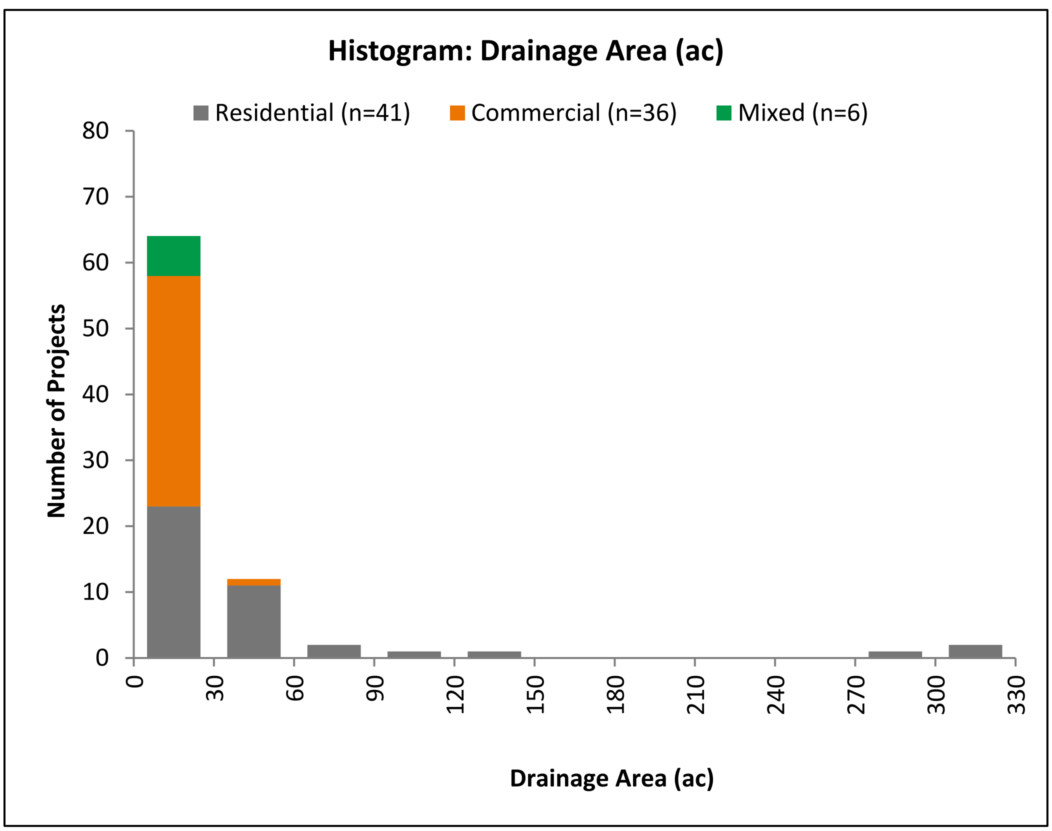

Figure 4-11. Histogram of Drainage Area, All Facilities (acres)

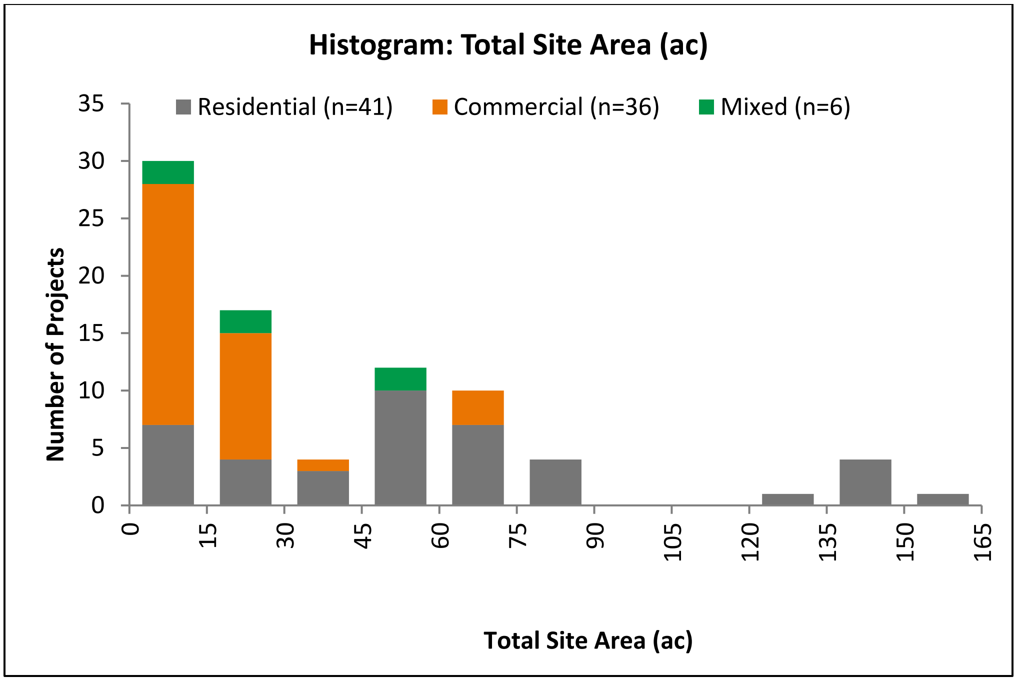

Figure 4-12. Histogram of Total Site Area, All Facilities (acres)

Note: Total Site Area was not available for all data points evaluated.

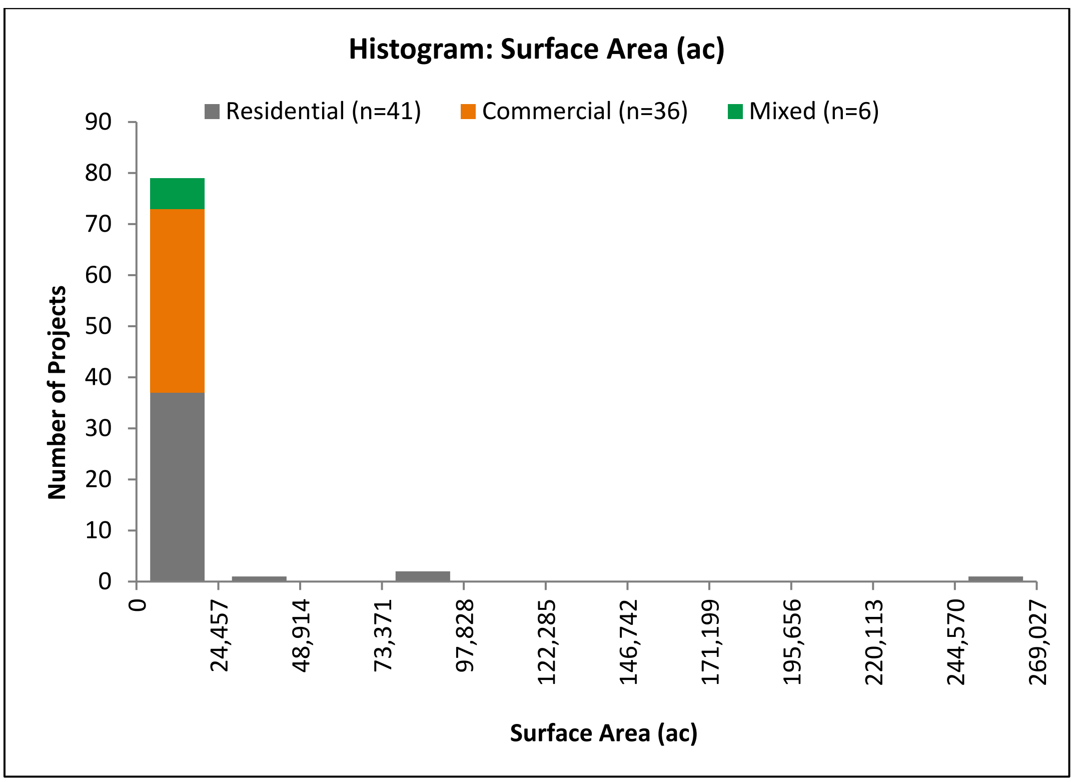

Figure 4-13. Histogram of Surface Area, All Facilities (acres)

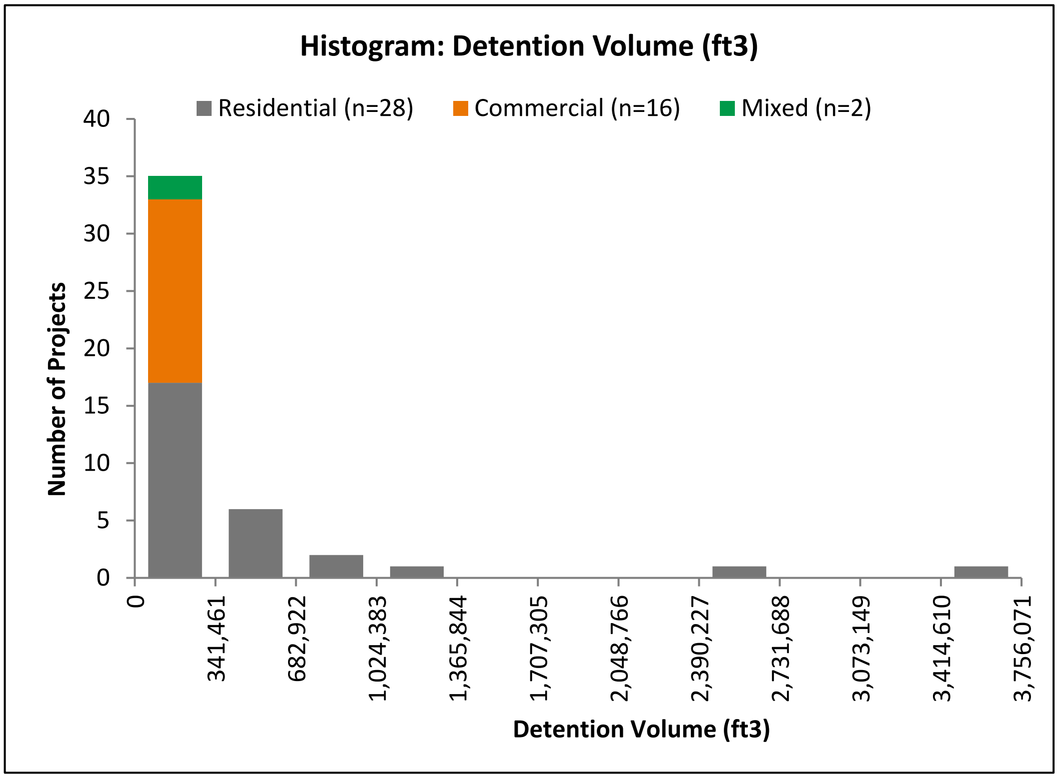

Figure 4-14. Histogram of Detention Pond Volume, All Detention Ponds (cubic foot/feet [ft^3])

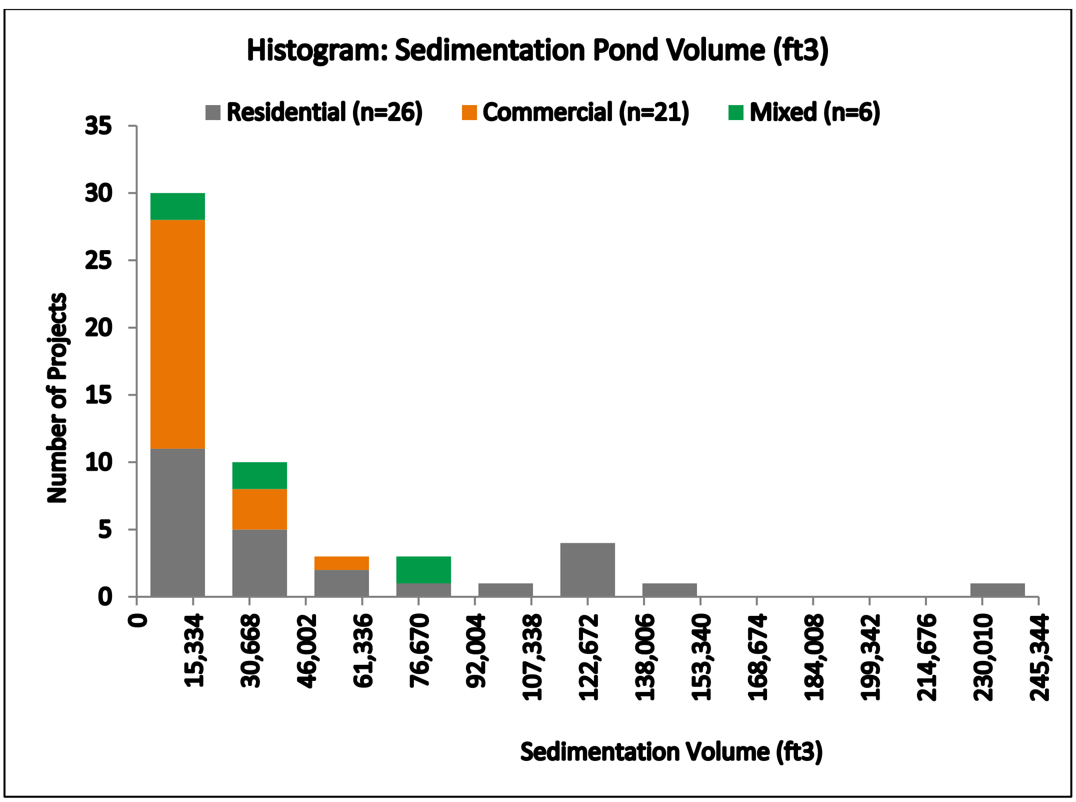

Figure 4-15. Histogram of Sedimentation Pond Volume, All Water Quality Ponds (ft^3)

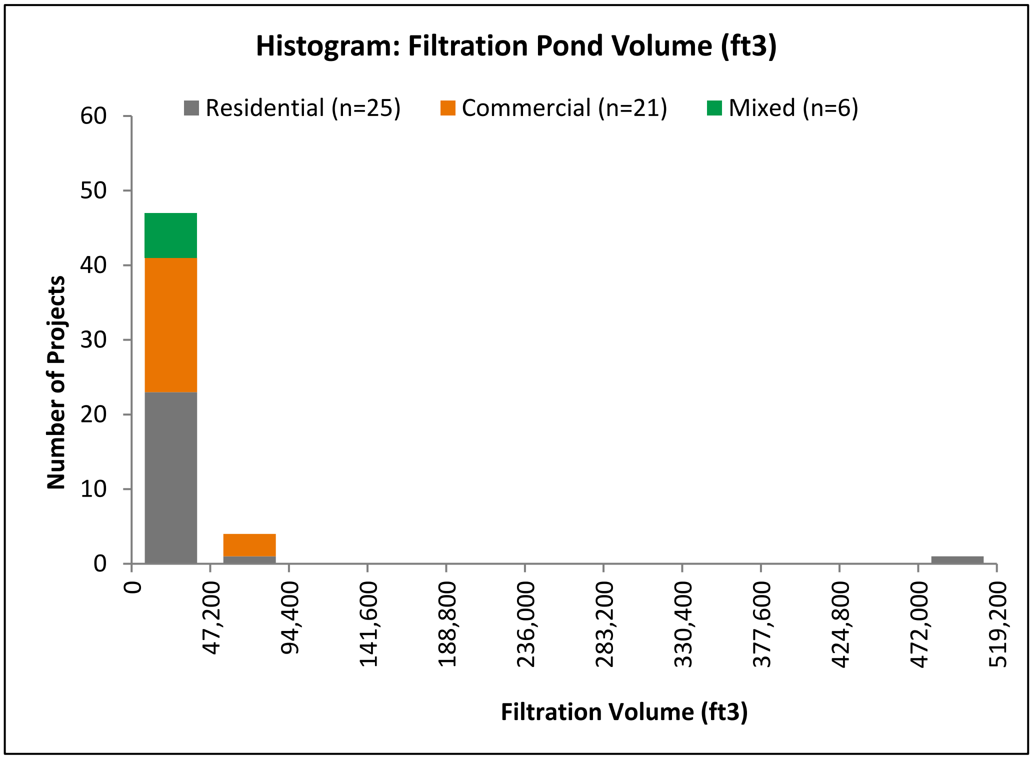

Figure 4-16. Histogram of Filtration Pond Volume, All Water Quality Ponds (ft^3)

4.2.3 Correlation of Costs and Design Parameters

As noted in the previous section, data are not normally distributed (see also Appendix D). Therefore, the data were log transformed before calculating correlation of coefficients and their significance. Table 4-6 summarizes the correlation matrix for Water Quality Ponds.

Table 4-6 Correlation Matrix, Water Quality Ponds

Log Transformed	Total Costs ($)	Impervious Area (ac)	Drainage Area (ac)	Total Site Area (ac)	Surface Area (ac)	WQ Volume (ft^3)
Total Costs ($)	1.000	0.221	0.552	0.267	0.458	0.447
Impervious Area (ac)		1.000	0.461	0.964	0.069	0.428
Drainage Area (ac)			1.000	0.552	0.428	0.932
Total Site Area (ac)				1.000	0.145	0.519
Surface Area (ac)					1.000	0.355
WQ Volume (ft^3)						1.000
Correlation coefficient (Total Costs)		0.221	0.552	0.267	0.458	0.447
t-statistic (significance)		1.606	4.683	1.957	3.639	3.530
p-value		0.116	0.000	0.057	0.001	0.001
t critical value (2 D.F.) = 2.009						

Note, while there are 44 records associated with water quality ponds, 6 records were not included because of missing data.
ac = acre(s)
p-value = probability value
t-statistic =
t critical =

Table 4-7 summarizes the correlation matrix for Detention Ponds.

Table 4-7. Detention Pond Correlation Matrix (n = 20)

Log Transformed	Total Costs ($)	Impervious Area (ac)	Drainage Area (ac)	Total Site Area (ac)	Surface Area (ac)	Detention Volume (ft^3)
Total Costs ($)	1.000	0.562	0.766	0.616	0.605	0.723
Impervious Area (ac)		1.000	0.602	0.909	0.623	0.649
Drainage Area (ac)			1.000	0.782	0.860	0.937
Total Site Area (ac)				1.000	0.732	0.769
Surface Area (ac)					1.000	0.944
Detention Volume (ft^3)						1.000
Correlation coefficient (Total Costs)		0.562	0.766	0.616	0.605	0.723
t-statistic (significance)		4.800	8.432	5.523	5.372	7.406
p-value		2.032E-05	1.410E-10	1.923E-06	3.156E-06	3.837E-09
t critical value (2 D.F.) = 2.009						
Note: While there are 40 records associated with detention ponds, 20 records were not included because of missing data.						

Table 4-8 summarizes the correlation matrix for WQ/DET Ponds.

Table 4-8. WQ/DET Pond Correlation Matrix (n = 19)

Log Transformed	Total Costs ($)	Impervious Area (ac)	Drainage Area (ac)	Total Site Area (ac)	Detention Surface Area (ac)	WQ Surface Area (ac)	Detention Volume (ft^3)	WQ Control Volume (ft^3)
Total Costs ($)	1.000	0.666	0.733	0.638	0.698	0.846	0.762	0.711
Impervious Area (ac)		1.000	0.616	0.953	0.532	0.699	0.704	0.627
Drainage Area (ac)			1.000	0.650	0.962	0.854	0.920	0.935
Total Site Area (ac)				1.000	0.549	0.665	0.664	0.634
Detention Surface Area (ac)					1.000	0.832	0.935	0.868
WQ Surface Area (ac)						1.000	0.892	0.877
Detention Volume (ft3)							1.000	0.877
WQ Control Volume (ft3)								1.000

Table 4-8. WQ/DET Pond Correlation Matrix (n = 19)

Log Transformed	Total Costs ($)	Impervious Area (ac)	Drainage Area (ac)	Total Site Area (ac)	Detention Surface Area (ac)	WQ Surface Area (ac)	Detention Volume (ft^3)	WQ Control Volume (ft^3)
Correlation coefficient (Total Costs)		0.666	0.733	0.638	0.698	0.846	0.762	0.711
t-statistic (significance)		6.313	7.612	5.865	6.888	11.237	8.308	7.149
p-value		1.407E-07	1.960E-09	6.217E-07	2.104E-08	3.084E-14	2.090E-10	8.897E-09
t critical value (2 D.F.) = 2.009								

Note: While there are 20 records associated with detention ponds, 1 record was not included because of missing data.

4.2.4 Bivariate Regression Analysis

The project team conducted a bivariate regression analysis to test whether impervious area (x) significantly (statistically speaking) predicts total costs (y) of an SCM facility. In most cases, the data are not normally distributed, thus the project team completed a log-log transformation of the data. Reference Appendix E to aid in the translation of the regression discussion that follows. Bivariate regressions are similar to the scatter plots discussed previously (see Section 4.2.1), except the bivariate regressions enable the project team to evaluate total costs versus impervious area added, whereas the scatter plots show total costs per impervious acre versus impervious area added. The power trendline from the scatter plots provides R^2 as a measure of how reliable the model is (y per x vs. x). Bivariate regressions (y vs. x) provide more robust statistical results to measure how good is the model. An R^2 of 100 percent does not mean the model is good. Bivariate regressions allow us to determine the significance of the model by looking at the significance F value (or p-value for the x coefficient). In other words, the bivariate regression results provide additional information about the predictive formula that is not available in the scatter plot. The bivariate regression analysis does not produce a rate (dollar per impervious acre); rather, it provides a predictive model to estimate total costs based on impervious area. In this case, instead of a rate table, one would use a formula to estimate total SCM costs. The project team evaluated samples for the two land use categories in the bivariate regressions separately, as well as combined. Based on the analyses conducted, the separate regressions do not produce results that are significant. Combining the samples provides a better relationship.

4.2.4.1 Commercial Detention Ponds

Table 4-9 summarizes the regression output resulting from the bivariate regression analysis conducted for detention ponds constructed on "commercial" properties, which include commercial, mixed-use, and multi-family residential land use types. The results show that impervious area explains 36% of variance in total costs (R^2=0.36, F(1,25)=14.1, p<0.001). The regression suggests that impervious area significantly predicted total costs (β=0.4434, p<0.001), and the predictive model includes:

$y = \beta_0 + \beta_1 * x$

$\ln(y) = \beta_0 + \beta_1 * \ln(IA)$

$y = \exp(11.4444) * IA ^\wedge 0.4434$

$y = 93{,}379 * IA ^\wedge 0.4434$

For example, the estimated total costs for a detention pond facility constructed on a commercial property associated with an impervious area of 10 acres: Total Costs = 93,379 * 10 ^ 0.4434 = $259,000

Table 4-9. Bivariate Regression Output for Commercial Detention Ponds (Total Costs vs. Impervious Area)

Regression Statistics						
Multiple R	0.60					
R^2	0.36					
Adjusted R^2	0.34					
Standard Error	0.72					
Observations	27					
ANOVA						
	df	**SS**	**MS**	**F**	**Significance F**	
Regression	1	7.36	7.36	14.11	<0.001	
Residual	25	13.04	0.52			
Total	26	20.40				
	Coefficients	**Standard Error**	**t-Stat**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	11.4444	0.20	55.90	<0.001	11.0228	11.8661
ln(IA)	0.4434	0.12	3.76	<0.001	0.2003	0.6865

ANOVA = analysis of variance, a statistical method in which the variation in a set of observations is divided into distinct components.

< = less than

df = degrees of freedom

F = F statistic

ln(IA) = natural logarithm of impervious area

MS = mean squares

SS = sum of squares

t-Stat = a measure of how extreme a statistical estimate is

4.2.4.2 Single-family Residential Detention Ponds

Table 4-10 summarizes the regression output resulting from the bivariate regression analysis conducted for detention ponds constructed on single-family residential properties. The results show that impervious area explains 16% of variance in total costs (R^2=0.16, F(1,21)=2.155, p=0.17). The p-value for this regression suggests that impervious area does not significantly predict total costs (β=0.2483, p=0.17), and the model should not be used. The predictive model includes:

$y = \beta_0 + \beta_1 * x$

$\ln(y) = \beta_0 + \beta_1 * \ln(IA)$

y = exp(11.7296) * IA ^ 0.2483

y = 124,191 * IA ^ 0.2483

For example, the estimated total costs for a detention pond facility constructed on a single-family residential property associated with an impervious area of 10 acres: Total Costs = 124,191 * 10 ^ 0.2483 = $220,000

Table 4-10. Bivariate Regression Output for Single-family Residential Detention Ponds (Total Costs vs. Impervious Area)

Regression Statistics						
Multiple R	0.40					
R^2	0.16					
Adjusted R^2	0.09					
Standard Error	0.67					
Observations	13					
ANOVA						
	df	**SS**	**MS**	**F**	**Significance F**	
Regression	1	0.9678	0.9678	2.1550	0.1701	
Residual	11	4.9399	0.4491			
Total	12	5.9077				
	Coefficients	**Standard Error**	**t-Stat**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	11.7296	0.417	28.155	0.000	10.813	12.647
ln(IA)	0.2483	0.169	1.468	0.170	-0.124	0.621

4.2.4.3 All Detention Ponds (commercial and single-family residential land uses combined)

Table 4-11 summarizes the regression output resulting from the bivariate regression analysis conducted for detention ponds constructed on commercial and single-family residential properties combined. The results show that impervious area explains 15% of variance in total costs (R^2=0.31, F(1,38)=17.44, p<0.001). The regression suggests that impervious area significantly predicted total costs (β=0.368, p<0.01), and the predictive model includes:

$y = \beta_0 + \beta_1 * x$

$\ln(y) = \beta_0 + \beta_1 * \ln(IA)$

y = exp(11.5075) * IA ^ 0.3735

y = 99,462 * IA ^ 0.3735

For example, the estimated total costs for a detention pond facility constructed on a property (residential or commercial land use type) associated with an estimated impervious area of 10 acres: Total Costs = 99,462 * 10 ^ 0.3735 = $235,000.

Table 4-11. Bivariate Regression Output for All Detention Ponds (Total Costs vs. Impervious Area)

Regression Statistics						
Multiple R	0.56					
R^2	0.31					
Adjusted R^2	0.30					
Standard Error	0.70					
Observations	40					
ANOVA						
	df	**SS**	**MS**	**F**	**Significance F**	
Regression	1	8.47	8.47	17.44	<0.001	
Residual	38	18.46	0.49			
Total	39	26.93				
	Coefficients	**Standard Error**	**t-Stat**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	11.5075	0.1789	64.3072	<0.001	11.1453	11.8698
ln(IA)	0.3735	0.0894	4.1757	<0.001	0.1924	0.5545

4.2.4.4 Commercial Water Quality Ponds

Table 4-12 summarizes the regression output resulting from the bivariate regression analysis conducted for water quality ponds constructed on "commercial" properties, which include commercial, mixed-use, and multi-family residential land use types. The results show that impervious area explains 16% of variance in total costs (R^2=0.08, F(1,22)=1.85, p=0.19). The p-value for this regression suggests that impervious area does not significantly predict total costs (β=0.1916, p=0.19) and the model should not be used. The predictive model includes:

$y = \beta_0 + \beta_1 * x$

$\ln(y) = \beta_0 + \beta_1 * \ln(IA)$

$y = \exp(11.5503) * IA \wedge 0.1916$

$y = 103{,}808 * IA \wedge 0.1916$

For example, the estimated total costs for a water quality pond facility constructed on a commercial property associated with an impervious area of 10 acres: Total Costs = 103,808 * 10 ^ 0.1916 = $161,400

Table 4-12. Bivariate Regression Output for Commercial Water Quality Ponds (Total Costs vs. Impervious Area)

Regression Statistics	
Multiple R	0.28
R^2	0.08
Adjusted R^2	0.04
Standard Error	0.73
Observations	24

Table 4-12. Bivariate Regression Output for Commercial Water Quality Ponds (Total Costs vs. Impervious Area)

Regression Statistics						
ANOVA						
	df	**SS**	**MS**	**F**	**Significance F**	
Regression	1	0.99	0.99	1.85	0.19	
Residual	22	11.77	0.54			
Total	23	12.76				
	Coefficients	**Standard Error**	**t-stat**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	11.5503	0.31	37.19	<0.001	10.91	12.19
ln(IA)	0.1916	0.14	1.36	0.19	-0.10	0.48

4.2.4.5 Single-family Residential Water Quality Ponds

Table 4-13 summarizes the regression output resulting from the bivariate regression analysis conducted for water quality ponds constructed on single-family residential properties. The results show that impervious area explains 16% of variance in total costs (R^2=0.10, F(1,18)=2.03, p=0.17). The p-value for this regression suggests that impervious area does not significantly predict total costs (β=0.4689, p=0.17), and the model should not be used. The predictive model includes:

$y = \beta_0 + \beta_1 * x$

$\ln(y) = \beta_0 + \beta_1 * \ln(IA)$

y = exp(11.2018) * IA ^ 0.4689

y = 73,265 * IA ^ 0.4689

For example, the estimated total costs for a water quality pond facility constructed on a single-family residential property associated with an impervious area of 10 acres: Total Costs = 73,265 * 10 ^ 0.4689 = $215,700.

Table 4-13. Bivariate Regression Output for Single-family Residential Water Quality Ponds (Total Costs vs. Impervious Area)

Regression Statistics					
Multiple R	0.32				
R^2	0.10				
Adjusted R^2	0.05				
Standard Error	1.18				
Observations	20				
ANOVA					
	df	**SS**	**MS**	**F**	**Significance F**
Regression	1	2.84	2.84	2.03	0.17
Residual	18	25.20	1.40		
Total	19	28.04			

Table 4-13. Bivariate Regression Output for Single-family Residential Water Quality Ponds (Total Costs vs. Impervious Area)

Regression Statistics						
	Coefficients	**Standard Error**	**t-stat**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	11.2018	1.02	10.94	<0.001	9.05	13.35
ln(IA)	0.4689	0.33	1.42	0.17	-0.22	1.16

4.2.4.6 All Water Quality Ponds (commercial and single-family residential land uses combined)

With commercial and residential records combined, the project team found a better regression model could be developed than with each land use type individually. Table 4-14 summarizes the regression output resulting from the bivariate regression analysis conducted for water quality ponds constructed on commercial and single-family residential properties combined. The results show that impervious area explains 15 percent of variance in total costs (R^2=0.15, $F(1,42)$=7.66, $p<0.01$). The regression suggests that impervious area significantly predicted total costs (β=0.368, $p<0.01$), and the predictive model includes:

$y = \beta_0 + \beta_1 * x$

$\ln(y) = \beta_0 + \beta_1 * \ln(IA)$

$y = \exp(11.3437) * IA \wedge 0.368$

$y = 84{,}435 * IA \wedge 0.368$

For example, the estimated total costs for a detention pond constructed on a property (residential or commercial land use type) associated with an estimated impervious area of 10 acres: Total Costs = 84,435 * 10 ^ 0.368 = $197,000.

Table 4-14. Bivariate Regression Output for All Water Quality Ponds (Total Costs vs. Impervious Area)

Regression Statistics						
Multiple R	0.39					
R^2	0.15					
Adjusted R^2	0.13					
Standard Error	0.96					
Observations	44					
ANOVA						
	df	**SS**	**MS**	**F**	**Significance F**	
Regression	1	7.09	7.09	7.66	<0.01	
Residual	42	38.90	0.93			
Total	43	45.99				
	Coefficients	**Standard Error**	**t-stat**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	11.3437	0.35	32.14	<0.001	10.63	12.06
ln(IA)	0.3680	0.13	2.77	<0.01	0.10	0.64

4.2.4.7 Commercial Stacked (WQ/DET) Ponds

The available data included only three stacked (WQ/DET) ponds associated with commercial land use, thus a reliable regression cannot be developed.

4.2.4.8 Single-family Residential Stacked (WQ/DET) Ponds

Table 4-15 summarizes the regression output resulting from the bivariate regression analysis conducted for stacked (WQ/DET) ponds constructed on single-family residential properties. The results show that impervious area explains 16% of variance in total costs (R^2=0.35, F(1,15)=8.09, p=0.01). The regression suggests that impervious area significantly predicted total costs (β=0.4945, p=0.01), and the predictive model includes:

$y = \beta_0 + \beta_1 * x$

$\ln(y) = \beta_0 + \beta_1 * \ln(IA)$

y = exp(11.8432) * IA ^ 0.4945

y = 139,141 * IA ^ 0.4945

For example, the estimated total costs for a WQ/DET pond facility constructed on a single-family residential property associated with an impervious area of 10 acres: Total Costs = 139,141 * 10 ^ 0.4945 = $434,490

Table 4-15. Bivariate Regression Output for Single-family Residential WQ/DET Ponds (Total Costs vs. Impervious Area)

Regression Statistics						
Multiple R	0.59					
R^2	0.35					
Adjusted R^2	0.31					
Standard Error	0.74					
Observations	17					
ANOVA						
	df	**SS**	**MS**	**F**	**Significance F**	
Regression	1	4.43	4.43	8.09	0.01	
Residual	15	8.22	0.55			
Total	16	12.65				
	Coefficients	**Standard Error**	**t-stat**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	11.8432	0.46	25.86	<0.001	10.87	12.82
ln(IA)	0.4945	0.17	2.84	0.01	0.12	0.87

4.2.4.9 All WQ/DET Ponds (commercial and single-family residential combined)

Table 4-16 summarizes the regression output resulting from the bivariate regression analysis conducted for WQ/DET ponds constructed on commercial and single-family residential properties combined. The results show that impervious area explains 15% of variance in total costs (R^2=0.33, F(1,18)=8.77, p<0.01). The regression suggests that impervious area significantly predicted total costs (β=0.4744, p<0.01), and the predictive model includes:

$y = \beta_0 + \beta_1 * x$

$\ln(y) = \beta_0 + \beta_1 * \ln(IA)$

y = exp(11.8495) * IA ^ 0.4744

y = 140,020 * IA ^ 0.4744

For example, the estimated total costs for a WQ/DET pond facility constructed on a commercial property associated with an impervious area of 10 acres: Total Costs = 140,020 * 10 ^ 0.4744 = $417,400.

Table 4-16. Bivariate Regression Output for All WQ/DET Ponds (Total Costs vs. Impervious Area)

Regression Statistics						
Multiple R	0.57					
R^2	0.33					
Adjusted R^2	0.29					
Standard Error	0.69					
Observations	20					
ANOVA						
	df	**SS**	**MS**	**F**	**Significance F**	
Regression	1	4.19	4.19	8.77	<0.01	
Residual	18	8.60	0.48			
Total	19	12.79				
	Coefficients	**Standard Error**	**t-stat**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	11.8495	0.43	27.80	<0.001	10.95	12.75
ln(IA)	0.4744	0.16	2.96	<0.01	0.14	0.81

4.2.5 Multivariate Regression Analysis

4.2.5.1 Detention Ponds

The project team conducted a multivariate regression analysis to test if design criteria for detention ponds (e.g., impervious area, drainage area, total site area, surface area, and detention volume; referred to as independent variables) significantly predict total costs (dependent variable) of SCM facilities constructed on commercial and single-family residential land use types. To test if data are normally distributed, the project team used the Shapiro-Wilk normality test and transformed data as needed. The project team conducted stepwise regression to determine validity of various models and selected the best model based on the F statistic, which is an overall measure of significance of a particular model. There were 20 detention pond projects that had available data for all variables, including 5 on single-family residential and 15 on commercial land use types.

Single-family Residential Land Use

The project team evaluated data associated with detention ponds constructed on single-family residential land use. The results show that impervious area, drainage area, and detention volume variables are significant. Table 4-17 summarizes the regression output of the selected model (log-linear), and the results suggest that impervious area, drainage area, and detention volume variables explain 99% of variance in total costs (R^2=0.99, $F(1,3)$=42.7, p=0.11). The predictive model includes:

$y = \beta 0 + (\beta 1 * IA) + (\beta 2 * DetVol) + (\beta 3 * DA)$

$\ln(y) = \beta 0 + (\beta 1 * IA) + (\beta 2 * DetVol) + (\beta 3 * DA)$

$y = \exp(\beta 0 + (\beta 1 * IA) + (\beta 2 * DetVol) + (\beta 3 * DA))$

$y = \exp(12.3 + (3.051E-02 * IA) - (1.007E-06 * DetVol) - (1.357E-02 * DA))$

Table 4-17. Multivariate Regression Results of Total Costs and Design Criteria for Single-family Residential Detention Ponds

Regression Statistics						
Multiple R	1.00					
R^2	0.99					
Adjusted R^2	0.97					
Standard Error	0.08					
Observations	5.00					
ANOVA						
	df	**SS**	**MS**	**F**	**Significance F**	
Regression	3	0.82	0.27	42.70	0.11	
Residual	1	0.01	0.01			
Total	4	0.82				
	Coefficients	**Standard Error**	**t-stat**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	12.30	0.08	159.83	<0.01	11.32	13.28
Impervious Area (ac)	0.03	3.22E-03	9.46	0.07	-0.01	0.07
Detention Volume (ft^3)	-1.01E-06	1.38E-07	-7.32	0.09	0.00	0.00
Drainage Area (ac)	-0.01	3.17E-03	-4.28	0.15	-0.05	0.03

Commercial Land Use

The project team evaluated data associated with detention ponds constructed on “commercial” land use, which includes commercial, multi-family residential, and mixed-use developments. The results show that detention volume, drainage area, and total site area variables are significant. Table 4-18 summarizes the regression output of the selected model (linear), and the results suggest that the independent variables explain 68% of variance in total costs (R^2=0.68, $F(3,11)=7.8$, $p=0.0045$). The predictive model includes:

$y = \beta_0 + (\beta_1 * DetVol) + (\beta_2 * DA) + (\beta_3 * TotalSiteArea)$

$y = 56{,}924 + (2.6495 * DetVol) - (15{,}461 * DA) + (3{,}176 * TotalSiteArea))$

Table 4-18. Multivariate Regression Results of Total Costs and Design Criteria for Commercial Detention Ponds

Regression Statistics						
Multiple R	0.82					
R^2	0.68					
Adjusted R^2	0.59					
Standard Error	57,847					
Observations	15					
ANOVA						
	df	**SS**	**MS**	**F**	**Significance F**	
Regression	3	7.87E+10	2.62E+10	7.84	0.004	
Residual	11	3.68E+10	3.35E+09			
Total	14	1.15E+11				
	Coefficients	**Standard Error**	**t-stat**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	56,924	23,260	2.45	0.03	5,730	108,118
Detention Volume (ft^3)	2.6495	0.90	2.94	0.01	0.67	4.63
Drainage Area (ac)	-15,461	7,474	-2.07	0.06	-31,913	990
Total Site Area (ac)	3,176	1,445	2.20	0.05	-5	6,358

4.2.5.2 Water Quality Ponds

The project team conducted a multivariate regression analysis to test if design criteria for water quality ponds (e.g., impervious area, drainage area, total site area, surface area, and water quality volume [sedimentation volume and filtration volume combined]; referred to as independent variables) significantly predict total costs (dependent variable) of SCM facilities constructed on commercial and single-family residential land use types. To test if data are normally distributed, the project team used the Shapiro-Wilk normality test and transformed data as needed. The project team conducted stepwise regression to determine validity of various models and selected the best model based on the F statistic, which is an overall measure of significance of a particular model. There were 38 water quality pond projects that had available data for all variables, including 14 on residential and 24 on commercial land use types.

Single-family Residential Land Use

The project team evaluated data associated with water quality ponds constructed on single-family residential land use. Table 4-19 summarizes the regression output of the selected model (log-linear). The results suggest that water quality volume and drainage area explain 35% of variance in total costs (R^2=0.35, F(2,11)=3.02, p=0.09). The predictive model includes:

$y = \beta_0 + (\beta_1 * \text{WQ Vol}) + (\beta_2 * \text{DA})$

$\ln(y) = \beta_0 + (\beta_1 * \text{WQ Vol}) + (\beta_2 * \text{DA})$

$y = \exp(11.91 - (7.64E\text{-}06 * \text{WQ Vol}) + (0.0637 * \text{DA}))$

Table 4-19. Multivariate Regression Results of Total Costs and Design Criteria for Single-family Residential Water Quality Ponds

Regression Statistics						
Multiple R	0.60					
R^2	0.35					
Adjusted R^2	0.24					
Standard Error	0.98					
Observations	14					
ANOVA						
	df	**SS**	**MS**	**F**	**Significance F**	
Regression	2	5.84	2.92	3.02	0.09	
Residual	11	10.64	0.97			
Total	13	16.47				
	Coefficients	**Standard Error**	**t-stat**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	11.91	0.41	29.19	0.00	11.02	12.81
(WQ_vol)	-7.64E-06	0.00	-1.67	0.12	-1.77E-05	2.46E-06
(DA)	0.0637	0.03	2.46	0.03	0.01	0.12

Commercial Land Use

The project team evaluated data associated with water quality ponds constructed on "commercial" land use, which includes commercial, multi-family residential, and mixed-use developments. Table 4-20 summarizes the regression output of the selected model (log-linear). The results suggest that impervious area, surface area, and total site area explain 57% of variance in total costs (R^2=0.57, $F(3,20)$=8.85, $p<0.001$). The predictive model includes:

$y = \beta_0 + (\beta_1 * IA) + (\beta_2 * SA) + (\beta_2 * \text{Site Area})$

$\ln(y) = \beta_0 + (\beta_1 * IA) + (\beta_2 * SA) + (\beta_2 * \text{Site Area})$

$y = \exp(11.53 – (0.09 * IA) + (2.12 * SA) + (0.04 * \text{Site Area}))$

Table 4-20. Multivariate Regression Results of Total Costs and Design Criteria for Commercial Water Quality Ponds

Regression Statistics	
Multiple R	0.76
R^2	0.57
Adjusted R^2	0.51
Standard Error	0.52
Observations	24

Table 4-20. Multivariate Regression Results of Total Costs and Design Criteria for Commercial Water Quality Ponds

ANOVA						
	df	**SS**	**MS**	**F**	**Significance F**	
Regression	3	7.28	2.43	8.85	<0.001	
Residual	20	5.48	0.27			
Total	23	12.76				
	Coefficients	**Standard Error**	**t-stat**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	11.53	0.18	62.74	<0.001	11.14	11.91
Impervious Area (ac)	-0.09	0.05	-1.56	0.13	-0.20	0.03
Surface Area (ac)	2.12	0.42	5.00	<0.001	1.24	3.00
Total Site Area (ac)	0.04	0.03	1.63	0.12	-0.01	0.10

4.2.5.3 Stacked (WQ/DET) Ponds

The project team conducted a multivariate regression analysis to test if design criteria for a new category of SCMs, stacked (WQ/DET) ponds (e.g., impervious area, water quality volume, detention volume, drainage area, detention surface area, water quality surface area, and total site area; referred to as independent variables), significantly predict total costs (dependent variable) of SCM facilities constructed on commercial and single-family residential land use types. To test if data are normally distributed, the project team used the Shapiro-Wilk normality test and transformed data as needed. The project team conducted stepwise regression to determine validity of various models and selected the best model based on the F statistic, which is an overall measure of significance of a particular model. There are 19 stacked pond projects that had available data for all variables, including 16 on residential and 3 on commercial land use types.

Single-family Residential Land Use

The project team evaluated data associated with water quality ponds constructed on single-family residential land use. Table 4-21 summarizes the regression output of the selected model (linear). The results suggest that the independent variables used in the regression explain 94% of variance in total costs (R^2=0.94, F(6,10)=29.05, p<0.001) and where the intercept is constant (i.e., equal to zero). The predictive model includes:

y = β0 + (β1 * IA) + (β2 * WQ_vol) + (β3 * DET_vol) + (β4 * DET_sa) + (β5 * WQ_sa) + (β4 * Total Site Area)

y = (54,979 * IA) + (1.51 * WQ_vol) - (0.64 * DET_vol) + (93,444 * DET_sa) + (364,020 * WQ_sa) - (15,427 * Total Site Area)

Table 4-21. Multivariate Regression Results of Total Costs and Design Criteria for Single-family Residential WQ/DET Ponds

Regression Statistics	
Multiple R	0.97
R^2	0.95
Adjusted R^2	0.82
Standard Error	227,571

Table 4-21. Multivariate Regression Results of Total Costs and Design Criteria for Single-family Residential WQ/DET Ponds

Regression Statistics						
Observations	16					
ANOVA						
	df	**SS**	**MS**	**F**	**Significance F**	
Regression	6	9.03E+12	1.50E+12	29.05	<0.001	
Residual	10	5.18E+11	5.18E+10			
Total	16	9.55E+12				
	Coefficients	***Standard Error***	***t-stat***	***p-value***	***Lower 95%***	***Upper 95%***
Intercept	0					
IA	54,979	18,580	2.96	0.01	13,580	96,378
WQ_vol	1.51	0.85	1.78	0.10	-0.37	3.39
DET_vol	-0.64	0.22	-2.85	0.02	-1.14	-0.14
DET_sa	93,444	28,049	3.33	<0.01	30,946	155,942
WQ_sa	364,020	136,117	2.67	0.02	60,733	667,307
Total Site Area	-15,427	6,182	-2.50	0.03	-29,201	-1,654

Note: Intercept was kept constant to improve the regression

Commercial Land Use

The available data included only three stacked (WQ/DET) ponds associated with commercial land use, which includes commercial, multi-family residential, and mixed-use developments; thus, a reliable regression cannot be developed.

4.2.6 Summary of Statistical Analyses and Regressions

Statistical analyses were completed for 104 SCMs that are classified as "water quality pond," "detention pond," or "WQ/DET Pond." In addition, data were further categorized by land use type as single-family residential or "commercial," which includes commercial, multi-family residential, and mixed-use development land uses. The analyses included the XY scatter plots/power trendline fit (total costs per impervious acre versus impervious area), bivariate regressions (total costs versus impervious area), and multivariate regressions (total costs versus independent variables). In the resulting predictive models (including the XY scatter plots), in most cases, the analysis specific to single-family residential or commercial/multi-family residential/mixed-use land use types independently does not produce a statistically reliable model. In these cases, combining the two land use categories ("combined") produced a better result. Table 4-22 provides a summary of the regression results, and the models in bold text are ones that are estimated to provide statistically reliable results, as discussed in Section 4.2.5.

Figure 4-17 provides example calculations for project sites based on the regression models summarized in Table 4-22. Total costs are estimated based on the regression model for SCM type and property type and compared to the actual costs provided in the sample datasets. For the example project sites included on Figure 4-17, on a percentage of actual costs, the various models predict costs that are 25 to 50% more or less than actual. Some models predict costs at or near the actual amount. This is to be expected because regression models represent best fit given the available data. In some cases, collecting data for additional project sites and updating the regression model could provide better results. The project team recommends use of the combined models as it offers balance between the two independent land use type models based on R^2 value. The bivariate models for the combined models offer reliable models based on the F statistic and significance F values reported in Table 4-22. The multivariate models for DET and WQ Ponds also offer reliable models based on the F statistic and significance F values reported in Table 4-22.

Table 4-22. Summary of Regression Results of Total Costs and Design Criteria

SCM Facility	Property Type	Sample Size	Formula	Model Statistics	Functional Form
Power Trendline Fit (Total Costs per Impervious Acre vs. Impervious Area)					
Detention Pond	Residential	n = 13	y = 124,151 * IA ^ -0.75	R^2 = 0.64	N/A
Detention Pond	Commercial	n = 26	y = 75,618 * IA ^ -0.436	R^2 = 0.33	N/A
Detention Pond	**Combined**	**n = 39**	**y = 87,068 * IA ^ -0.561**	**R^2 = 0.48**	**N/A**
Water Quality Pond	Residential	n = 18	y = 42,948 * IA ^ -0.426	R^2 = 0.07	N/A
Water Quality Pond	Commercial	n = 23	y = 89,339 * IA ^ -0.744	R^2 = 0.50	N/A
Water Quality Pond	**Combined**	**n = 41**	**y = 73,703 * IA ^ -0.626**	**R^2 = 0.34**	**N/A**
WQ/DET Pond	Residential	n = 17	y = 139,187 * IA ^-0.505	R^2 = 0.36	N/A
WQ/DET Pond	Commercial	n = 3	y = 814,647 * IA ^ -1.238	R^2 = 0.65	N/A
WQ/DET Pond	**Combined**	**n =20**	**y = 140,063 * IA ^ -0.525**	**R^2 = 0.38**	**N/A**
Bivariate Regression (Total Costs vs. Impervious Area)					
Detention Pond	Residential	n = 13	y = 124,191 * IA ^ 0.248	R^2=0.16, F(1,21)=2.155, p=0.17	log-log
Detention Pond	Commercial	n = 27	y = 93,379 * IA ^ 0.4434	R^2=0.36, F(1,25)=14.1, p<0.001	log-log
Detention Pond	**Combined**	**n = 40**	**y = 99,462 * IA ^ 0.3735**	**R^2=0.31, F(1,38)=17.44, p<0.001**	**log-log**
Water Quality Pond	Residential	n = 20	y = 73,265 * IA ^ 0.4689	R^2=0.10, F(1,18)=2.028, p=0.17	log-log
Water Quality Pond	Commercial	n = 24	y = 103,808 * IA ^ 0.1916	R^2=0.07, F(1,22)=1.85, p=0.19	log-log
Water Quality Pond	**Combined**	**n = 44**	**y = 84,435 * IA ^ 0.368**	**R^2=0.15, F(1,42)=7.66, p<0.01**	**log-log**
WQ/DET Pond	Residential	n = 17	y = 139,141 * IA ^ 0.4945	R^2=0.35, F(1,15)=8.09, p=0.01	log-log
WQ/DET Pond	Commercial	n = 3	N/A, only 3 data points	N/A	N/A
WQ/DET Pond	**Combined**	**n = 20**	**y = 140,020 * IA ^ 0.4744**	**R^2=0.33, F(1,18)=8.77, p<0.01**	**log-log**
Multivariate Regression (Total Costs vs. independent variables)					
Detention Pond	Residential	n = 5	y = exp(12.3) + (3.051E-02 * IA) - (1.007E-06 * DetVol) - (1.357E-02 * DA)	R^2=0.99, F(1,3)=42.7, p=0.11	log-linear

Table 4-22. Summary of Regression Results of Total Costs and Design Criteria

SCM Facility	Property Type	Sample Size	Formula	Model Statistics	Functional Form
Detention Pond	**Commercial**	**n = 15**	**y = 56,924 + (2.6495 * DetVol) - (15,461 * DA) + (3,176 * TotalSiteArea)**	**R^2=0.68, F(3,11)=7.8, p<0.01**	**linear**
Water Quality Pond	Residential	n = 14	y = exp(11.91) – (7.64E-06*WQ Vol) + (0.0637 *DA)	R^2=0.35, F(2,11)=3.02, p=0.09	log-linear
Water Quality Pond	**Commercial**	**n = 24**	**y = exp(11.53) – (0.085 * WQ Vol) + (2.12 * SA) + (0.045 * Site Area)**	**R^2=0.57, F(3,20)=8.85, p<0.001**	**log-linear**
WQ/DET Pond	**Residential**	**n = 16**	**y = (54,979 * IA) + (1.51 * WQ_vol) - (0.64 * DET_vol) + (93,444 * DET_sa) + (364,020 * WQ_sa) - (15,427 * Total Site Area)**	**R^2=0.35, F(1,15)=8.09, p=0.01**	**linear**
WQ/DET Pond	Commercial	n = 3	N/A, only 3 data points	N/A, only 3 data points	N/A

N/A = not applicable

Facility Type:	Detention Pond	
Property Type:	Commercial	
Project Site:	China Town Center	
Impervious Area (acres):	13.99	
Drainage Area (acres):	36.9	
Detention Volume (ft3):	295,379	
Total Site Area (acres):	20.9	
	Estimated Total Costs	**Pct. of Actual**
Actual	$310,600	
Scatter Plot		
Commercial	$335,750	108%
Combined	$279,792	90%
Bivariate Regression		
Commercial	$300,815	97%
Combined	$266,450	86%
Multivariate Regression		
Commercial	$335,953	108%

Facility Type:	Detention Pond	
Property Type:	Residential	
Project Site:	Avana Phase 2, Section 2	
Impervious Area (acres):	14.02	
Drainage Area (acres):	30.44	
Detention Volume (ft3):	204,592	
	Estimated Total Costs	**Pct. of Actual**
Actual	$193,000	
Scatter Plot		
Residential	$308,380	160%
Combined	$280,346	145%
Bivariate Regression		
Residential	$239,036	124%
Combined	$266,647	138%
Multivariate Regression		
Residential	$181,420	94%

Facility Type:	Water Quality Pond	
Property Type:	Commercial	
Project Site:	AE New Control Center	
Impervious Area (acres):	9.87	
Surface Area (acres):	0.32	
WQ Volume (ft3):	55,103	
Total Site Area (acres):	12.34	
	Estimated Total Costs	**Pct. of Actual**
Actual	$178,600	
Scatter Plot		
Commercial	$315,904	177%
Combined	$207,312	116%
Bivariate Regression		
Commercial	$160,975	90%
Combined	$196,094	110%
Multivariate Regression		
Commercial	$97,040	54%

Facility Type:	Water Quality Pond	
Property Type:	Residential	
Project Site:	Avery Ranch Boulevard West	
Impervious Area (acres):	10.23	
Drainage Area (acres):	13.24	
WQ Volume (ft3):	60,260	
	Estimated Total Costs	**Pct. of Actual**
Actual	$287,800	
Scatter Plot		
Residential	$61,382	21%
Combined	$143,224	50%
Bivariate Regression		
Residential	$217,988	76%
Combined	$198,683	69%
Multivariate Regression		
Residential	$148,747	52%

Facility Type:	WQ/DET Pond	
Property Type:	Commercial	
Project Site:	Parmer Crossing Phase 1	
Impervious Area (acres):	13.60	
Surface Area (acres):	0.32	
WQ Volume (ft3):	55,103	
Total Site Area (acres):	12.34	
	Estimated Total Costs	**Pct. of Actual**
Actual	$528,000	
Scatter Plot		
Commercial	$394,276	75%
Combined	$462,255	88%
Bivariate Regression		
Commercial	na	
Combined	$482,921	91%
Multivariate Regression		
Commercial	na	

Facility Type:	WQ/DET Pond	
Property Type:	Residential	
Project Site:	Easton Park 2B (Phase 1)	
Impervious Area (acres):	25.50	
WQ Volume (ft3):	169,405	
DET Volume (ft3):	499,941	
WQ Surface Area (acres)	2.08	
DET Surface Area (acres)	1.97	
Total Site Area (acres):	83.26	
	Estimated Total Costs	**Pct. of Actual**
Actual	$1,027,000	
Scatter Plot		
Residential	$612,061	60%
Combined	$561,056	55%
Bivariate Regression		
Residential	$690,257	67%
Combined	$650,839	63%
Multivariate Regression		
Residential	$995,978	97%

Figure 4-17. Example Calculations for Project Sites

SECTION 5

Identification of Cost Indices

So that WPD does not have to perform this analysis on an annual basis to maintain reasonable payment structures compared to current conditions, the project team evaluated options for different cost indices that may be applied.

The most widely used index for measuring inflation is the Consumer Price Index for all Urban Consumers (CPI-U). The CPI-U is maintained by the Bureau of Labor Statistics. While it is possible to evaluate CPI for different expense categories, the total for all items can be used for evaluating inflation trends. Table 5-1 summarizes the historical CPI-U for the period 2000 to 2018.

Table 5-1. Consumer Price Index (2000 to 2018)

Year	October Value	Percent Change from Prior Year (October to -October)
2000	174	
2001	177.7	2.1
2002	181.3	2.0
2003	185	2.0
2004	190.9	3.2
2005	199.2	4.3
2006	201.8	1.3
2007	208.9	3.5
2008	216.573	3.7
2009	216.177	-0.2
2010	218.711	1.2
2011	226.421	3.5
2012	231.317	2.2
2013	233.546	1.0
2014	237.433	1.7
2015	237.838	0.2
2016	241.729	1.6
2017	246.663	2.0
2018	252.885	2.5

Source: https://www.bls.gov/cpi/tables/historical-cpi-u-201709.pdf

In terms of evaluating escalation of construction cost, a widely used cost index for construction-related activities is the ENR CCI, and this is the index WPD currently uses for annual adjustment of CCCs of both the RSMP and the UWSCF. Table 5-2 summarizes the historical ENR CCI for the period 2000 to 2018. While the CPI-U is a good measure of inflation, it is broad and may under estimate changes in price of construction related activities and/or materials. There may be specific Consumer Price Index numbers related to construction, but the ENR CCI provides good measure of price changes related to construction and is readily available. Note that the October values for each year are provided. The City's fiscal year (FY) begins in October, thus that is the value they have used for the annual adjustment currently incorporated in the RSMP AND UWSCF payment structures and is the value selected for index comparison.

Table 5-2. ENR CCI (2000 to 2018)

Year	ENR CCI, October value	Percent Change from Prior Year (October to October)
2000	6259	2.2
2001	6397	2.8
2002	6579	2.9
2003	6771	8.0
2004	7314	3.4
2005	7563	4.2
2006	7883	2.1
2007	8045	7.2
2008	8623	-0.3
2009	8596	3.8
2010	8921	2.5
2011	9147	2.5
2012	9376	3.3
2013	9689	2.0
2014	9886	2.4
2015	10128	3.0
2016	10434	3.7
2017	10817	3.4
2018	11183	2.2

Source: ENR CCI History, accessed February 2019

In addition, in reviewing the TCAD data and associated reports, the project team found that TCAD produces an annual report that identifies annual, overall (all types of land uses) appraisal roll growth as a percent change. Further, it provides a historical perspective with 20 years of annual growth. For the purposes of a land cost index, annual growth or an average, rolling annual growth over a period of years could be a justifiable and legitimate cost index. Table 5-3 summarizes the historical TCAD appraisal roll growth for the period 2000 to 2018. Note that the percent change from year to year is much greater for appraisal roll growth than the other two indices.

Table 5-3. TCAD Appraisal Roll Growth (2000 to 2018)

Year	Total Appraisal Roll	Percent Change from Previous Year
2000	$64,972,926,574	
2001	$76,239,437,225	17.34
2002	$79,727,729,212	4.58
2003	$76,468,302,754	-4.09
2004	$77,780,594,779	1.72
2005	$82,376,098,473	5.91
2006	$95,938,116,182	16.46
2007	$108,849,234,638	13.46
2008	$121,873,675,675	11.97
2009	$125,938,362,024	3.34
2010	$120,267,079,152	-4.50
2011	$123,208,234,157	2.45
2012	$128,178,132,877	4.03
2013	$136,622,559,636	6.59
2014	$154,506,308,992	13.09
2015	$179,967,508,052	16.48
2016	$204,504,305,741	13.63
2017	$224,402,312,205	9.73
2018	Not Yet Published	

Source: TCAD, 2017

Based on a comparison of these three indices, industry knowledge, and optimal consistency with current methods, the project team recommends the continued use of the ENR CCI for the RSMP and UWSCF participation payment estimates. The baseline index value should be updated to the October 2018 value.

Results and Recommendations, Updates to RSMP and UWSCF Payment Structure

The following are the project team's recommendations to make the payment structure consistent with current conditions.

6.1 Land Cost Maximum Value

The preferred option for the 2018 RSMP and UWSCF update is to apply a land value cap of 80% to either the current, applicable appraisal district value or the value obtained from a certified appraisal if one is provided by the applicant, then apply a one-time ICAF.

6.2 Construction Cost Component

The CCC and SICC include an annual inflation adjustment. While this helps some with standard and localized inflation, there are confounding factors that may warrant a revision to these components. Further, the current cost structure underestimates the construction costs for the sample projects evaluated. The predictive models resulting from the statistical analyses conducted suggest the following:

1. The models produced during the power trendline fit (scatter plot) using all land use types was statistically better compared to the predictive models produced using the individual land use types (i.e., single-family residential versus commercial/multi-family residential/mixed-use).
2. The models produced for the WQ/DET ponds using commercial/multi-family residential/mixed-use data only are unreasonable due to a low number of data points available.
3. The models produced during the bivariate analyses result in equations that are more precise than the ranges of values resulting from the power trendline fit model.
4. The models produced during the multivariate analyses did not result in statistically significant models for all land use types and SCM types.

Following the analyses, WPD chose to:

- Maintain the use of the power trendline fit due to the complexities associated with applying the models produced using the bivariate analyses (e.g., differing values for each development).
- Use the models produced during the power trendline fit for all land use types ("combined").
- Do not consider the option of a stacked, or combined, facility due to the lack of data available.

Table 6-1 provides a recommended, updated RSMP CCC rate structure based on the project team's statistical analysis.

Table 6-1. Recommended RSMP (Detention Ponds) CCC Rate Structure

Impervious Area (acres)*		All Land Use Types
		$y = 87{,}068x^{-0.561}$
From	To	n = 39
0	1	$129,000
1.01	2	$70,000

Table 6-1. Recommended RSMP (Detention Ponds) CCC Rate Structure

Impervious Area (acres)*		**All Land Use Types**
		$y = 87{,}068x^{-0.561}$
From	**To**	**n = 39**
2.01	5	$44,000
5.01	10	$29,000
10.01	20	$20,000
20.01	50	$12,000
50.01	100	$8,000
100.01	500	$4,000

Costs expressed in October 2018 dollars
Excludes outlier.
*Calculation of cost per impervious acre based on mid-point. For example, the mid-point between 1.01 and 2 is 1.505.

Table 6-2 provides a recommended, updated UWSCF SICC rate structure based on the project team's statistical analysis.

Table 6-2. Recommended UWSCF (Water Quality Ponds) SICC Rate Structure

Impervious Area (acres)*		**All Land Use Types**
		$y = 73{,}703x^{-0.626}$
From	**To**	
		n = 41
0	1	$114,000
1.01	2	$58,000
2.01	5	$34,000
5.01	10	$21,000
10.01	20	$14,000
20.01	and greater	$8,000

Costs expressed in October 2018 dollars
Excludes outliers.
*Calculation of cost per impervious acre based on mid-point. For example, the mid-point between 1.01 and 2 is 1.505. The mid-point used for the final category incorporated the mid-point between 20.01 and 50 acres.

6.3 Recommendations

The following sections provide the project team's recommendations for modifications to the existing Payment in lieu of structure. Appendix F provides example payment calculations.

6.3.1 Recommendations for the RSMP Update

Based on review of land and construction cost data, the project team's recommendations include the following:

- Apply a land value cap of 80% for the LCC to either the current, applicable appraisal district value or the value from a certified appraisal if one is provided by the applicant, then apply a one-time ICAF to calculate the necessary LCC.
- Continue use of the assumption of 5% of the site area as the area required for a detention facility (used when calculating the LCC) and use of the ENR CCI as an annual inflation adjustment to the CCC, with the baseline index set to October 2018.
- Update the CCC cost structure as provided in Table 6-1.

6.3.2 Recommendations for the UWSCF Update

Based on review of land and construction cost data, the project team's recommendations include the following:

- Update the UWSCF SICC by using the payment structure presented in Table 6-2. Note the updated structure has smaller impervious area ranges (i.e, more impervious area groupings) than the current SICC structure, similar to the RSMP LCC impervious area groupings except that the delineation ends at 20 acres and greater.
- Continue use of \$0.10 per ft^2 for the Building Component.
- Update the SAC as follows:
  - Apply a land value cap of 80% to either the current, applicable appraisal district value or the value from a certified appraisal if one is provided by the applicant.
  - Incorporate an assumption of 3%, instead of the assumed 5% of the site area, as the area required for a facility.
- Continue use of the ENR CCI as an annual inflation adjustment to the SICC, with the baseline index set to October 2018, which is 11,183 as provided in Table 5-2.

Benchmark RSMP against Other Cities

Since the City has experienced significant growth since the last comprehensive evaluation of the RSMP program in 2002, the City's RSMP has continued to evolve during this time, as well. Thus, in addition to updating the data used to determine the payment structure for the RSMP and UWSCF, the second phase of the project included a "benchmarking" effort of WPD's program against similar programs in other cities.

7.1 High-Level Comparison

For comparison to WPD's in lieu of payment option, CH2M researched 10 localities (Table 7-1) that have RSMPs and offer property owners the ability to provide payment in lieu of constructing on-site stormwater detention and/or other stormwater treatment facilities. This is intended to serve as a high-level evaluation of each candidate program, the result of which was to enable reduction of the list to three comparable programs for which to develop more detailed evaluations.

Table 7-1. Research-Targeted Localities

Item	Localities
1	Alpharetta, GA
2	DuPage County, IL
3	Green Bay, WI
4	Louisville MSD, KY
5	New Braunfels, TX
6	Redmond, WA
7	San Antonio, TX
8	Tulsa, OK
9	Universal City, TX
10	Washington, DC (as led by the Department of Energy & Environment

DOEE = Department of Energy & Environment
MSD = Metropolitan Sewer District

For each locality, information for several parameters were collected (when easily obtained) to evaluate these municipal programs, including:

- Population
- Service area
- In lieu of fee or payment (ILF, $/unit)
- Number of applications per year
- Options for participation
- Revenues
- Expenditures
- Staffing (full-time employees [FTEs] of ILF Program
- Key users

- Level of Use
- Eligibility Criteria
- How the fee is calculated

Table 7-2 provides a summary list of the payment structure for each of the 10 localities that were evaluated.

Table 7-2. Comparison of Fees

Localities	Payment Structure
Alpharetta, GA	Varies, includes one-time fee based on construction cost of the facility and ongoing operations fees assessed annually
DuPage County, IL	\$500 per 1,000 ft^2
Green Bay, WI	Varies based on cost of land, engineering design, and construction
Louisville MSD, KY	• Calculated, proportionate share of the cost of new, regional stormwater facility • Calculated prorata share of the total cost of existing facility based upon the capacity required plus interest accrued at 7% annually from time of completion of construction • Where regional facilities have not been constructed or where costs have not been estimated, the fee is based on the average cost of constructing on-site detention facilities within Jefferson County and the amount of additional runoff in ft^3 generated by the 100-year, 1-hour duration event • Additional 20% surcharge for those properties outside Louisville MSD's Drainage Service Area
New Braunfels, TX	\$600.00 per lot (single-family lots) \$0.14 per ft^2 (all others)
Redmond, WA	City-wide: \$958 per 2,000 ft^2 Downtown sub-basin: \$5,435 per 2,000 ft^2 Overlake sub-basin: \$8,539 per 2,000 ft^2
San Antonio, TX	Single-family: \$0.15 per ft^2 impervious area added Multi-family: \$0.20 per sq. ft. impervious area added Industrial: \$0.20 per ft^2 impervious area added Public Facilities: \$0.20 per ft^2 impervious area added Commercial: \$0.25 per ft^2 impervious area added
Tulsa, OK	\$0.74 per sq. ft.
Universal City, TX	Single-family: \$0.15 per ft^2 Multi-family: \$0.15 per ft^2 Commercial/Industrial: \$0.20 per ft^2 Public Facilities (including schools): \$0.15 per ft^2 impervious Building permits with additional impervious area: \$0.15 per ft^2
Washington, DC	\$3.61 per gallon of Offv

Offv = off-site retention volume

Additional, readily available information collected via online resources is presented in Appendix G.

7.2 Detailed Comparison

Based on initial evaluation of the 10 localities described in Section 8.1 and industry knowledge, WPD selected San Antonio, Texas; Louisville MSD in Kentucky; and DOEE in Washington, DC for additional, detailed evaluation. The following sections provide a table summary and more detailed information to identify potential elements that could be adapted to improve the City's program or that should not be considered due to less than desirable results.

7.2.1 San Antonio, Texas

Population	1,413,881
Service Area	Bexar County, covering most of the City of San Antonio (CoSA): Leon Creek Watershed (West), San Antonio River Watershed (Central), and Salado Creek Watershed (East).
ILF Structure	Single-family: \$0.15 per ft^2 impervious area added Multi-family: \$0.20 per ft^2 impervious area added Industrial: \$0.20 per ft^2 impervious area added Public Facilities: \$0.20 per ft^2 impervious area added Commercial: \$0.25 per ft^2 impervious area added Inner City Reinvestment Infill Policy: 50% of new payment categories Infill Development Zone: no payment Impervious Cover Increases Less Than 100 ft^2: no payment
Options for participation	a.) Construction of on-site detention facilities b.) Participation in the construction of an existing mitigation project, such as oversizing existing facilities or other means c.) Payment of the payment in lieu of onsite detention (the "FILO Payment")
Revenues	\$6.5 million estimated for FY 2018, beginning balance of \$4.8 million in available funds \$6.0 million actual for FY 2017, beginning balance of \$0.34 million in available funds \$5.1 million actual for FY 2016, beginning balance of \$2.4 million in available funds
Expenditures	\$8.3 million proposed for FY 2018 \$6.1 million estimated for FY 2017 \$4.8 million actual in FY 2016
Staffing (FTEs) of ILF Program	Storm Water Plan Review team of 12 engineers, 3 support staff
How is the payment calculated	Increased Impervious Cover (ft^2) multiplied by appropriate rate
Sources	ACS U.S. Census. DP05. ACS Demographic and Housing Estimates. 2011-2015 ACS 5-Year Estimates. FY 2019 Proposed Operating & Capital Budget, CoSA FY 2018 Proposed Operating & Capital Budget, CoSA San Antonio, Texas Ordinance 2013-01-31-0074 Amending the methodology for calculating the payment in lieu of on-site detention; increasing payments to all land use categories; and amending article v, chapter 35 of the unified development code Interview with Jake Powell, Storm Water Engineering Manager, CoSA Transportation and Capital Improvements, via phone, December 19, 2019

ACS = American Community Survey
FILO = fee in lieu of

CoSA's Regional Storm Water Management Program (RSWMP), often referred to as the FILO program (which stands for fee in lieu of), was established in 1997. By then, CoSA had established a preference for addressing stormwater runoff increases regionally, rather than site by site. They believe that several smaller facilities collectively alter the timing of stormwater runoff associated with different storms, thus making stormwater management more difficult to address. At the time of creation, the RSWMP fee structure was based solely on the land development type, and the fee was paid per acre. Rates were divided into three categories: residential, non-residential less than 65% impervious cover, and non-residential greater than 65% impervious cover. Residential was the lowest of the rates. The fee was paid with the plat application, and the total RSWMP revenues did not provide enough money to support the activities it was intended to fund.

In 2013, CoSA adopted a new ordinance that changed the RSWMP fee structure to its current structure, a unit rate of so many cents per ft^2 of impervious cover (it was updated to account for minimal inflation in 2015, as well). For residential land use (single and multi-family have separate fees), the fee is paid at full recordation of plat. For non-residential land use, the fee is paid with the building permit, and rates vary between commercial, industrial, and public land uses. CoSA staff believes rates by ft^2 of impervious cover is more desirable than the previous method of rates by acre because, with this method, developers of larger sites are not penalized if no impervious cover is added.

Every developer must participate in the RSWMP, and the following information identifies three ways to do so:

1. The developer can simply pay the FILO if no adverse impact[4] exists (according to a licensed engineer's analysis).
2. The developer must provide on-site detention if the developer estimates an adverse impact[4].
3. The developer can participate in the construction of an existing mitigation project. Examples of mitigation include increasing the size of an existing culvert, repairing an existing culvert, implementing channel or pipeline improvements, etc.

FILOs collected by CoSA replenish a special revenue fund, which is similar to an enterprise fund in that it is not tied to the general fund. CoSA received approximately $7 million of FILO payments in FY 2018. This fund is used for regional drainage projects, studies, land acquisitions, and Storm Water Plan Review staff labor; it is not used for operations and maintenance. Expenditures from the special revenue fund are allotted once per year by City Council. In other words, each October 1 (the start of the FY), there are a certain number of projects associated with a specific dollar value that have been approved by City Council as projects that will be implemented with FILO money during that FY.

Another option for project implementation is through development agreements, although this option is not currently codified. If a developer identifies a project that has not been approved by City Council for the associated FY but would provide mitigation for his or her development, the developer and CoSA can enter an agreement wherein CoSA agrees that the mitigation project provides compliance with the RSWMP.

The fee restructure in 2013 was roughly based on two-thirds of the cost of implementing detention projects. As a result, simply making a FILO payment is nearly always the least expensive option; approximately 90% of projects are associated with a FILO payment, not on-site detention. However, acknowledging that a contractor can sometimes implement projects more efficiently, they believe the spirit of the program is met using the development agreement option.

In terms of fee generation, residential development composes approximately one-half; commercial composes approximately one-third; and the remainder is a split of multi-family, industrial, public, schools, and other land uses. Residential and mixed-use development types where the developer controls a relatively large amount of land account for more participation in mitigation projects than other land uses. If development implementation is phased, CoSA adds "time triggers" for compliance.

Developer-led design and construction of mitigation projects must comply with CoSA standard permitting process for design. CoSA does assign staff for inspections during construction, depending on the type of improvements; an engineer of record provides certification of compliance upon completion.

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[4] Up to 2,000 feet downstream or to nearest studied floodplain, whichever is closer.

If the built project is "public", CoSA will maintain. If not public, CoSA negotiates a maintenance agreement with the developer.

The entire Storm Water Plan Review team (12 engineers, 3 support staff) is funded via the special revenue fund; inspections are provided through development services (a separate group). When CoSA maintains constructed infrastructure long term, maintenance is funded through stormwater operations (also a separate group).

Note that, in the research and analyses conducted preceding the code modifications in 2013, CoSA estimated that the resulting FILO payments would generate more payment totals than they have. The original estimate was $8.5 million per year for the first few years. They have only reached $7 million in FY 2018, even though FILO fees can be substantial for the development community and development has exceeded previous estimates. CoSA will soon be releasing a request for qualifications to select a consultant to aid them in review of their RSWMP/FILO fee structure and optimization of the use of the funds. CoSA hopes to address whether the current adverse impact analysis approach is reasonable, whether 2,000 feet is reasonable for assessing downstream impacts, the definition of an adverse impact, and how can the code can be optimized.

7.2.2 Louisville Metropolitan Sewer District, Kentucky

Population	608,732
Service Area	Louisville, Kentucky Metropolitan Area
RFF Structure	• Calculated, proportionate share of the cost of new, regional stormwater facility • Calculated prorata share of the total cost of existing facility based upon the capacity required plus interest accrued at 7% annually from time of completion of construction • Where regional facilities have not been constructed or where costs have not been estimated, the fee is based on the average cost of constructing on-site detention facilities within Jefferson County and the amount of additional runoff in ft^3 generated by the 100-year, 1-hour duration event • Additional 20% surcharge for those properties outside Louisville MSD's Drainage Service Area
Options for participation	Voluntary agreement between property owner and Louisville MSD. RFF is payment in lieu of constructing on-site drainage detention facilities that mitigate direct impacts of property owner's project.
Revenues	Do not keep records
Expenditures	Do not keep records
Staffing (FTEs) of RFF Program	Seven staff members that review stormwater and sanitary sewer plans from private developers, each is associated with making participation RFF-eligibility determinations
Calculation of payment	The developer must calculate an increased runoff volume and a cost per ft^3 of increased runoff. The latter is calculated using a log equation or fee curves, with different equation or curve for residential versus commercial/industrial. The payment is determined by multiplying the two values together.
Sources:	ACS US Census. DP05. ACS DEMOGRAPHIC AND HOUSING ESTIMATES. 2011-2015 American Community Survey 5-Year Estimates. http://www.louisvillemsd.org/sites/default/files/file_repository/News/Rate%20Schedule%202017-2018%206.9%25greencopyfina0720SD..pdf Email communication with David Johnson, Development and Stormwater Services Director, Louisville MSD Office Memorandum, June 24, 1996, Regional Facility Fee Policy

RFF = Regional Facility Fee

According to Louisville MSD staff, "for the most part," Louisville MSD requires detention since there are regulations that require a developer to mitigate proposed stormwater discharge rates to predeveloped conditions for the 2-, 10-, 25-, and 100-year storm events for new developments in Jefferson County. There are (relatively) rare cases where Louisville MSD will allow a RFF in lieu of detention, such as when a site drains directly to a river (i.e., the Ohio River) or a stream with no downstream capacity limitations, the site is located in the bottom third of the watershed (as long as capacity is available), or the property immediately downstream is undevelopable due to assignment as a park, conservation area, or similar. The RFF policy allows a developer to pay a proportionate share of the cost of regional stormwater facilities that have been or are proposed to be constructed by Louisville MSD; the fee is the developer's prorata share of the total cost of the facility based upon the capacity required plus interest accrued at 7% annually from time of completion of construction, or the actual cost of providing additional capacity necessary to serve the development. Where regional facilities have not been constructed or where costs have not been estimated, the fee is based on the average cost of constructing on-site detention facilities within Jefferson County and the amount of additional runoff in ft^3 generated by the 100-year, 1-hour duration event. This resulted in equations and associated curves for developer use, estimated using completed, actual project costs. Note that for developments that increase runoff volume by less than 0.5 acre-feet, the payment is \$0.50 per ft^3 for residential subdivisions and \$0.70 per ft^3 for commercial and industrial developments. Outside Louisville MSD's Drainage Service Area, an additional 20% surcharge is added to address the estimated cost of maintenance since Louisville MSD would not receive monthly drainage service charges from these properties.

Louisville MSD also considers downstream floodplains in the determination of eligibility, which can lead to detention requirements in a watershed, no matter the location of the site. Louisville MSD does not consider hardships or site constraints as underground storage is an option to meet detention requirements. To determine if capacity exists, waterbodies are analyzed for a length from property discharge to intersection with a major stream ("solid blue line" on a U.S. Geological Survey topographic map).

The RFF is used for less than 5% of developments; participation has reduced over time. Modifying the regulations such that flows must be mitigated greatly decreased participation over time as the "low hanging fruit" was developed first. Now, developing sites are typically located in less than ideal locations (with respect to applying the RFF) and often are associated with neighbors with drainage concerns.

Louisville MSD currently has seven staff that review stormwater and sanitary sewer plans from private developers. Each of those seven people (individually) are associated with making participation determinations, with final approval from the Director of the department. Louisville MSD has not documented revenues received or dollars spent associated with RFF participation.

7.2.3 Department of Energy and Environment (Washington, DC)

Population	647,484
Service Area	Washington, DC
In Lieu Fee Structure	\$3.61[5] per gallon of Offv (or \$27.00 per ft^3)
Options for participation	1. Projects that achieve SWRv with on-site GI 2. Stormwater Retention Credits (SRC) 3. Payment of ILF 4. Combination of these options.

[5] The ILF of \$3.67 proposed in June 2017 does not appear to have been approved.

Revenues	FY 2015: $133,819; FY 2016: $5,807; FY 2017: $5,855
Expenditures	FY 2015: $114,388; FY 2016: $5,807; FY 2017: $5,855
Staffing (FTEs) of Program	10 plan review staff, another team of 10 inspectors who provide inspection during and following construction (regardless of if a project is on- or off-site), and 4 staff who support the credit program specifically (in addition to other programs)
How is the payment calculated	Based on Offv, which is the portion of a SWRv that is not retained on-site and must be achieved through use of SRCs or payment of ILF (or a combination thereof).
Sources:	American Community Survey (ACS) US Census. DP05. ACS DEMOGRAPHIC AND HOUSING ESTIMATES. 2011-2015 American Community Survey 5-Year Estimates. DOEE. *Stormwater In-Lieu Payment Special Purpose Revenue Fund FY 2017 Summary Report.* Interview with Brian Van Wye, Associate Director, and Matthew Espie, Manager of the Stormwater Retention Credit Trading Program and Stormwater Database, DOEE, District of Columbia

GI = green infrastructure

SRC = Stormwater Retention Credits

SWRv = Stormwater Retention Volume

7.2.3.1 General

The FY 2014 Budget Support Act of 2013 established the Stormwater in Lieu Fee Special Purpose Revenue Fund (ILF Fund), which is administered by the DOEE. Per DOEE regulation, developers must provide stormwater retention. Two types of development projects trigger these requirements: (1) major land disturbing activities are development projects that disturb 5,000 ft^2 or more of land area (includes redevelopment), and (2) "major substantial" improvement activities, which are renovation or addition projects where the cost of improvement equals at least 50% of the pre-project assessed value[6] of the structure and the combined footprint of the improved area and land disturbance is greater than or equal to 5,000 ft^2. The 2013 Stormwater Rule requires these projects to achieve their SWRv with on-site GI, SRCs, payment of in lieu fee (ILF), or a combination of these options. Offv is the portion of a SWRv that is not retained on-site and must be achieved through use of SRCs or payment of ILF. Just as the on-site GI of regulated projects must be operational as of sites' final construction inspection, their Offv must be met at the same time.

If off-site compliance is selected, the developer pays the ILF or the SRC payment year after year, in perpetuity. The obligation is added to the deed of the property, so it transfers with a sale. The developer can pay per year or can choose less frequent, multi-year payments. The obligation is forever or until the site is redeveloped.

One-half of stormwater retention must be achieved on property, and the other half can be met through some combination of the three options (on-site, ILF, or SRC). There is a process to seek relief from the 50% on-site rule. Also note the combination can change from year to year, e.g., if the developer generates their own credits via another project in a subsequent year. The regulations are the same regardless of property type.

[6] The "assessed value" is defined by the property tax assessment agency.

Of the 150 to 200 projects submitted for approval per year, 14% comply with stormwater management requirements using off-site options. DOEE has a team of 10 plan review staff, another team of 10 inspectors who provide inspection during and following construction (regardless of if a project is on- or off-site), and 4 staff who support the SRC program specifically (in addition to other programs). DOEE staff estimated a total of 1.5 to 2 FTEs for credit generation oversite, off-site compliance, and data tracking/analysis, etc. for the SRC program.

Residents in the area see two stormwater utility fees collected on their water bill: one to address the combined sewer overflow challenges (which is largely funding a tunnel project), the other funds the programs used for complying with Municipal Separate Storm Sewer System requirements, described herein.

7.2.3.2 ILF Fund

The ILF Fund is used to install GI that captures stormwater runoff and protects District waterbodies. The original ILF fee was based on the District's cost to build and maintain GI, using actual, diverse types of projects across the District, to determine what the true costs would be. Land value, maintenance costs, value of money (investment percent), etc. were included in addition to construction cost. Note DOEE does not own land, so ILF-funded projects must be placed on land owned by a partner agency. DOEE developed the original payment to be $3.50 per gallon of Offv per year, and this value is adjusted annually using the consumer price index. DOEE initiates a rule-making process every year to adjust the fees.

As one of two off-site compliance options, the ILF is less commonly used than the other (SRC) because the traded credits are cheaper. The ILF is effectively the high end of the market of the SRCs, but it is always available and has an unlimited supply (to date, there have always been SRCs available for purchase). DOEE does not desire or expect to receive many ILF payments; instead, they prefer for the SRCs to be used because there is a clear framework for how the credits are certified and maintained over time. Projects funded by the ILF funds are done in partnership with other entities and are not associated with the same requirements as projects that qualify as SRCs. DOEE goes so far as to specifically state on their website that they recommend a developer use SRCs instead of paying ILF.

7.2.3.3 SRC Program

DOEE catalogs built projects that generate credits. Credit project creators are required to provide DOEE with a copy of a maintenance contract or demonstrate who on their staff has the skills and capacity in their schedule to do the maintenance work. If a credit is not maintained, the owner must "retire" it from the market and purchase a replacement credit. Because projects funded by the ILF funds are done in partnership with other entities, and those other agencies' missions are not related to restoring the environment, they do not have the same luxury with the ILF program. DOEE annual reports for the SRC program include environmental outcomes based on runoff reduction and runoff volume captured, infiltrated, reused, or evapotranspired.

SRC credits are translated to gallon by gallon, year by year. Through the SRC program, DOEE knows exactly where the volume is being captured. There is some flexibility in the District where the credits are generated; the goal is to place them where GI has the greatest water quality benefit – which is often not necessarily where development is. One-third of the District has combined sewers; a large tunnel project is addressing runoff from this area. The other two-thirds drains directly to water bodies regulated by DOEE, thus this is the best location for GI credit, where the water bodies have runoff without treatment.

DOEE tracks to what extent projects are meeting credits in "high priority" areas, and they have a database for this purpose. Their stormwater management guidebook provides guidance on how to calculate the amount of stormwater runoff necessary to develop credits, and an equation to calculate the storage necessary to hold that amount of runoff. Each possible SCM from which to choose has an assigned amount of storage, e.g., a rain garden has a defined depth of filter media, void space, plus ponding. They compare the retention volume provided to that of pre-project conditions, which translates to a volume of credit. One credit is equivalent to one gallon of capacity, same as a gallon of capture volume required.

DOEE has automated the system to the extent practical, thus there are processes “built-in” to other programs to reduce administrivia and online system submittal needs. Developers can generate, sell and “use” credits all through online tools. This automation allows for easy recording of who owns what credit, and trades can be approved instantly. DOEE does not serve as the credit program “banker”, more a “ledger”. DOEE issues serial numbers for the credits, then the credit owner documents the trade. DOEE has produced a template contract and registry of sales to allow for public knowledge of the dollar value of credits.

DOEE considered several different approaches before selecting their current SRC program methodology. DOEE sets and enforces the rules for the market, reviews designs to ensure compliance, ensures a fair market, and develops technical guidance that defines what each GI structure can retain. DOEE tries to reduce the cost of transactions by reducing the fees common to all buyers; for example, this resulted in the template contract, the GI financial return calculator, and the geographic information system viewer (so developers could see large areas of impervious surface in the District, ripe for credit development). These improvement ideas were generated mostly from feedback from the development community.

In hindsight, DOEE does wish they could have disallowed GI built prior to the initiation of the SRC program to generate stormwater credits (but realize there is no situation in which this would have happened). They believe DOEE was the first jurisdiction to have this kind of program, and local stakeholder opposition caused failure implementing it previously. They had no real “track record” of a credit system to reference and use as proof of good environmental results. Thus, they had to allow existing GI facilities built after May 1, 2009, which was when the stormwater fees switched to being based on impervious surface, to be part of the program. This effectively created two credit markets, one with existing GI facilities already owned (i.e., a sunk cost) and one for new infrastructure, which is not a fair economic competition. Resulting credits for existing GI are much less expensive than for new projects.

DOEE is in the process of modifying the regulations to address the “windfall credits” to the extent they believe they can. For example, DOEE has created a “price lock” in which addresses the windfall credit competition challenge by purchasing credits in newly constructed GI (the components above that which is required by regulation), in the MS4 area only. The developer has an option to sell their credits to DOEE for the first 12 years of credit certification. The two entities sign a contract pre-project and set a price based on the location and year. DOEE sets aside dollars to meet that agreement. DOEE currently has $11.5 million in escrow reserved to purchase credits. Before a developer starts construction, he/she knows that he/she can sell credits to DOEE at a fixed rate to mitigate a case in which there is no market at the desired time of sale (e.g., if a cheaper, windfall credit was available at the time or there was not a market). This also helps focus GI in high priority areas based on the location limitations. While relatively new, this price lock program has already become a major component of the SRC program.

Since the price lock program was announced, eight aggregators started designing projects, which injected relatively significant demand. The program was announced as a grant in the spring of 2016, and DOEE started accepting applications in the fall of 2017; this resulted in GI projects that would not have been built otherwise. Some have sold all of their credits to DOEE, some none, and some a combination. Similar to a grant to fund GI construction, this leads to a high degree of confidence in a project. The grant is contingent upon providing maintenance in perpetuity; the payment depends on it.

7.3 Conclusions and Recommendations

During the detailed investigation, CH2M found a few themes that seemed significant. One is the wide variation in applicability of a payment in lieu of option, which results in a wide range of revenues (and resulting expenditures). CoSA's payment structure and application are reflective of their preference for regional facilities due, to summarize, to the desire to better estimate urban-altered hydrology. The payments in lieu of on-site detention are based on two-thirds of estimated actual costs of providing detention, similar to the capped rates currently provided by WPD. While this incentivizes participation in regional facilities, CoSA has established a program that is inherently unable to fund itself. Conversely, Louisville MSD allows less than 5% of developments to participate in the RFF; the area is such that it is uncommon to find a property without downstream capacity limitations. Further, DOEE faces challenges when implementing regional facilities due to the necessity of multiple agencies with differing perspectives involved; as a result, their preference for credit projects is such that DOEE specifically states on their website that they recommend use of the SRC program instead of paying ILF.

Another theme of interest is the foundation for the payment and how widely it varies. CoSA originally based their payment structure on land development type, and the fee was paid per acre. In 2013, CoSA changed the structure such that there is a unit rate of so many cents per ft^2 of impervious cover added. Louisville MSD's payment structure is solely based on a defined portion of the cost of constructing a new or existing regional facility. DOEE's payment structure is based on a cost per gallon of the portion of the required SWRv that is not retained on-site, per year and in perpetuity.

The number of staff supporting each program appears to be dependent on program participation (relatively), considering DOEE's staff includes those supporting the SRC program, as well. When incorporating construction cost, the CoSA, like WPD, bases their payment on the avoided cost of on-site detention; conversely, Louisville MSD and DOEE base their payment structure on the cost of the regional facility replacing on-site detention.

The RSMP program is structured so similarly to CoSA's, WPD may benefit from peer to peer sharing, both now and following the implementation of CoSA's upcoming payment structure review. One potential option for WPD to consider is the use of a structured development agreement in which a developer identifies, designs, and constructs a project that would achieve project mitigation. Further, WPD could consider translating impervious area additions to volumes of runoff that must be mitigated, which may be more tangible for the development community to understand and for the community to support.

SECTION 8

Stakeholder Outreach

Stakeholder outreach is expected to occur in the Fall of 2019. Summaries of those meetings will be included following completion of the outreach process.

SECTION 9

References

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City of Austin (COA). 2017. *Drainage Criteria Manual, Section 8.2.0, Regional Stormwater Management Program.*

Department of Energy & Environment (DOEE). 2017. *Stormwater In-Lieu Payment Special Purpose Revenue Fund FY 2017 Summary Report*.

Travis Central Appraisal District (TCAD). 2017. *2017 Annual Report*. December 19.

Interview with Jake Powell, Storm Water Engineering Manager, CoSA Transportation and Capital Improvements, via phone. December 19, 2019

Appendix A
Description of Data Provided by Doucet+Chan

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TECHNICAL MEMOORANDUM

Regional Stormwater Management Program (RSMP) and Urban Watersheds Structural Control Fund (UWSCF) Fee Cost Study

Date: March 14, 2019

Prepared For: CH2M Hill, Heather Harris, PE

Prepared By: Tom Hegemier, PE, D.WRE, CFM

CH2M Hill contracted with Doucet and Associates, Inc. (Doucet) to define water quality pond and detention pond costs for twenty-three recent projects for which Doucet+Chan (a division of Doucet) designed and were constructed by contractors. The projects were selected from our archived records and resulted in a total of thirty-three water quality and detention pond cost evaluations.

Quantity take-offs were conducted for each site stormwater facility from the construction plans. In addition, other information such as impervious cover, site area, peak runoff rates, times of concentration and other information from the plans were added to the spreadsheet titled "Cost Study.xls". This spreadsheet summarizes the complete project findings including the estimated construction costs, estimated engineering fees to design the stormwater measures, and cost per acre of pond drainage area. Individual stormwater basin quantities and computed construction costs can be found in the spreadsheet titled "Individual WQ and detention basin cost summary.xls".

Unit costs for over 60 individual bid items were obtained from several sources. We first used City of Austin (COA) Bid tabs that were provided to us. The bid tabs included four projects from 2008 and 2009 and two projects from 2013. The bid unit prices from individual contractors were averaged for each project and then all projects were averaged for the 2008/2009 projects and the 2013 projects. All costs were adjusted to 2018 using an ENR cost factor of 1.304 for 2008/2009, 1.15 for 2013, and 1.03 for 2017. In many bid items, the pre-adjusted unit costs for 2008/2009 projects were greater than the 2013 project unit costs. In addition, costs were not consistent from contractor to contractor as each may prepare their total project bid based on multiple factors during project construction.

Since many of the bid items from our quantity take-off were not included in the provided bid tabs, we used the COA Average Bid Prices from March 2015 (from the COA website), Austin TXDOT costs from June to August 2017, and Statewide TXDOT Moving Average Costs from June 2017 to provide cost numbers for the remaining unit items. This information was also compared to bid tab unit cost numbers to help validate findings. The cost information for each item can be found in the spreadsheet "Cost spreadsheet.xls". Costs in green are from the provided bid tabs, costs in red are from TXDOT, and costs in blue are from the COA Average Bid Prices, 2015.

Since costs are highly variable and can be dependent upon site geology, topography, existing utility conflicts, transportation/traffic management, and other factors, we suggest that the individual item unit costs be reviewed with City of Austin staff. We recommend that recent bid tabs be used to evaluate the item unit costs to ensure that the most recent and appropriate cost information is included in this analysis. To facilitate this process, the three spreadsheets are linked such that an item unit cost can be changed in the file "Cost spreadsheet.xls" and the other spreadsheets will be automatically updated. Another factor to consider in the cost analysis is that the COA bid tabs were for projects in an existing urban environment and considered more as retrofits when compared to land development projects that often take place in greenfield conditions with fewer constraints. Thus, there is the potential for retrofit project unit item costs to be higher than new development unit item costs due to utility conflicts and traffic management. We coordinated with the Land Development Division at Doucet and found that private development projects receive contractor bids based on a lump sum for drainage and stormwater, water, wastewater, streets, etc. Thus, we were not able to directly compare development drainage costs with the City bid tab unit costs.

In summary, the water quality and detention pond construction cost estimates can be a helpful tool in evaluating the RSMP and UWSCF fee structures. As noted above, we recommend a review of the unit bid item construction cost estimates and comparison to recent bid tabs to finalize appropriate unit item costs to facilitate support of potential modifications to the RSMP and UWSCF fees.

Appendix B
Detailed List of Projects

Unique Item # (Do not duplicate or change)	Project Name	Data Set	Property Type	Facility Type	Total Site Area (Ac)	Impervious Cover (%)	Impervious Area (ac)	Drainage Area (ac)	Detention Volume (ft3)	WQ Control Volume (ft3)	Sed Pond Volume (ft3)	Filtration Pond Volume (ft3)	Surface Area (ac)	Detention Surface Area (ac)	WQ Surface Area (ac)	Construction Cost Estimate	Engineering Cost Estimate	Total Costs ($)	Total Costs Per Acre of Impervious Area
45	Davis Spring Section 5D Detention Pond	2002	residential	Detention Pond		100.00	7.00									$466,600	$93,300	$559,900	$79,986
69	L	2002	commercial	Detention Pond		90.00	22.50									$771,900	$154,400	$926,300	$41,169
65	H	2002	commercial	Detention Pond		70.00	17.50									$419,500	$83,900	$503,400	$28,766
61	D	2002	commercial	Detention Pond		40.00	10.00									$388,900	$77,800	$466,700	$46,670
47	Harris Branch Parkway, Phase I, Pond B	2002	residential	Detention Pond		100.00	6.00									$342,200	$68,400	$410,600	$68,433
51	Park 22 Phase 1B	2002	residential	Detention Pond		0.00	11.00									$278,500	$55,700	$334,200	$30,382
68	K	2002	commercial	Detention Pond		90.00	9.00									$267,600	$53,500	$321,100	$35,678
64	G	2002	commercial	Detention Pond		70.00	7.00									$262,400	$52,500	$314,900	$44,986
60	C	2002	commercial	Detention Pond		40.00	4.00									$242,300	$48,500	$290,800	$72,700
50	Mustang Ranch at Davis Springs	2002	residential	Detention Pond		100.00	11.00									$219,500	$43,900	$263,400	$23,945
67	J	2002	commercial	Detention Pond		90.00	4.50									$197,900	$39,600	$237,500	$52,778
63	F	2002	commercial	Detention Pond		70.00	3.50									$189,500	$37,900	$227,400	$64,971
59	B	2002	commercial	Detention Pond		40.00	2.00									$185,100	$37,000	$222,100	$111,050
53	Parke at Anderson Mill Pond	2002	residential	Detention Pond		0.00	8.00									$178,800	$35,800	$214,600	$26,825
49	Jack's Pond Section Three	2002	residential	Detention Pond		100.00	18.00									$173,400	$34,700	$208,100	$11,561
66	I	2002	commercial	Detention Pond		90.00	1.80									$140,300	$28,100	$168,400	$93,556
62	E	2002	commercial	Detention Pond		70.00	1.40									$138,900	$27,800	$166,700	$119,071
58	A	2002	commercial	Detention Pond		40.00	0.80									$136,800	$27,400	$164,200	$205,250
40	Angus Ranch Subdivision	2002	residential	Detention Pond		50.00	3.00									$92,400	$18,500	$110,900	$36,967
46	Harris Branch Parkway, Phase I, Pond A	2002	residential	Detention Pond		100.00	2.00									$31,100	$6,200	$37,300	$18,650
5	126 Ac Tract Subdivision (Cool Springs)	2017	residential	Detention Pond	126	45.00	56.70	45.71	323,128				1.88	1.88		$405,200	$81,000	$486,200	$8,575
16	North Central Community Health Center	2017	commercial	Detention Pond	7.437	56.19	4.18	5.92	67,676				0.35	0.35		$258,200	$51,600	$309,800	$74,135
33	China Town Center	2017	commercial	Detention Pond	20.88	67.00	13.99	36.86	295,379				1.34	1.34		$258,800	$51,800	$310,600	$22,202
29	Baty Elementary School Site Improvements East Det Pond	2017	commercial	Detention Pond	14.64	68.70	10.06	4.46	56,628				0.40	0.40		$185,100	$37,000	$222,100	$22,083
36	NE Elementary Det Pond	2017	commercial	Detention Pond	70.344	8.60	6.05	20.10	80,786				0.54	0.54		$149,800	$30,000	$179,800	$29,721
6	Albert Road 2 Ac Tract (Matthew Park Subd)	2017	residential	Detention Pond	2.16	44.00	0.95	2.22	8,660				0.10	0.10		$175,900	$35,200	$211,100	$222,117
25	St. James Episcopal Church	2017	commercial	Detention Pond	1.65	13.00	0.21	17.41	128,902				0.69	0.69		$130,400	$26,100	$156,500	$729,604
10	AISD Guerrero Thompson ES Det Pond 3	2017	commercial	Detention Pond	18.7	53.00	9.91	4.23	29,612				0.28	0.28		$127,900	$25,600	$153,500	$15,488
17	Pflugerville Library Expansion (ask John King)	2017	commercial	Detention Pond	4.59	52.70	2.42	4.53	78,786				0.28	0.28		$120,300	$24,100	$144,400	$59,696
7	AISD Guerrero Thompson ES Det Pond 1	2017	commercial	Detention Pond	18.7	44.00	8.23	4.23	39,407				0.32	0.32		$119,700	$23,900	$143,600	$17,453
27	Baty Elementary School Site Improvements West Det Pond	2017	commercial	Detention Pond	14.64	68.70	10.06	4.46	17,248				0.07	0.07		$83,500	$16,700	$100,200	$9,963
20	Avery Ranch Fire / EMS Station	2017	commercial	Detention Pond	2.68	28.30	0.76	2.93	18,664				0.11	0.11		$72,200	$14,400	$86,600	$114,182
14	Asian American Resource Center	2017	commercial	Detention Pond	15.01	52.50	7.88	3.55	33,000				0.18	0.18		$60,600	$12,100	$72,700	$9,226
23	Texas Village Condo	2017	commercial	Detention Pond	2.42	65.00	1.57	2.42	16,187				0.06	0.06		$64,000	$12,800	$76,800	$48,824
21	EMS Station 33	2017	commercial	Detention Pond	2.37	95.00	2.25	0.35	3,450				0.04	0.04		$50,500	$10,100	$60,600	$26,915
2	Two Wheel Brewery	2017	commercial	Detention Pond	0.891	32.00	0.29	0.89	3,600				0.07	0.07		$16,700	$3,300	$20,000	$70,146
26	Far Southeast EMS Station	2017	commercial	Detention Pond	2	75.00	1.50	0.44	5,604				0.15	0.15		$13,800	$2,800	$16,600	$11,067
102	Ring Tract Section 1 C8J-2013-0226.1B	2018	residential	Detention Pond	87	39.00	33.93	54.93	418,501				2.65	2.65		$154,300	$30,900	$185,200	$5,458
90	Easton Park 2B (Phase 2)	2018	residential	Detention Pond	66.44	37.37	24.83	21.48	845,669				4.94	4.94		$125,000	$25,000	$150,000	$6,041
109	Avana Phase 2, Section 2	2019	residential	Detention Pond	149.12	9.40	14.02	30.44	204,592				0.63	0.63		$160,800	$32,200	$193,000	$13,769

Unique Item # (Do not duplicate or change)	Project Name	Data Set	Property Type	Facility Type	Total Site Area (Ac)	Impervious Cover (%)	Impervious Area (ac)	Drainage Area (ac)	Detention Volume (ft3)	WQ Control Volume (ft3)	Sed Pond Volume (ft3)	Filtration Pond Volume (ft3)	Surface Area (ac)	Detention Surface Area (ac)	WQ Surface Area (ac)	Construction Cost Estimate	Engineering Cost Estimate	Total Costs ($)	Total Costs Per Acre of Impervious Area
54	Parmer North Section One, Phase I & II (McCallen Pass)	2002	residential	Water Quality Pond	150.5	80.00	120.40	295.40	3,418,055				5.61		5.61	$3,498,700	$699,700	$4,198,400	$34,870
42	Avery Ranch West Phase 1	2002	residential	Water Quality Pond	136.6	45.70	62.43	303.60	16,514				1.82		1.82	$1,066,900	$213,400	$1,280,300	$20,509
44	Cottage at Champions Forest, LTD	2002	residential	Water Quality Pond	7.91	45.00	3.56	7.91	28,727	24,929	19,127	5,802	0.21		0.21	$1,066,900	$213,400	$1,280,300	$359,685
52	Park Central Section	2002	residential	Water Quality Pond	38.846	80.00	31.08	31.85	396,876				1.90		1.90	$485,600	$97,100	$582,700	$18,750
48	Harris Ridge Phase 3, Sec 3	2002	residential	Water Quality Pond	25.41	23.00	5.84	45.30					0.31		0.31	$406,000	$81,200	$487,200	$83,363
41	Avery Ranch Boulevard West	2002	residential	Water Quality Pond	18.785	54.46	10.23	13.24		60,260	18,550	41,710	0.35		0.35	$239,800	$48,000	$287,800	$28,132
43	Canterbury Trails Section IV	2002	residential	Water Quality Pond	16.16	40.70	6.58	68.95	289,486				1.00		1.00	$239,800	$48,000	$287,800	$43,758
55	Waterloo Subdivision	2002	residential	Water Quality Pond	46.632	29.30	13.66	14.06	71,514	45,449	35,817	9,632	0.35		0.35	$172,100	$34,400	$206,500	$15,114
56	Waterloo Subdivision	2002	residential	Water Quality Pond		100.00	23.00									$172,100	$34,400	$206,500	$8,978
32	China Town Center	2017	commercial	Water Quality Pond	20.88	74.90	15.64	29.00		101,318	24,197	77,121	0.96		0.96	$365,500	$73,100	$438,600	$28,045
34	Public Safety Training Facility	2017	commercial	Water Quality Pond	42.54	58.90	25.06	17.74		64,338	16,880	47,458	0.49		0.49	$266,400	$53,300	$319,700	$12,759
30	Baty Elementary School Site Improvements East WQ Pond	2017	commercial	Water Quality Pond	14.64	57.40	8.40	5.58		30,444	12,481	17,963	0.14		0.14	$261,500	$52,300	$313,800	$37,342
9	AISD Guerrero Thompson ES WQ Pond 2	2017	commercial	Water Quality Pond	18.7	54.00	10.10	3.99		13,090	10,941	2,149	0.30		0.30	$265,400	$53,100	$318,500	$31,541
15	North Central Community Health Center	2017	commercial	Water Quality Pond	7.437	58.00	4.31	5.70		19,314	11,697	7,618	0.15		0.15	$244,200	$48,800	$293,000	$67,927
39	SW Elementary School	2017	commercial	Water Quality Pond	16.84	45.00	7.58	8.95		92,958	46,479	46,479	0.33		0.33	$146,200	$29,200	$175,400	$23,146
18	AE New Control Center	2017	commercial	Water Quality Pond	12.34	80.00	9.87	13.80		55,103	42,041	13,062	0.32		0.32	$148,800	$29,800	$178,600	$18,092
28	Baty Elementary School Site Improvements West WQ Pond	2017	commercial	Water Quality Pond	14.64	63.40	9.28	3.23		25,814	12,545	13,269	0.07		0.07	$144,100	$28,800	$172,900	$18,628
38	NE Elementary WQ Pond2	2017	commercial	Water Quality Pond	70.344	45.00	31.65	5.43		15,380	9,043	6,337	0.09		0.09	$140,800	$28,200	$169,000	$5,339
24	St. James Episcopal Church	2017	commercial	Water Quality Pond	1.65	34.00	0.56	7.34		29,156	14,405	14,751	0.14		0.14	$125,800	$25,200	$151,000	$269,162
12	North Parking Lot Expansion	2017	commercial	Water Quality Pond	10.32	86.00	8.88	1.77		6,840	3,940	2,900	0.07		0.07	$114,900	$23,000	$137,900	$15,538
31	COA Del Valle Fire Station	2017	commercial	Water Quality Pond	2.595	36.00	0.93	2.59		10,785	8,625	2,160	0.12		0.12	$99,800	$20,000	$119,800	$128,238
1	5406 William Cannon Drive	2017	commercial	Water Quality Pond	3.64	89.00	3.24	1.26		5,574	2,934	2,640	0.03		0.03	$112,600	$22,500	$135,100	$41,703
11	AISD Guerrero Thompson ES WQ Pond 3	2017	commercial	Water Quality Pond	18.7	53.00	9.91	4.23		16,326	12,851	3,475	0.34		0.34	$105,100	$21,000	$126,100	$12,723
37	NE Elementary WQ Pond1	2017	commercial	Water Quality Pond	70.344	55.00	38.69	1.57		8,280	3,588	4,692	0.07		0.07	$69,900	$14,000	$83,900	$2,169
13	Asian American Resource Center	2017	commercial	Water Quality Pond	15.01	52.54	7.89	3.55		14,850	10,902	3,948	0.02		0.02	$87,100	$17,400	$104,500	$13,251
22	Texas Village Condo	2017	commercial	Water Quality Pond	2.42	80.10	1.94	1.97		11,167	4,972	6,195	0.05		0.05	$84,600	$16,900	$101,500	$52,362
19	Avery Ranch Fire / EMS Station	2017	commercial	Water Quality Pond	2.68	86.10	2.31	0.84		6,305	4,267	2,038	0.05		0.05	$75,300	$15,100	$90,400	$39,177
8	AISD Guerrero Thompson ES WQ Pond 1	2017	commercial	Water Quality Pond	18.7	80.00	14.96	0.65		2,596	1,594	1,002	0.06		0.06	$78,300	$15,700	$94,000	$6,283
35	Austin Seafood and Steak House	2017	commercial	Water Quality Pond	1.791	63.54	1.14	1.79		7,679	3,543	4,136	0.03		0.03	$42,700	$8,500	$51,200	$44,991
77	Preston Park Section 2A C8J-2015-0134.2B	2018	mixed	Water Quality Pond	23.12	54.00	12.48	20.00		82,245	67,845	14,400	0.80		0.80	$547,400	$109,500	$656,900	$52,616
75	Ring Tract Section 1 C8J-2013-0226.1B	2018	residential	Water Quality Pond	87	39.00	33.93	54.93		191,144	154,932	36,212	0.79		0.79	$504,000	$100,800	$604,800	$17,825
89	Easton Park 2B (Phase 2)	2018	residential	Water Quality Pond	66.44	36.52	24.26	6.50		33,195	21,419	11,776	0.15		0.15	$449,100	$89,800	$538,900	$22,210
78	Preston Park Section 2A C8J-2015-0134.2B	2018	mixed	Water Quality Pond	23.12	61.50	14.22	8.41		34,570	28,636	5,934	0.80		0.80	$289,600	$57,900	$347,500	$24,439
97	Bellingham Meadows Section 2	2018	Residential	Water Quality Pond	61.532	44.40	27.32	8.17		68,435	39,377	29,058	0.14		0.14	$290,500	$58,100	$348,600	$12,760
92	Colorado Crossing 9 Section 1 and 2 C8-2013-0081.4B.SH	2018	residential	Water Quality Pond	49.84	46.40	23.13	14.47		40,620	18,496	22,124	0.18		0.18	$134,100	$26,800	$160,900	$6,958
94	Cantarra II Phase 1-2 C8-2014-0138.3B	2018	residential	Water Quality Pond	48.3	45.00	21.74	7.52		35,244	18,914	16,330	0.26		0.26	$93,600	$18,700	$112,300	$5,167
85	Fort Dessau Condos Phase 2 SP-2015-0253C	2018	residential	Water Quality Pond	37.43	30.00	11.23	4.14		21,098	9,092	12,006	0.08		0.08	$91,700	$18,300	$110,000	$9,796
82	Malone Subdivision Section One C8-2015-0271.1B	2018	residential	Water Quality Pond	45.88	46.90	21.52	20.28		262,848	223,157	39,691	0.24		0.24	$63,700	$12,700	$76,400	$3,551
99	Colorado Crossing 9 Section 1 and 2 C8-2013-0081.4B.SH	2018	residential	Water Quality Pond	49.84	48.10	23.97	3.35		9,754	4,294	5,460	0.04		0.04	$32,200	$6,400	$38,600	$1,610
81	Malone Subdivision Section One C8-2015-0271.1B	2018	residential	Water Quality Pond	45.88	34.20	15.69	12.84		177,680	126,892	50,788	0.67		0.67	$32,000	$6,400	$38,400	$2,447
72	South Congress Commercial Park Plans	2018	mixed	Water Quality Pond	10.6	80.00	8.48	1.96		7,683	5,029	2,654	0.05		0.05	$29,600	$5,900	$35,500	$4,186
73	South Congress Commercial Park Plans	2018	mixed	Water Quality Pond	10.6	80.00	8.48	5.22		18,384	7,604	10,780	0.11		0.11	$29,600	$5,900	$35,500	$4,186
108	Avana Phase 2, Section 2	2019	residential	Water Quality Pond	149.12	36.13	53.88	40.93		191,289	267		1.15		1.15	$1,018,200	$203,600	$1,221,800	$22,678
113	Sun Chase South Section 1	2019	residential	Water Quality Pond	56.41	38.00	21.44	12.00		29,621	23,221	20,396	0.11		0.11	$130,900	$26,200	$157,100	$7,329

Unique Item # (Do not duplicate or change)	Project Name	Data Set	Property Type	Facility Type	Total Site Area (Ac)	Impervious Cover (%)	Impervious Area (ac)	Drainage Area (ac)	Detention Volume (ft3)	WQ Control Volume (ft3)	Sed Pond Volume (ft3)	Filtration Pond Volume (ft3)	Surface Area (ac)	Detention Surface Area (ac)	WQ Surface Area (ac)	Construction Cost Estimate	Engineering Cost Estimate	Total Costs ($)	Total Costs Per Acre of Impervious Area
86	Estancia Hill Country Section 4 C8J-2009-0142.02.2B	2018	residential	WQ/DET Pond	17.585	67.30	11.83	145.67	2,593,203	595,453	112,784	472,669	9.57	7.39	2.17	$1,006,900	$201,400	$1,208,300	$102,098
87	Easton Park 2B (Phase 1)	2018	residential	WQ/DET Pond	83.26	30.63	25.50	56.45	499,941	169,405	125,502	43,903	4.05	1.97	2.08	$855,800	$171,200	$1,027,000	$40,271
84	Heritage Oaks at Pearson Ranch East C8J-2014-0058.1B	2018	residential	WQ/DET Pond	41.42	34.00	14.08	41.20	130,060	123,751	94,651	29,100	1.56	0.78	0.78	$822,700	$164,500	$987,200	$70,100
91	Easton Park 2B (Phase 3)	2018	residential	WQ/DET Pond	48.7	36.60	17.82	40.19	531,550	144,841	115,642	29,199	3.85	2.04	1.81	$631,200	$126,200	$757,400	$42,493
96	Bellingham Meadows Section 1	2018	Residential	WQ/DET Pond	61.532	21.20	13.04	103.00	463,914	471,755			3.36	1.99	1.37	$593,400	$118,700	$712,100	$54,589
88	Easton Park 2B (Phase 1)	2018	residential	WQ/DET Pond	83.26	27.25	22.69	14.98	124,705	113,088	69,628	43,460	1.31	0.69	0.62	$482,000	$96,400	$578,400	$25,493
79	Parker Creek Ranch Phase 1 C8-2016-0145.1B	2018	Mixed	WQ/DET Pond	47.43	46.10	21.87	24.39	131,341	114,411	75,403	39,008	1.28	0.65	0.64	$345,100	$69,000	$414,100	$18,939
80	Parker Creek Ranch Phase 1 C8-2016-0145.1B	2018	Mixed	WQ/DET Pond	47.43	32.19	15.27	17.15	83,459	57,767	38,934	18,833	0.89	0.65	0.24	$275,400	$55,100	$330,500	$21,647
71	The Vistas of Austin Section 1 C8J-2007-1061.01.1B	2018	residential	WQ/DET Pond	148.84	35.00	52.09	68.66	1,105,740	107,921			3.25	2.68	0.57	$264,700	$52,900	$317,600	$6,097
83	Lynnbrook Square SP-2017-0016D	2018	residential	WQ/DET Pond	4.024	44.00	1.77	3.93	36,973	11,004	7,037	3,967	0.47	0.30	0.17	$210,200	$42,000	$252,200	$142,441
70	Woodbridge Subdivision C8-2015-0200.1B	2018	residential	WQ/DET Pond	2.87	55.00	1.58	2.35	15,335	9,433	7,505	1,928	0.19	0.13	0.06	$149,300	$29,900	$179,200	$113,525
98	Cantarra II Phase 1-2 C8-2014-0138.3B	2018	residential	WQ/DET Pond	48.3	47.40	22.89	38.81	427,732	278,152			1.23	1.23		$122,300	$24,500	$146,800	$6,412
74	Silveredge Creek Subdivision C8-2016-0153.0B	2018	residential	WQ/DET Pond	8.308	25.65	2.13	3.56	11,790	13,337	8,087	5,250	0.22	0.18	0.04	$63,300	$12,700	$76,000	$35,664
112	Sun Chase South Section 1	2019	residential	WQ/DET Pond	56.41	20.00	11.28	302.54	879,476	260,053			14.75	13.26	1.49	$1,140,500	$228,100	$1,368,600	$121,308
105	Addison Section 3	2019	residential	WQ/DET Pond	60.6	47.51	28.79	20.99	254,218	65,431	49,848	15,583	2.09	0.99	1.10	$1,021,300	$204,300	$1,225,600	$42,569
107	Addison Section 3	2019	residential	WQ/DET Pond	60.6	40.93	24.80	20.62	184,582	54,549	45,733	8,816	1.29	0.72	0.57	$591,000	$118,200	$709,200	$28,593
106	Addison Section 3	2019	residential	WQ/DET Pond	60.6	44.42	26.92	14.00	168,944	42,564	42,564	18,970	1.23	0.61	0.62	$573,700	$114,700	$688,400	$25,573
111	Parmer Crossing Phase 1	2019	commercial	WQ/DET Pond	25.604	53.10	13.60	25.04	138,180	87,933	33,919	54,014	1.40	0.99	0.41	$440,000	$88,000	$528,000	$38,836
104	Fort Dessau Phase 3	2019	residential	WQ/DET Pond	13.14	33.20	4.36	9.55	60,944	27,815	22,615	5,200	0.34	0.51	0.34	$208,100	$41,600	$249,700	$57,238
110	Colorado Crossing III Section 5	2019	residential	WQ/DET Pond	9.356	55.00	5.15	20.88	102,608	87,806			1.64	1.00	0.64	$128,500	$25,700	$154,200	$29,966

Appendix C
Land Cost Data Analysis

C.1 Undeveloped Land

Table C-1 summarizes the descriptive statistics for land costs (dollars per acre [$/acre]) for undeveloped properties. Based on statistical analysis, outliers were identified and excluded from further use. An outlier was defined as two (or more) standard deviations from the average.

Table C-1. Descriptive Statistics for Undeveloped Land by Land Use Type

	Count	Average	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
Single-family Residential								
Lot Size (acres)	109	2.68	6.04	0.05	0.19	0.38	1.94	48.04
Land Costs ($/acre)		$830,311	$949,895	$13,259	$123,330	$406,977	$1,166,667	$3,921,569
Commercial								
Lot Size (acres)	67	9.21	24.43	0.11	1.35	2.52	5.83	150.16
Land Costs ($/acre)		$764,015	$1,438,962	$6,177	$85,735	$194,954	$487,686	$6,800,000
Multi-family Residential								
Lot Size (acres)	20	10.17	11.64	0.26	1.90	5.69	12.92	43.00
Land Costs ($/acre)		$401,863	$408,886	$85,714	$142,258	$199,558	$554,045	$1,615,385

Source: Atrium Real Estate Services, August 2017.

Table C-2 summarizes the descriptive statistics for land costs ($/acre) excluding the outliers.

Table C-2. Descriptive Statistics for Undeveloped Land by Land Use Type, adjusted for outliers based on land costs ($/acre)

	Count	Average	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
Single-family Residential								
Lot Size (acres)	101	2.88	6.24	0.06	0.21	0.38	1.94	48.04
Land Costs ($/acre)		$637,023	$672,232	$13,259	$114,000	$406,977	$1,166,667	$2,694,611
Commercial								
Lot Size (acres)	62	9.93	25.27	0.11	1.60	2.52	5.83	150.16
Land Costs ($/acre)		$408,549	$641,257	$6,177	$84,845	$194,954	$487,686	$3,333,333

Table C-2. Descriptive Statistics for Undeveloped Land by Land Use Type, adjusted for outliers based on land costs ($/acre)

	Count	Average	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
Multi-family Residential								
Lot Size (acres)	19	10.69	11.72	0.50	2.12	5.69	12.92	43.00
Land Costs ($/acre)		$337,993	$300,594	$85,714	$130,497	$199,558	$554,045	$1,086,976

Source: Atrium Real Estate Services, August 2017.

Table C-3 provides a comparison of the updated, undeveloped land costs ($/acre, excluding outliers) with those provided in the 2002 Report.

Table C-3. Comparison of Undeveloped Land Costs ($/acre) With Those Provided in the 2002 Report

	2002 Study[1]		**2017 Study[2]**	
	Average	**Standard Deviation**	**Average**	**Standard Deviation**
Single-family Residential				
Land Costs ($/acre)	$140,623	$89,697	$637,023	$672,232
Commercial				
Land Costs ($/acre)	$158,596	$97,939	$408,549	$641,257
Multi-family Residential				
Land Costs ($/acre)	-	-	$337,993	$300,594

[1] City of Austin Regional Stormwater Management Program and Urban Watersheds Structural Control Fund Payment Study. June 28, 2002.
[2] Atrium Real Estate Services, August 2017.

Further, Figure C-1 provides a graphical representation of undeveloped land costs ($/acre, 2017) versus lot size, including all sample properties.

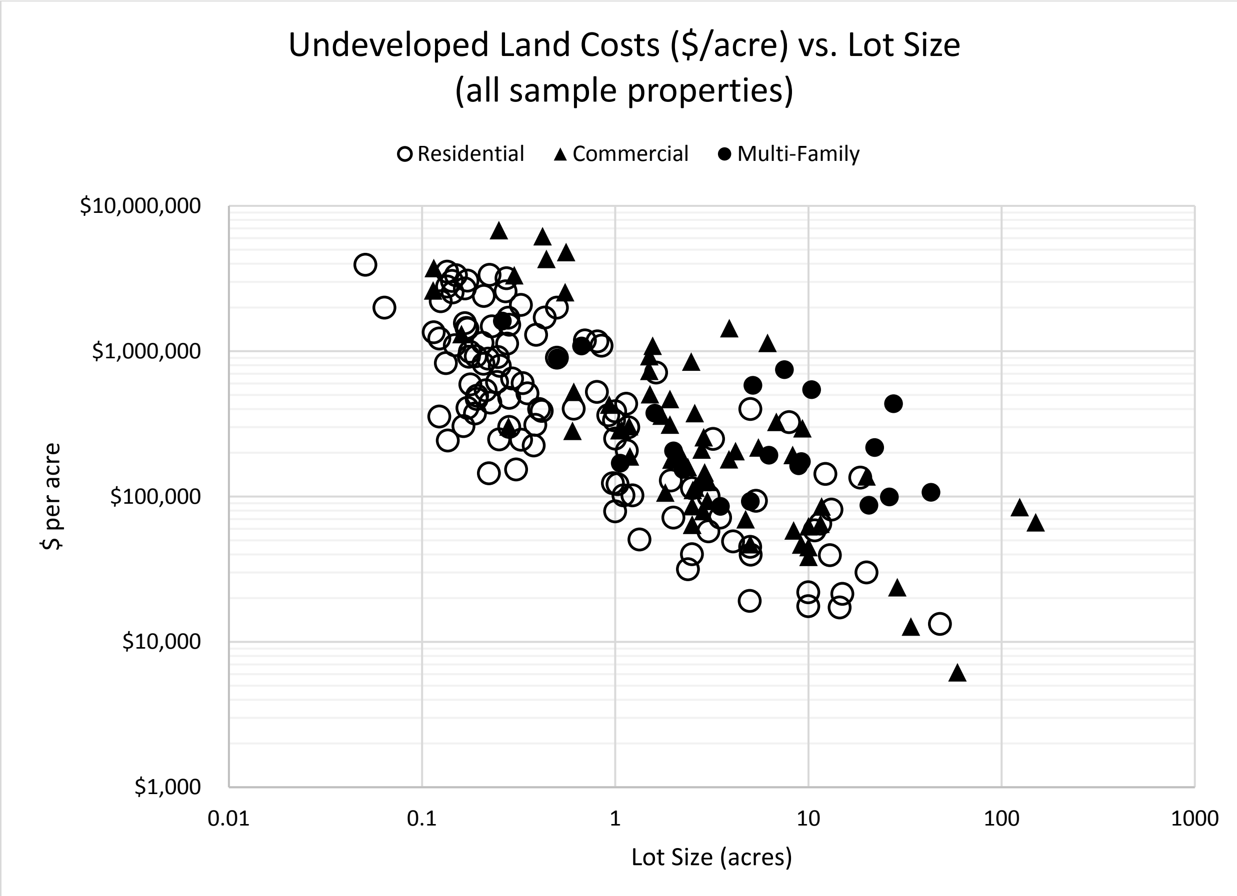


Figure C-1. Undeveloped Land Costs ($/acre) vs. Lot Size (all sample properties)

C.2 Developed Land

In addition to land costs for undeveloped properties, data were collected for developed properties. Table C-4 provides a summary of the descriptive statistics for building and lot sizes by land use type.

Table C-4. Descriptive Statistics for Sales Price and Building and Lot Sizes by Land Use Type

	Count	Average	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
Single-family Residential								
Sales Price ($/ft^2)	112	$254	$213	$45	$128	$195	$297	$1,382
Building Size (ft^2)	112	1,901	951	480	1,148	1,662	2,309	5,261
Lot Size (acres)	106	0.54	1.07	0.01	0.14	0.19	0.28	6.11
Commercial								
Sales Price ($/ft^2)	71	$271	$159	$50	$159	$229	$361	$897
Building Size (ft^2)	71	23,661	46,124	972	2,992	5,174	13,100	223,033
Lot Size (acres)	63	4.24	12.01	0.13	0.41	1.11	3.06	83.90

Table C-4. Descriptive Statistics for Sales Price and Building and Lot Sizes by Land Use Type

	Count	Average	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
Multi-family Residential								
Sales Price ($/ft^2)	84	$184	$98	$57	$124	$152	$220	$589
Building Size (ft^2)	84	134,737	167,341	1,290	2,114	29,304	266,774	757,866
Lot Size (acres)	83	8.36	13.26	0.15	0.22	0.99	13.13	56.33

Source: Atrium Real Estate Services, August 2017.
$/ft^2 = dollar(s) per square foot/feet

C.2.1 Developed Land, Single-family Residential Land Use

Table C-5 provides a summary of the descriptive statistics collected for the previously developed land with a single-family residential land use, including single-family residential building and lot sizes by general area (e.g., North, etc.). The tables that follow provide additional detail by watershed within each general area. Figure C-2 provides a graphical illustration of the watersheds of interest and general areas.

Table C-5. Descriptive Statistics for Developed Land, Single-family Residential Land Use: Building and Lot Sizes by General Area

	Count	Average	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
All Single-family Residential								
Building Size (SF)	112	1,901	951	480	1,148	1,662	2,309	5,261
Lot Size (acres)	106	0.54	1.07	0.01	0.14	0.19	0.28	6.11
North								
Building Size (SF)	12	1,614	716	929	1,048	1,549	1,807	3,302
Lot Size (acres)	10	0.14	0.08	0.00	0.12	0.17	0.19	0.22
Northwest								
Building Size (SF)	12	2,487	929	1,274	1,867	2,302	3,369	4,136
Lot Size (acres)	11	0.31	0.34	0.00	0.18	0.24	0.28	1.37
Central								
Building Size (SF)	24	1,939	943	566	1,075	2,072	2,441	3,984
Lot Size (acres)	21	0.19	0.26	0.00	0.04	0.16	0.23	1.27
East								
Building Size (SF)	27	1,417	484	480	1,098	1,203	1,725	2,467
Lot Size (acres)	27	0.17	0.09	0.04	0.12	0.14	0.18	0.51
Southwest								
Building Size (SF)	21	2,450	1,312	892	1,520	1,818	3,500	5,261

Table C-5. Descriptive Statistics for Developed Land, Single-family Residential Land Use: Building and Lot Sizes by General Area

	Count	Average	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
Lot Size (acres)	21	0.94	1.47	0.11	0.19	0.25	1.00	6.11
Southeast								
Building Size (SF)	16	1,713	626	786	1,211	1,631	2,209	2,816
Lot Size (acres)	16	1.45	1.84	0.10	0.14	0.34	2.88	5.31

Source: Atrium Real Estate Services, August 2017.

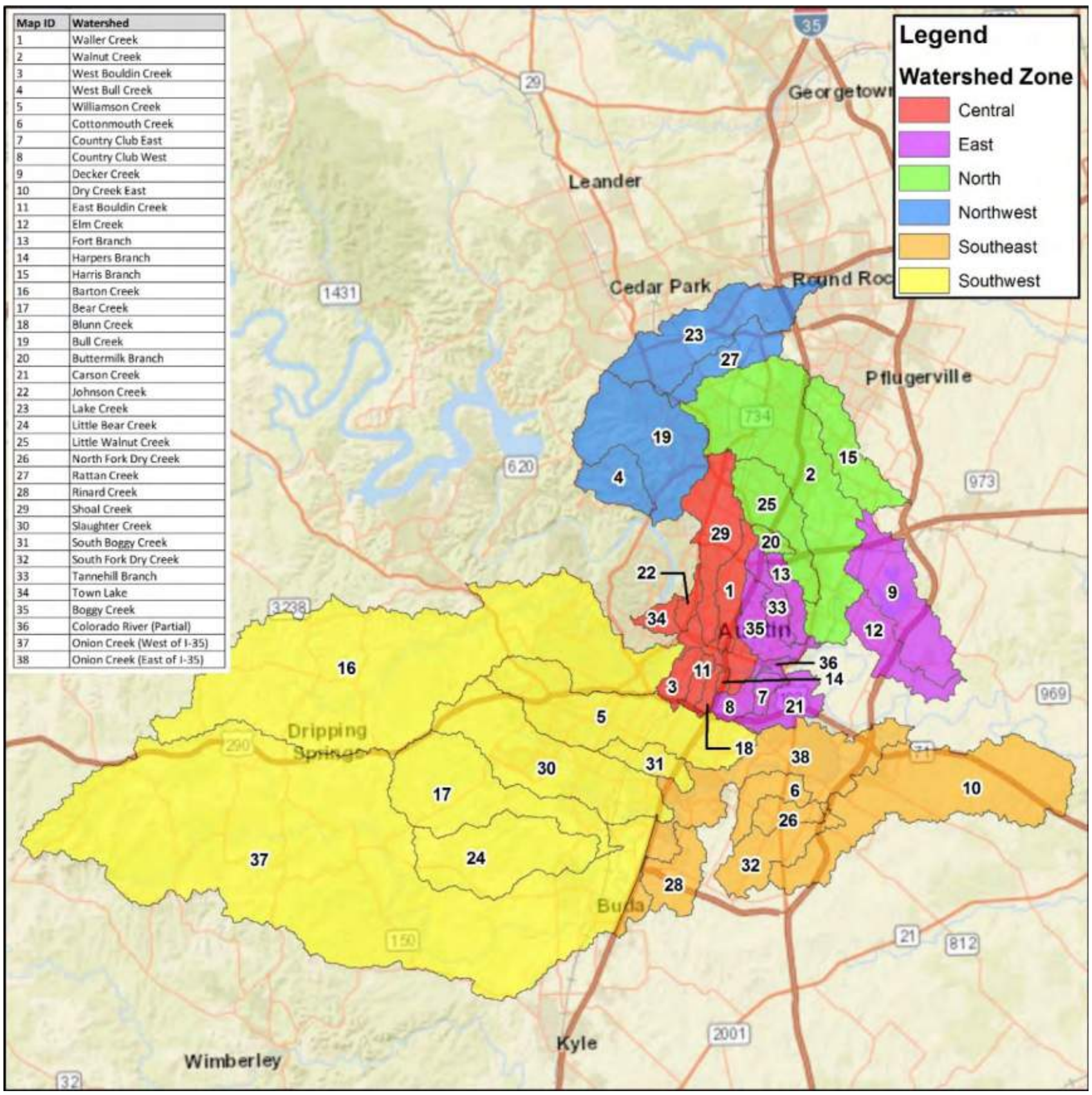


Figure C-2. Graphical Representation of the Watersheds of Interest and General Areas.

Table C-6 provides a summary of the descriptive statistics for the developed land, single-family residential land use, building and lot sizes by general area and by watershed.

Table C-6. Developed Land: Low, Average, and High Single-family Residential Building and Lot Sizes by Watershed (last six months)

	Building Size (SF)			Lot Size (acres)		
	Low	**Average**	**High**	**Low**	**Average**	**High**
North						
Buttermilk	1,050	2,024	2,468	0.17	0.19	0.21
Walnut Creek	1,042	1,100	1,734	-	0.09	0.21
Little Walnut	936	1,451	1,646	-	0.17	0.22
Harris Branch	929	1,685	3,302	0.14	0.14	0.17
Northwest						
Rattan Creek	1,556	2,127	3,541	0.19	0.24	0.28
Lake Creek	1,274	1,970	2,400	-	0.25	0.28
Bull Creek	2,203	3,361	4,136	0.18	0.28	0.38
West Bull Creek	1,367	2,518	3,392	0.15	0.17	1.37
Central						
Waller Creek	566	2,225	3,984	0.01	0.15	0.23
Shoal Creek	1,474	2,227	2,403	-	0.12	0.20
Town Lake	661	2,880	3,617	-	0.01	0.58
Harper's Branch	2,098	2,556	3,100	0.09	0.16	0.27
Blunn Creek	984	986	1,115	0.04	0.19	0.23
East Bouldin	1,931	2,058	2,930	0.18	0.24	1.27
West Bouldin	812	1,702	2,085	0.09	0.14	0.18
Johnson Creek	876	1,105	2,168	-	0.03	0.24
East						
Elm Creek	1,203	1,657	2,467	0.11	0.13	0.13
Decker Creek	867	2,068	2,168	0.13	0.14	0.17
Country Club East	1,071	1,097	1,817	0.09	0.11	0.13
Country Club West	1,066	1,164	1,485	0.04	0.09	0.21
Carson Creek	884	1,708	1,742	0.09	0.28	0.35
Colorado River	1,180	1,357	1,394	0.09	0.14	0.15
Boggy Creek	480	1,099	1,810	0.14	0.14	0.17
Tannehill	1,088	1,140	1,509	0.18	0.26	0.51
Fort Branch	1,150	1,166	2,429	0.17	0.19	0.20
Southwest						
Barton	3,500	4,615	5,261	0.26	1.65	2.12

Table C-6. Developed Land: Low, Average, and High Single-family Residential Building and Lot Sizes by Watershed (last six months)

	Building Size (SF)			Lot Size (acres)		
	Low	Average	High	Low	Average	High
Williamson	1,100	1,626	1,818	0.21	0.21	0.25
South Boggy Creek	1,218	1,520	2,095	0.11	0.15	0.16
Slaughter	892	3,209	3,482	0.13	0.17	0.24
Bear Creek	2,232	3,578	4,375	0.19	0.20	1.00
Little Bear Creek	1,368	1,530	3,552	0.49	1.30	6.11
Onion Creek (west of IH 35)	1,096	1,624	1,766	0.30	1.00	3.58
Southeast						
Rinard	1,231	1,649	2,279	0.14	0.22	5.31
South Fork Dry Creek	992	1,000	1,612	0.30	0.33	0.34
Dry Creek East	1,416	2,601	2,816	3.24	3.91	4.55
Cottonmouth	1,667	1,845	2,185	0.10	0.15	0.53
North Fork Dry Creek	1,152	1,152	1,152	1.02	1.02	1.02
Onion Creek (east of IH 35)	786	1,597	2,582	0.11	0.13	2.76

Source: Atrium Real Estate Services, August 2017.

C.2.2 Developed Land, Commercial Land Use

Table C-7 provides a summary of the descriptive statistics for previously developed land with a commercial land use, including commercial building and lot sizes by general area.

Table C-7. Descriptive Statistics for Developed Land, Commercial Land Use, Including Building and Lot Sizes by General Area

	Count	Average	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
All Multi-family Residential								
Building Size (SF)	71	23,661	46,124	972	2,992	5,174	13,100	223,033
Lot Size (acres)	63	0.54	1.07	0.01	0.14	0.19	0.28	6.11
North								
Building Size (SF)	9	32,423	45,553	972	5,578	17,200	24,700	137,615
Lot Size (acres)	9	2.70	2.83	-	0.75	1.65	3.00	8.65
Northwest								
Building Size (SF)	9	24,844	44,491	998	3,650	5,520	10,600	136,444
Lot Size (acres)	7	2.52	2.63	-	0.63	2.11	3.31	8.67

Table C-7. Descriptive Statistics for Developed Land, Commercial Land Use, Including Building and Lot Sizes by General Area

	Count	Average	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
Central								
Building Size (SF)	18	4,248	2,893	1,000	2,472	3,231	4,705	11,772
Lot Size (acres)	18	0.34	0.29	-	0.16	0.21	0.41	1.01
East								
Building Size (SF)	10	49,696	89,658	1,952	3,765	6,146	19,300	223,033
Lot Size (acres)	10	5.56	14.36	-	0.26	0.50	1.49	46.22
Southwest								
Building Size (SF)	19	24,056	34,497	994	3,597	6,000	27,250	103,000
Lot Size (acres)	19	7.52	19.05	-	0.42	1.97	3.91	83.90
Southeast								
Building Size (SF)	6	22,344	40,730	1,000	1,637	4,079	15,843	104,315
Lot Size (acres)	6	2.61	1.54	0.64	1.53	2.90	3.18	4.90

Source: Atrium Real Estate Services, August 2017.

Table C-8 provides a summary of the descriptive statistics for developed land, commercial land use, including building and lot sizes by general area and by watershed.

Table C-8. Developed Land: Low, Average, and High Commercial Building and Lot Sizes by Watershed (last six months)

	Building Size (SF)			Lot Size (acres)		
	Low	Average	High	Low	Average	High
North						
Buttermilk	8,816	8,816	8,816	1.51	1.51	1.51
Walnut Creek	18,000	76,000	137,615	2.11	5.94	8.65
Little Walnut	5,578	17,200	24,700	0.67	0.75	1.65
Harris Branch	972	1,949	2,925	-	1.50	3.00
Northwest						
Rattan Creek	-	-	-	-	-	-
Lake Creek	2,085	8,060	136,444	0.50	3.07	8.67
Bull Creek	998	3,650	9,400	-	0.63	1.17
West Bull Creek	-	-	-	-	-	-
Central						
Waller Creek	1,984	3,354	10,119	0.13	0.15	1.00

Table C-8. Developed Land: Low, Average, and High Commercial Building and Lot Sizes by Watershed (last six months)

	Building Size (SF)			Lot Size (acres)		
	Low	**Average**	**High**	**Low**	**Average**	**High**
Shoal Creek	3,040	3,167	7,956	0.25	0.40	0.42
Town Lake	2,398	2,692	4,680	-	0.15	0.21
Harper's Branch	-	-	-	-	-	-
Blunn Creek	-	-	-	-	-	-
East Bouldin	1,000	3,771	11,772	0.15	0.42	0.71
West Bouldin	2,197	2,958	5,176	0.18	0.18	1.01
Johnson Creek	2,198	2,746	3,294	0.17	0.19	0.20
East						
Elm Creek	-	-	-	-	-	-
Decker Creek	4,560	4,560	4,560	1.00	1.00	1.00
Country Club East	-	-	-	-	-	-
Country Club West	-	-	-	-	-	-
Carson Creek	3,432	109,622	215,812	0.23	23.23	46.22
Colorado River	-	-	-	-	-	-
Boggy Creek	3,500	6,086	6,206	-	0.21	0.44
Tannehill	9,969	22,410	223,033	0.56	1.65	4.93
Fort Branch	1,952	1,952	1,952	0.35	0.35	0.35
Southwest						
Barton	2,984	5,000	70,000	-	0.68	16.01
Williamson	3,108	65,190	103,000	-	2.47	13.86
South Boggy Creek	994	994	994	-	-	-
Slaughter	2,115	6,000	6,694	-	0.58	1.97
Bear Creek	4,085	5,056	6,027	2.96	5.36	7.77
Little Bear Creek	-	-	-	-	-	-
Onion Creek (west of IH 35)	5,000	12,000	14,200	1.11	1.55	83.90
Southeast						
Rinard	-	-	-	-	-	-
South Fork Dry Creek	-	-	-	-	-	-
Dry Creek East	1,800	1,800	1,800	4.90	4.90	4.90
Cottonmouth	6,358	6,358	6,358	3.20	3.20	3.20
North Fork Dry Creek	1,000	1,000	1,000	1.15	1.15	1.15

Table C-8. Developed Land: Low, Average, and High Commercial Building and Lot Sizes by Watershed (last six months)

	Building Size (SF)			Lot Size (acres)		
	Low	Average	High	Low	Average	High
Onion Creek (east of IH 35)	-	-	-	-	-	-

Source: Atrium Real Estate Services, August 2017.

C.2.3 Developed Land, Multi-family Residential

Table C-9 provides a summary of the descriptive statistics for previously developed land, multi-family residential land use, including building and lot sizes by general area.

Table C-9. Descriptive Statistics for Developed Land, Multi-family Residential Land Use, Building and Lot Sizes by General Area

	Count	Average	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
All Multi-family Residential								
Building Size (SF)	84	134,737	167,341	1,290	2,114	29,304	266,774	757,866
Lot Size (acres)	83	0.54	1.07	0.01	0.14	0.19	0.28	6.11
North								
Building Size (SF)	13	132,839	169,188	2,096	2,700	36,334	236,504	534,024
Lot Size (acres)	11	5.57	7.01	0.16	0.48	2.29	8.12	18.12
Northwest								
Building Size (SF)	10	289,037	270,264	1,936	53,732	251,001	427,496	757,866
Lot Size (acres)	10	17.82	15.52	0.18	3.44	16.29	29.72	41.23
Central								
Building Size (SF)	26	84,734	122,980	1,290	1,823	3,932	190,133	331,935
Lot Size (acres)	26	1.90	3.49	-	0.19	0.28	2.25	14.48
East								
Building Size (SF)	14	67,213	109,849	1,464	1,945	2,959	117,681	297,552
Lot Size (acres)	14	2.96	4.99	0.16	0.23	0.34	3.28	15.93
Southwest								
Building Size (SF)	19	186,984	136,277	1,672	25,028	261,722	299,764	332,000
Lot Size (acres)	19	18.51	19.02	0.17	1.77	13.26	24.34	56.33

Table C-9. Descriptive Statistics for Developed Land, Multi-family Residential Land Use, Building and Lot Sizes by General Area

	Count	Average	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
Southeast								
Building Size (SF)	2	1,918	269	1,728	1,823	1,918	2,013	2,108
Lot Size (acres)	2	0.22	0.08	0.16	0.19	0.22	0.25	0.28

Source: Atrium Real Estate Services, August 2017.

Table C-10 provides a summary of the descriptive statistics for developed land, multi-family residential land use, including building and lot sizes by general area and by watershed.

Table C-10. Developed Land: Low, Average, and High Multi-family Residential Building and Lot Sizes by Watershed (last six months)

	Building Size (SF)			Lot Size (acres)		
	Low	Average	High	Low	Average	High
North						
Buttermilk	2,700	36,334	67,545	0.17	1.50	4.21
Walnut Creek	13,200	13,200	13,200	0.66	0.66	0.66
Little Walnut	2,116	23,000	534,024	0.23	2.29	17.53
Harris Branch	2,096	272,000	330,601	0.48	16.06	18.12
Northwest						
Rattan Creek	2,116	261,148	481,074	0.18	15.12	38.33
Lake Creek	1,936	266,760	757,866	0.26	13.00	33.21
Bull Creek	2,124	208,556	240,854	0.20	17.46	19.25
West Bull Creek	667,936	667,936	667,936	41.23	41.23	41.23
Central						
Waller Creek	1,822	50,872	215,000	0.19	1.57	2.72
Shoal Creek	1,728	115,532	223,500	-	0.17	1.03
Town Lake	3,944	118,960	331,935	0.27	3.15	14.48
Harper's Branch	1,290	1,665	302,000	0.15	0.16	4.00
Blunn Creek	-	-	-	-	-	-
East Bouldin	1,792	3,357	21,000	0.21	0.52	0.54
West Bouldin	1,824	307,902	315,491	0.19	3.48	10.35
Johnson Creek	1,440	2,162	3,920	0.16	0.17	0.19

Table C-10. Developed Land: Low, Average, and High Multi-family Residential Building and Lot Sizes by Watershed (last six months)

	Building Size (SF)			Lot Size (acres)		
	Low	Average	High	Low	Average	High
East						
Elm Creek	3,520	3,520	3,520	0.22	0.22	0.22
Decker Creek	1,983	1,983	1,983	0.44	0.44	0.44
Country Club East	-	-	-	-	-	-
Country Club West	1,932	1,932	1,932	0.28	0.28	0.28
Carson Creek	-	-	-	-	-	-
Colorado River	-	-	-	-	-	-
Boggy Creek	5,702	149,351	293,000	0.23	2.14	4.04
Tannehill	1,536	15,072	28,608	0.20	0.59	0.99
Fort Branch	1,464	2,398	152,053	0.25	0.40	6.68
Southwest						
Barton	3,612	270,000	294,490	0.20	9.47	24.53
Williamson	1,914	266,816	323,943	0.21	23.45	45.30
South Boggy Creek	-	-	-	-	-	-
Slaughter	2,618	295,629	329,535	0.18	29.04	56.33
Bear Creek	-	-	-	-	-	-
Little Bear Creek	-	-	-	-	-	-
Onion Creek (west of IH 35)	-	-	-	-	-	-
Southeast						
Rinard	-	-	-	-	-	-
South Fork Dry Creek	2,108	2,108	2,108	0.28	0.28	0.28
Dry Creek East	-	-	-	-	-	-
Cottonmouth	-	-	-	-	-	-
North Fork Dry Creek	-	-	-	-	-	-
Onion Creek (east of IH 35)	-	-	-	-	-	-

Source: Atrium Real Estate Services, August 2017.

Appendix D
Construction Cost Statistical Analysis Output

DATA SET # 1: Detention Pond

1. Property Class: Residential

```
Fitted Model: Y = exp(12.3 + 3.051e-02X1 - 1.007e-06 X2 - 1.357e-02 X3)
```

Selected Data

```
        Y       X1       X2    X3        X4     X5 X6 X7          X8  DATA OUTLIER
1  486200 56.70000 323127.6 45.71 1.8800000 126.00 NA NA residential Data1       N
6  211100  0.95040   8660.0  2.22 0.1000000   2.16 NA NA residential Data1       N
18 185200 33.93000 418501.0 54.93 2.6501607  87.00 NA NA residential Data1       N
19 150000 24.82863 845669.0 21.48 4.9359045  66.44 NA NA residential Data1       N
20 193000 14.01728 204592.0 30.44 0.6342975 149.12 NA NA residential Data1       N
> attach(dat)
> length(dat$Y)
[1] 5
> # Test for Outliers [Use dixon and grubbs when n<=25]
> dixon.test(Y,opposite = FALSE, two.sided = FALSE)$p.value[[1]]
[1] 0.005262253
> grubbs.test(Y,opposite = FALSE, two.sided = FALSE)$p.value
[1] 0.004587339
> #Test Normality
> qqnorm(Y)
> shapiro.test(Y)

        Shapiro-Wilk normality test

data:  Y
W = 0.70698, p-value = 0.01131

> Y1 <- log(Y)
> qqnorm(Y1)
> shapiro.test(Y1)

        Shapiro-Wilk normality test

data:  Y1
W = 0.80336, p-value = 0.08628
> fit1 <- lm(log(Y)~X1+X2,data=dat)
> summary(fit1)

Call:
lm(formula = log(Y) ~ X1 + X2, data = dat)

Residuals:
       1        6       18       19       20 
 0.13816  0.10170 -0.28384  0.10024 -0.05626 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept)  1.215e+01  2.118e-01  57.356 0.000304 ***
X1           1.979e-02  6.307e-03   3.138 0.088323 .  
X2          -9.710e-07  4.268e-07  -2.275 0.150682    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2482 on 2 degrees of freedom
Multiple R-squared:  0.8503,   Adjusted R-squared:  0.7006 
F-statistic: 5.681 on 2 and 2 DF,  p-value: 0.1497

> fit1 <- lm(log(Y)~X1+X2+X3,data=dat)
> summary(fit1)

Call:
lm(formula = log(Y) ~ X1 + X2 + X3, data = dat)
```

```
Residuals:
        1         6        18        19        20 
 0.008766 -0.031207 -0.040557  0.002374  0.060624 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)   
(Intercept)  1.230e+01  7.696e-02 159.833  0.00398 **
X1           3.051e-02  3.224e-03   9.465  0.06702 . 
X2          -1.007e-06  1.375e-07  -7.318  0.08646 . 
X3          -1.357e-02  3.170e-03  -4.280  0.14611   
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.07985 on 1 degrees of freedom
Multiple R-squared:  0.9923,	Adjusted R-squared:  0.969 
F-statistic:  42.7 on 3 and 1 DF,  p-value: 0.1119

THIS IS THE BEST MODEL
Y = exp(12.3+3.051e-02X1 -1.007e-06 X2 -1.357e-02 X3)

> fit1 <- lm(log(Y)~X1+X2+X3+X4,data=dat)
> summary(fit1)

Call:
lm(formula = log(Y) ~ X1 + X2 + X3 + X4, data = dat)

Residuals:
ALL 5 residuals are 0: no residual degrees of freedom!

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.228e+01         NA      NA       NA
X1           3.125e-02         NA      NA       NA
X2          -1.413e-07         NA      NA       NA
X3          -1.392e-02         NA      NA       NA
X4          -1.451e-01         NA      NA       NA

Residual standard error: NaN on 0 degrees of freedom
Multiple R-squared:      1,	Adjusted R-squared:    NaN 
F-statistic:   NaN on 4 and 0 DF,  p-value: NA

> fit1 <- lm(log(Y)~X3+X4,data=dat)
> summary(fit1)

Call:
lm(formula = log(Y) ~ X3 + X4, data = dat)

Residuals:
        1         6        18        19        20 
 0.619653  0.028229 -0.356999 -0.008639 -0.282244 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)   
(Intercept) 12.220392   0.511604  23.886  0.00175 **
X3           0.009754   0.013640   0.715  0.54875   
X4          -0.101883   0.147929  -0.689  0.56216   
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.544 on 2 degrees of freedom
Multiple R-squared:  0.2809,	Adjusted R-squared:  -0.4382 
F-statistic: 0.3906 on 2 and 2 DF,  p-value: 0.7191

> fit1 <- lm(log(Y)~X3+X4+X5,data=dat)
> summary(fit1)

Call:
lm(formula = log(Y) ~ X3 + X4 + X5, data = dat)
```

```
Residuals:
       1        6       18       19       20 
 0.61318  0.05206 -0.32860 -0.01711 -0.31953 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)  
(Intercept) 12.1976969  0.7914264  15.412   0.0412 *
X3           0.0084665  0.0266409   0.318   0.8041  
X4          -0.0987368  0.2134941  -0.462   0.7242  
X5           0.0006517  0.0093238   0.070   0.9556  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.7675 on 1 degrees of freedom
Multiple R-squared:  0.2844,	Adjusted R-squared:  -1.862 
F-statistic: 0.1325 on 3 and 1 DF,  p-value: 0.9291
> fit <- lm(log(Y)~X1+X2+X4,data=dat)
> step <- stepAIC(fit, direction="both")
Start:  AIC=-10.59
log(Y) ~ X1 + X2 + X4

       Df Sum of Sq     RSS      AIC
- X4    1   0.00176 0.12321 -12.5165
- X2    1   0.00226 0.12372 -12.4960
<none>              0.12145 -10.5883
- X1    1   0.59079 0.71225  -3.7438

Step:  AIC=-12.52
log(Y) ~ X1 + X2

       Df Sum of Sq     RSS      AIC
<none>              0.12321 -12.5165
+ X4    1   0.00176 0.12145 -10.5883
- X2    1   0.31894 0.44215  -8.1277
- X1    1   0.60651 0.72972  -5.6227
> step$anova # display results
Stepwise Model Path 
Analysis of Deviance Table

Initial Model:
log(Y) ~ X1 + X2 + X4

Final Model:
log(Y) ~ X1 + X2


  Step Df    Deviance Resid. Df Resid. Dev       AIC
1                             1  0.1214546 -10.58826
2 - X4  1 0.001755161         2  0.1232098 -12.51652
> summary(fit)

Call:
lm(formula = log(Y) ~ X1 + X2 + X4, data = dat)

Residuals:
       1        6       18       19       20 
 0.13533  0.11976 -0.26596  0.10032 -0.08945 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)  
(Intercept)  1.213e+01  3.213e-01  37.758   0.0169 *
X1           2.003e-02  9.082e-03   2.206   0.2710  
X2          -5.193e-07  3.805e-06  -0.136   0.9136  
X4          -7.566e-02  6.294e-01  -0.120   0.9238  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
Residual standard error: 0.3485 on 1 degrees of freedom
Multiple R-squared:  0.8525,	Adjusted R-squared:  0.4098 
F-statistic: 1.926 on 3 and 1 DF,  p-value: 0.4768
> fit <- lm(log(Y)~X1+X2+X5,data=dat)
> step <- stepAIC(fit, direction="both")
Start:  AIC=-10.87
log(Y) ~ X1 + X2 + X5

       Df Sum of Sq     RSS      AIC
- X5    1   0.00849 0.12321 -12.5165
<none>              0.11472 -10.8736
- X2    1   0.32580 0.44052  -6.1462
- X1    1   0.49914 0.61386  -4.4871

Step:  AIC=-12.52
log(Y) ~ X1 + X2

       Df Sum of Sq     RSS      AIC
<none>              0.12321 -12.5165
+ X5    1   0.00849 0.11472 -10.8736
- X2    1   0.31894 0.44215  -8.1277
- X1    1   0.60651 0.72972  -5.6227
> step$anova # display results
Stepwise Model Path 
Analysis of Deviance Table

Initial Model:
log(Y) ~ X1 + X2 + X5

Final Model:
log(Y) ~ X1 + X2


  Step Df    Deviance Resid. Df Resid. Dev       AIC
1                             1  0.1147185 -10.87356
2 - X5  1 0.008491233         2  0.1232098 -12.51652
> summary(fit)

Call:
lm(formula = log(Y) ~ X1 + X2 + X5, data = dat)

Residuals:
       1        6       18       19       20 
 0.13049  0.05298 -0.29386  0.09012  0.02027 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)  
(Intercept)  1.220e+01  3.415e-01  35.714   0.0178 *
X1           2.128e-02  1.020e-02   2.086   0.2846  
X2          -9.855e-07  5.848e-07  -1.685   0.3409  
X5          -9.654e-04  3.548e-03  -0.272   0.8309  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3387 on 1 degrees of freedom
Multiple R-squared:  0.8606,	Adjusted R-squared:  0.4425 
F-statistic: 2.058 on 3 and 1 DF,  p-value: 0.464
```

2. Property Class: Commercial

```
Fitted Model: Y = 2.65X2 - 1.546e+04X3 + 3.176e+03X5
```

```
     Y        X1     X2     X3    X4     X5 X6 X7         X8  DATA OUTLIER
2 309800  4.178850  67676  5.917 0.350  7.437 NA NA commercial Data1       N
3 310600 13.989600 295379 36.860 1.340 20.880 NA NA commercial Data1       N
4 222100 10.057680  56628  4.460 0.400 14.640 NA NA commercial Data1       N
5 179800  6.049584  80786 20.100 0.536 70.344 NA NA commercial Data1       N
7 156500  0.214500 128902 17.410 0.686  1.650 NA NA commercial Data1       N
8 153500  9.911000  29612  4.230 0.275 18.700 NA NA commercial Data1       N
> length(dat$Y)
[1] 15
>
> # Test for Outliers [Use dixon and grubbs when n<=25]
> dixon.test(Y,opposite = FALSE, two.sided = FALSE)$p.value[[1]]
[1] 0.2977021
> grubbs.test(Y,opposite = FALSE, two.sided = FALSE)$p.value
[1] 0.3195221
> shapiro.test(Y)

        Shapiro-Wilk normality test

data:  Y
W = 0.92157, p-value = 0.2035
> fit <- lm(Y~X1+X2+X3+X4+X5,data=dat)
> summary(fit)

Call:
lm(formula = Y ~ X1 + X2 + X3 + X4 + X5, data = dat)

Residuals:
   Min     1Q Median     3Q    Max 
-65881 -29873   2464  19255 143105 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  47104.235  29566.040   1.593    0.146
X1             974.243   5117.784   0.190    0.853
X2               1.891      1.523   1.242    0.246
X3          -15197.514   8989.179  -1.691    0.125
X4          164200.316 272083.213   0.603    0.561
X5            2686.972   1910.544   1.406    0.193

Residual standard error: 62500 on 9 degrees of freedom
Multiple R-squared:  0.6956,	Adjusted R-squared:  0.5266 
F-statistic: 4.114 on 5 and 9 DF,  p-value: 0.03192

> step <- stepAIC(fit, direction="both")
Start:  AIC=335.62
Y ~ X1 + X2 + X3 + X4 + X5

       Df  Sum of Sq        RSS    AIC
- X1    1 1.4154e+08 3.5294e+10 333.68
- X4    1 1.4225e+09 3.6575e+10 334.22
<none>               3.5152e+10 335.62
- X2    1 6.0235e+09 4.1176e+10 336.00
- X5    1 7.7254e+09 4.2878e+10 336.60
- X3    1 1.1164e+10 4.6316e+10 337.76

Step:  AIC=333.68
Y ~ X2 + X3 + X4 + X5
```

```
       Df  Sum of Sq        RSS    AIC
- X4    1 1.5158e+09 3.6810e+10 332.31
<none>               3.5294e+10 333.68
- X2    1 7.2836e+09 4.2577e+10 334.50
+ X1    1 1.4154e+08 3.5152e+10 335.62
- X5    1 1.2084e+10 4.7378e+10 336.10
- X3    1 1.5076e+10 5.0370e+10 337.02

Step:  AIC=332.31
Y ~ X2 + X3 + X5

       Df  Sum of Sq        RSS    AIC
<none>               3.6810e+10 332.31
+ X4    1 1.5158e+09 3.5294e+10 333.68
+ X1    1 2.3482e+08 3.6575e+10 334.22
- X3    1 1.4319e+10 5.1129e+10 335.24
- X5    1 1.6159e+10 5.2968e+10 335.77
- X2    1 2.8950e+10 6.5760e+10 339.02
> step$anova # display results
Stepwise Model Path 
Analysis of Deviance Table

Initial Model:
Y ~ X1 + X2 + X3 + X4 + X5

Final Model:
Y ~ X2 + X3 + X5


  Step Df   Deviance Resid. Df  Resid. Dev      AIC
1                            9 35152287060 335.6236
2 - X1  1  141540895        10 35293827954 333.6839
3 - X4  1 1515786308        11 36809614262 332.3146
> #Selected Model
> fit1 <- lm(Y~X2+X3+X5,data=dat)
> summary(fit1)

Call:
lm(formula = Y ~ X2 + X3 + X5, data = dat)

Residuals:
   Min     1Q Median     3Q    Max 
-65803 -30422  -3817  21018 141435 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)  
(Intercept)  5.692e+04  2.326e+04   2.447   0.0324 *
X2           2.650e+00  9.008e-01   2.941   0.0134 *
X3          -1.546e+04  7.474e+03  -2.069   0.0629 .
X5           3.176e+03  1.445e+03   2.197   0.0503 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 57850 on 11 degrees of freedom
Multiple R-squared:  0.6813,	Adjusted R-squared:  0.5944 
F-statistic: 7.838 on 3 and 11 DF,  p-value: 0.004475
THIS IS THE BEST MODEL
Y = 2.65X2 - 1.546e+04X3 + 3.176e+03X5

Call:
lm(formula = log(Y) ~ X2 + X3 + X5, data = dat)

Residuals:
    Min      1Q  Median      3Q     Max 
-1.2510 -0.3586  0.0858  0.4047  0.8300 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
```

```
(Intercept)  1.083e+01  2.609e-01  41.519 1.92e-13 ***
X2           2.363e-05  1.010e-05   2.339   0.0392 *
X3          -1.481e-01  8.383e-02  -1.767   0.1050
X5           3.493e-02  1.621e-02   2.155   0.0542 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.6488 on 11 degrees of freedom
Multiple R-squared:  0.5559,  Adjusted R-squared:  0.4348
F-statistic:  4.59 on 3 and 11 DF,  p-value: 0.02564

lm(formula = log(Y) ~ log(X2) + log(X3) + log(X5), data = dat)

Residuals:
     Min       1Q   Median       3Q      Max
-0.87975 -0.21784  0.00062  0.22177  0.64442

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  5.45198    2.52994   2.155   0.0542 .
log(X2)      0.57373    0.27815   2.063   0.0636 .
log(X3)     -0.09448    0.28808  -0.328   0.7491
log(X5)      0.16643    0.12486   1.333   0.2095
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4606 on 11 degrees of freedom
Multiple R-squared:  0.7762,  Adjusted R-squared:  0.7151
F-statistic: 12.72 on 3 and 11 DF,  p-value: 0.0006752
```

DATA SET # 2: Water Quality Pond

Two Equally Reasonable Models:

```
Y = exp(11.81-7.910e-06*X2 + 6.728e-02 *X3)
```

```
Y = 4.905E10 X3^1.145 * X4^0.873/X2^1.283
```

1. Property Class: Residential

```
          Y       X1     X2    X3         X4     X5 X6 X7          X8  DATA OUTLIER
21 1280300  3.55950  24929  7.91 0.2118931  7.910 NA NA residential Data2       N
22  287800 10.23031  60260 13.24 0.3518160 18.785 NA NA residential Data2       N
23  206500 13.66318  45449 14.06 0.3474542 46.632 NA NA residential Data2       N
45  604800 33.93000 191144 54.93 0.7891185 87.000 NA NA residential Data2       N
46  538900 24.26389  33195  6.50 0.1504591 66.440 NA NA residential Data2       N
49  160900 23.12576  40620 14.47 0.1796832 49.840 NA NA residential Data2       N
> length(dat$Y)
[1] 13
> # Test for Outliers [Use dixon and grubbs when n<=25]
> dixon.test(Y,opposite = FALSE, two.sided = FALSE)$p.value[[1]]
[1] 0.03530587
> grubbs.test(Y,opposite = FALSE, two.sided = FALSE)$p.value
[1] 0.1241305
> shapiro.test(Y)

     Shapiro-Wilk normality test

data:  Y
W = 0.74643, p-value = 0.001686

> Y1 <- log(Y)
> qqnorm(Y1)
> shapiro.test(Y1)

     Shapiro-Wilk normality test

data:  Y1
W = 0.94633, p-value = 0.5438
```

```
> fit <- lm(log(Y)~X1+X2+X3+X4+X5,data=dat)
> step <- stepAIC(fit, direction="both")
Start:  AIC=6.94
log(Y) ~ X1 + X2 + X3 + X4 + X5

       Df Sum of Sq     RSS    AIC
- X4    1   0.18466  8.9926 5.2089
- X5    1   0.26519  9.0731 5.3247
- X1    1   0.40643  9.2143 5.5255
<none>               8.8079 6.9391
- X3    1   2.56125 11.3692 8.2574
- X2    1   2.72811 11.5360 8.4468

Step:  AIC=5.21
log(Y) ~ X1 + X2 + X3 + X5

       Df Sum of Sq     RSS    AIC
- X5    1    0.7780  9.7706 4.2876
- X1    1    0.8394  9.8320 4.3690
<none>               8.9926 5.2089
- X2    1    2.5799 11.5725 6.4878
+ X4    1    0.1847  8.8079 6.9391
- X3    1    4.2510 13.2436 8.2413

Step:  AIC=4.29
log(Y) ~ X1 + X2 + X3

       Df Sum of Sq     RSS    AIC
- X1    1    0.0634  9.8340 2.3717
<none>               9.7706 4.2876
```

```
+ X5    1    0.7780  8.9926 5.2089
+ X4    1    0.6975  9.0731 5.3247
- X2    1    2.8670 12.6376 5.6325
- X3    1    4.9106 14.6812 7.5810

Step:  AIC=2.37
log(Y) ~ X2 + X3

       Df Sum of Sq     RSS    AIC
<none>                9.8340 2.3717
+ X4    1    0.5260  9.3080 3.6571
- X2    1    2.8610 12.6951 3.6914
+ X1    1    0.0634  9.7706 4.2876
+ X5    1    0.0020  9.8320 4.3690
- X3    1    6.3671 16.2011 6.8617
> step$anova # display results
Stepwise Model Path
Analysis of Deviance Table

Initial Model:
log(Y) ~ X1 + X2 + X3 + X4 + X5

Final Model:
log(Y) ~ X2 + X3


  Step Df  Deviance Resid. Df Resid. Dev      AIC
1                           7   8.807913 6.939114
2 - X4  1 0.1846640         8   8.992577 5.208851
3 - X5  1 0.7780240         9   9.770601 4.287572
4 - X1  1 0.0634084        10   9.834009 2.371665
> summary(fit)

Call:
lm(formula = log(Y) ~ X1 + X2 + X3 + X4 + X5, data = dat)

Residuals:
    Min      1Q  Median      3Q     Max 
-1.1776 -0.5513 -0.2608  0.5468  1.7148 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept)  1.198e+01  6.560e-01  18.265 3.65e-07 ***
X1          -7.060e-02  1.242e-01  -0.568    0.588    
X2          -8.341e-06  5.664e-06  -1.472    0.184    
X3           5.993e-02  4.201e-02   1.427    0.197    
X4           8.348e-01  2.179e+00   0.383    0.713    
X5           2.209e-02  4.811e-02   0.459    0.660    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.122 on 7 degrees of freedom
Multiple R-squared:  0.4566,   Adjusted R-squared:  0.06845 
F-statistic: 1.176 on 5 and 7 DF,  p-value: 0.4068
> fit1 <- lm(log(Y)~X2+X3,data=dat)
> summary(fit1)

Call:
lm(formula = log(Y) ~ X2 + X3, data = dat)

Residuals:
    Min      1Q  Median      3Q     Max 
-1.3993 -0.4758 -0.3155  0.3438  1.9156 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept)  1.181e+01  4.266e-01  27.687 8.76e-11 ***
X2          -7.910e-06  4.638e-06  -1.706   0.1189    
```

```
X3           6.728e-02  2.644e-02   2.545   0.0291 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9917 on 10 degrees of freedom
Multiple R-squared:  0.3933,   Adjusted R-squared:  0.2719
F-statistic: 3.241 on 2 and 10 DF,  p-value: 0.08221

Y = exp(11.81-7.910e-06*X2 + 6.728e-02 *X3)

> fit <- lm(log(Y)~log(X1)+log(X2)+log(X3)+log(X4)+log(X5),data=dat)
> step <- stepAIC(fit, direction="both")
Start:  AIC=4.9
log(Y) ~ log(X1) + log(X2) + log(X3) + log(X4) + log(X5)

          Df Sum of Sq     RSS    AIC
- log(X5)  1    0.0031  7.5302 2.9017
- log(X1)  1    0.0839  7.6110 3.0404
- log(X4)  1    1.0801  8.6072 4.6394
<none>                  7.5271 4.8963
- log(X3)  1    2.7616 10.2887 6.9593
- log(X2)  1    4.0572 11.5844 8.5012

Step:  AIC=2.9
log(Y) ~ log(X1) + log(X2) + log(X3) + log(X4)

          Df Sum of Sq     RSS    AIC
- log(X1)  1    0.6459  8.1761 1.9714
- log(X4)  1    1.1922  8.7224 2.8123
<none>                  7.5302 2.9017
+ log(X5)  1    0.0031  7.5271 4.8963
- log(X3)  1    2.8394 10.3696 5.0611
- log(X2)  1    4.0761 11.6063 6.5258

Step:  AIC=1.97
log(Y) ~ log(X2) + log(X3) + log(X4)

          Df Sum of Sq     RSS    AIC
<none>                  8.1761 1.9714
- log(X4)  1    1.9910 10.1671 2.8047
+ log(X1)  1    0.6459  7.5302 2.9017
+ log(X5)  1    0.5651  7.6110 3.0404
- log(X3)  1    2.2282 10.4043 3.1044
- log(X2)  1    4.6084 12.7845 5.7827
> step$anova # display results
Stepwise Model Path
Analysis of Deviance Table

Initial Model:
log(Y) ~ log(X1) + log(X2) + log(X3) + log(X4) + log(X5)

Final Model:
log(Y) ~ log(X2) + log(X3) + log(X4)


       Step Df    Deviance Resid. Df Resid. Dev      AIC
1                                  7   7.527127 4.896332
2 - log(X5)  1 0.003097146         8   7.530224 2.901680
3 - log(X1)  1 0.645858407         9   8.176082 1.971428

lm(formula = log(Y) ~ log(X2) + log(X3) + log(X4), data = dat)

Residuals:
     Min       1Q   Median       3Q      Max
-1.12885 -0.70139 -0.08612  0.44291  1.44374

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
```

```
(Intercept)  24.6161     6.1176   4.024   0.0030 **
log(X2)      -1.2826     0.5695  -2.252   0.0508 .
log(X3)       1.1450     0.7311   1.566   0.1518
log(X4)       0.8730     0.5897   1.480   0.1729
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9531 on 9 degrees of freedom
Multiple R-squared:  0.4956,   Adjusted R-squared:  0.3274
F-statistic: 2.947 on 3 and 9 DF,  p-value: 0.09098
```

Best Model:

Y = 4.905E10 X3^1.145 * X4^0.873/X2^1.283

2. Property Class: Commercial

Two Models, use either one:

Y =exp(11.53-0.08502 X1 +2.1199 X4 + 0.04453 X5)

*Y = 406593.83*X4^0.4902*

```
Y        X1        X2      X3    X4      X5  X6 X7          X8  DATA OUTLIER
24 438600 15.63912 101318.0 29.000 0.962 20.880 NA NA commercial Data2       N
25 319700 25.05606  64338.0 17.740 0.490 42.540 NA NA commercial Data2       N
26 313800  8.40336  30444.0  5.580 0.144 14.640 NA NA commercial Data2       N
27 318500 10.09800  13090.0  3.990 0.303 18.700 NA NA commercial Data2       N
28 293000  4.31346  19314.3  5.701 0.153  7.437 NA NA commercial Data2       N
29 175400  7.57800  92958.0  8.950 0.330 16.840 NA NA commercial Data2       N
```

```
> length(dat$Y)
[1] 24
> # Test for Outliers [Use dixon and grubbs when n<=25]
> dixon.test(Y,opposite = FALSE, two.sided = FALSE)$p.value[[1]]
[1] 0.007150564
> grubbs.test(Y,opposite = FALSE, two.sided = FALSE)$p.value
[1] 0.003709759
> #Test Normality
> qqnorm(Y)
> shapiro.test(Y)

        Shapiro-Wilk normality test

data:  Y
W = 0.84055, p-value = 0.001467
        Shapiro-Wilk normality test

data:  Y1
W = 0.96922, p-value = 0.6478
> fit <- lm(log(Y)~X1+X2+X3+X4+X5,data=dat)
> step <- stepAIC(fit, direction="both")
Start:  AIC=-23.93
log(Y) ~ X1 + X2 + X3 + X4 + X5

       Df Sum of Sq    RSS     AIC
- X2    1   0.00004 5.3699 -25.934
- X3    1   0.05517 5.4251 -25.689
<none>              5.3699 -23.934
- X1    1   0.66665 6.0366 -23.125
- X5    1   0.71987 6.0898 -22.915
- X4    1   1.19126 6.5612 -21.125

Step:  AIC=-25.93
log(Y) ~ X1 + X3 + X4 + X5

       Df Sum of Sq    RSS     AIC
- X3    1   0.11427 5.4842 -27.428
```

```
<none>               5.3699 -25.934
- X1    1   0.71827 6.0882 -24.921
- X5    1   0.76531 6.1353 -24.736
+ X2    1   0.00004 5.3699 -23.934
- X4    1   1.19620 6.5661 -23.107

Step:  AIC=-27.43
log(Y) ~ X1 + X4 + X5

       Df Sum of Sq     RSS     AIC
<none>                5.4842 -27.428
- X1    1    0.6711  6.1553 -26.658
- X5    1    0.7247  6.2089 -26.450
+ X3    1    0.1143  5.3699 -25.934
+ X2    1    0.0591  5.4251 -25.689
- X4    1    6.8496 12.3338  -9.977
> step$anova # display results
Stepwise Model Path
Analysis of Deviance Table

Initial Model:
log(Y) ~ X1 + X2 + X3 + X4 + X5

Final Model:
log(Y) ~ X1 + X4 + X5


  Step Df     Deviance Resid. Df Resid. Dev       AIC
1                             18   5.369907 -23.93384
2 - X2  1 3.660424e-05        19   5.369944 -25.93367
3 - X3  1 1.142727e-01        20   5.484217 -27.42831
> fit1 <- lm(log(Y)~X1+X4+X5,data=dat)
> summary(fit1)


lm(formula = log(Y) ~ X1 + X4 + X5, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-1.04353 -0.19548 -0.02908  0.33255  0.88697 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 11.52687    0.18371  62.744  < 2e-16 ***
X1          -0.08502    0.05435  -1.564    0.133    
X4           2.11990    0.42415   4.998 6.91e-05 ***
X5           0.04453    0.02739   1.626    0.120    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.5237 on 20 degrees of freedom
Multiple R-squared:  0.5703,	Adjusted R-squared:  0.5059 
F-statistic: 8.849 on 3 and 20 DF,  p-value: 0.0006193
```

Selected Model:

Y =exp(11.53-0.08502 X1 +2.1199 X4 + 0.04453 X5)

```
> step <- stepAIC(fit, direction="both")
Start:  AIC=-22.44
log(Y) ~ log(X1) + log(X2) + log(X3) + log(X4) + log(X5)

          Df Sum of Sq    RSS     AIC
- log(X3)  1   0.00073 5.7156 -24.437
- log(X2)  1   0.03480 5.7496 -24.294
- log(X1)  1   0.07334 5.7882 -24.134
- log(X5)  1   0.09987 5.8147 -24.024
<none>                 5.7148 -22.440
```

```
- log(X4)  1   1.08916 6.8040 -20.253

Step:  AIC=-24.44
log(Y) ~ log(X1) + log(X2) + log(X4) + log(X5)

          Df Sum of Sq    RSS     AIC
- log(X1)  1   0.07531 5.7909 -26.122
- log(X5)  1   0.10353 5.8191 -26.006
- log(X2)  1   0.17998 5.8955 -25.693
<none>                 5.7156 -24.437
+ log(X3)  1   0.00073 5.7148 -22.440
- log(X4)  1   1.25594 6.9715 -21.669

Step:  AIC=-26.12
log(Y) ~ log(X2) + log(X4) + log(X5)

          Df Sum of Sq    RSS     AIC
- log(X5)  1   0.04947 5.8403 -27.918
- log(X2)  1   0.25501 6.0459 -27.088
<none>                 5.7909 -26.122
+ log(X1)  1   0.07531 5.7156 -24.437
+ log(X3)  1   0.00270 5.7882 -24.134
- log(X4)  1   1.23421 7.0251 -23.486

Step:  AIC=-27.92
log(Y) ~ log(X2) + log(X4)

          Df Sum of Sq    RSS     AIC
- log(X2)  1   0.25193 6.0923 -28.905
<none>                 5.8403 -27.918
+ log(X5)  1   0.04947 5.7909 -26.122
+ log(X1)  1   0.02125 5.8191 -26.006
+ log(X3)  1   0.00669 5.8336 -25.946
- log(X4)  1   1.49132 7.3317 -24.460

Step:  AIC=-28.9
log(Y) ~ log(X4)

          Df Sum of Sq     RSS     AIC
<none>                  6.0923 -28.905
+ log(X2)  1    0.2519  5.8403 -27.918
+ log(X3)  1    0.2291  5.8632 -27.825
+ log(X5)  1    0.0464  6.0459 -27.088
+ log(X1)  1    0.0115  6.0808 -26.950
- log(X4)  1    6.6713 12.7635 -13.155
> step$anova # display results
Stepwise Model Path 
Analysis of Deviance Table

Initial Model:
log(Y) ~ log(X1) + log(X2) + log(X3) + log(X4) + log(X5)

Final Model:
log(Y) ~ log(X4)


       Step Df     Deviance Resid. Df Resid. Dev       AIC
1                                  18   5.714823 -22.43977
2 - log(X3)  1 0.0007321622        19   5.715555 -24.43670
3 - log(X1)  1 0.0753120324        20   5.790867 -26.12252
4 - log(X5)  1 0.0494653519        21   5.840332 -27.91839
5 - log(X2)  1 0.2519313242        22   6.092264 -28.90482
> fit1 <- lm(log(Y)~log(X4),data=dat)
> summary(fit1)

Call:
lm(formula = log(Y) ~ log(X4), data = dat)
```

```
Residuals:
     Min       1Q   Median       3Q      Max 
-1.37636 -0.25627  0.02631  0.36198  0.69092 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 12.91557    0.22940  56.302  < 2e-16 ***
log(X4)      0.49020    0.09987   4.908 6.58e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 

Residual standard error: 0.5262 on 22 degrees of freedom
Multiple R-squared:  0.5227,   Adjusted R-squared:  0.501 
F-statistic: 24.09 on 1 and 22 DF,  p-value: 6.581e-05
```

Y = 406593.83*X4^0.4902

DATA SET # 3: WQ/DET Pond

1. Property Class: Residential

Multivariate Best Model:

Y = 5.498e+04 X1 + 1.508 X2-6.373e-01 X3 +9.344e+04 X5 +3.640e+05 X6-1.543e+04 X7

One Parameter Best Model:

Y = 697459.69* X6^0.6243

```
2.          Y       X1     X2        X3     X4        X5        X6     X7          X8  DATA OUTLIER
3.   59 1208300 11.83470 595453 2593203.0 145.67 7.3940083 2.1730716 17.585 residential Data3       N
4.   60 1027000 25.50254 169405  499941.0  56.45 1.9656336 2.0845271 83.260 residential Data3       N
5.   61  987200 14.08280 123751  130060.5  41.20 0.7775712 0.7775712 41.420 residential Data3       N
6.   62  757400 17.82420 144841  531550.0  40.19 2.0439853 1.8101010 48.700 residential Data3       N
7.   63  712100 13.04478 471755  463914.0 103.00 1.9900000 1.3700000 61.532 residential Data3       N
8.   64  578400 22.68835 113088  124705.0  14.98 0.6862489 0.6219238 83.260 residential Data3       N
> length(dat$Y)
[1] 16
> # Test for Outliers [Use dixon and grubbs when n<=25]
> dixon.test(Y,opposite = FALSE, two.sided = FALSE)$p.value[[1]]
[1] 0.832831
> grubbs.test(Y,opposite = FALSE, two.sided = FALSE)$p.value
[1] 0.6367902
        Shapiro-Wilk normality test

data:  Y
W = 0.93048, p-value = 0.2481
lm(formula = Y ~ X1 + X2 + X3 + X4 + X5 + X6 + X7, data = dat)

Residuals:
    Min      1Q  Median      3Q     Max 
-411625 -103194   21591   75787  381671 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)  
(Intercept)  7.295e+04  1.394e+05   0.523   0.6150  
X1           5.026e+04  2.195e+04   2.290   0.0513 .
X2           1.404e+00  1.648e+00   0.852   0.4189  
X3          -5.956e-01  4.022e-01  -1.481   0.1769  
X4          -4.711e+02  8.920e+03  -0.053   0.9592  
X5           9.963e+04  2.017e+05   0.494   0.6346  
X6           3.402e+05  1.648e+05   2.064   0.0729 .
X7          -1.434e+04  7.277e+03  -1.971   0.0842 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 249300 on 8 degrees of freedom
Multiple R-squared:  0.8135,	Adjusted R-squared:  0.6503 
F-statistic: 4.984 on 7 and 8 DF,  p-value: 0.01901

> step <- stepAIC(fit, direction="both")
Start:  AIC=402.56
Y ~ X1 + X2 + X3 + X4 + X5 + X6 + X7

       Df  Sum of Sq        RSS    AIC
- X4    1 1.7339e+08 4.9748e+11 400.56
- X5    1 1.5166e+10 5.1248e+11 401.04
- X2    1 4.5151e+10 5.4246e+11 401.95
<none>               4.9731e+11 402.56
- X3    1 1.3632e+11 6.3363e+11 404.43
- X7    1 2.4152e+11 7.3883e+11 406.89
- X6    1 2.6478e+11 7.6209e+11 407.39
- X1    1 3.2601e+11 8.2332e+11 408.62
```

```
Step:  AIC=400.56
Y ~ X1 + X2 + X3 + X5 + X6 + X7

       Df  Sum of Sq        RSS    AIC
<none>                 4.9748e+11 400.56
- X2    1 1.1653e+11 6.1401e+11 401.93
+ X4    1 1.7339e+08 4.9731e+11 402.56
- X7    1 2.6622e+11 7.6370e+11 405.42
- X3    1 2.9791e+11 7.9539e+11 406.07
- X6    1 3.1125e+11 8.0873e+11 406.34
- X1    1 3.2641e+11 8.2389e+11 406.64
- X5    1 4.9269e+11 9.9017e+11 409.58
> step$anova # display results
Stepwise Model Path
Analysis of Deviance Table

Initial Model:
Y ~ X1 + X2 + X3 + X4 + X5 + X6 + X7

Final Model:
Y ~ X1 + X2 + X3 + X5 + X6 + X7


  Step Df  Deviance Resid. Df   Resid. Dev      AIC
1                           8 497309290218 402.5582
2 - X4  1 173393098         9 497482683316 400.5638

lm(formula = Y ~ X1 + X2 + X3 + X5 + X6 + X7, data = dat)

Residuals:
    Min      1Q  Median      3Q     Max
-409925 -102515   20701   75422  376313

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  7.538e+04  1.241e+05   0.608   0.5585
X1           5.028e+04  2.069e+04   2.430   0.0380 *
X2           1.334e+00  9.189e-01   1.452   0.1805
X3          -5.797e-01  2.497e-01  -2.322   0.0454 *
X5           8.911e+04  2.985e+04   2.986   0.0153 *
X6           3.433e+05  1.447e+05   2.373   0.0417 *
X7          -1.445e+04  6.585e+03  -2.195   0.0558 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 235100 on 9 degrees of freedom
Multiple R-squared:  0.8134,   Adjusted R-squared:  0.689
F-statistic: 6.539 on 6 and 9 DF,  p-value: 0.006728
```

The above model is further improved by removing the constant term as:

```
lm(formula = Y ~ X1 + X2 + X3 + X5 + X6 + X7 - 1, data = dat)

Residuals:
    Min      1Q  Median      3Q     Max
-376439 -110815   38928  109890  392487

Coefficients:
     Estimate Std. Error t value Pr(>|t|)
X1  5.498e+04  1.858e+04   2.959   0.0143 *
X2  1.508e+00  8.451e-01   1.785   0.1047
X3 -6.373e-01  2.236e-01  -2.850   0.0172 *
X5  9.344e+04  2.805e+04   3.331   0.0076 **
X6  3.640e+05  1.361e+05   2.674   0.0233 *
X7 -1.543e+04  6.182e+03  -2.496   0.0317 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
Residual standard error: 227600 on 10 degrees of freedom
Multiple R-squared:  0.9457,	Adjusted R-squared:  0.9132
F-statistic: 29.05 on 6 and 10 DF,  p-value: 9.002e-06
```

Best Model:

Y = 5.498e+04 X1 + 1.508 X2-6.373e-01 X3 +9.344e+04 X5 +3.640e+05 X6-1.543e+04 X7

```
lm(formula = Y ~ X1 + X3 + X5 + X6 + X7, data = dat)

Residuals:
    Min      1Q  Median      3Q     Max 
-384839  -80055   -1961  100517  417428 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)   
(Intercept)  1.315e+05  1.243e+05   1.058  0.31473   
X1           3.097e+04  1.671e+04   1.854  0.09345 . 
X3          -3.002e-01  1.677e-01  -1.791  0.10361   
X5           7.349e+04  2.934e+04   2.505  0.03120 * 
X6           4.544e+05  1.295e+05   3.510  0.00563 **
X7          -8.916e+03  5.659e+03  -1.576  0.14619   
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 247800 on 10 degrees of freedom
Multiple R-squared:  0.7697,	Adjusted R-squared:  0.6546 
F-statistic: 6.684 on 5 and 10 DF,  p-value: 0.005524
lm(formula = log(Y) ~ X1 + X2 + X3 + X5 + X6 + X7, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.88986 -0.20895  0.03023  0.20952  0.72794 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept)  1.182e+01  2.844e-01  41.563 1.35e-11 ***
X1           1.008e-01  4.743e-02   2.125   0.0625 .  
X2           3.276e-06  2.106e-06   1.555   0.1543    
X3          -1.236e-06  5.723e-07  -2.161   0.0590 .  
X5           1.352e-01  6.841e-02   1.977   0.0794 .  
X6           6.884e-01  3.317e-01   2.076   0.0677 .  
X7          -2.536e-02  1.509e-02  -1.680   0.1272    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.5389 on 9 degrees of freedom
Multiple R-squared:  0.7679,	Adjusted R-squared:  0.6131 
F-statistic: 4.962 on 6 and 9 DF,  p-value: 0.01644


> fit <- lm(log(Y)~log(X1)+log(X2)+log(X3)+log(X4)+log(X5)+log(X6)+log(X7),da
ta=dat)
> step <- stepAIC(fit, direction="both")
Start:  AIC=-12.49
log(Y) ~ log(X1) + log(X2) + log(X3) + log(X4) + log(X5) + log(X6) + 
    log(X7)

          Df Sum of Sq    RSS      AIC
- log(X7)  1   0.00001 2.6969 -14.4876
- log(X1)  1   0.00031 2.6972 -14.4858
```

```
- log(X3)  1   0.00735 2.7043 -14.4441
- log(X5)  1   0.10284 2.7998 -13.8889
- log(X4)  1   0.18722 2.8841 -13.4138
- log(X2)  1   0.24311 2.9400 -13.1067
<none>                 2.6969 -12.4877
- log(X6)  1   1.34609 4.0430  -8.0096

Step:  AIC=-14.49
log(Y) ~ log(X1) + log(X2) + log(X3) + log(X4) + log(X5) + log(X6)

          Df Sum of Sq    RSS      AIC
- log(X1)  1   0.00327 2.7002 -16.4682
- log(X3)  1   0.01081 2.7077 -16.4236
- log(X5)  1   0.10588 2.8028 -15.8715
- log(X4)  1   0.20802 2.9049 -15.2988
- log(X2)  1   0.24435 2.9413 -15.0999
<none>                 2.6969 -14.4876
+ log(X7)  1   0.00001 2.6969 -12.4877
- log(X6)  1   1.41574 4.1127  -9.7363

Step:  AIC=-16.47
log(Y) ~ log(X2) + log(X3) + log(X4) + log(X5) + log(X6)

          Df Sum of Sq    RSS     AIC
- log(X3)  1   0.03500 2.7352 -18.262
- log(X5)  1   0.22413 2.9243 -17.192
- log(X4)  1   0.29390 2.9941 -16.815
- log(X2)  1   0.30429 3.0045 -16.760
<none>                 2.7002 -16.468
+ log(X1)  1   0.00327 2.6969 -14.488
+ log(X7)  1   0.00297 2.6972 -14.486
- log(X6)  1   1.67766 4.3779 -10.736

Step:  AIC=-18.26
log(Y) ~ log(X2) + log(X4) + log(X5) + log(X6)

          Df Sum of Sq    RSS     AIC
- log(X5)  1   0.19115 2.9263 -19.181
- log(X4)  1   0.28410 3.0193 -18.681
- log(X2)  1   0.28772 3.0229 -18.662
<none>                 2.7352 -18.262
+ log(X3)  1   0.03500 2.7002 -16.468
+ log(X1)  1   0.02746 2.7077 -16.424
+ log(X7)  1   0.01697 2.7182 -16.362
- log(X6)  1   2.38630 5.1215 -10.226

Step:  AIC=-19.18
log(Y) ~ log(X2) + log(X4) + log(X6)

          Df Sum of Sq    RSS     AIC
- log(X4)  1   0.09359 3.0199 -20.678
- log(X2)  1   0.17281 3.0991 -20.263
<none>                 2.9263 -19.181
+ log(X5)  1   0.19115 2.7352 -18.262
+ log(X7)  1   0.09568 2.8307 -17.713
+ log(X1)  1   0.09390 2.8324 -17.703
+ log(X3)  1   0.00202 2.9243 -17.192
- log(X6)  1   2.20652 5.1329 -12.191

Step:  AIC=-20.68
log(Y) ~ log(X2) + log(X6)

          Df Sum of Sq    RSS     AIC
- log(X2)  1   0.07922 3.0992 -22.263
<none>                 3.0199 -20.678
+ log(X7)  1   0.13025 2.8897 -19.383
+ log(X1)  1   0.10810 2.9118 -19.261
+ log(X4)  1   0.09359 2.9263 -19.181
```

```
+ log(X3)  1   0.01774 3.0022 -18.772
+ log(X5)  1   0.00064 3.0193 -18.681
- log(X6)  1   2.44891 5.4688 -13.176

Step:  AIC=-22.26
log(Y) ~ log(X6)

          Df Sum of Sq     RSS      AIC
<none>                  3.0992 -22.2633
+ log(X1)  1    0.1222  2.9770 -20.9067
+ log(X7)  1    0.1162  2.9829 -20.8749
+ log(X2)  1    0.0792  3.0199 -20.6777
+ log(X5)  1    0.0177  3.0814 -20.3550
+ log(X3)  1    0.0001  3.0990 -20.2639
+ log(X4)  1    0.0000  3.0991 -20.2634
- log(X6)  1    8.1619 11.2611  -3.6198
> step$anova # display results
Stepwise Model Path 
Analysis of Deviance Table

Initial Model:
log(Y) ~ log(X1) + log(X2) + log(X3) + log(X4) + log(X5) + log(X6) + 
    log(X7)

Final Model:
log(Y) ~ log(X6)


       Step Df     Deviance Resid. Df Resid. Dev       AIC
1                                   8   2.696917 -12.48767
2 - log(X7)  1 5.828275e-06         9   2.696923 -14.48764
3 - log(X1)  1 3.271779e-03        10   2.700195 -16.46824
4 - log(X3)  1 3.499924e-02        11   2.735194 -18.26218
5 - log(X5)  1 1.911463e-01        12   2.926340 -19.18138
6 - log(X4)  1 9.359336e-02        13   3.019934 -20.67766
7 - log(X2)  1 7.922411e-02        14   3.099158 -22.26333
> fit1 <- lm(log(Y)~log(X6),data=dat)
> summary(fit1)

Call:
lm(formula = log(Y) ~ log(X6), data = dat)

Residuals:
    Min      1Q  Median      3Q     Max 
-1.2258 -0.2424  0.0824  0.3799  0.5045 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  13.4552     0.1304 103.163  < 2e-16 ***
log(X6)       0.6243     0.1028   6.072 2.88e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4705 on 14 degrees of freedom
Multiple R-squared:  0.7248,	Adjusted R-squared:  0.7051 
F-statistic: 36.87 on 1 and 14 DF,  p-value: 2.876e-05
```

BEST MODEL:

Y = 697459.69* X6^0.6243

9. Property Class: Commercial

Only 3 data points, no reliable model can be fitted.

Appendix E
Key to Regression Results

Key to Regression Results

Example

Conducted a bivariate regression analysis to test if impervious area (x) significantly predicts total costs (y) of a BMP facility. Since data are not normally distributed, completed a log-log transformation of the data. Table # summarizes the regression output and the results show that impervious area explains 27 percent of variance in total costs (R^2=0.27, $F(1,83)$=30.5, p<0.001). Also, the regression shows that impervious area significantly predicted total costs (β=0.37, p<0.001) and the predictive model includes the following:

$y = \beta_0 + \beta_1 * x$

$\ln(y) = \beta_0 + \beta_1 * \ln(x)$

$y = \exp(11.42) * x^{0.37}$

Table #. Bivariate Regression Output (Total Costs vs. Impervious Area)

Regression Statistics	
R Square	0.27
Adjusted R Square	0.26
Standard Error	0.69
Observations	85.00

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.00	14.69	14.69	30.50	<0.001
Residual	83.00	39.98	0.48		
Total	84.00	54.67			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	11.42	0.13	85.98	<0.001	11.15	11.68
ln(IA)	0.37	0.07	5.52	<0.001	0.23	0.50

Where:

x is the value predictor variable

β_0 is the intercept coefficient

β_1 is the predictor variable coefficient, in the example natural log of impervious area. The p-value is used to determine if predictor variable is significant.

R^2 is the correlation coefficient that helps identify the linear relationship between two variables and is not indictive of causation.

F is the calculated F statistic and is used to help determine the significance of the regression model.

Significance F is the p-value associated with the test statistic, assuming a two tail test and alpha = 0.05.

Appendix F
Example Payment Calculation Comparisons

Appendix F – Payment Calculation Examples

Regional Stormwater Management Program - Comparison Calculations

Commercial/Multi-Family Residential/Mixed Use – Straight Commercial Example

Payment Component	Current Payment ($)	Recommended Payment – Separate ($)	Recommended Payment – Combined ($)
Construction Cost	$179,498.88	$318,200.00	$348,400.00
Land Cost	$42,000.00	$99,911.00	$99,911.00
Total Payment	**$221,498.88**	**$418,111.00**	**$448,311.00**

Site Information: Site area: 7 acres, 80% proposed impervious cover (**increase from 0% to 80%**), appraisal of $250,000/acre

Commercial/Multi-Family Residential/Mixed Use – Straight Commercial Example

Payment Component	Current Payment ($)	Recommended Payment – Separate ($)	Recommended Payment – Combined ($)
Construction Cost	$133,944.24	$171,400.00	$203,400.00
Land Cost	$42,000.00	$99,911.00	$99,911.00
Total Payment	**$175,944.24**	**$271,311.00**	**$303,311.00**

Site Information: Site area: 7 acres, 80% proposed impervious cover (**increase from 50% to 80%**), appraisal of $250,000/acre

Single Family Residential – Large Development Example

Payment Component	Current Payment ($)	Recommended Payment – Separate ($)	Recommended Payment – Combined ($)
Construction Cost	$331,461.00	$876,000.00	$796,000.00
Land Cost	$120,000.00	$347,238.00	$347,238.00
Total Payment	**$451,461.00**	**$1,223,238.00**	**$1,143,238.00**

Site Information: 60 acres, 50% proposed impervious cover (**increase from 0% to 50%**), appraisal of $150,000 / acre

Commercial/Multi-Family Residential/Mixed Use – Multi-family/Mixed-Use Example (like a high rise residential with retail on the first floor)

Payment Component	Current Payment ($)	Recommended Payment – Separate ($)	Recommended Payment – Combined ($)
Construction Cost	$29,066.58	$29,355.00	$36,765.00
Land Cost	$1,800.00	$15,923.28	$15,923.28
Total Payment	**$30,866.58**	**$45,278.28**	**$52,688.28**

Site Information: 0.3 acres, 95% proposed impervious cover (**increase from 0% to 95%**), appraisal of $800,000 / acre

Commercial/Multi-Family Residential/Mixed Use – Multi-family/Mixed-Use Example (like a high rise residential with retail on the first floor)

Payment Component	Current Payment ($)	Recommended Payment – Separate ($)	Recommended Payment – Combined ($)
Construction Cost	$4,589.46	$4,635.00	$5,805.00
Land Cost	$1,800.00	$15,923.28	$15,923.28
Total Payment	**$6,389.46**	**$20,558.28**	**$21,728.28**

Site Information: 0.3 acres, 95% proposed impervious cover (**increase from 80% to 95%**), appraisal of $800,000 / acre

Single Family Residential – Small Lot Example (1 into 2 or 3)

Payment Component	Current Payment ($)	Recommended Payment – Separate ($)	Recommended Payment – Combined ($)
Construction Cost	$13,385.93	$47,025.00	$29,025.00
Land Cost	$1,000.00	$8,874.25	$8,874.25
Total Payment	**$14,385.93**	**$55,899.25**	**$37,899.25**

Site Information: 0.5 acres, 45% proposed impervious cover (**increase from 0% to 45%**), appraisal of $500,000 / acre

Single Family Residential – Small Lot Example (1 into 2 or 3)

Payment Component	Current Payment ($)	Recommended Payment – Separate ($)	Recommended Payment – Combined ($)
Construction Cost	$8,923.95	$31,350.00	$19,350.00
Land Cost	$1,000.00	$8,874.25	$8,874.25
Total Payment	**$9,923.95**	**$40,224.25**	**$28,224.25**

Site Information: 0.5 acres, 45% proposed impervious cover (**increase from 15% to 45%**), appraisal of $500,000 / acre

Urban Watersheds Structural Control Fund - Comparison Calculations

Commercial/Multi-Family Residential/Mixed Use

Payment Component	Current Payment ($)	Recommended Payment – Combined ($)
Site Impervious Cover Component	$15,502.18	$32,490.00
Building Component	$7,200.00	$7,200.00
Site Area Component	$1,800.00	$64,000.01
Total Payment	**$24,502.18**	**$103,690.01**

Site Information: 0.3 acres, 95% proposed impervious cover (**increase from 0% to 95%**), appraisal of $800,000 / acre

Single Family Residential – Small Lot Example (1 into 2 or 3)

Payment Component	Current Payment ($)	Recommended Payment – Combined ($)
Site Impervious Cover Component	$15,389.71	$33,345.00
Building Component	$150.00	$150.00
Site Area Component	$2,600.00	$31,200.00
Total Payment	**$18,139.71**	**$64,695.00**

Site Information: 0.5 acres, 45% proposed impervious cover (**increase from 15% to 45%**), appraisal of $500,000 / acre

Appendix G
Readily Available Information, High-Level Comparison, Benchmark Analysis

Readily Available Information, High-Level Comparison, Benchmark Analysis

Payment in Lieu Stormwater Management Programs*

*Note those three entities selected for more detailed analysis are not included herein.

Alpharetta, Georgia	
Population	65,799 (estimated 2017)
Service Area	City of Alpharetta
ILF	Varies
Number of Applications per Year	Unknown
Options for participation	1. Required detention (including channel protection) must be met onsite. A minimum of 75% of the runoff reduction/water quality treatment must be provided onsite. The remainder of the runoff reduction/water quality treatment may be met by a fee-in-lieu payment. 2. Not available for parcels where a downstream property is negatively impacted.
Revenues	Unknown
Expenditures	Unknown
Staffing FTEs of ILF Program	Unknown
Key Users	Developers
Level of Use	Unknown
Eligibility Criteria	1. Projects must be constructed/implemented in the same watershed as the projects served by the runoff reduction. 2. Parcels being redeveloped, contingent upon approval by the Community Development Director. 3. Not available for parcels where a downstream property is negatively impacted by the current conditions or where increased runoff rate or volume from the new development will cause an adverse impact. 4. All of the required detention (including channel protection) must be met onsite. A minimum of 75% of the runoff reduction/water quality treatment must be provided on-site. The remainder of the runoff reduction/water quality treatment may be met by a fee-in-lieu payment
How is the fee calculated	1. One-time fee is based on the construction cost of the specific facility where volume credits are available. 2. O&M costs are funded through an O&M fee assessed annually.
Sources:	ACS U.S. Census City of Alpharetta Stormwater Management Design Manual

% = percent
ACS = American Community Survey
FTE = Full Time Employees
ILF = In Lieu of fee
O&M = operation and maintenance
U.S. = United States

DuPage County, Illinois

Population	930,128 (estimated 2017)
Service Area	DuPage County
ILF	PCBMP (Water Quality) Fee in Lieu: $500 per 1,000 square feet of new impervious area Detention Variance Fee: ● Salt Creek $133,000 per acre-foot ● East Branch DuPage River $106,000 per acre-foot ● West Branch DuPage River $ 94,000 per acre-foot ● Sawmill Creek $ 87,000 per acre-foot ● Des Plaines River Tributaries $133,000 per acre-foot ● Fox River Tributaries $ 81,000 per acre-foot
Number of Applications per Year	Unknown
Options for participation	If onsite SCM or detention infeasible
Revenues	$82,900 (estimated total, 2019)
Expenditures	$193,000 (estimated total, 2019)
Staffing FTEs of ILF Program	Unknown
Key Users	Developers
Level of Use	Unknown
Eligibility Criteria	1. If it is not practical to install a PCBMP, as defined, the applicant submit documentation and/or a narrative describing the hardship. If the Stormwater Director finds that installing a PCBMP is impractical, the applicant may participate. 2. Variances to site runoff storage requirements are granted by the Stormwater Director.
How is the fee calculated	Based on new impervious area added or detention variance (acre-foot)
Sources:	ACS U.S. Census DuPage County Countywide Stormwater And Flood Plain Ordinance, Revised 2013. http://www.dupageco.org/EDP/Stormwater_Management/Regulatory_Services/1420/ DuPage County, IL. Proposed FY2019 Financial Plan Executive & Financial Summaries

% = percent
ACS = American Community Survey
FTE = Full Time Employees
FY = fiscal year
ILF = In Lieu of fee
O&M = operation and maintenance
PCBMP = post-construction best management practice
SCM = Structural Control Measure
U.S. = United States

Green Bay, Wisconsin	
Population	105,116 (estimated 2017)
Service Area	Town of Green Bay
ILF	$2,700 per equivalent runoff unit (defined as 3,000 square feet)
Number of Applications per Year	Unknown
Options for participation	Unknown
Revenues	Unknown
Expenditures	Unknown
Staffing FTEs of ILF Program	Unknown
Key Users	Unknown
Level of Use	Unknown
Eligibility Criteria	Fee In Lieu Of Onsite Storm Water Management is available if a waiver of all or part of the minimum onsite storm water management is granted by the Director of Public Works or where a waiver is provided because adequate storm water facilities are provided by the City of Green Bay downstream of the proposed development.
How is the fee calculated	Negotiated individually, considering an “equitable distribution” of the cost of land, engineering design, and construction.
Sources:	ACS U.S. Census Green Bay Code of Ordinances, Chapter 30, Storm Water Management City of Green Bay Special Assessment Rates

$ = dollars
ACS = American Community Survey
FTE = Full Time Employees
ILF = In Lieu of fee
U.S. = United States

New Braunfels, Texas

Population	79,152 (estimated 2017)
Service Area	City of New Braunfels
ILF	1. One-family (unattached) and two family (duplex) residential developments, $600.00 per lot. 2. Residential development other than one-family and two-family, $0.14 per square foot of impervious cover. 3. Non-residential, $0.14 per square foot of impervious cover 4. The stormwater connection fee calculation shall not include the area of any drainage easements or rights of usage or permanent detention facilities if they are in a previous condition.
Number of Applications per Year	Unknown
Options for participation	1. On-site drainage improvements 2. Off-site drainage improvements 3. On-site and off-site drainage improvements 4. Stormwater connection fee in lieu of Options 1 -3.
Revenues	FY 2018 Budget: $75,000
Expenditures	FY 2018 CIP: $215,000
Staffing FTEs of ILF Program	Unknown
Key Users	Owners and/or developers of property to be developed
Level of Use	Unknown
Eligibility Criteria	Proposed development is located within 3,000 feet of a city drainage system, no appreciable downstream impact, connection to city drainage system available, and city drainage system has capacity to accept the stormwater.
How is the fee calculated	Fee determined by acreage, number of lots and property use
Sources:	ACS U.S. Census New Braunfels, Texas FY 2017-18 Proposed Budget and Plan of Municipal Services. Chapter 143 - Municipal Drainage Utility Systems

$ = dollars
ACS = American Community Survey
CIP = Capital Improvement Plan
FTE = Full Time Employees
FY = fiscal year
ILF = In Lieu of fee
U.S. = United States

Redmond, WA

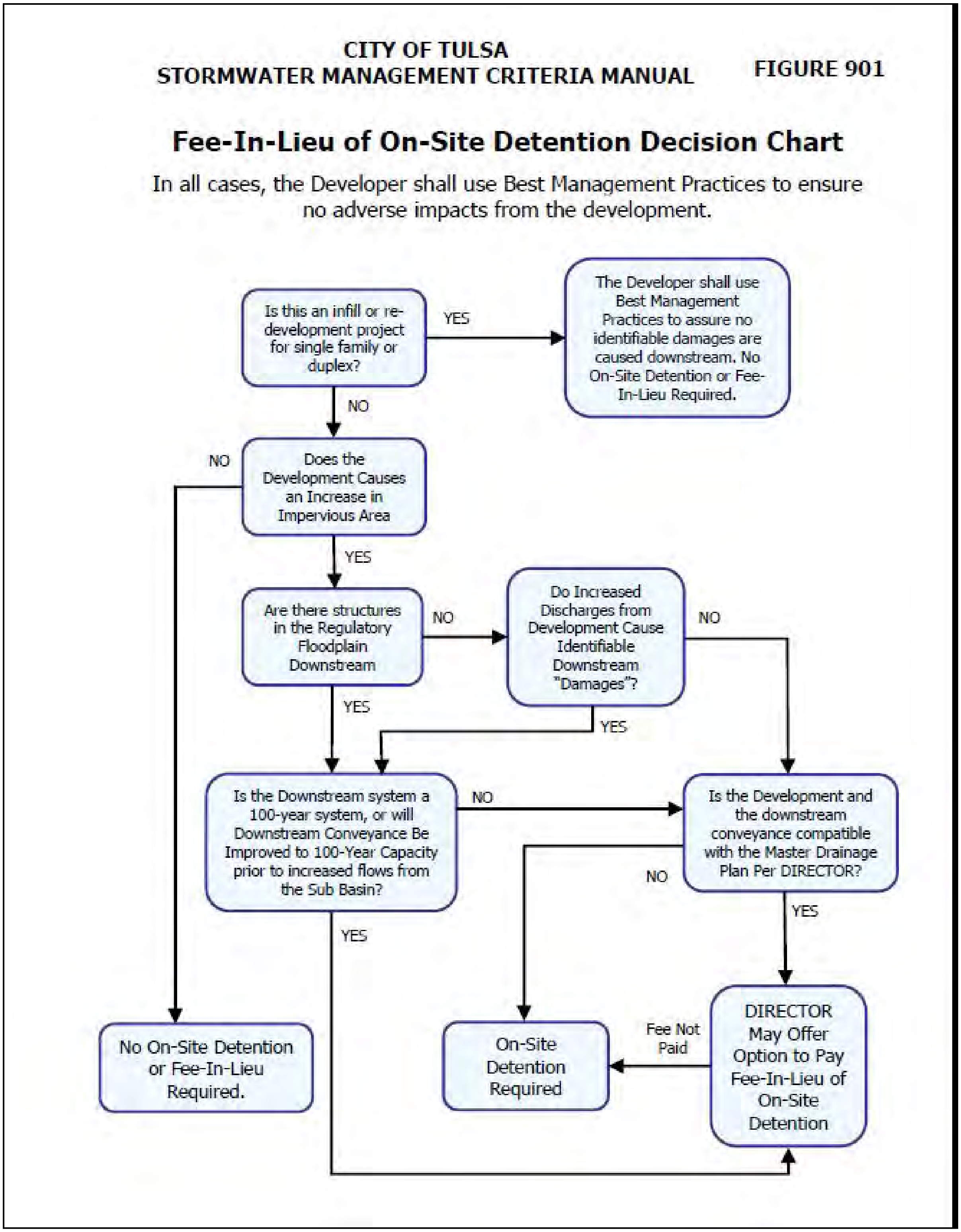
Population	64,291 (estimated 2017)
Service Area	City of Redmond
ILF	Citywide: $1,342 per impervious unit Downtown sub-basin: $5,979 per impervious unit Overlake sub-basin: $10,929 per impervious unit
Number of Applications per Year	Unknown
Options for participation	Stormwater capital facilities charges are assessed to all parcels that are proposed to be developed within the city.
Revenues	Unknown
Expenditures	Unknown
Staffing FTEs of ILF Program	Unknown
Key Users	Developers
Level of Use	Unknown
Eligibility Criteria	N/A
How is the fee calculated	One impervious unit = 2,000 square feet of impervious surface area, truncated (rounded down) to the nearest tenth. For the downtown and overlake sub-basin charges, an 80% credit is available for approved private infiltration facility meeting current standards.
Sources:	ACS U.S. Census City of Redmond Municipal Code Chapter 13.20 Stormwater Capital Facilities Charges.

% = percent
$ = dollars
ACS = American Community Survey
FTE = Full Time Employees
ILF = In Lieu of fee
N/A = not applicable
U.S. = United States

Tulsa, OK

Population	401,800 (estimated 2017)
Service Area	City of Tulsa
ILF	\$0.74 per ft^2 of increased impervious area
Number of Applications per Year	Unknown
Options for participation	All development
Revenues	Unknown
Expenditures	Unknown
Staffing FTEs of ILF Program	Unknown
Key Users	Developers
Level of Use	Unknown
Eligibility Criteria	1. The Master Drainage Plan for the watershed in which the development is located must include downstream storage or other improvements identified for "in lieu of" payments in place of on-site detention. 2. The developer must adequately demonstrate that "in lieu of" downstream storage or other improvements will mitigate the increased runoff from the development. 3. No direct identifiable adverse impacts to downstream properties. 4. See Figure 901 on the following page.
How is the fee calculated	Based on the proposed increase in impervious area, using the impervious area in the 1977 aerial photos as a basis, considering any changes since that time due to previous permits. If the development plan includes making improvements to the downstream capacity of the existing stormwater system, the developer will receive a credit, based on the amount of increase planned.
Sources:	ACS U.S. Census City of Tulsa Stormwater Criteria Manual

ACS = American Community Survey
ft^2 = square feet
FTE = Full Time Employees
FY = fiscal year
ILF = In Lieu of fee
O&M = operation and maintenance
PCBMP = post-construction best management practice
SCM = Structural Control Measure
U.S. = United States



Source: Fee-in-Lieu of Detention, Tulsa, Oklahoma: Best Management Practice (Presentation), accessed via [*http://www.floods.org/ace-files/Conferences/OKC/ppts/Fee-in-Lieu_Detention_Tulsa_OK_Robison.pptx*](http://www.floods.org/ace-files/Conferences/OKC/ppts/Fee-in-Lieu_Detention_Tulsa_OK_Robison.pptx)

Universal City, Texas

Population	20,532 (estimated 2017)
Service Area	City of Universal City
ILF	Single Family: Unconfirmed Multi Family: \$0.15 per ft^2 Commercial/Industrial: \$0.20 per ft^2 Public Facilities (including schools): \$0.15 per ft^2 Building permits with additional impervious area: \$0.15 per ft^2
Number of Applications per Year	Unknown
Options for participation	1. Payment of a fee in lieu of on-site detention. 2. Construction of a RSWDF to mitigate an existing flooding problem with contributions from the City and/or other property owners. 3. Participation in the construction of a RSWDF by another owner, developer, or builder to mitigate increased stormwater runoff anticipated by the ultimate development of the watershed. 4. Other methods authorized by the City Manager or his designee.
Revenues	Unknown
Expenditures	Unknown
Staffing FTEs of ILF Program	Unknown
Key Users	Developers
Level of Use	Unknown
Eligibility Criteria	1. Sites must be available for regional stormwater facilities in the same watershed as the development 2. No significant adverse impact to other properties downstream
How is the fee calculated	Increase in impervious area multiplied by appropriate rate (by land use type)
Notes:	The Stormwater Detention and Runoff Control Ordinance states, "The City has determined that regional stormwater detention is preferable to site specific detention." The discussion of the Regional Stormwater Detention Program is extremely similar to CoSA's, including definition of adverse impact to be within 2,000 feet downstream of the facility.
Sources:	ACS US Census. Universal City, Texas Ordinance No. 569-D-2014 Universal City Stormwater Detention and Runoff Control Ordinance City of Universal City Development Services Department Residential Plan Submittal Checklist City of Universal City Development Services Department Commercial Plan Submittal Checklist

\$ = dollars
ACS = American Community Survey
CoSA = City of San Antonio
ft^2 = square feet
FTE = Full Time Employees
FY = fiscal year
ILF = In Lieu of fee
O&M = operation and maintenance
PCBMP = post-construction best management practice
RSWDF = regional stormwater detention facilities
SCM = Structural Control Measure
U.S. = United States

M E M O R A N D U M

TO: Kevin Shunk, P.E., CFM, Managing Engineer
Watershed Protection Department

FROM: Karl McArthur, P.E., CFM, Supervising Engineer
Watershed Protection Department

DATE: November 14, 2019

SUBJECT: Refinement of Payment Rate Structure for Regional Stormwater Management Program – Residential Development

The proposed rate structure for the Regional Stormwater Management Program (RSMP) payment calculation combines data for commercial/multi-family residential/mixed-use developments and single-family residential developments to produce a single combined cost curve that defines the construction component rate structure. The proposed rate structure correlates well with construction costs for most development types, however, it does not scale well to small residential developments. Cost data available for these small developments is very limited, but what is available supports a somewhat lower construction cost for these cases. Based on this finding, the Watershed Protection Department has adjusted the Proposed Combined rate structure from the study report for single family residential development. The purpose of this memorandum is to explain the refinement of the cost curves produced for the rate structure for the Construction Cost Component (CCC) of the payment calculation from the 2019 Payment Rate Structure Study Update for the Regional Stormwater Management Program and Urban Watersheds Structural Control Fund ("Regional Stormwater Management Program Participation Payment and Urban Watersheds Structural Control Fund Payment Methodology Modifications" 2019, CH2M Hill Engineers, Inc. report).

The refined Single-Family Residential Development construction cost rate structure adjusts the cost for the first acre of impervious cover and retains the combined costs for the larger areas. The rate for the first acre was adjusted based on the established cost curve shifting the value for the first acre from the midpoint of the 0 to 1-acre area range to the 75% point in this range. The adjustment to the cost for the first acre results in a lower payment amount than commercial/multi-family residential/mixed-use developments of the same size. The proposed Single-Family Residential Development rate structure for the CCC continues up to over 100 acres with the same $/acre rates as the Proposed Combined rate structure from the study report.

The following table compares the current Commercial and Residential rates for increasing impervious coverage from the 2002 Study, the current adjusted construction cost rates, and the proposed construction cost rates. "Current Commercial (Adjusted)" and "Current Residential (Adjusted)" use the Engineering New Record – Construction Cost Index Adjustment Factor (ENR CCI AF) of 1.6998 to adjust the current rates from 2002 to 2018 dollars. These adjusted amounts reflect the current rates for the RSMP program. The last two columns are the Proposed Commercial and Residential rate structures, which are identical except for the first acre rate for residential development. The proposed per acre costs will be adjusted annually based on the September ENR CCI AF divided by the September 2018 index value of 11170.28. This matches the current cost adjustment procedure with a reset of the index value.

Impervious Acres			**Cost per impervious acre**					
	From	To	2002 Commercial	2002 Residential	Current Commercial (Adjusted)	Current Residential (Adjusted)	Proposed Commercial	Proposed Residential
A1	0	1	$60,000	$35,000	$101,991	$59,495	$129,000	$103,000
A2	1.01	2	$18,000	$15,000	$30,597	$25,498	$70,000	$70,000
A3	2.01	5	$8,000	$10,000	$13,599	$16,998	$44,000	$44,000
A4	5.01	10	$6,000	$7,000	$10,199	$11,899	$29,000	$29,000
A5	10.01	20	$5,000	$5,000	$8,499	$8,499	$20,000	$20,000
A6	20.01	50	$4,000	$3,000	$6,799	$5,100	$12,000	$12,000
A7	50.01	100	$2,500	$2,000	$4,250	$3,400	$8,000	$8,000
A8	100.01	>	$2,500	$1,500	$4,250	$2,550	$4,000	$4,000

This proposed change to the rate structure means that a small single-family residential development (0.5 acres increasing impervious cover from 0% to 45%) would see a change from $13,386.28 to $23,175. A small multi-family and/or mixed-use development (0.7 acres increasing from 0% to 100%) would see a change from $81,592.56 to $103,200 for the Construction Cost Component. A large single-family residential development (60 acres increasing impervious cover from 0% to 50%) would see the Construction Cost Component change from $331,469.77 to $770,000. Refer to the example calculations presented below for details of these calculations.

The proposed changes to the Land Cost Component, which is the second half of the RSMP payment calculation, are documented in the full 2019 report. In brief, the static land value caps of $40,000/acre for single-family residential and $120,000/acre for commercial/multi-family residential/mixed-use will be removed and the calculation will be based on 80% of the appraised land value from either the appropriate appraisal district or a certified appraisal provided by the applicant. The assumption of 5% of a site being used for on-site detention was validated with this study and so will remain. An adjustment factor for impervious cover, which is identical to the one used for the Drainage Utility Fee (DUF), will be used to adjust the Land Cost Component based on the proposed impervious cover relative to the weighted City average. This provides additional relief primarily for small, lower density single family subdivision developments by adjusting the Land Cost Component downward.

As explained in this memorandum, the refined Proposed Combined CCC rate structure is recommended for the Proposed Residential CCC rate structure and the Proposed Combined CCC rate structure from the report is recommended for the Proposed Commercial CCC rate structure.

Examples Based on Refined Methodology for Single Family Subdivisions

Single-Family Residential Development Examples (Subdivision Cases Only)

Note: The examples presented are calculated based on fiscal year 2018 values. The ENR adjustment factor will change for subsequent years.

Single-Family Example (large development)		
Total Site Area (acres)	*60.0*	
	Existing	Proposed
Impervious Cover (%)	0%	50%
Impervious Cover (acres)	*0*	*30*
Land Appraisal ($/acre)	*$150,000.00*	
2018 ENR CCI AF (CCC)	1.6998	1.0000
I.C. AF (LCC)	n/a	0.9646
	Current Payment	**Proposed Payment**
Land Value ($/acre)	$40,000.00	$120,000.00
Construction Cost Component	$331,469.77	$770,000.00
Land Cost Component	$120,000.00	$347,238.00
Total	$451,469.77	$1,117,238.00

Single-Family Example (small resubdivision)		
Total Site Area (acres)	*0.5*	
	Existing	Proposed
Impervious Cover (%)	0%	45%
Impervious Cover (acres)	*0*	*0.225*
Land Appraisal ($/acre)	*$500,000.00*	
2018 ENR CCI AF (CCC)	1.6998	1.0000
I.C. AF (LCC)	n/a	0.8874
	Current Payment	**Proposed Payment**
Land Value ($/acre)	$40,000.00	$400,000.00
Construction Cost Component	$13,386.28	$23,175.00
Land Cost Component	$1,000.00	$8,874.25
Total	$14,386.28	$32,049.25

Single-Family Example (small resubdivision)		
Total Site Area (acres)	*0.5*	
	Existing	Proposed
Impervious Cover (%)	15%	45%
Impervious Cover (acres)	*0.075*	*0.225*
Land Appraisal ($/acre)	*$500,000.00*	
2018 ENR CCI AF (CCC)	1.6998	1.0000
I.C. AF (LCC)	n/a	0.8874
	Current Payment	**Proposed Payment**
Land Value ($/acre)	$40,000.00	$400,000.00
Construction Cost Component	$8,923.95	$15,450.00
Land Cost Component	$1,000.00	$8,874.25
Total	$9,923.95	$24,324.25

Examples using Combined Recommended Rate Structure without adjustment

Single-Family Example (large development)		
Total Site Area (acres)	*60.0*	
	Existing	Proposed
Impervious Cover (%)	0%	50%
Impervious Cover (acres)	*0*	*30*
Land Appraisal ($/acre)	*$150,000.00*	
2018 ENR CCI AF (CCC)	1.6998	1.0000
I.C. AF (LCC)	n/a	0.9646
	Current Payment Calculation	**Proposed Residential**
Land Value ($/acre)	$40,000.00	$120,000.00
Construction Cost Component	$331,461.00	$796,000.00
Land Cost Component	$120,000.00	$347,238.00
Total	$451,461.00	$1,143,238.00

Single-Family Example (small resubdivision)		
Total Site Area (acres)	*0.5*	
	Existing	Proposed
Impervious Cover (%)	0%	45%
Impervious Cover (acres)	*0*	*0.225*
Land Appraisal ($/acre)	*$500,000.00*	
2018 ENR CCI AF (CCC)	1.6998	1.0000
I.C. AF (LCC)	n/a	0.8874
	Current Payment Calculation	**Proposed Residential**
Land Value ($/acre)	$40,000.00	$400,000.00
Construction Cost Component	$13,385.93	$29,025.00
Land Cost Component	$1,000.00	$8,874.25
Total	$14,385.93	$37,899.25

Single-Family Example (small resubdivision)		
Total Site Area (acres)	*0.5*	
	Existing	Proposed
Impervious Cover (%)	15%	45%
Impervious Cover (acres)	*0.075*	*0.225*
Land Appraisal ($/acre)	*$500,000.00*	
2018 ENR CCI AF (CCC)	1.6998	1.0000
I.C. AF (LCC)	n/a	0.8874
	Current Payment Calculation	**Proposed Residential**
Land Value ($/acre)	$40,000.00	$400,000.00
Construction Cost Component	$8,923.95	$19,350.00
Land Cost Component	$1,000.00	$8,874.25
Total	$9,923.95	$28,224.25

Welcome!

- This is a stakeholder meeting for Regional Stormwater Management Program (RSMP) and Urban Watershed Structural Control Fund (UWSCF) Payment Structure Updates

- Please sign in and take a handout

- We will have time for questions after the presentation

Regional Stormwater Management Program Participation Payment and Urban Watersheds Structural Control Fund Payment Methodology Modifications

Tom Franke

Emily Booth

Karl McArthur

Agenda

- Introduction and Study Overview
- Payment Study Results and Recommendations
- Proposed Payment Structure Changes
- Next Steps
- Q&A

Introduction

- Alternative compliance through payment in lieu of on-site controls:
  - Detention (RSMP)
  - Water quality improvement facilities (UWSCF)
- Payments are meant to reflect the approximate cost of on-site controls
- Revenues used for regional facilities and other structural improvements
- Previous update occurred in 2002
- Recently completed study recommends updated payment structures

Study Overview

- Recent construction cost and land cost data
- Changes to land and construction costs
  - Payment structure recommendations
- Benchmarking of Austin’s RSMP against similar programs

Construction Costs

- Adjusted costs associated with projects used in 2002 study to 2018 values
- Collected additional stormwater control construction cost data,
  - some provided by Doucet+Chan,
  - others provided by WPD for accepted controls
- Developed updated cost curves (dollars per acre of impervious cover)

Land Costs

- Collected data of actual real estate sales to:
  - Develop descriptive statistics
  - Define alternatives to the current land cap values
- Re-evaluated use of appraisal district land costs
- Additional data from constructed controls
  - Validated assumption of 5% of total site area for a detention facility
  - Justified change from 5% to 3% for water quality facilities

Cost Indices

- Reviewed options for cost indices for construction costs
  - Consumer Price Index for all Urban Consumers
  - Engineering News-Record Construction Cost Index (used currently)
- Land Cost Considerations
  - Travis Central Appraisal District annual, overall appraisal roll growth, as a percent change

Study Results and Recommendations - RSMP CCC

- Update the CCC structure
  - Combine Commercial/Multi-family and Single-family rate structures
- ENR CCI as an annual inflation adjustment to the Construction Cost Component (CCC)
  - Adjustment factor baseline set to 2018 (from 2002)

Study Results and Recommendations – RSMP LCC

- Replace static land value cap with cap of 80% of the appraised land value
- Apply a one-time Impervious Cover Adjustment Factor (ICAF)
- Continue use of the assumption of 5% of the total site area as the area required for a detention facility

Highlights of Proposed Changes – Construction Cost Component

- Update rate structures for all land uses
- Adjustment of Single-Family Residential rate structure from Proposed Combined curve
- Use of Proposed Combined rate structure for Commercial/Multi-family/Mixed-use
- Update ENR CCI Adjustment Factor with 2018 baseline

Highlights of Proposed Changes – Land Cost Component

- Percentage of appraised land value (80%) rather than straight appraised land value with static cap
- Adjustment factor for relative impervious cover (from Drainage Charge calculation) added
  - The ICAF will only be applied to SF Residential and other sites that have a proposed impervious cover less than the weighted city average of 52.3%

Revised RSMP CCC Rate Structure

	Increase in Impervious Cover (acres)		Structure from 2002 Report		2002 Structure Adjusted to FY19 Values		Structure from 2018 Report with Revised Residential First Acre	
	From	To	Commercial	Residential	Current Commercial (Adjusted)	Current Residential (Adjusted)	Proposed Commercial	Proposed Residential
A1	0	1	$60,000	$35,000	$101,991	$59,495	$129,000	$103,000
A2	1.01	2	$18,000	$15,000	$30,597	$25,498	$70,000	$70,000
A3	2.01	5	$8,000	$10,000	$13,599	$16,998	$44,000	$44,000
A4	5.01	10	$6,000	$7,000	$10,199	$11,899	$29,000	$29,000
A5	10.01	20	$5,000	$5,000	$8,499	$8,499	$20,000	$20,000
A6	20.01	50	$4,000	$3,000	$6,799	$5,100	$12,000	$12,000
A7	50.01	100	$2,500	$2,000	$4,250	$3,400	$8,000	$8,000
A8	100.01	>	$2,500	$1,500	$4,250	$2,550	$4,000	$4,000

RSMP Calculation – Construction Cost Component

- CCC: each additional acre of impervious cover is multiplied by the updated rate structure
- ENR AF: the CCC subtotal is multiplied by an adjustment factor to account for changes in construction costs

RSMP Calculation – Land Cost Component

- LCC: (Value per acre)*80%*5%*(Land Cost Area)*ICAF
  - Value per acre is the Land Appraisal Value divided by the appraisal land area
  - Land Cost Area is the Total Site Area minus any deductible Land Area (in acres)
  - 80% is the cap of the land value
  - 5% is the assumed site area for detention
- ICAF: adjustment factor for lower-than-average relative impervious cover

Commercial RSMP Example

Total Site Area (acres)	*2.0*			
	Assume 0% Impervious		Assume Existing Impervious	
	Existing	Proposed	Existing	Proposed
Impervious Cover (%)	0%	80%	30%	80%
Impervious Cover (acres)	0	*1.6*	*0.6*	1.6
Land Appraisal ($/acre)	$250,000			
ENR CCI AF (CCC)	1.6998	1.0000	1.6998	1.0000
I.C. AF (LCC)	n/a	1.0000	n/a	1.000
	Current	Proposed	Current	Proposed
Land Value ($/acre)	$120,000	$200,000	$120,000	$200,000
Construction Cost Component	$120,346	$171,000	$101,988	$129,000
Land Cost Component	$12,000	$20,000	$12,000	$20,000
Total	**$120,346**	**$191,000**	**$113,988**	**$149,000**

Multi-family/Mixed Use RSMP Example

Total Site Area (acres)	0.5			
	Assume 0% Impervious		Assume Existing Impervious	
	Existing	Proposed	Existing	Proposed
Impervious Cover (%)	0%	90%	50%	90%
Impervious Cover (acres)	0	0.45	0.25	0.45
Land Appraisal ($/acre)	$2,000,000			
2018 ENR CCI AF (CCC)	1.6998	1.0000	1.6998	1.0000
I.C. AF (LCC)	n/a	1.0000	n/a	1.0000
	Current	Proposed	Current	Proposed
Land Value ($/acre)	$120,000	$1,600,000	$120,000	$1,600,000
Construction Cost Component	$45,895	$58,050	$20,398	$25,800
Land Cost Component	$3,000	$40,000	$3,000	$40,000
Total	**$48,895**	**$98,050**	**$23,398**	**$65,800**

Single Family (large development) RSMP Example

Total Site Area (acres)	60.0				
	Assume 0% Impervious			Assume Existing Impervious	
	Existing	Proposed	Report	Existing	Proposed
Impervious Cover (%)	0%	50%	50%	15%	50%
Impervious Cover (acres)	0	30	30	18	30
Land Appraisal ($/acre)	$150,000				
2018 ENR CCI AF (CCC)	1.6998	1.0000	1.0000	1.6998	1.0000
I.C. AF (LCC)	n/a	0.9646	0.9646	n/a	0.9646
	Current	Proposed	Report	Current	Proposed
Land Value ($/acre)	$40,000	$120,000	$120,000	$40,000	$120,000
Construction Cost Component	$331,461	$770,000	$796,000	$285,566	$662,000
Land Cost Component	$120,000	$347,238	$347,238	$120,000	$347,238
Total	**$451,461**	**$1,117,238**	**$1,143,238**	**$405,566**	**$1,009,238**

Single Family (small resubdivision) RSMP Example

Total Site Area (acres)	0.5				
	Assume 0% Impervious			Assume Existing Impervious	
	Existing	Proposed	Report	Existing	Proposed
Impervious Cover (%)	0%	45%	45%	30%	45%
Impervious Cover (acres)	0	0.225	0.225	0.075	0.225
Land Appraisal ($/acre)	$500,000				
2018 ENR CCI AF (CCC)	1.6998	1.0000	1.0000	1.6998	1.0000
I.C. AF (LCC)	n/a	0.8874	0.8874	n/a	0.8874
	Current	Proposed	Report	Current	Proposed
Land Value ($/acre)	$40,000	$400,000	$400,000	$40,000	$400,000
Construction Cost Component	$13,386	$23,175	$29,025	$4,462	$9,675
Land Cost Component	$1,000	$8,874	$8,874	$1,000	$8,874
Total	**$14,386**	**$32,049**	**$37,899**	**$5,462**	**$18,549**

Study Results and Recommendations – UWSCF

- Update the Site Impervious Cover Component (SICC) structure
- ENR CCI as an annual inflation adjustment to the SICC
- No changes to the Building Component
- Update Site Area Component (SAC) to reflect lower area assumed for WQ controls on-site
- Apply a land value cap of 80% to appraised land value

Highlights of Changes – Site Impervious Cover Component

- Update rate structure for all land uses
  - Break structure into more acre-groups
- Continue single rate structure for all land uses

Proposed UWSCF SICC Rate Structure

	Impervious Acres		Cost per impervious acre	
	From	To	Existing CO/MF/MU/SF*	Proposed CO/MF/MU/SF
A1	0	1	$ 52,614	$114,000
A2	1.01	2	$ 29,595	$58,000
A3	2.01	5	$ 18,086	$34,000
A3/A4	5.01	10	$ 18,086	$21,000
A4/A5	10.01	20	$ 13,153	$14,000
A5/A6	20.01	and greater	$ 9,865	$8,000

Highlights of Changes – Site Area Component

- Based on percentage of appraised land value (80%) rather than static cap per acre
- Lower area (3% instead of 5%) assumed for WQ controls on-site
- Site Area Component calculation includes specific site information for obtaining $/acre land value – similar to RSMP's LCC

UWSCF Calculation – Site Impervious Cover Component

- (SICC*ENR CCI AF) *+ Building Component* + SAC
- SICC: each additional acre of impervious cover is multiplied by the updated rate structure
- ENR AF: the SICC subtotal is multiplied by an adjustment factor to account for changes in construction costs

UWSCF Calculation – Building and Site Area Components

- *Building Component = $0.10/SF * (Building SF)*
- SAC = 80% * (Appraised Land Value/ Appraised Land Area) * 3% * Site Area
  - 80% is the cap of the land value
  - 3% is the assumed site area for WQ facility
- Building Component might be removed from the calculation

Commercial/ MF/ MU – UWSCF Example

Redeveloped Impervious (acres)	0.25	50% Existing Impervious
New Impervious (acres)	0.2	
Total Impervious (acres)	0.45	90% Proposed Impervious
R/T	0.316	
Building Area (SF)	72,000	
Commercial/Multifamily Site (acres)	0.500	this is LOC if greater than site area
Commercial/Multifamily Site ($)	$6,000	
Appraised Land Value ($)		$2,000,000
Appraised Land Area (acres)		0.5
	Current	Proposed Combined
Site Impervious Cover Component	$24,477	$51,300
Building Component	$7,200	$7,200
Site Area Component	$3,000	$48,000
Total	**$34,677**	**$106,500**

Commercial/ MF/ MU – UWSCF Example

Redeveloped Impervious (acres)	0	0% Existing Impervious
New Impervious (acres)	0.4	
Total Impervious (acres)	0.4	90% Proposed Impervious
R/T	0.000	
Building Area (SF)	72,000	e.g. 12,000 SF building with 6 floors
Commercial/Multifamily Site (acres)	0.500	this is LOC if greater than site area
Commercial/Multifamily Site ($)	$6,000	
Appraised Land Value ($)		$2,000,000
Appraised Land Area (acres)		0.5
	Current	Proposed Combined
Site Impervious Cover Component	$21,757	$51,300
Building Component	$7,200	$7,200
Site Area Component	$3,000	$48,000
Total	**$31,957**	**$106,500**

Single Family – UWSCF Example

Redeveloped Impervious (acres)	0.15	30% Existing Impervious
New Impervious (acres)	0.075	
Total Impervious (acres)	0.225	45% Proposed Impervious
R/T	0.400	
Building Area (SF)	1,500	
Single Family or Duplex Site (acres)	0.500	
Single Family or Duplex Site ($)	$4,000	
Appraised Land Value ($)		$500,000
Appraised Land Area (acres)		0.5
Component	Current	Proposed
Site Impervious Cover Component	$11,838	$25,650
Building Component	$150	$150
Site Area Component	$2,000	$12,000
Total	**$13,988**	**$37,800**

Next Steps

- Potential changes due to stakeholder feedback and discussions
- Planning for proposed rates to become effective for FY2021
- Rules posting for DCM/ECM changes to reflect these proposed rates
- Update payment calculators with appropriate CCI adjustment factor (reset baseline from 2002 to 2018 and adjust to 2019 in calculator).

Questions?

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Regional Stormwater Management Program Participation Payment and Urban Watersheds Structural Control Fund Payment Methodology Modifications

Important Terms and Equations

Acronyms/Terms

UWSCF – Urban Watersheds Structural Control Fund
SICC – Site Impervious Cover Component
SAC – Site Area Component
RSMP – Regional Stormwater Management Program
CCC – Construction Cost Component
LCC – Land Cost Component
ENR CCI AF – Engineering News Record Construction Cost Index Adjustment Factor
ICAF – Impervious Cover Adjustment Factor

Equations

UWSCF Payment Calc: (SICC*ENR CCI AF) *+ Building Component* + SAC

RSMP Payment Calc: (CCC*ENR CCI AF) + (LCC*ICAF)

> Where SICC and CCC use the proposed rate structures
>
> units are [$/acre (different rates) * acres = $]
>
> where ICAF is set to 1 for sites with above-average I.C.

*Building Component = $0.10/SF * Building SF*

> *Potentially going to be removed from calculation*
>
> *units are [$/SF * SF = $]*

SAC = 80% * (Appraised Land Value/ Appraised Land Area) * 3% * Site Area

> units are [$/acre * acre = $]

LCC = 80% * (Appraised Land Value/ Appraised Land Area) * 5% * (Land Cost Area)

> units are [$/acre * acre = $]
>
> Where Land Cost Area may include deductions from the total site area for things like dedicated floodplain easements – these are determined on a site by site basis by Watershed staff
>
> ICAF = (1.5425 x percent [proposed total] impervious cover) + 0.1933
>
> The impervious cover adjustment factor is from the Drainage Charge calculation and adjusts the land cost component up or down based on the total proposed impervious cover relative to the City's weighted average impervious cover (52.3%).