Stormwater Runoff Reduction by Street-Side Water Harvesting Features

Jennifer Psillas
Tucson Area GIS Cooperative
June 12, 2015

Assessing the Effect of Street-Side Water Harvesting on Stormwater Storage Capacity and Runoff Generation in the Rincon Heights Neighborhood, Tucson, Arizona

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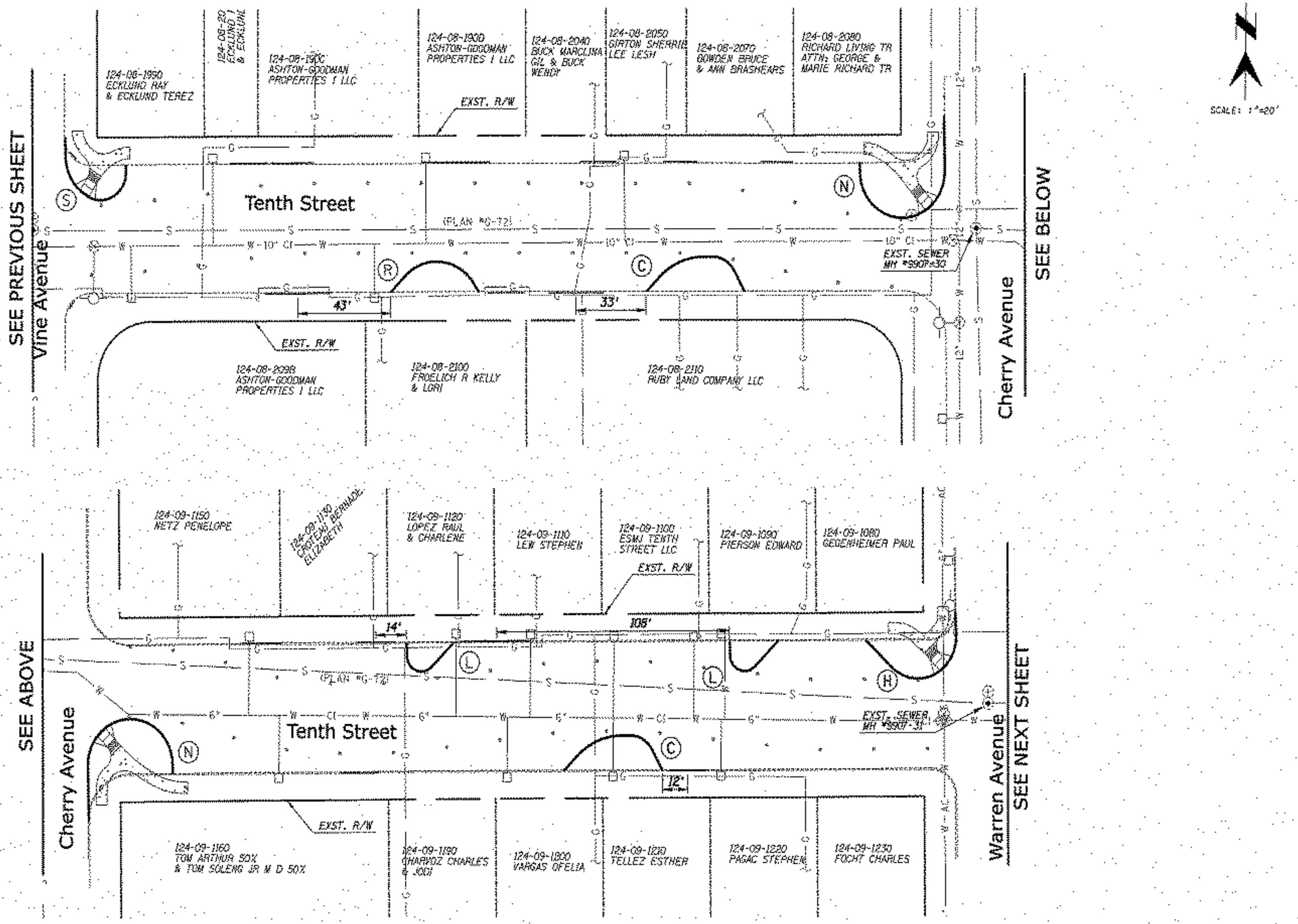
North Park Avenue south of East Adams Street
Photo: The University of Arizona, CLIMAS

East Drachman Street west of North Tyndall Avenue
Photo: Raquel Baranow

North Park Avenue and East 6th Street
Photo: John Brost

Problem – Rincon Heights

- Streets flooding
  - Stormwater runoff
- Non-point source pollution
  - Rincon Heights neighborhood
  - High School wash
- Vehicular Traffic



TENTH STREET IMPROVEMENTS

EEC Job No. 206002.05

DEPARTMENT OF TRANSPORTATION/ENGINEERING DIVISION

RINCON HEIGHTS NEIGHBORHOOD REINVESTMENT

11 of 22

CITY OF TUCSON

DSGN BY	KJH	07/08	
DRWN BY	DRE	07/08	
CHKD BY	SAM	07/08	PLAN NO. U-2007-016

NO.	DATE	REVISION	BY	CK	APPR

Expires 9-30-11

1-800-782-5348

Low Impact Development (LID)

- Manages stormwater as close to its source as possible
- Works with conventional flood control measures
- Decentralized, distributed system
- Incorporates natural design
- First line of defense; first flush, ½-inch runoff


Photo: Watershed Management Group

Photo: Watershed Management Group

Photo: Watershed Management Group

Photo: Watershed Management Group

Objectives

- Assess the potential effects street-side water harvesting chicanes have on the quantity of stormwater runoff in the Rincon Heights neighborhood study area
  - Stormwater storage capacity
  - Stormwater runoff generation

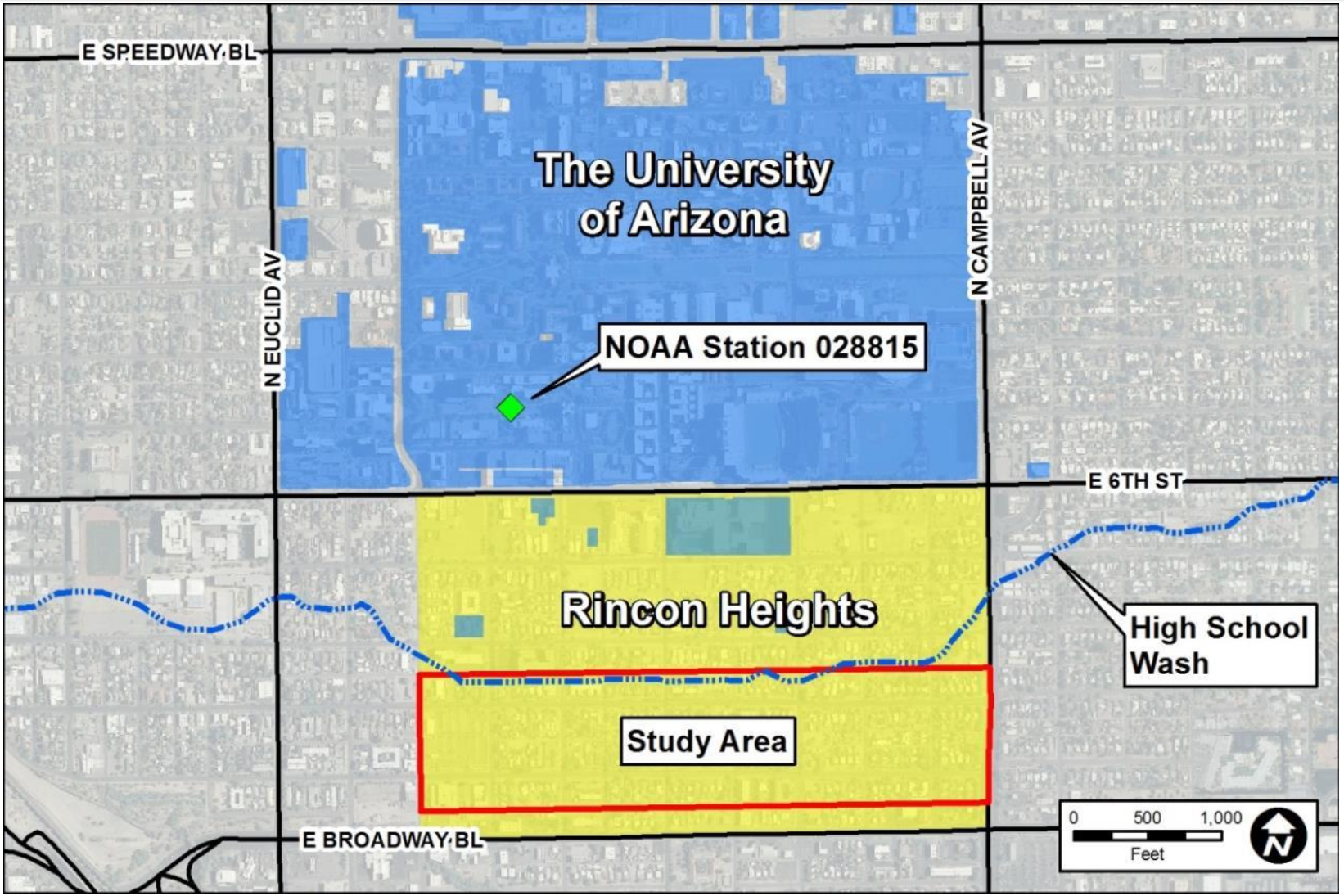
Objectives

- Storage capacity
  - Increase
  - Designed to retain water in basins
- Runoff Generation
  - Decrease
  - Change in Land Cover
- Total Stormwater Runoff Reduction

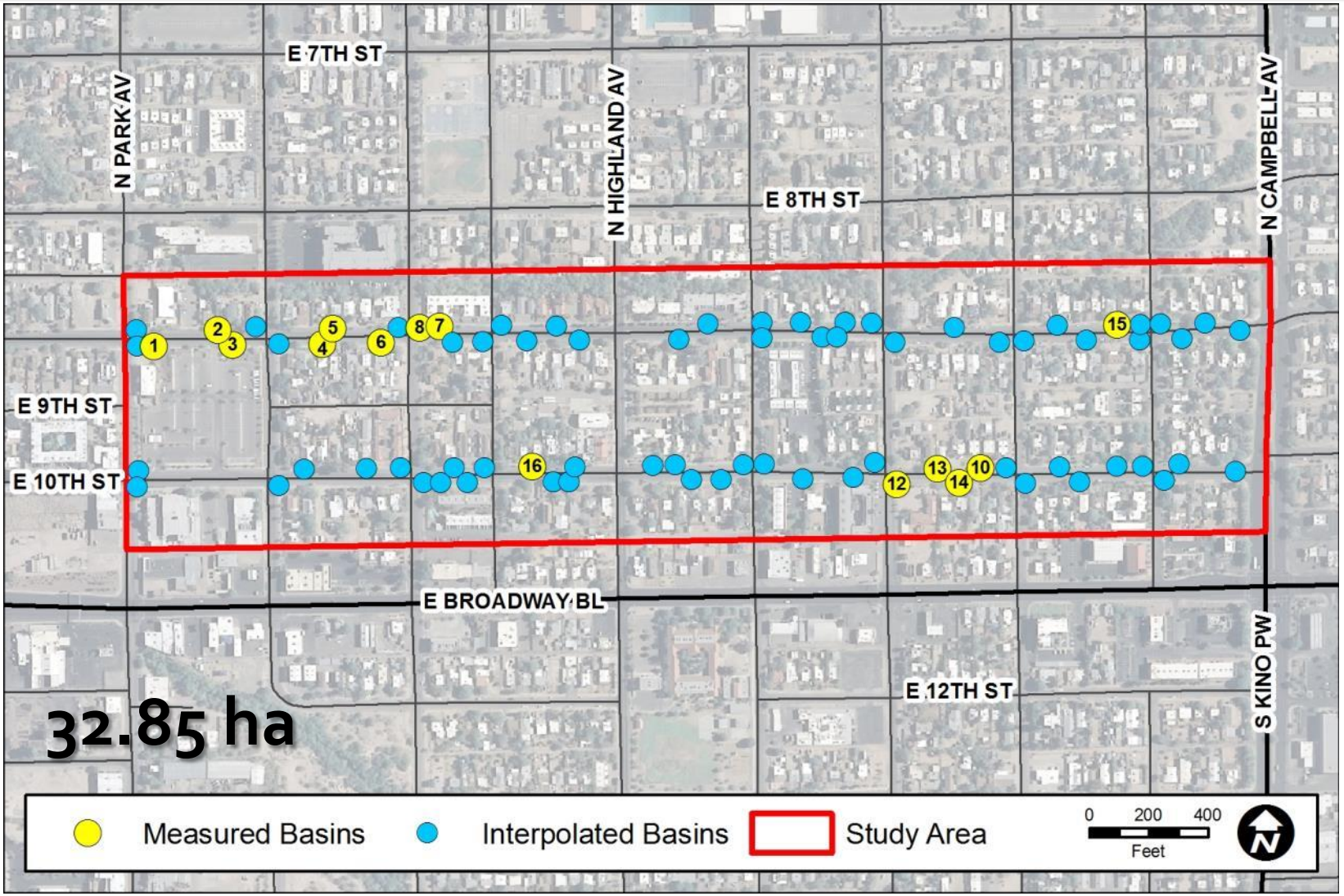
Assumptions

1) All chicanes are functioning as designed.
2) Every chicane receives runoff.
3) Rainfall is distributed uniformly.
4) Rainfall is retained with chicanes' basins.
5) No other water harvesting features.

Study Area


E SPEEDWAY BL
N EUCLID AV
The University of Arizona
N CAMPBELL AV
NOAA Station 028815
E 6TH ST
Rincon Heights
High School Wash
Study Area
E BROADWAY BL
0
500
1,000
Feet
N

Study Area


E 7TH ST
N PARK AV
N HIGHLAND AV
E 8TH ST
N CAMPBELL AV
E 9TH ST
E 10TH ST
E BROADWAY BL
E 12TH ST
S KINO PW
1
2
3
4
5
6
7
8
10
12
13
14
15
16
32.85 ha
Measured Basins
Interpolated Basins
Study Area
0
200
400
Feet
N

Mid-Block Basin

Photo: Watershed Management Group

Corner Basin

Photo: Watershed Management Group

Median Basin

Photo: Watershed Management Group

Methods

Methods – Storage Capacity

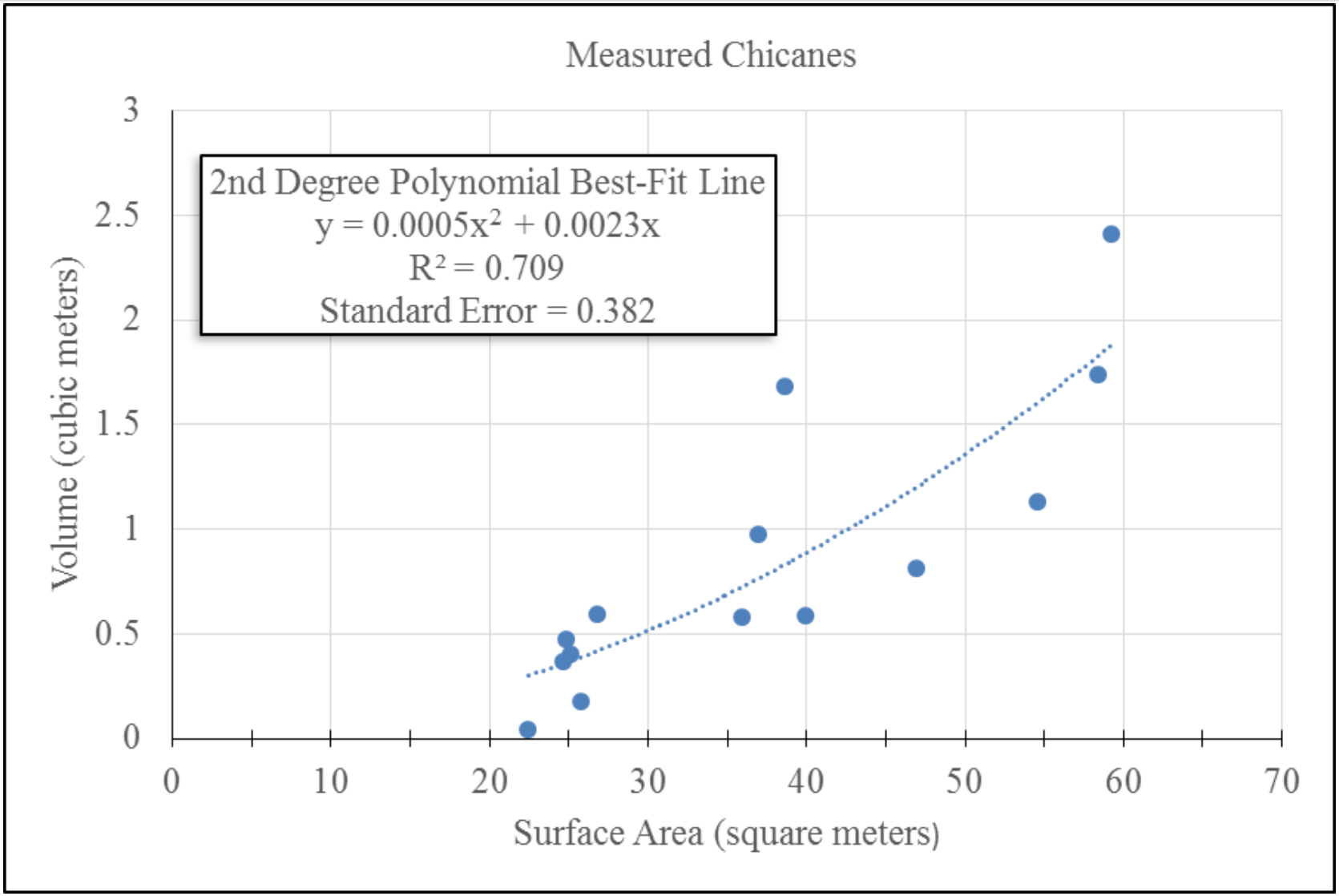
- 78 chicanes
- 14 measured (18%)
  - 2 corner
  - 12 mid-block
- 0.254 meter (10-inch) grid
- Cross-sectional profiles

Methods – Storage Capacity

$$V = \sum((D) * (L) * (W))$$

- where:
  - V = Basin Volume (m^3)
  - D = Depth (average depth below baseline, m)
  - L = Length ((# of measurements -1) * (0.254 m))
  - W = Width (0.254 meters)

Methods – Storage Capacity



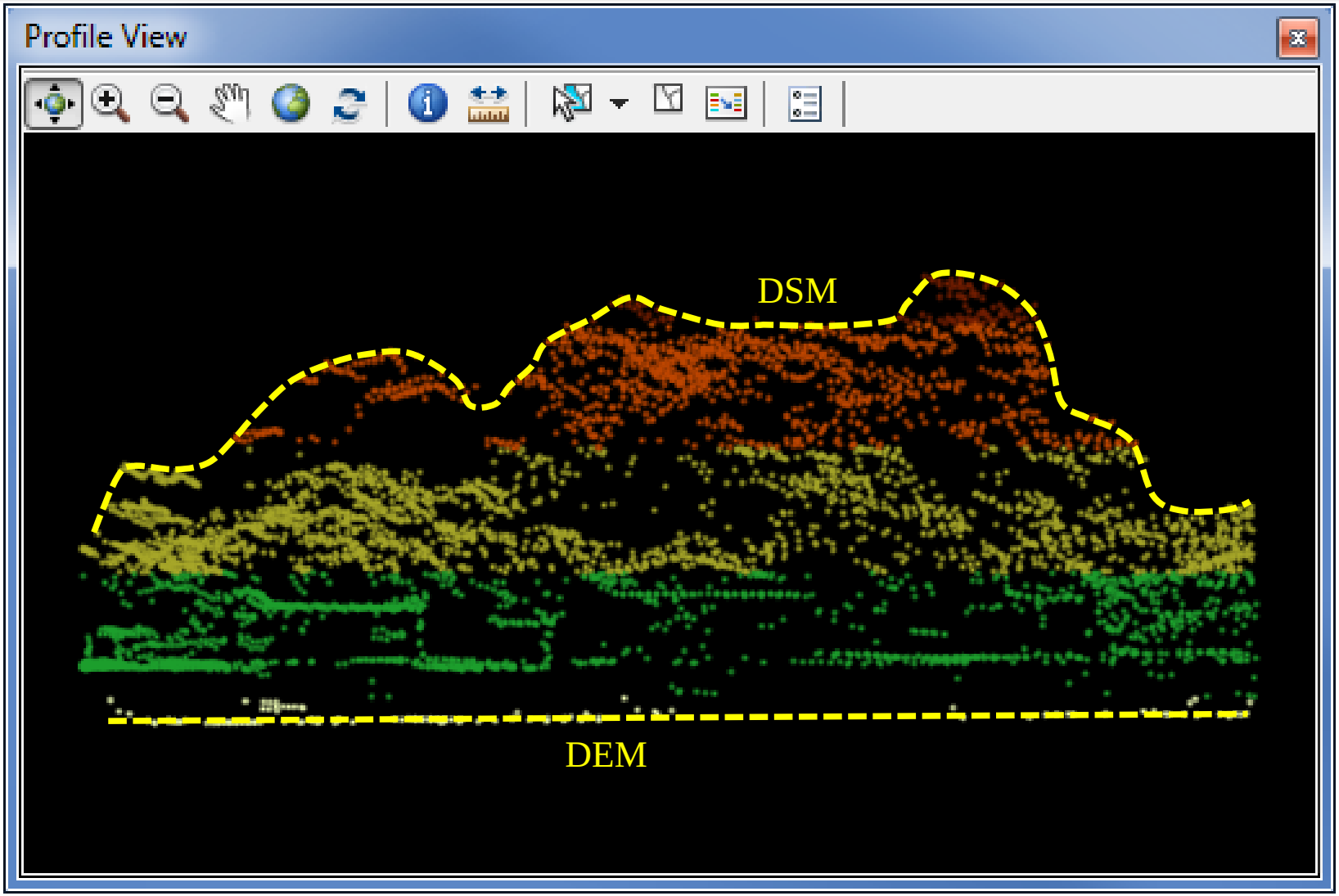
Methods – Runoff Generation

- Land Cover
- Unsupervised Classification – 6 Bands
- Runoff Calculations
  - Before chicane installation
  - After chicane installation

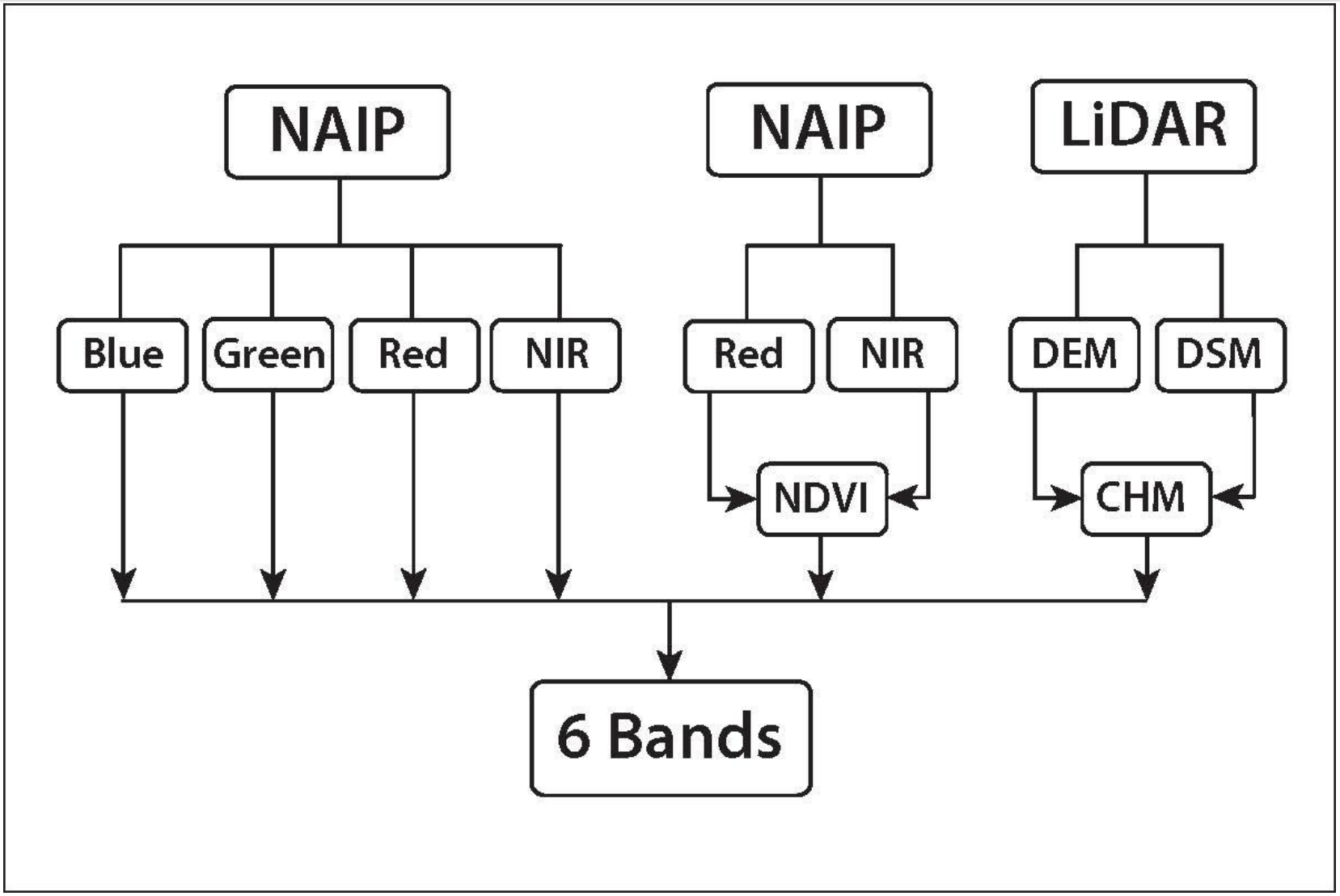
Methods – Runoff Generation

- Unsupervised Classification – 6 Bands
  - NAIP – 1 meter, 4-band imagery
    - Blue, Green, Red, NIR
    - Normalized Difference Vegetation Index (NDVI)
  - LiDAR
    - Digital Elevation Model (DEM)
    - Digital Surface Model (DSM)
    - Canopy Height Model (CHM)

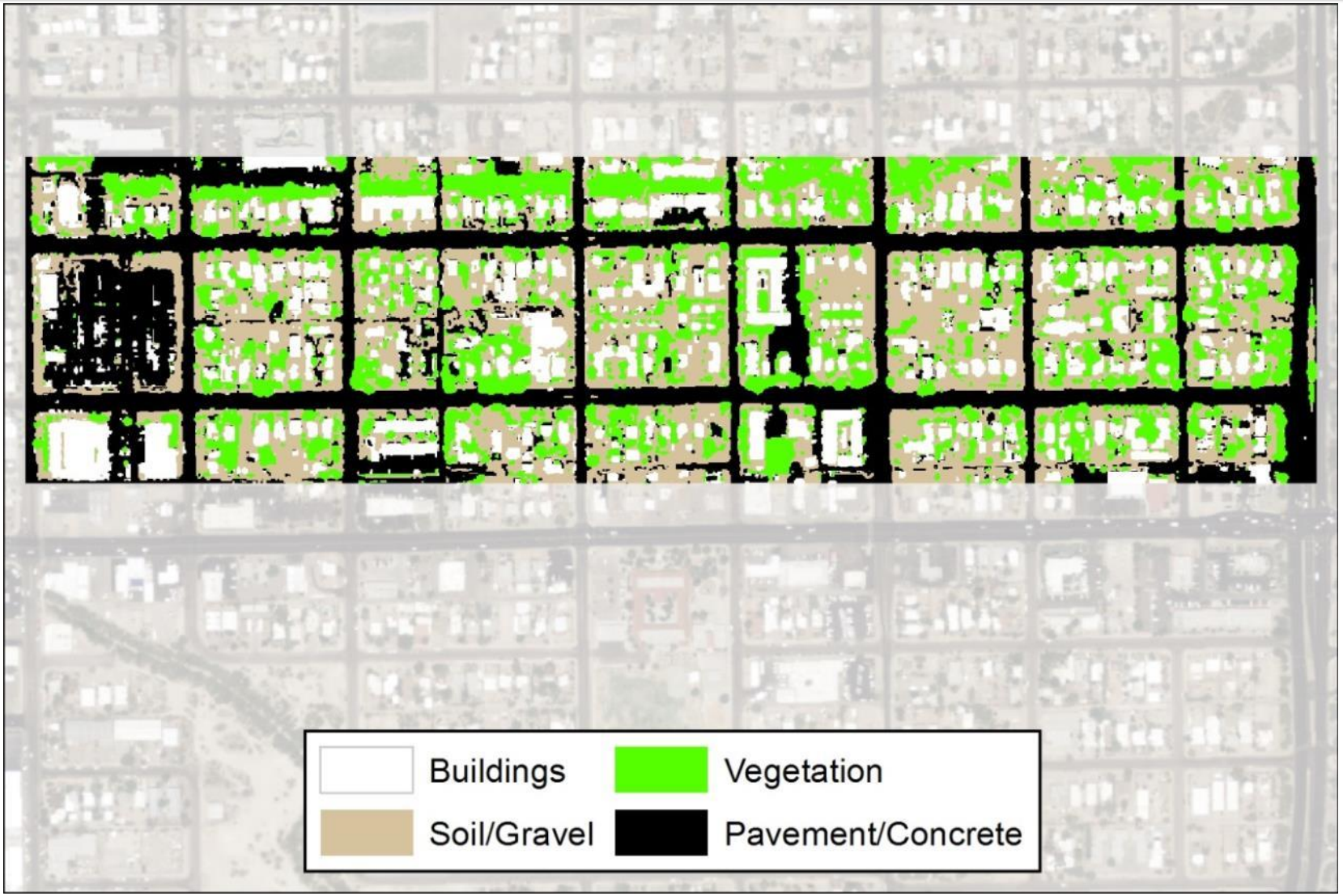
Methods – Runoff Generation



Methods – Runoff Generation



Unsupervised Classification



Error Matrix

	Reference Data				
Classification	Building	Soil/Gravel	Vegetation	Pavement/Concrete	Row Total
Building	41	2	1	6	50
Soil/Gravel	5	40	0	5	50
Vegetation	0	2	48	0	50
Pavement/Concrete	0	4	0	46	50
Column Total	46	48	49	57	200

Overall Accuracy = 175/200 = 87.5%

Producer's Accuracy (omission error)

Building = 41/46 = 89.1%, 10.9% omission error

Soil/Gravel = 40/48 = 83.3%, 16.7% omission error

Vegetation = 48/49 = 98.0%, 2% omission error

Pavement/Concrete = 46/57 = 80.7%, 19.3% omission error

User's Accuracy (commission error)

Building = 41/50 = 82.0%, 18% commission error

Soil/Gravel = 40/50 = 80%, 20% commission error

Vegetation = 48/50 = 96%, 4% commission errror

Pavement/Concrete = 46/50 = 92%, 8% comission error

Kappa Coefficient (K) = 0.83

Methods - Runoff Generation

$$Runoff = (A) * (r) * (c)$$

- where:
  - Runoff = stormwater runoff (m^3)
  - A = surface area, land cover class polygons (m^2)
  - r = rainfall depths (m)
  - c = runoff coefficient (dimensionless)

Methods – Runoff Generation

- 60-minute storm (r)
  - 1- year – 0.01969 m
  - 2- year – 0.02537 m
  - 10-year – 0.03988 m
  - 100-year – 0.06147 m
- Runoff Coefficients (c)
  - Buildings – 0.9
  - Soil/Gravel – 0.6
  - Vegetation – 0.35
  - Pavement/Concrete – 0.9

Results

Results – Storage Capacity

$$y = 0.0005x^2 + 0.0023x$$

- 78 chicanes
- Total Volume = 75.41 m^3

Results - Runoff Generation

- Chicanes = 3,042 m² (0.87%)

Land Cover Class	Area (square meters)			Percent of Total Area		
	Before	After	Difference	Before	After	Difference
Building	62,046	61,998	-48	17.67	17.82	0.14
Soil/Gravel	117,671	116,804	-867	33.52	33.56	0.04
Vegetation	70,796	70,316	-480	20.17	20.21	0.04
Pavement/Concrete	100,531	98,884	-1,647	28.64	28.41	-0.22
Total	351,044	348,002	-3,042	100	100	0

Results - Runoff Generation

Grid Code	Land Cover Class	Stormwater Runoff Before Chicanes (cubic meters) 1-Year (0.01969 m)	2-Year (0.02537 m)	10-Year (0.03988 m)	100-Year (0.06147m)
1	Building	1,099.24	1,416.95	2,226.84	3,432.46
2	Soil/Gravel	1,389.81	1,791.51	2,815.49	4,339.80
3	Vegetation	487.77	628.75	988.12	1,523.09
4	Pavement/Concrete	1,781.06	2,295.84	3,608.08	5,561.50
	Total	4,757.87	6,133.05	9,638.53	14,856.85

Grid Code	Land Cover Class	Stormwater Runoff After Chicanes (cubic meters) 1-Year (0.0.1969 m)	2-Year (0.02537 m)	10-Year (0.03988 m)	100-Year (0.06147m)
1	Building	1,098.39	1,415.86	2,225.12	3,429.80
2	Soil/Gravel	1,379.57	1,778.31	2,794.75	4,307.82
3	Vegetation	484.46	624.48	981.42	1,512.76
4	Pavement/Concrete	1,751.88	2,258.23	3,548.97	5,470.38
	Total	4,714.30	6,076.88	9,550.25	14,720.77

Results - Runoff Generation

Reduction in Stormwater Runoff Generation (cubic meters)			
1-Year	2-Year	10-Year	100-Year
43.58 (0.92%)	56.17 (0.92%)	88.28 (0.92%)	136.07 (0.92%)

Results – Total Reduction

	Total Potential Reduction in Stormwater Runoff (cubic meters)			
	1-Year	2-Year	10-Year	100-Year
Storage Capacity	75.41	75.41	75.41	75.41
Runoff Generation	43.58	56.17	88.28	136.07
Total	118.99	131.58	163.69	211.48
	(2.50%)	(2.15%)	(1.70%)	(1.42%)

Conclusions

- Chicanes = 3,042 m^2 (0.87%)
- Storage capacity increased – 75.41 m^3
- Runoff Generation reduced – 0.92%
- Smaller Storms – storage capacity, first flush, LID
- Larger Storms – runoff generation

Next Steps

- Storage Capacity – dynamic storage, infiltration rates, change over time
- Rainfall Volumes/Intensities
- Additional Studies
  - Dunbar Springs, Menlo Park, and Northwest neighborhoods

Acknowledgments

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Thank You