Stormwater Runoff Reduction by Street-Side Water Harvesting Features

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July 22, 2015

Outline

- Problem and Research Objectives
- Methods, Results, and Conclusions
- Next Steps

North Tucson Boulevard at East Seneca Street
Photo: Mike Christy/Arizona Daily Star, August 24, 2014

North Tucson Boulevard south of East Grant Road
Photo: Mamta Popat/Arizona Daily Star, August 26, 2014

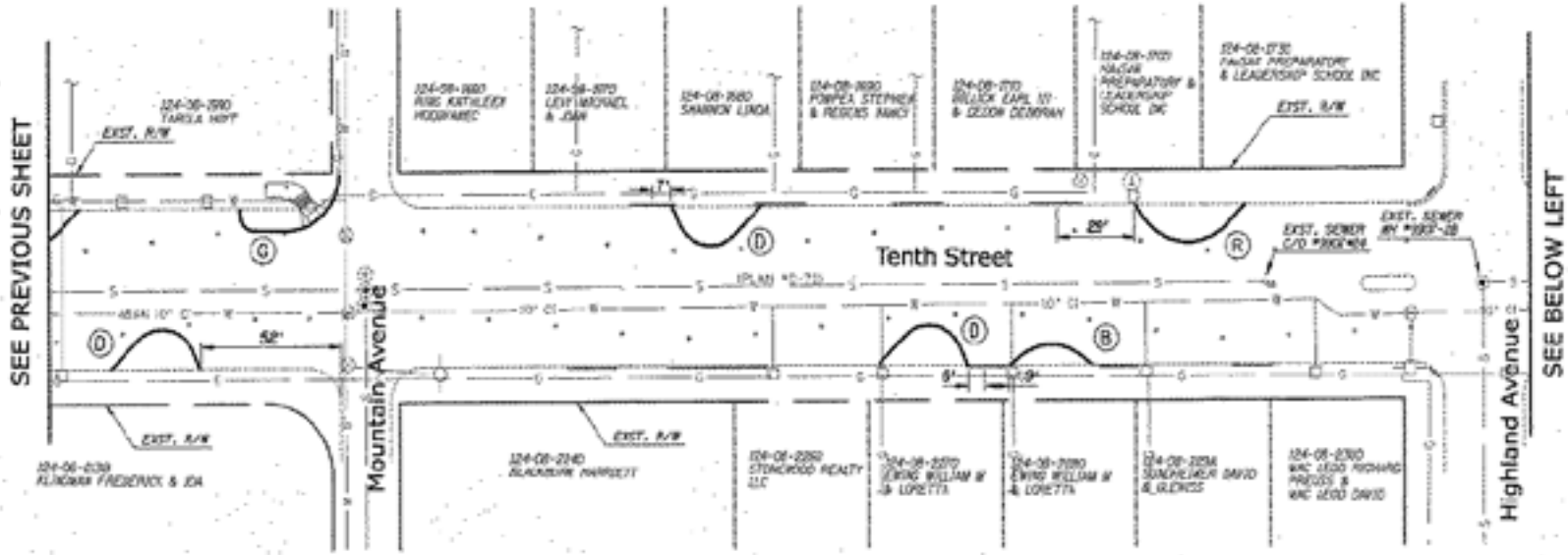
North Park Avenue and East 6th Street
Photo: John Brost

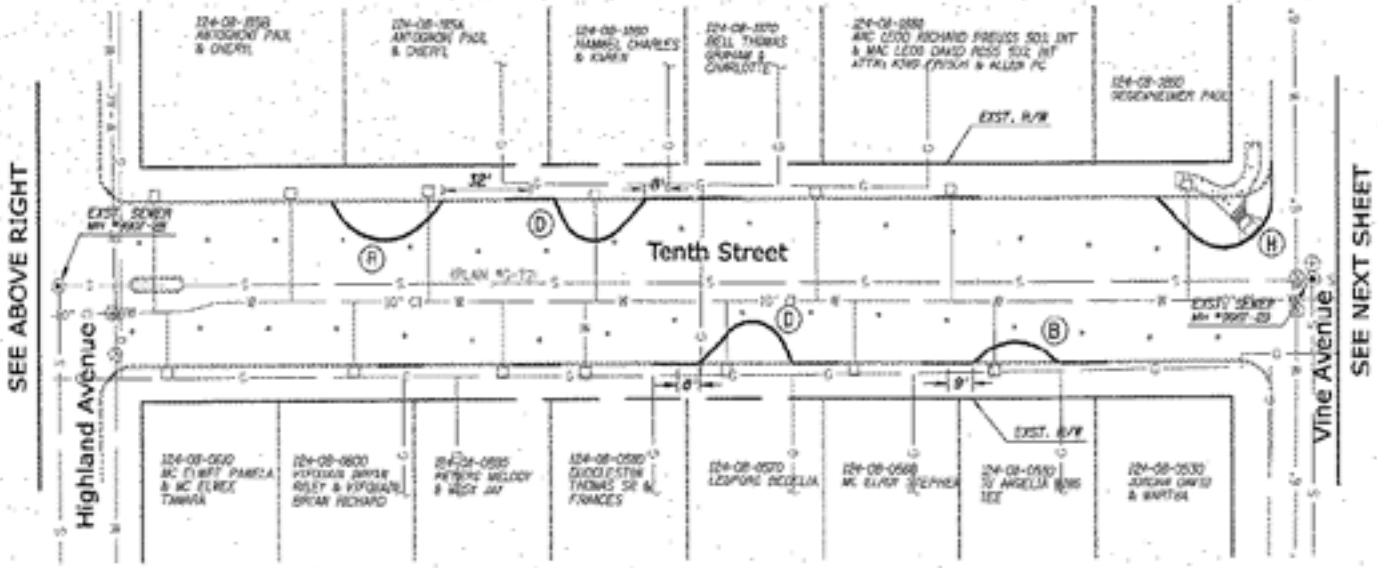
Problem

- Rincon Heights Neighborhood
- Flooding streets, stormwater runoff
- Non-point source pollution
  - Neighborhood, High School Wash
- Traffic
  - Vehicles, bicycles, pedestrians

Low Impact Development

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





TENTH STREET IMPROVEMENTS

DEPARTMENT OF TRANSPORTATION/ENGINEERING DIVISION

ROGER HEIGHTS NEIGHBORHOOD REINVESTMENT

10 of 22

CITY OF TUCSON

PLAN NO. C-2007-005

1-800-782-5348

Photo: Watershed Management Group

Photo: Watershed Management Group

Photo: Watershed Management Group

Photo: Watershed Management Group

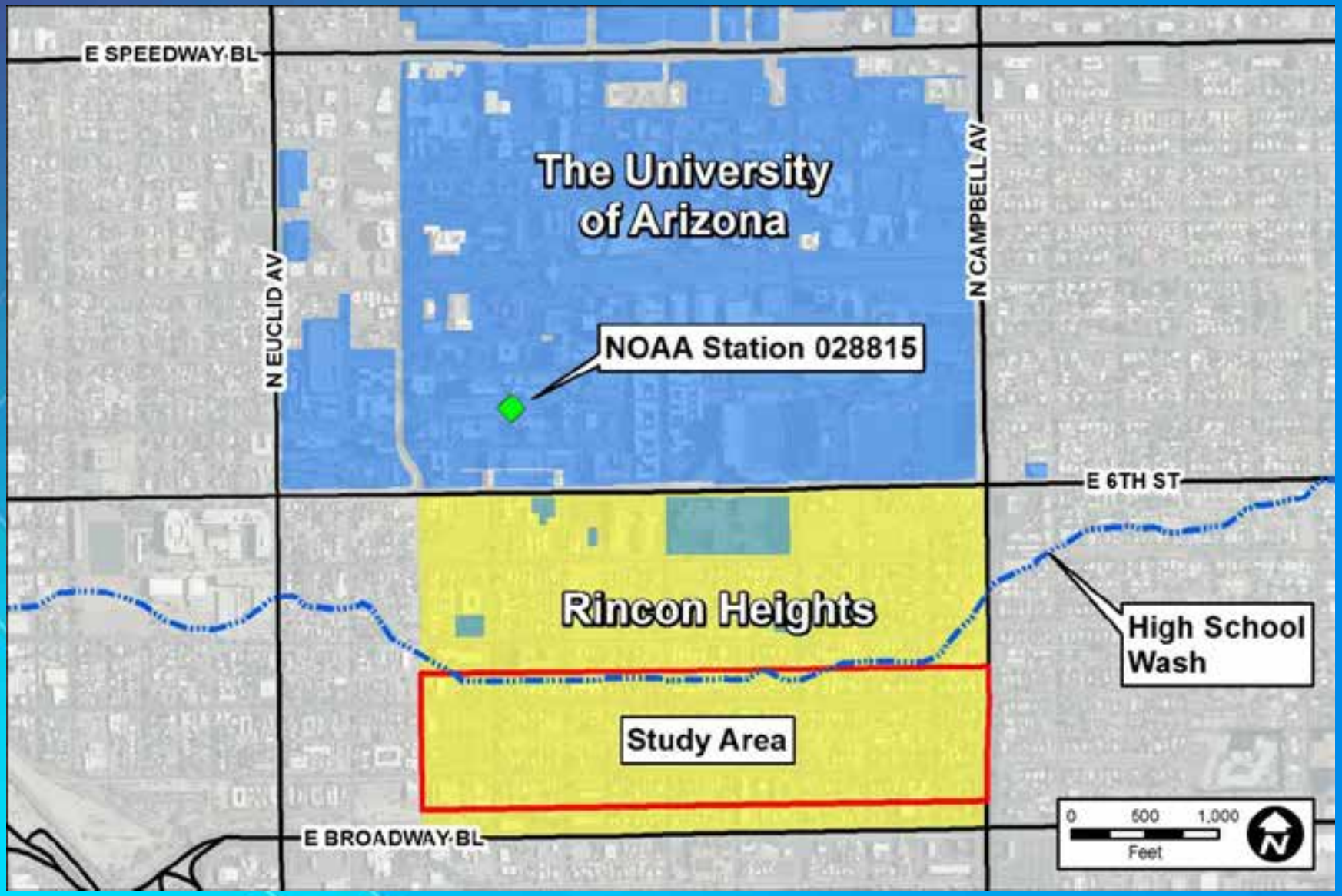
Objectives

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

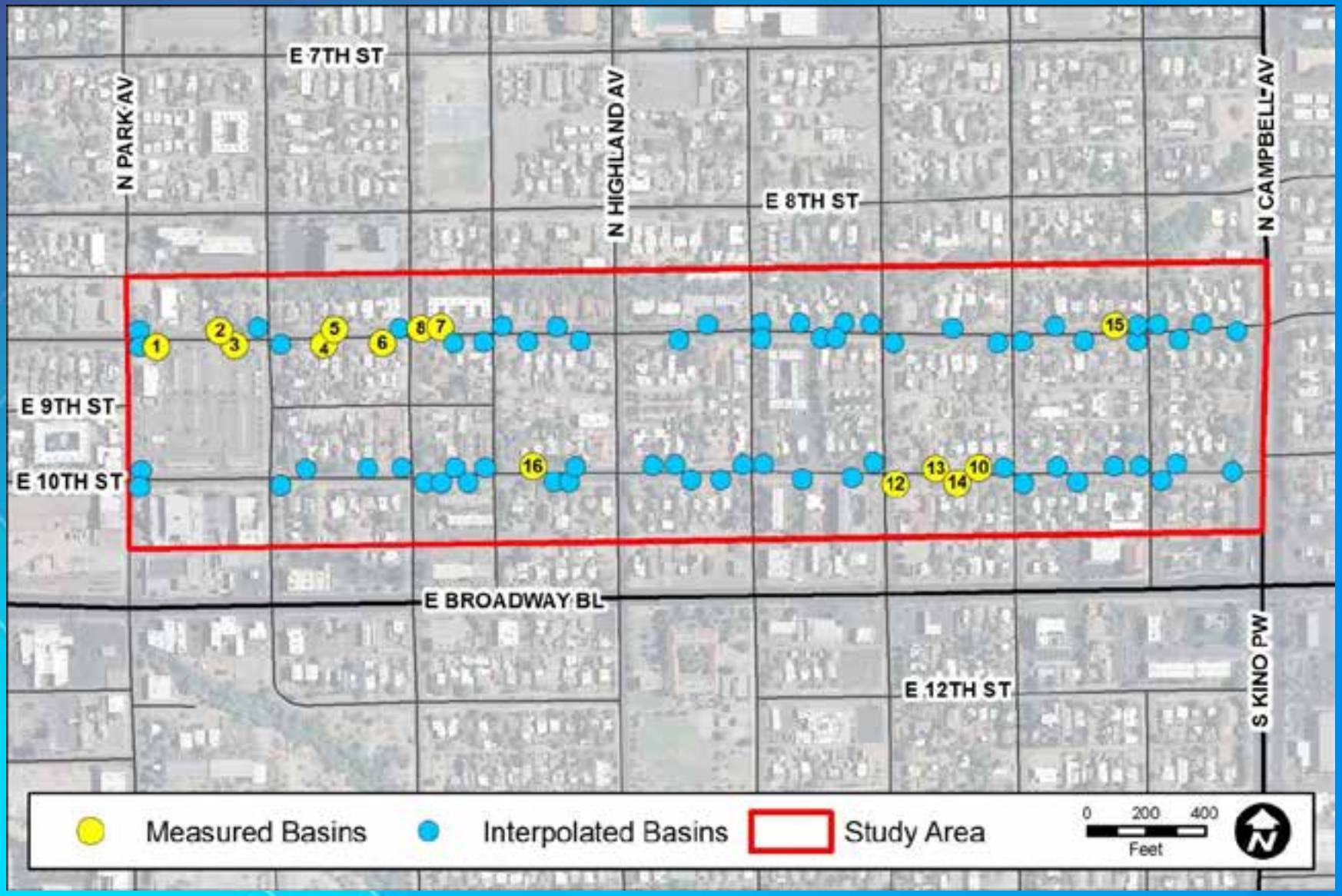
Assumptions

1. All basins are functioning as designed.
2. Every basin receives runoff from every rainfall event.
3. Rainfall is uniformly distributed.
4. Rainfall is retained within basins.
5. No other water harvesting features.

Study Area


E SPEEDWAY BL
The University of Arizona
N CAMPBELL AV
N EUCLID 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 - 33 ha, 78 basins



Mid-Block Basin

Photo: Watershed Management Group

Corner Basin

Photo: Watershed Management Group

Median Basin

Photo: Watershed Management Group

Methods

Methods – Storage Capacity

- 78 basins
- Measured 14 (18%) basins
  - 2 corner basins
  - 12 mid-block basins
- Volume – cross-sectional profiles
- 0.254 meter (10-inch) grid
- Surface Area – 2010 Pictometry orthos


Photo: Jennifer Psillas


Photo: Jennifer Psillas

Photo: Jennifer Psillas

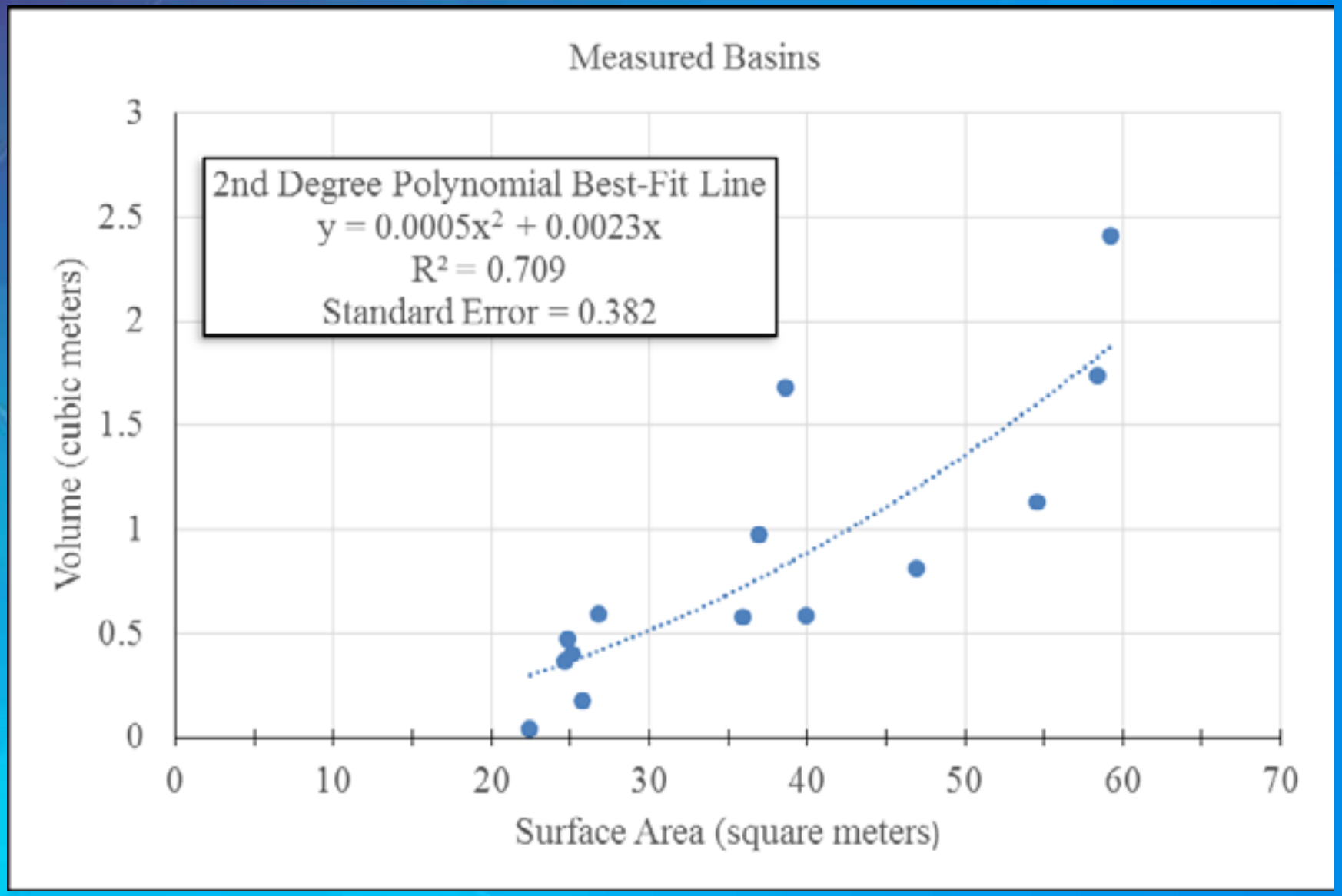
Methods – Storage Capacity

$$V = \Sigma\,[(D) * (L) * (W)]$$

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 m)

Methods – Storage Capacity



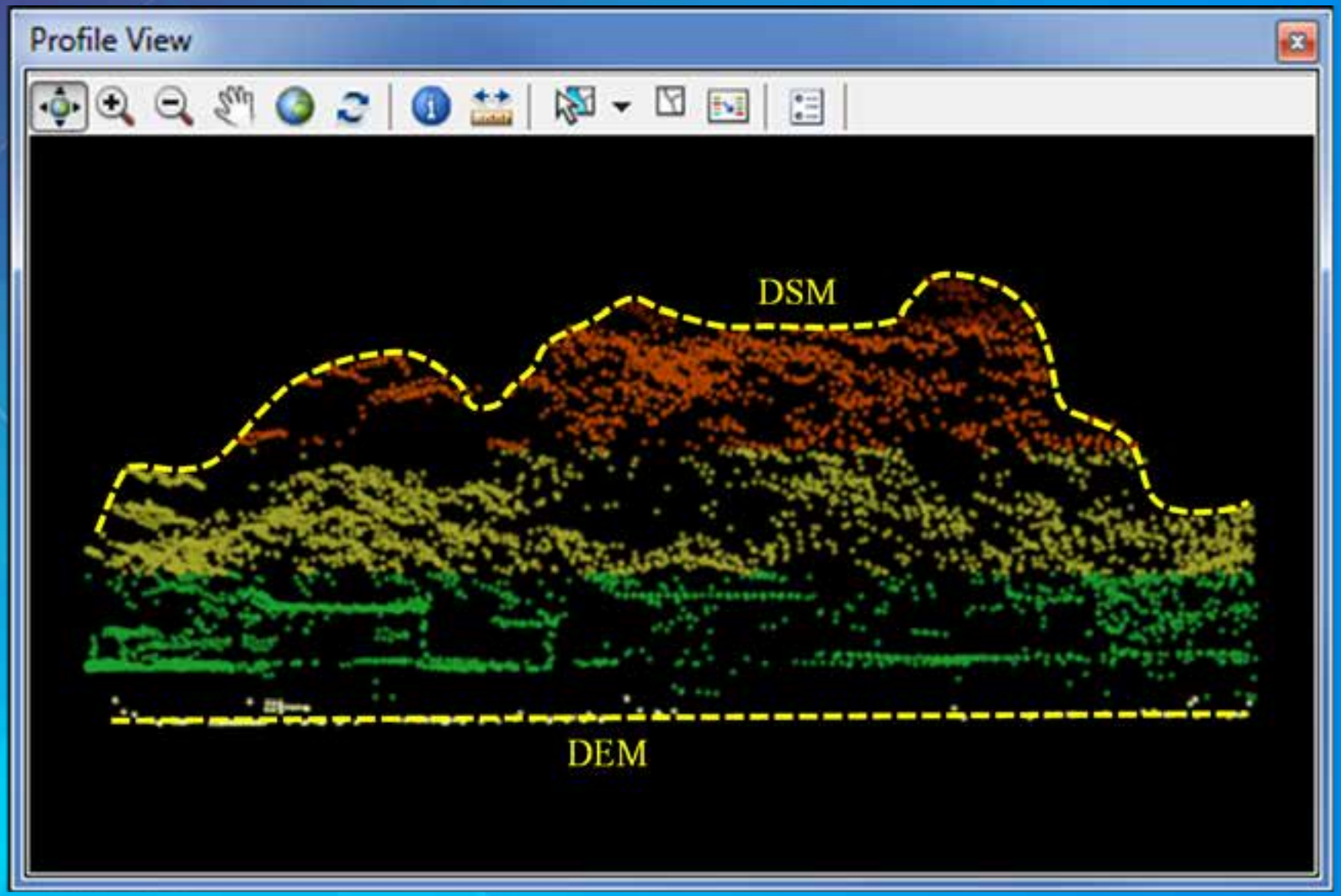
Methods – Runoff Generation

- Land Cover
- Unsupervised Classification
- Runoff Calculations
  - Before and after basin installation

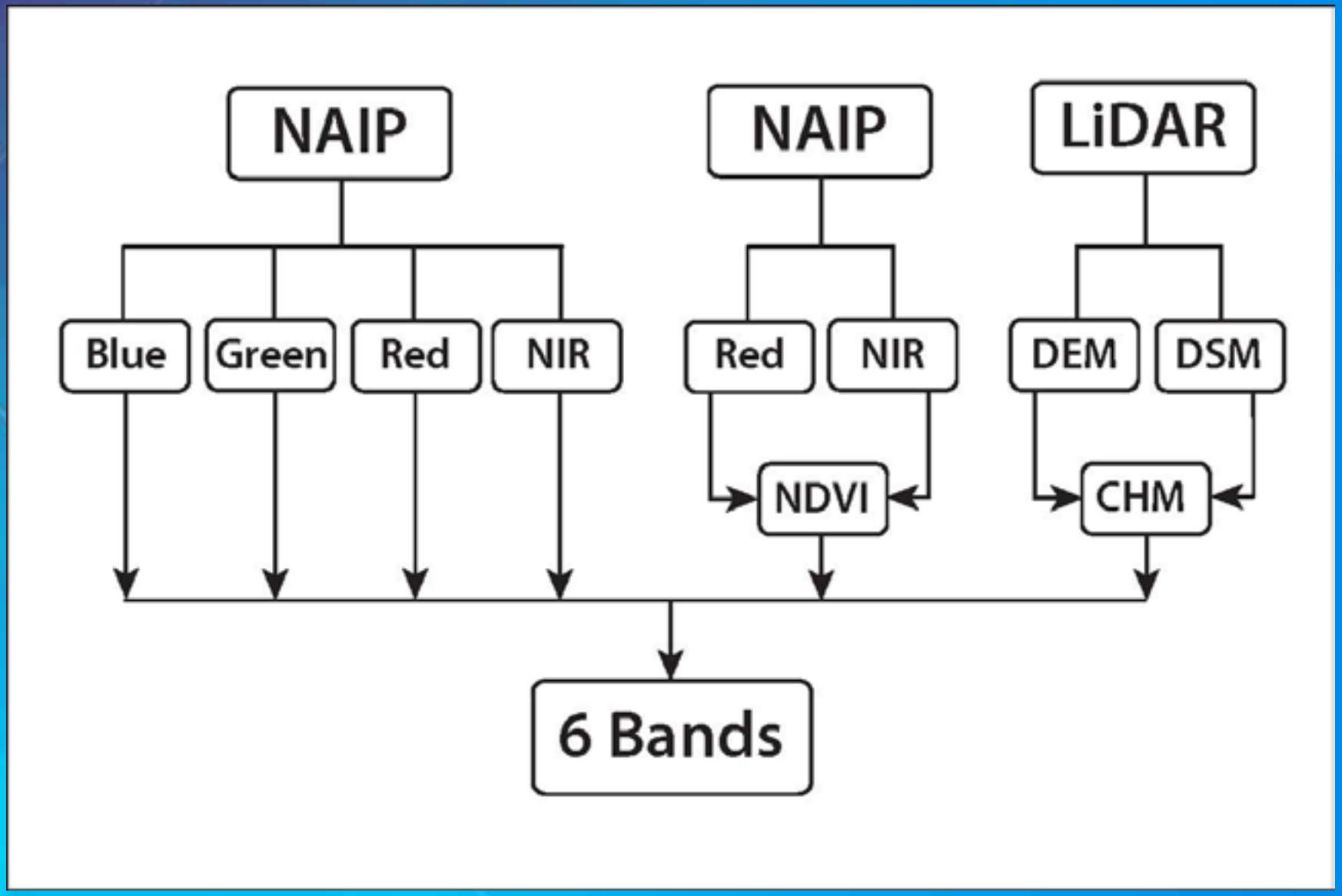
Methods – Runoff Generation

- Unsupervised Classification – 6 Bands
  - 2007 NAIP – 1-meter, 4-band imagery
    - Blue, Green, Red, NIR
    - Normalized Difference Vegetation Index (NDVI)
  - 2008 LiDAR
    - Digital Elevation Model (DEM)
    - Digital Surface Model (DSM)
    - Canopy Height Model (CHM)

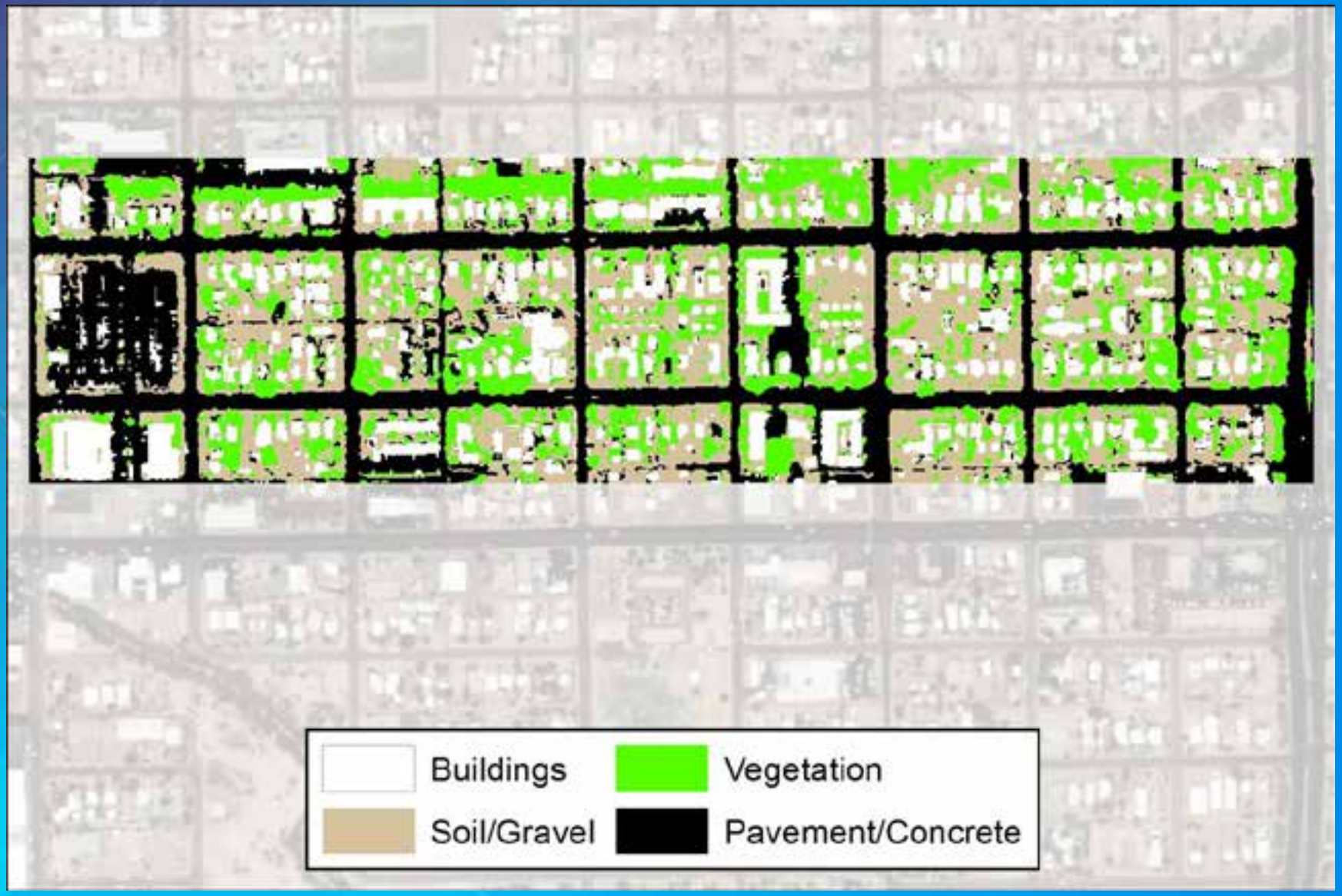
Methods – Runoff Generation



Methods – Runoff Generation



Unsupervised Classification



Unsupervised Classification

	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 polygons (m^2)
- r = Rainfall depths (m)
- c = Runoff coefficients

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 basins
- Volume = 75.41 m^3

Results – Runoff Generation

- 78 basins = 3,042 m^2 (0.87%)

Grid Code	Land Cover Class	Area (square meters)			Percent of Total Area		
		Before	After	Difference	Before	After	Difference
1	Building	62,046	61,998	-48	17.67	17.82	0.14
2	Soil/Gravel	117,671	116,804	-867	33.52	33.56	0.04
3	Vegetation	70,796	70,316	-480	20.17	20.21	0.04
4	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 Potential Reduction in Stormwater Runoff

	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

Conclusions

- 78 basins = 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

Next Steps

- Storage capacity – dynamic storage, infiltration rates, change over time
- Rainfall volumes/intensities
- Curve Number
- Additional studies
  - Dunbar Springs, Menlo Park, and Northwest Neighborhoods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Acknowledgments

- Field Data Collection
  - Eric Herman, Amy Dillon, Mary & Bill Willmon
- Documentation, Photos, Graphics
  - Camiliano Juarez, Pima County Neighborhood Reinvestment Program
  - Catlow Shipek, Watershed Management Group
  - Helen Wilson
- Graduate Committee
  - Phil Guertin, Craig Wissler, and Jim Riley

Thank You

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