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Stormwater Master Planning to Address Flooding, Hydromodification, and Water Quality

Kentucky Stormwater Association

July 20, 2017

Chris Rust, P.E.



Agenda

- **Stormwater Master Planning Considerations**
 - Water Quantity
 - Water Quality
 - Asset Management
 - Regulatory Compliance
- **Upper Woolper Creek Watershed Case Study**

Stormwater Master Planning Considerations

- Water Quantity



Flooding Issues

Detention/Retention Basins

Stormwater Master Planning Considerations

- Water Quality



Hydromodification Issues

Green Infrastructure

Stormwater Master Planning Considerations

- Asset Management



Storm Infrastructure Issues

- Regulatory Compliance

United States Environmental Protection Agency
Office of Water (4203) January 2000 (revised December 2005) Fact Sheet 2.7
EPA 833-F-00-009

Stormwater Phase II Final Rule

Post-Construction Runoff Control Minimum Control Measure

KPDES

KENTUCKY POLLUTANT DISCHARGE ELIMINATION SYSTEM

PERMIT

minimum control measure, one of the minimum control measures of the National Stormwater Management Program in order to meet the requirements of the Clean Water Act (CWA) and the National Pollutant Discharge Elimination System (NPDES) permit program. It is important to keep in mind that the minimum control measure is the most cost-effective

Necessary?

new development or existing development that has been shown to significantly contribute to runoff and erosion. The design for the minimum control measure is the most cost-effective

Post-Construction Runoff Control. The first is to prevent runoff. As runoff is prevented, pollutants such as sediment, nutrients, and pesticides (such as herbicides and insecticides) are not carried into receiving waters, such as lakes, streams, and rivers. The second kind of post-construction runoff control is to prevent runoff from the site. This is done by routing to drainage systems that prevent runoff from the site. The effects of this which often lead to a loss of

MS4 to develop, implement, and maintain their MS4 program and to prevent runoff of greater than 100,000 gallons per day of stormwater from the site. The implementation of post-construction runoff control measures is required by State, Tribal or local law.

Permit No.: KYG200000
AI No.: 35050

AUTHORIZATION TO DISCHARGE UNDER THE KENTUCKY POLLUTANT DISCHARGE ELIMINATION SYSTEM

Pursuant to Authority in KRS 224,

Small Municipal Separate Storm Sewer Systems (sMS4)

are authorized to discharge stormwater runoff from a small Municipal Separate Storm Sewer System (MS4) to receiving waters of the Commonwealth in accordance with effluent limitations, monitoring requirements and other conditions set forth in PARTS I, II, III, and IV hereof. The permit consists of this cover sheet, a table of contents, and PART I 4 pages, PART II 13 pages, PART III 2 pages, PART IV 1 page.

This permit shall become effective on April 1, 2010.

This permit and the authorization to discharge shall expire at midnight, March 31, 2015.

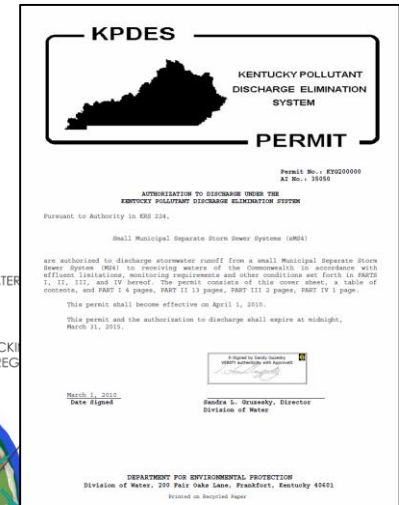
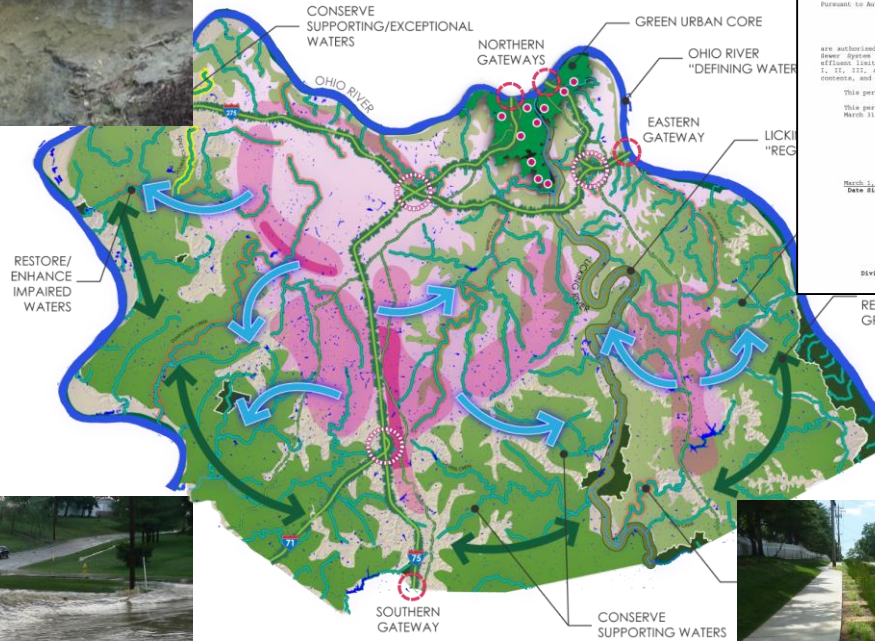
March 14, 2010
Date Signed

Sandra L. Gusevsky, Director
Division of Water

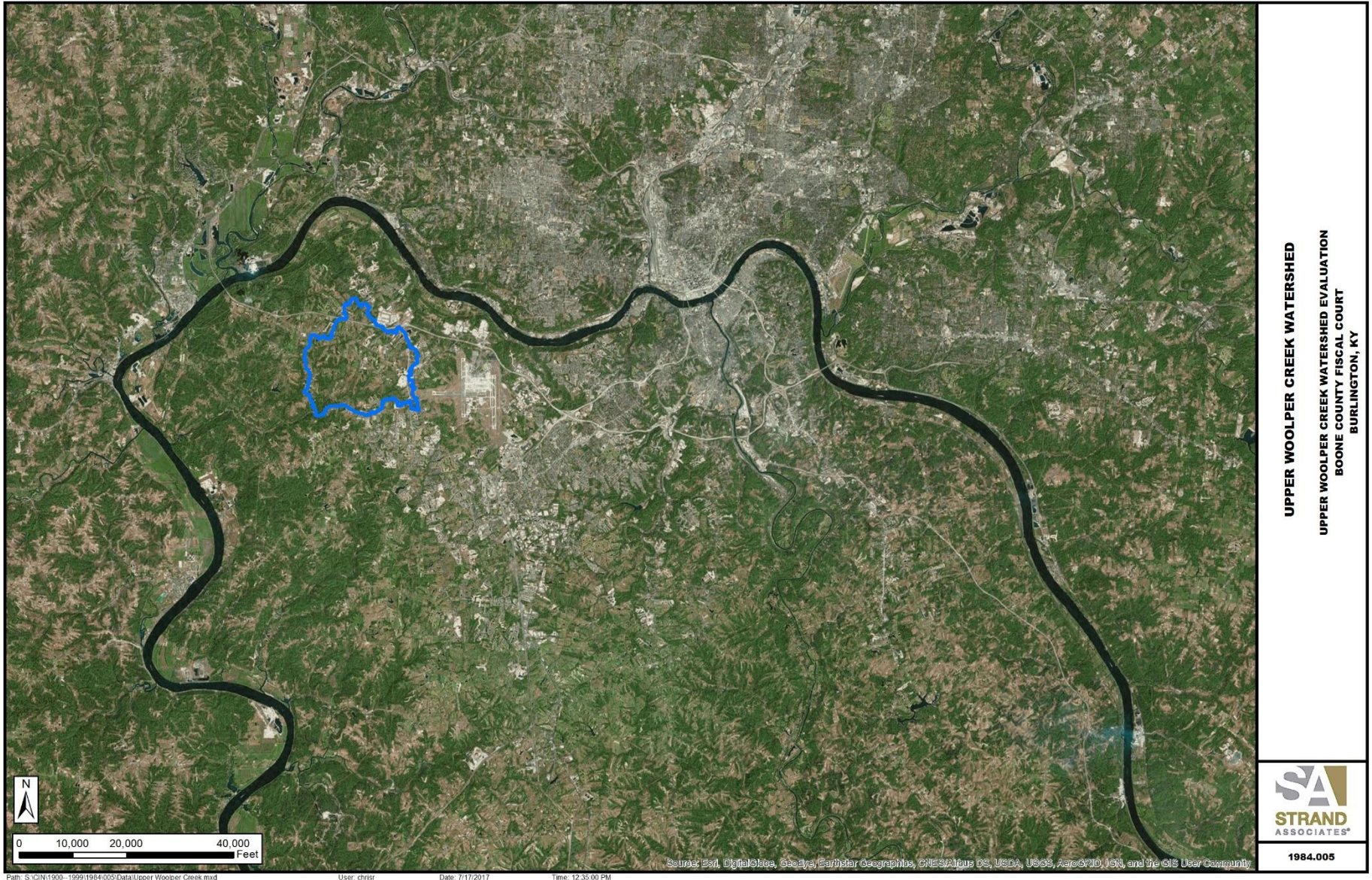
DEPARTMENT FOR ENVIRONMENTAL PROTECTION
Division of Water, 200 Fair Oaks Lane, Frankfort, Kentucky 40601
Printed on Recycled Paper

MS4 Program

Stormwater Master Planning Considerations



Upper Woolper Creek Watershed Case Study



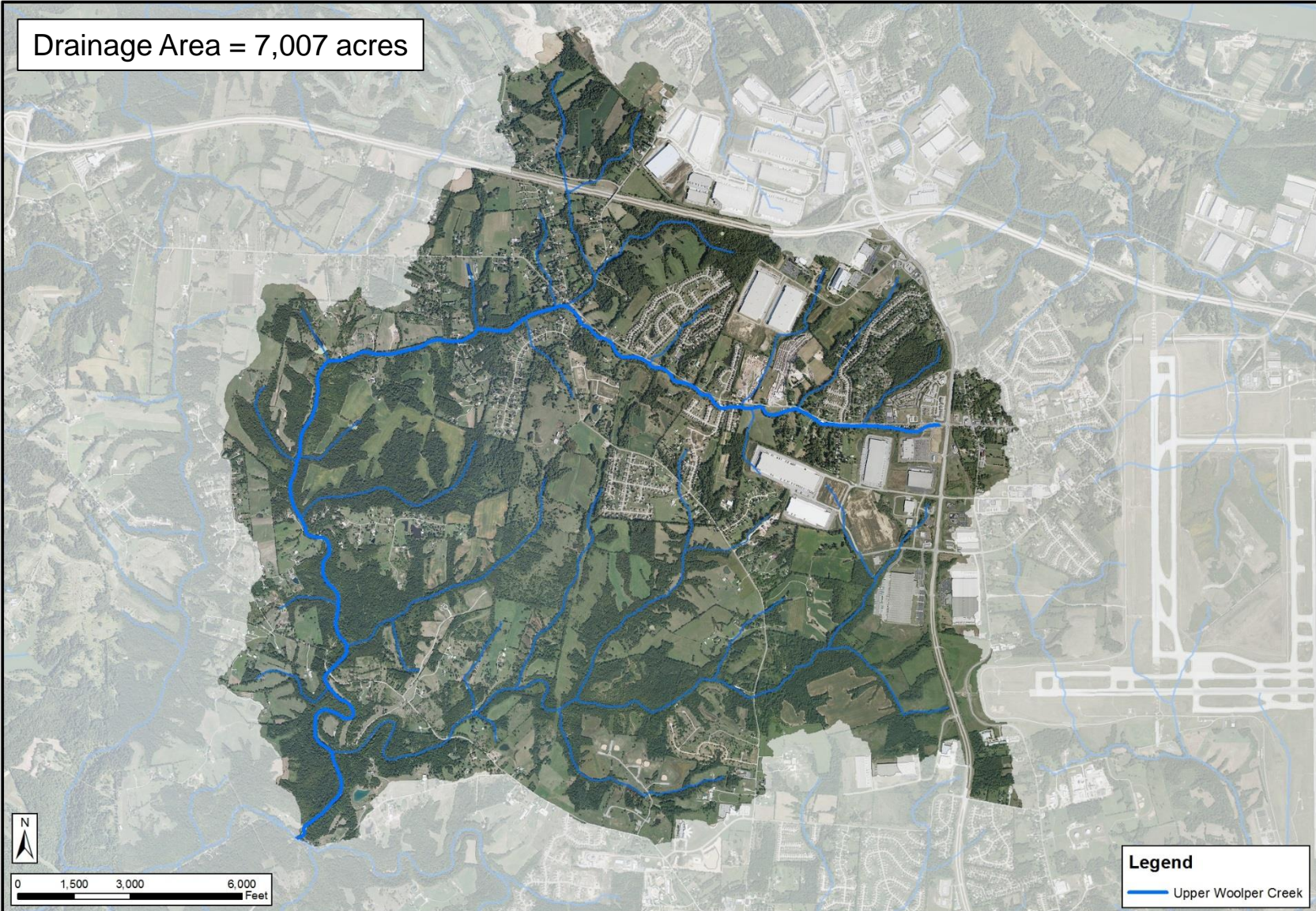
Upper Woolper Creek Watershed Case Study

- Project partners and collaboration key to the development and implementation of stormwater master plan.



Upper Woolper Creek Watershed Case Study

Drainage Area = 7,007 acres

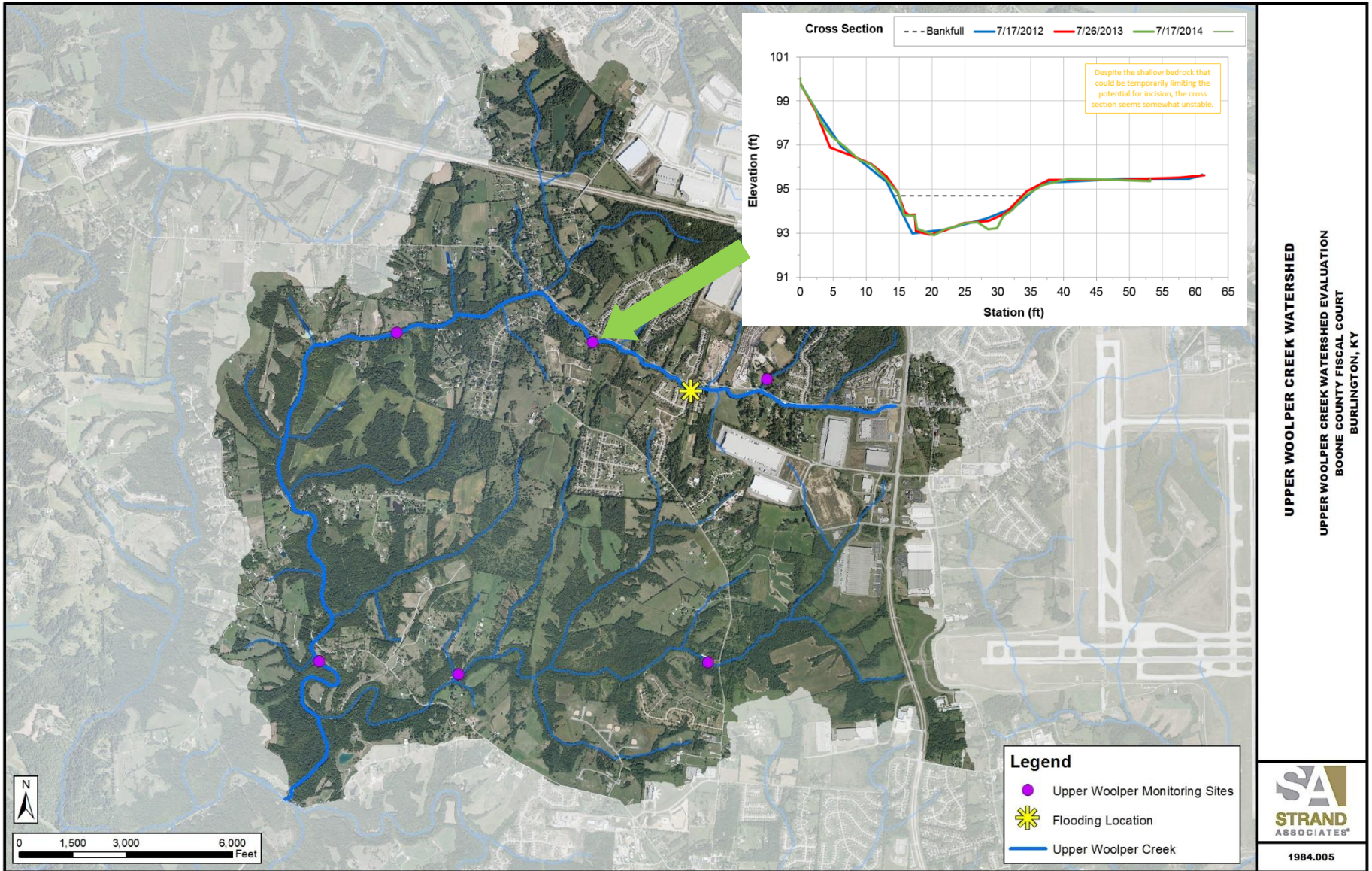


UPPER WOOLPER CREEK WATERSHED
UPPER WOOLPER CREEK EVALUATION
BOONE COUNTY CONSERVATION DISTRICT
BURLINGTON, KY



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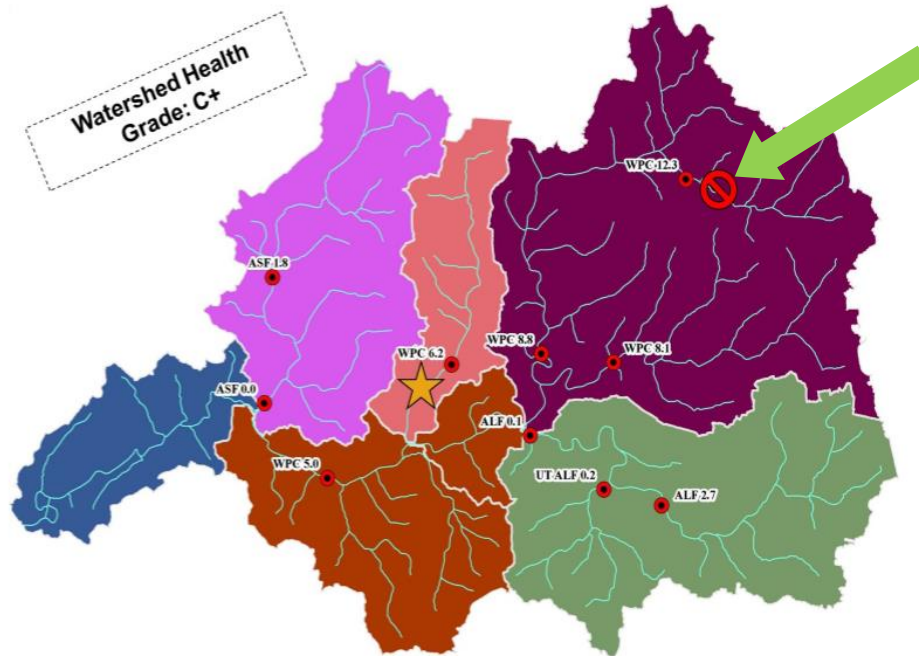
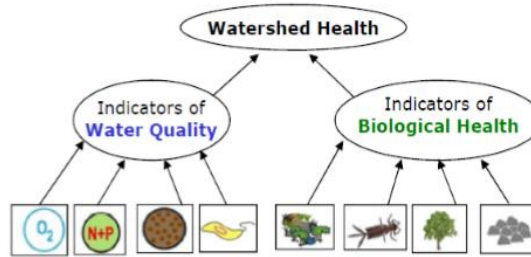
Hydromodification Issues



Water Quality Issues

How was Woolper Creek Graded?

1. Information collected was divided into indicators of **water quality** or indicators of **biological health**.
2. Each indicator received a grade, A through F, according to the results of our study, which were compared to health and science requirements and KDOW scientific information.
3. The grades from each biological health indicator were averaged to achieve a biological health score.
4. Similarly, each indicator of water quality was averaged to achieve a water quality score.
5. These two scores were averaged to achieve a **watershed health grade**.



Water quality issues within the watershed are worst in locations immediately downstream of Upper Woolper Creek watershed study area.

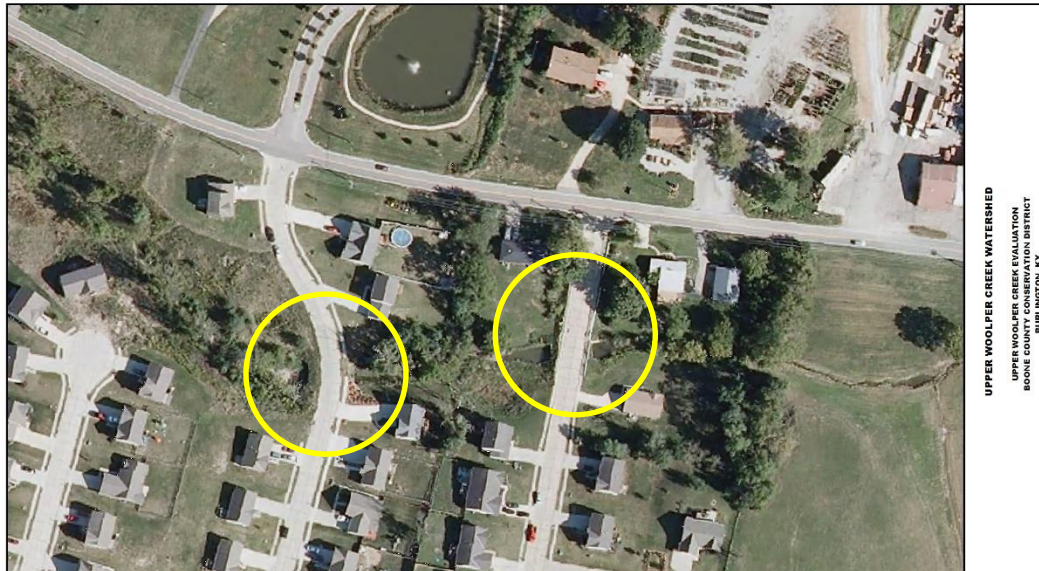
Worst in Show: WPC 12.3 had the lowest overall grade with a C. Degraded habitat, reduced bug populations, and high levels of *E. coli* were common themes. WPC 12.3 had the lowest riparian zone score in the watershed and tied with WPC 8.1 for the worst *E. coli* score.

Best in Show: Double Lick Creek (WPC 6.2) had the highest overall grade with a B+. Improved habitat, available cover and riparian zone along with a lack of sedimentation kept this site at the top. However, improvements could still be made to the *E. coli* scores.

Water Quantity / Flooding Issues



Evaluation of Existing Culverts



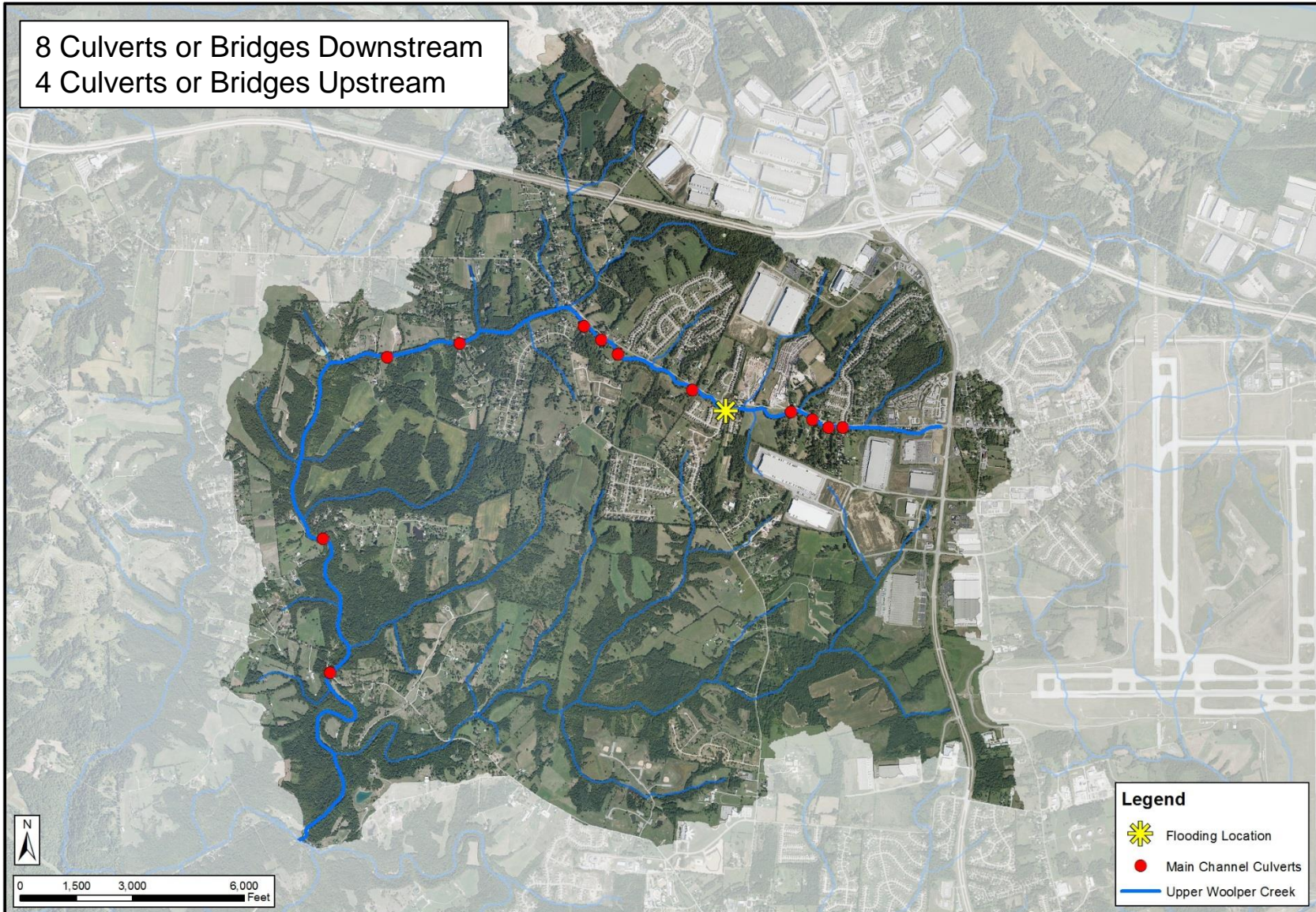
Lauren Meadows Drive Culvert



Benjamin Lane Culvert

Evaluation of Existing Culverts

8 Culverts or Bridges Downstream
4 Culverts or Bridges Upstream



Legend

- Flooding Location
- Main Channel Culverts
- Upper Woolper Creek

UPPER WOOLPER CREEK WATERSHED
UPPER WOOLPER CREEK WATERSHED EVALUATION
BOONE COUNTY FISCAL COURT
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Evaluation of Existing Culverts



Understanding of Historic Rainfall Events

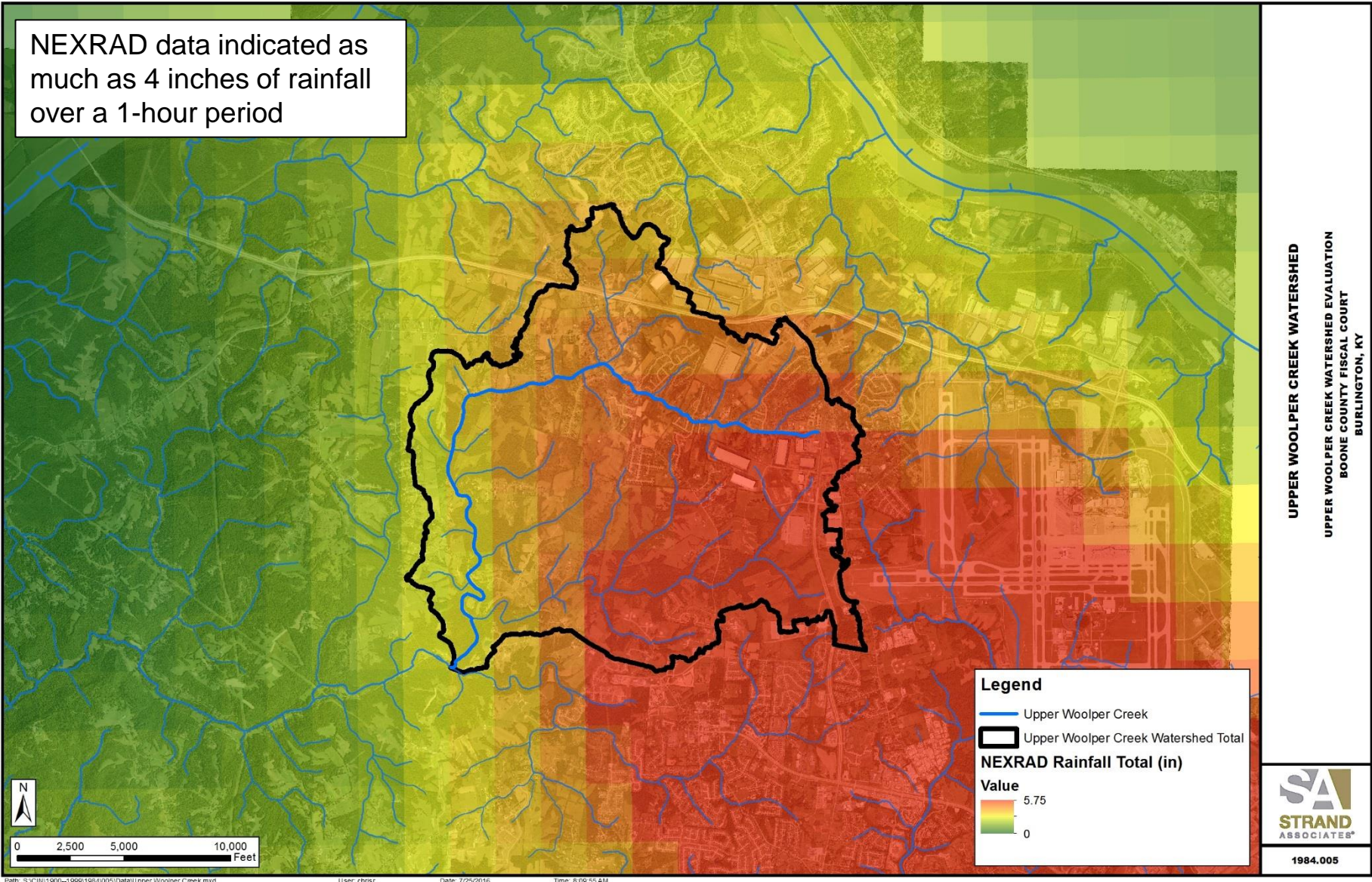
June 25, 2009 Rainfall Event (Hourly Rainfall Recorded at CVG Airport)

Time	Incremental Rainfall (in)	Cumulative Rainfall (in)
2:00 p.m.	0.11	0.11
6:00 p.m.	0.57	0.68
7:00 p.m.	1.95	2.63
8:00 p.m.	0.02	2.65

2.52 inches of rainfall with a 2-hour duration is approximately equivalent to a 10-year storm event.

Understanding of Historic Rainfall Events

NEXRAD data indicated as much as 4 inches of rainfall over a 1-hour period



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Upper Woolper Creek Watershed Existing Conditions

Drainage Area = 1,252 acres



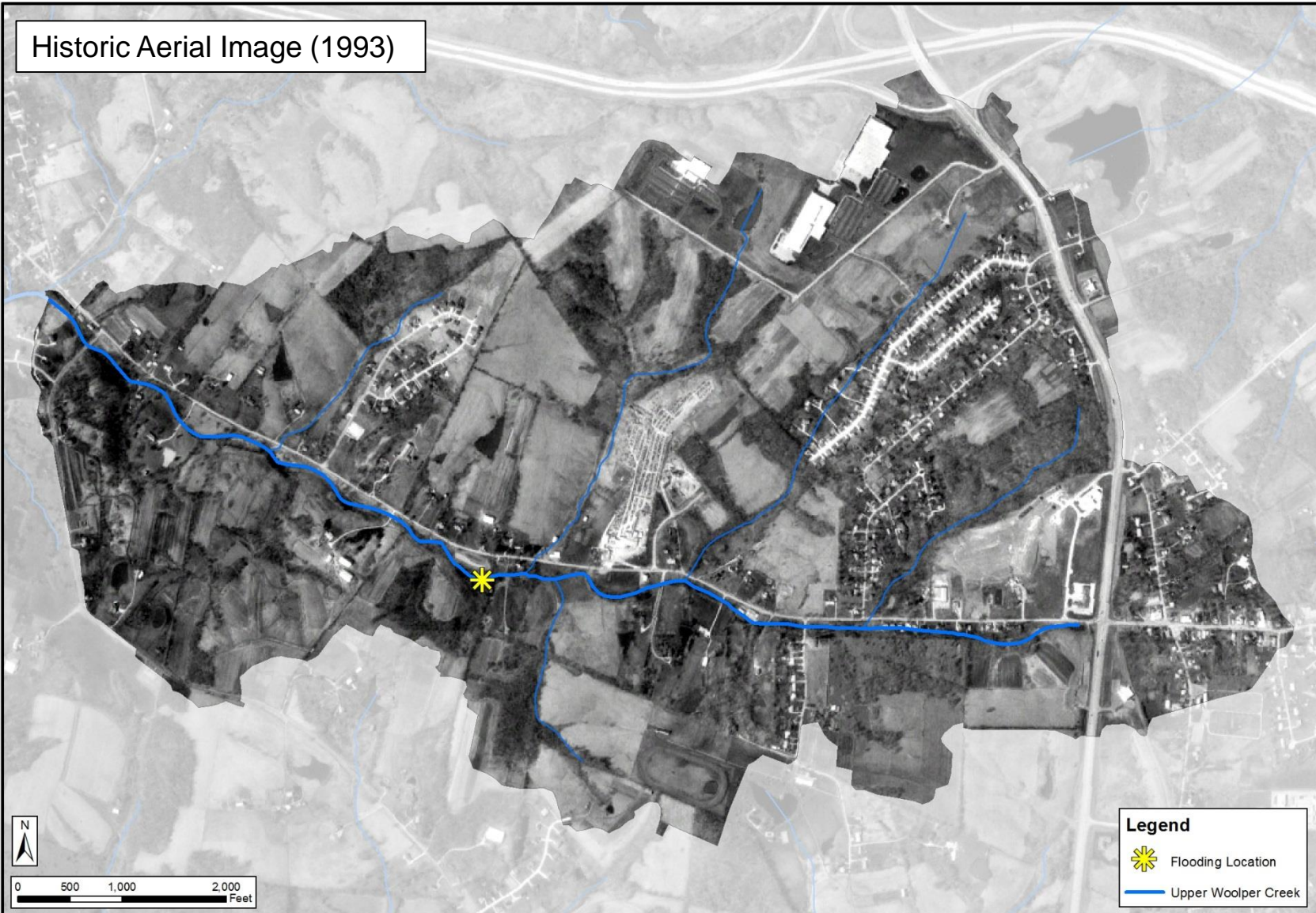
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Looking Back to Understand Land Cover Changes

Historic Aerial Image (1993)



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Legend

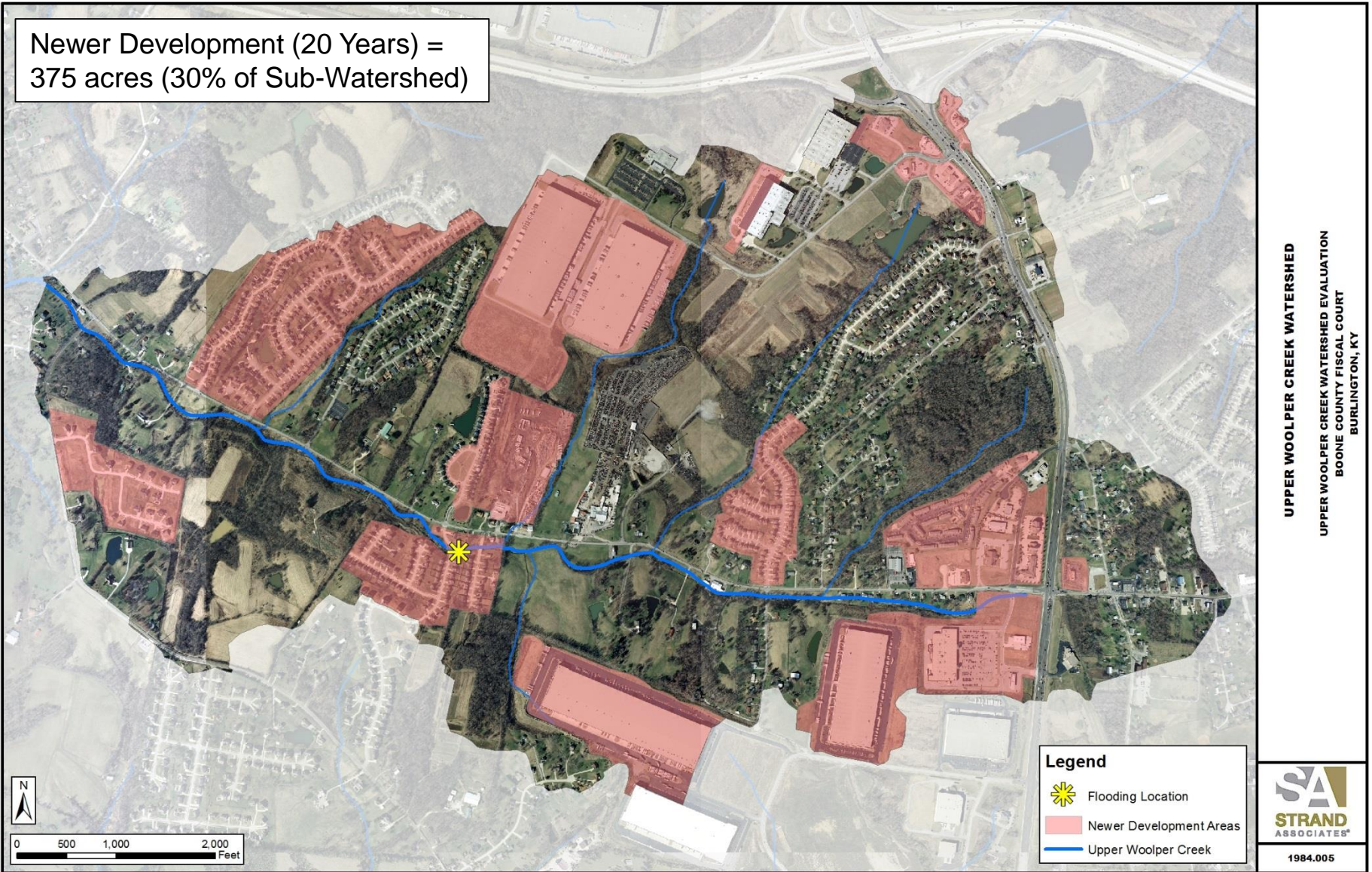
-  Flooding Location
-  Upper Woolper Creek



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Looking Back to Understand Land Cover Changes

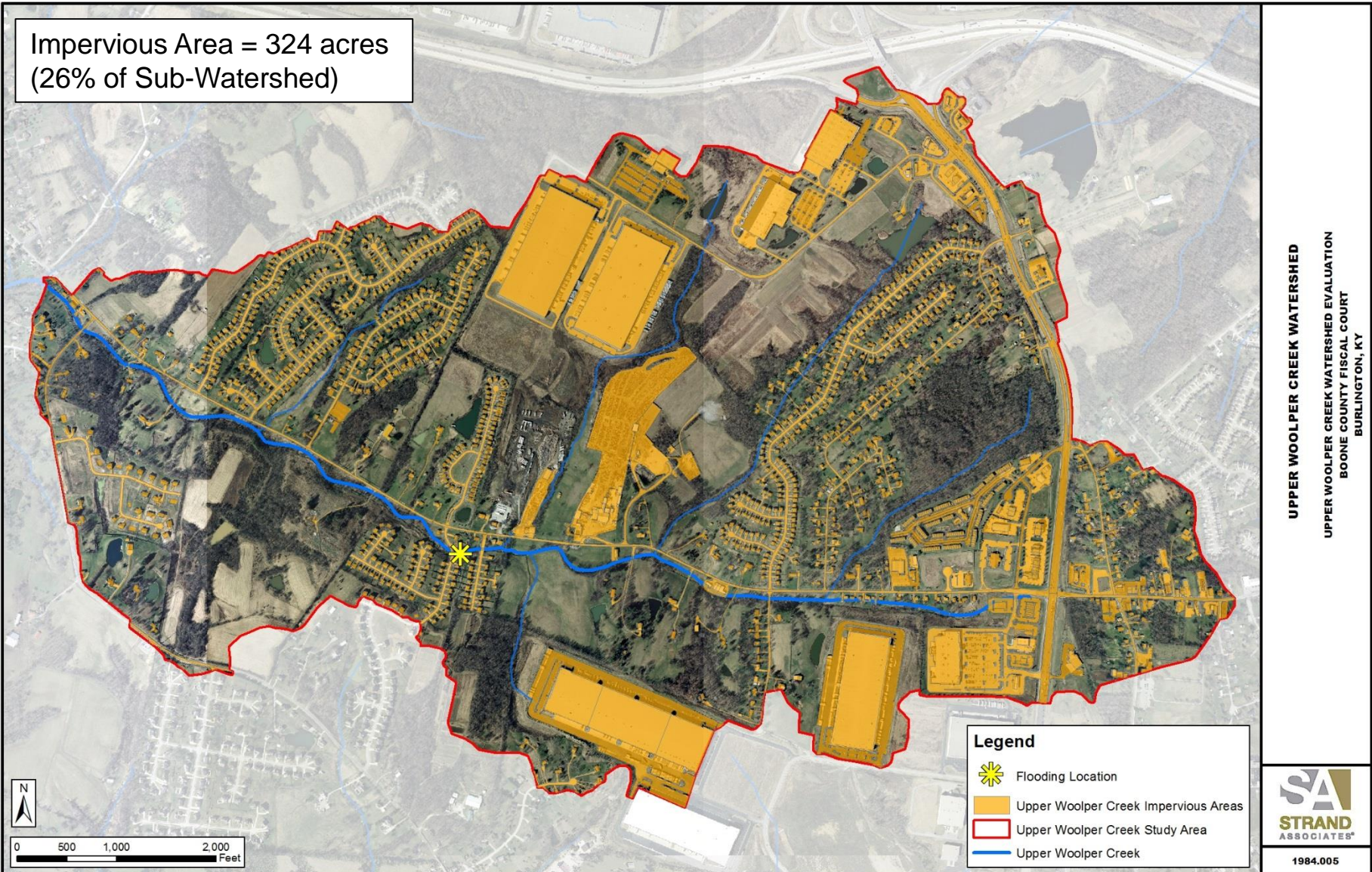
Newer Development (20 Years) =
375 acres (30% of Sub-Watershed)



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Impacts of Impervious Surfaces

Impervious Area = 324 acres
(26% of Sub-Watershed)

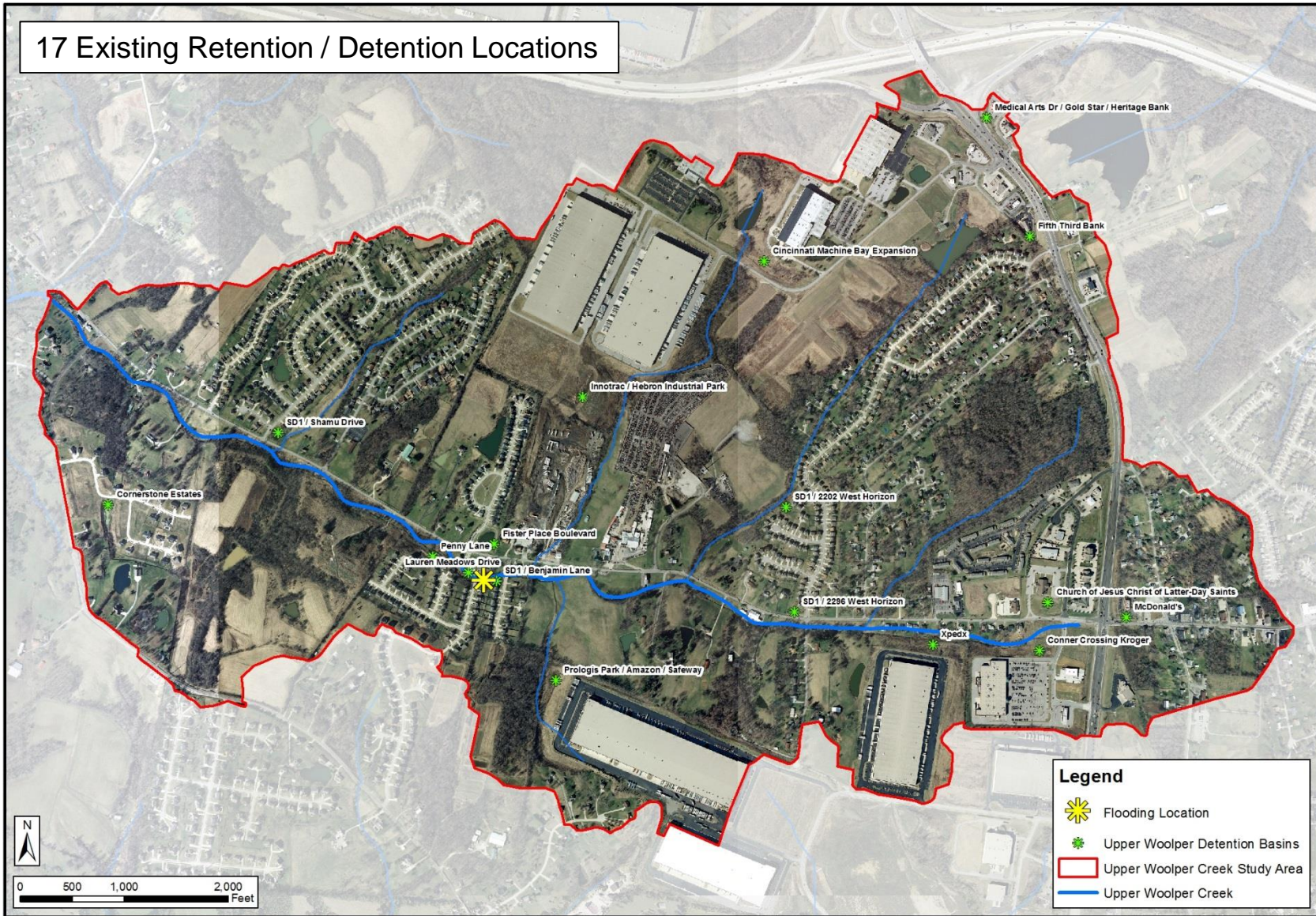


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Evaluation of Existing Detention Basins

17 Existing Retention / Detention Locations



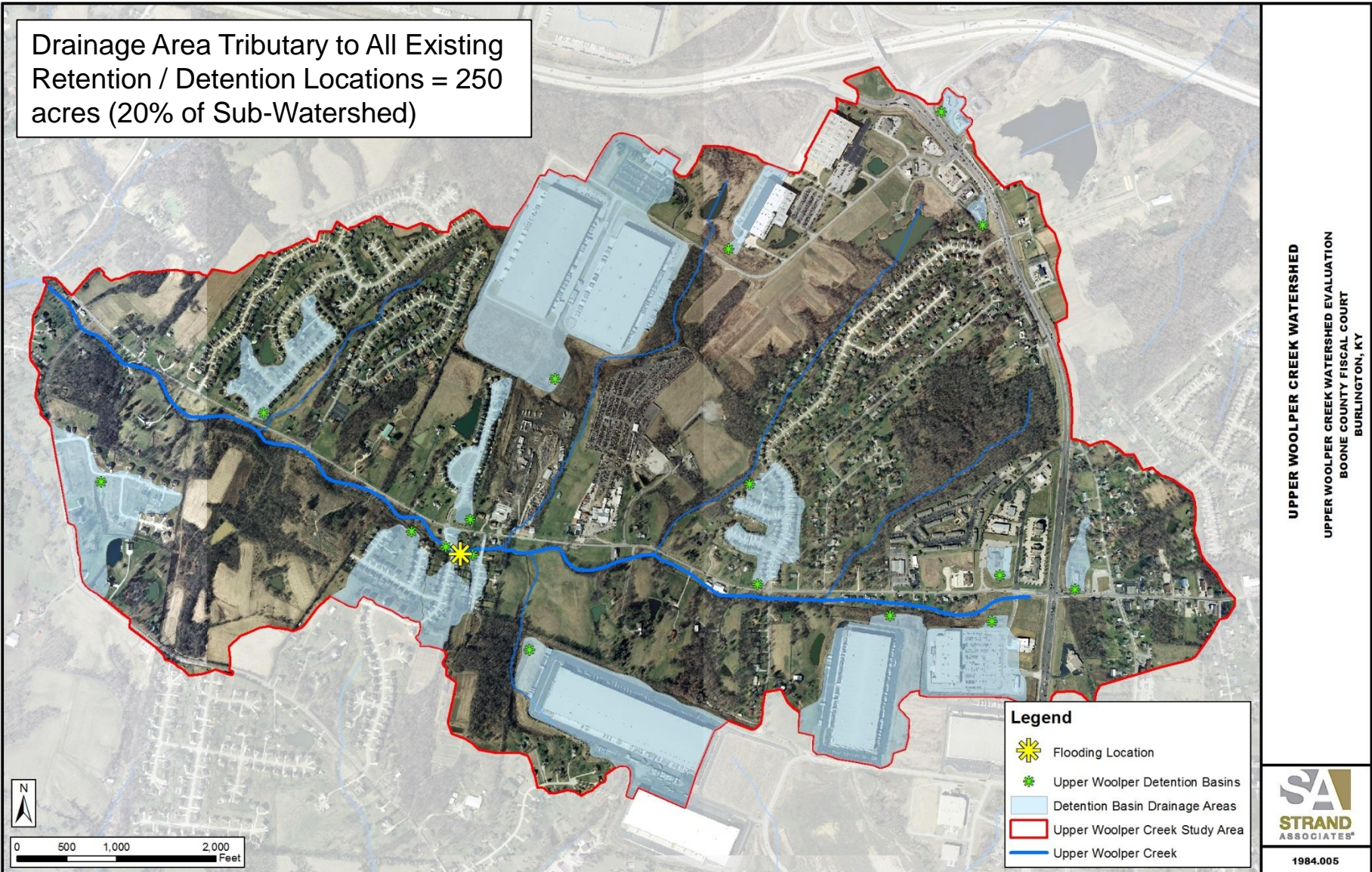
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Evaluation of Existing Detention Basins

Drainage Area Tributary to All Existing Retention / Detention Locations = 250 acres (20% of Sub-Watershed)

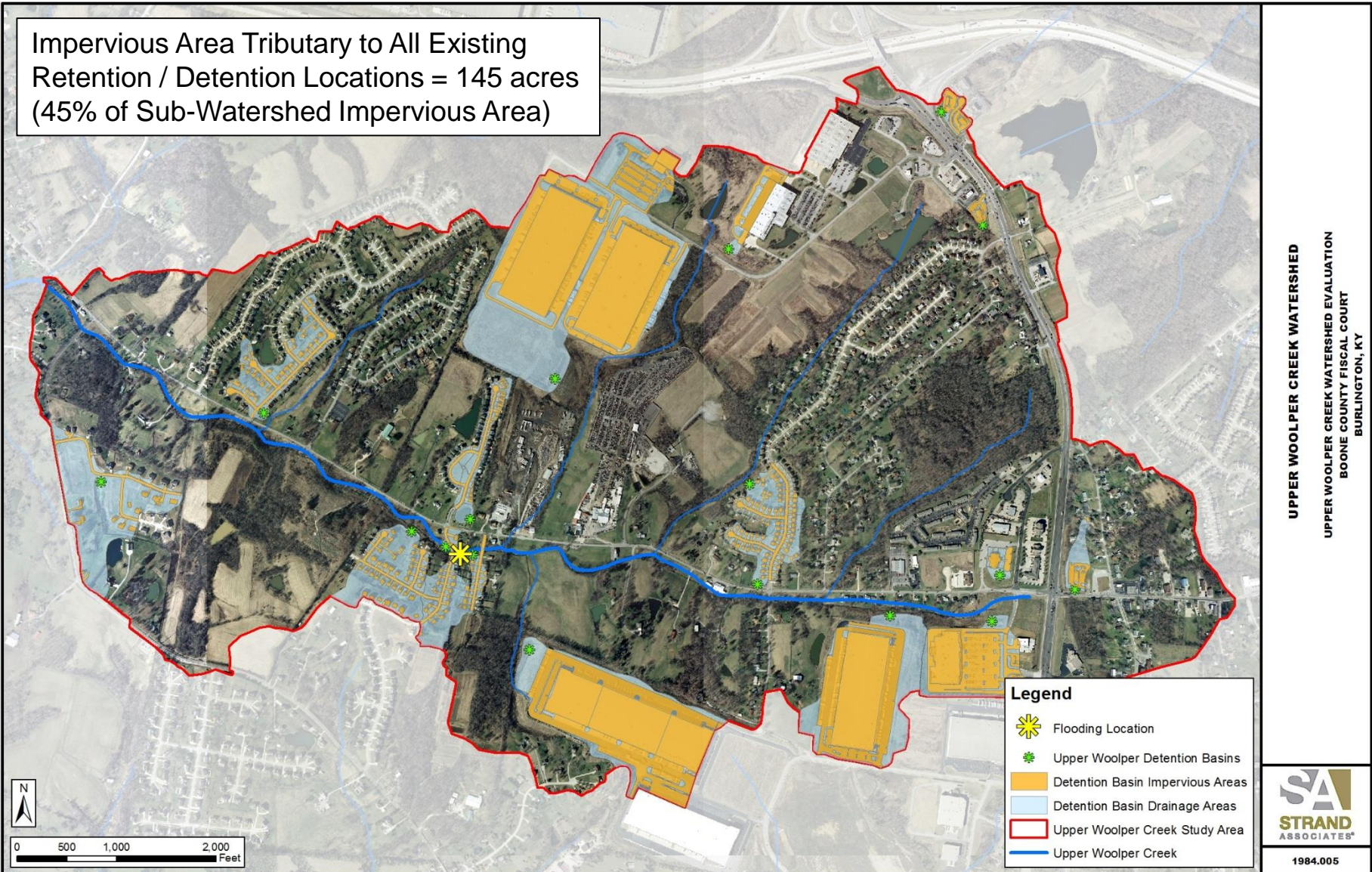


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Evaluation of Existing Detention Basins

Impervious Area Tributary to All Existing Retention / Detention Locations = 145 acres (45% of Sub-Watershed Impervious Area)



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Evaluation of Existing Detention Basins

Utilization of LiDAR-based data to estimate the stage-storage relationship and storage volume capacity of existing detention basins



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Evaluation of Existing Detention Basins

Basin #	Basin Name	Owner	Drainage Area (acres)	Impervious Area (acres)	Perc. Imperv.	Storage Vol. (ac-ft)
1	Innotrac / Hebron Industrial Park	Private - Industry	79.67	50.26	63.09%	20.31
2	Prologis Park / Amazon / Safeway	Private - Industry	39.12	32.44	82.92%	7.77
3	Xpedx	Private - Industry	31.14	21.60	69.36%	2.01
4	Cornerstone Estates	Residential	20.64	2.88	13.95%	2.61
5	Kroger / Conner Crossing	Private - Commercial	16.42	12.61	76.80%	3.08
6	Penny Lane	Residential	12.89	3.44	26.69%	0.43
7	Shamu Drive	SD1	10.76	4.32	40.15%	0.35
8	Lauren Meadows Drive	Residential	7.82	2.14	27.37%	0.06
9	2202 West Horizon	SD1	7.50	3.09	41.20%	0.11
10	Fister Place Boulevard	Residential	5.87	2.46	41.91%	0.64
11	2296 West Horizon	SD1	5.37	2.14	39.85%	0.22
12	Cincinnati Machine Bay Expansion	Private - Industry	4.02	2.65	65.92%	0.02
13	McDonald's	Private - Commercial	2.67	0.89	33.33%	0.07
14	Medical Arts Dr / Gold Star / Heritage Bank	Private - Commercial	1.95	1.37	70.26%	0.08
15	Church of Jesus Christ of Latter-Day Saints	Private - Religion	1.74	0.76	43.68%	0.25
16	Benjamin Lane	SD1	1.72	0.91	52.91%	0.04
17	Fifth Third Bank	Private - Commercial	0.95	0.67	70.53%	0.09
Total	-	-	250.25	144.63	-	38.15

Evaluation of Existing Detention Basins

BIG



Innotrac / Hebron Industrial Park

VS.

SMALL



Benjamin Lane



Prologis Park / Amazon / Safeway



Shamu Drive

Evaluation of Existing Detention Basins

Basin #	Basin Name	Owner	LIDAR Storage Vol. (ac-ft)	Design Storage Vol. (ac-ft)	Percent Difference	
1	Innotrac / Hebron Industrial Park	Private - Industry	20.31	20.53	-1.1%	✓
4	Cornerstone Estates	Residential	2.61	6.69	-61.0%	✗
5	Kroger / Conner Crossing	Private - Commercial	3.08	3.43	-10.2%	✓
6	Penny Lane	Residential	0.43	1.27	-66.1%	✗
7	Shamu Drive	SD1	0.35	0.63	-44.5%	✗
8	Lauren Meadows Drive	Residential	0.06	0.22	-72.1%	✗
9	2202 West Horizon	SD1	0.11	0.52	-78.9%	✗
10	Fister Place Boulevard	Residential	0.64	0.89	-27.7%	✗
11	2296 West Horizon	SD1	0.22	0.42	-49.0%	✗
12	Cincinnati Machine Bay Expansion	Private - Industry	0.02	0.34	-93.1%	✗
13	McDonald's	Private - Commercial	0.07	0.12	-46.4%	✗
14	Medical Arts Dr / Gold Star / Heritage Bank	Private - Commercial	0.08	0.11	-22.0%	✗
15	Church of Jesus Christ of Latter-Day Saints	Private - Religion	0.25	0.44	-43.3%	✗
Total	-	-	28.23	35.61	-20.7%	



Majority of existing detention basins appear to be undersized when comparing LIDAR-based storage volume to design-based storage volume (especially on smaller basins).

Identifying Opportunities for Detention Basin Retrofits

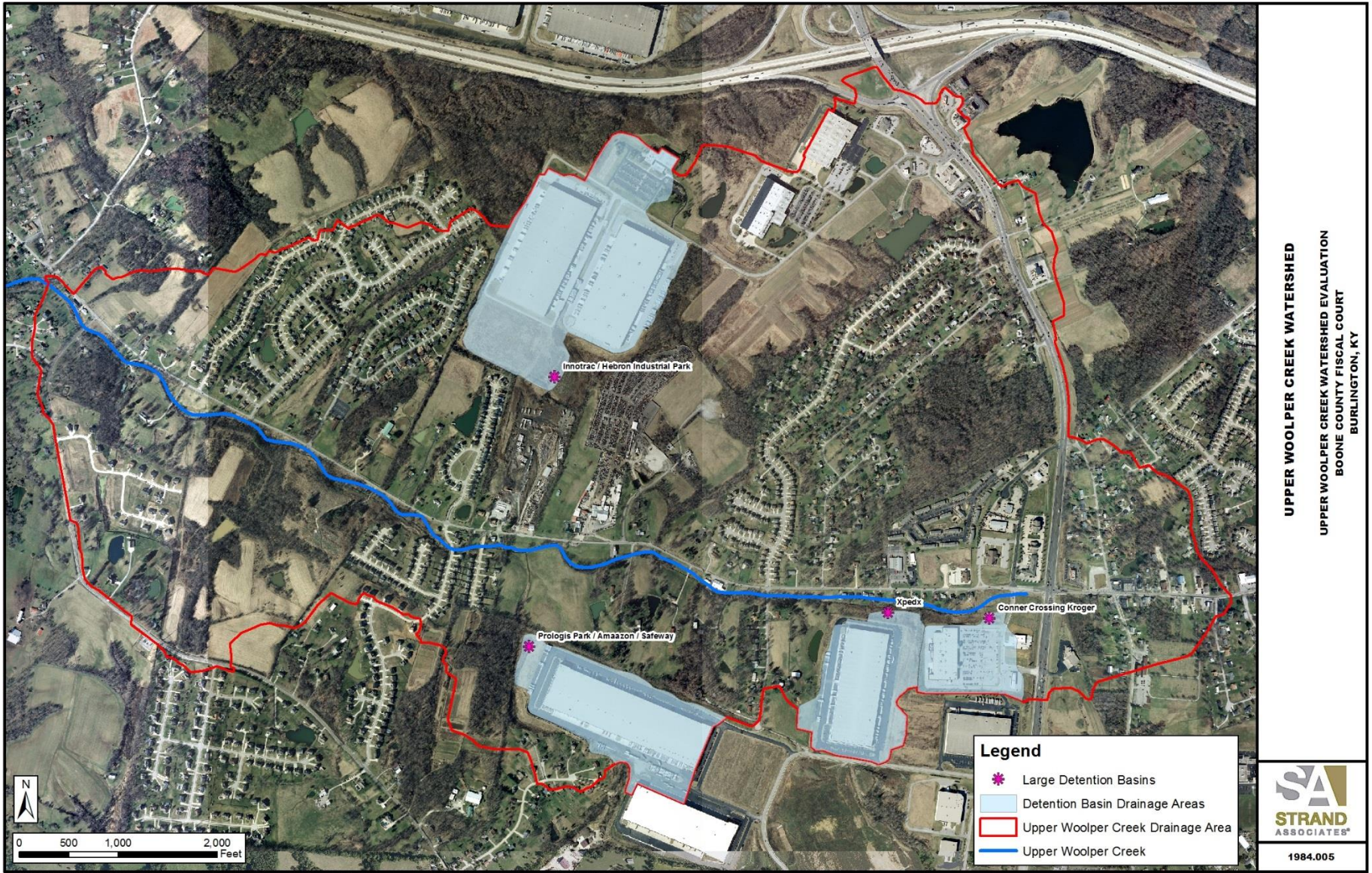
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5	Kroger / Conner Crossing	Private - Commercial	16.42	12.61	76.80%	3.08
6	Penny Lane	Residential	12.89	3.44	26.69%	0.43
7	Shamu Drive	SD1	10.76	4.32	40.15%	0.35

Statistics on “Big 4” Detention Basins:

- Total drainage area of 166.35 acres represents 66% of drainage area to all detention basins.
- Impervious drainage area of 116.91 acres represents 81% of impervious area to all detention basins.
- Storage volume of 33.2 ac-ft represents 87% of storage volume provided by all detention basins.

15	Church of Jesus Christ of Latter-Day Saints	Private - Religion	1.74	0.76	43.68%	0.25
16	Benjamin Lane	SD1	1.72	0.91	52.91%	0.04
17	Fifth Third Bank	Private - Commercial	0.95	0.67	70.53%	0.09
Total	-	-	250.25	144.63	-	38.15

Identifying Opportunities for Detention Basin Retrofits

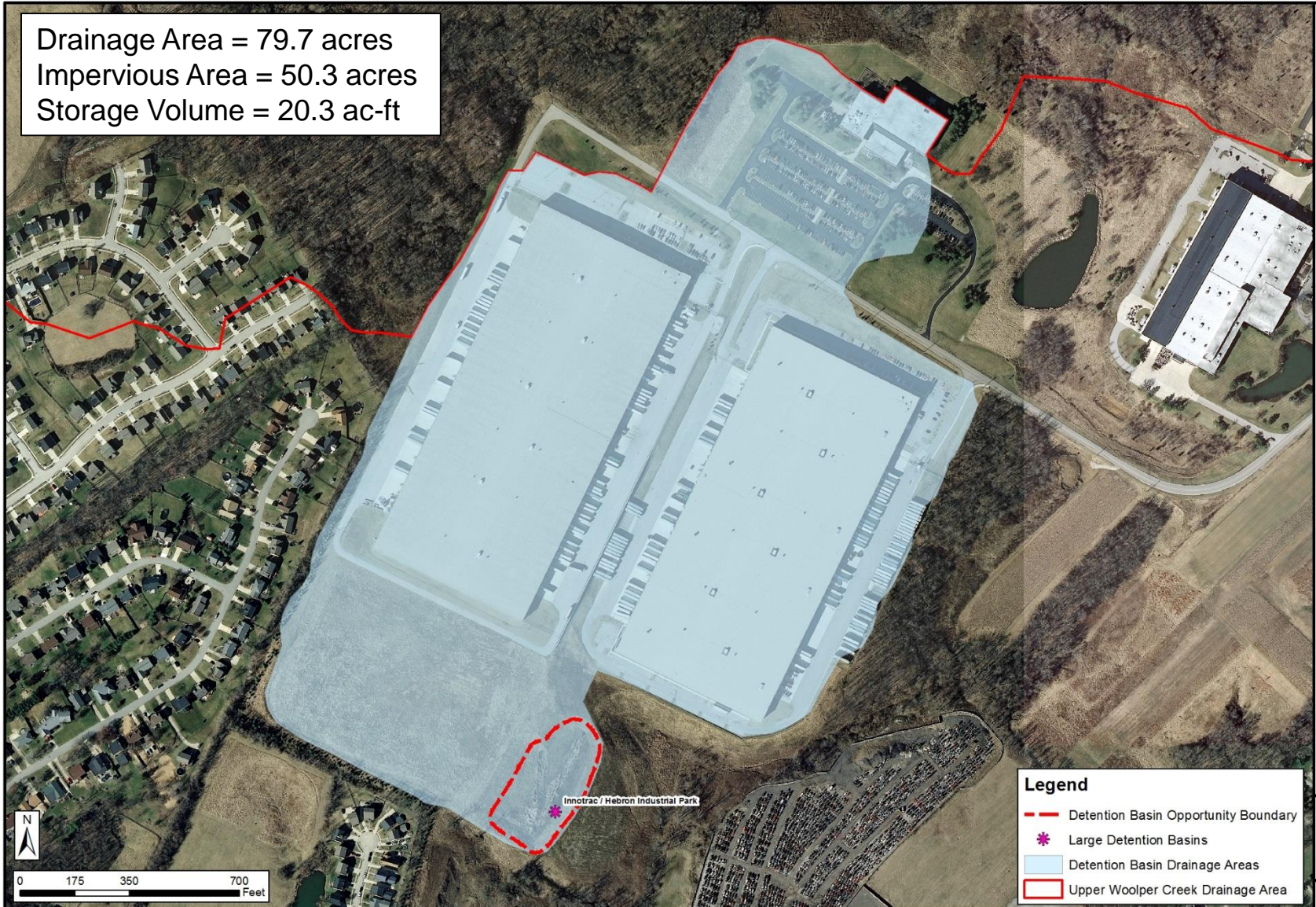


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BURLINGTON, KY



Identifying Opportunities for Detention Basin Retrofits

Drainage Area = 79.7 acres
Impervious Area = 50.3 acres
Storage Volume = 20.3 ac-ft



Legend

- Detention Basin Opportunity Boundary
- * Large Detention Basins
- Detention Basin Drainage Areas
- Upper Woolper Creek Drainage Area

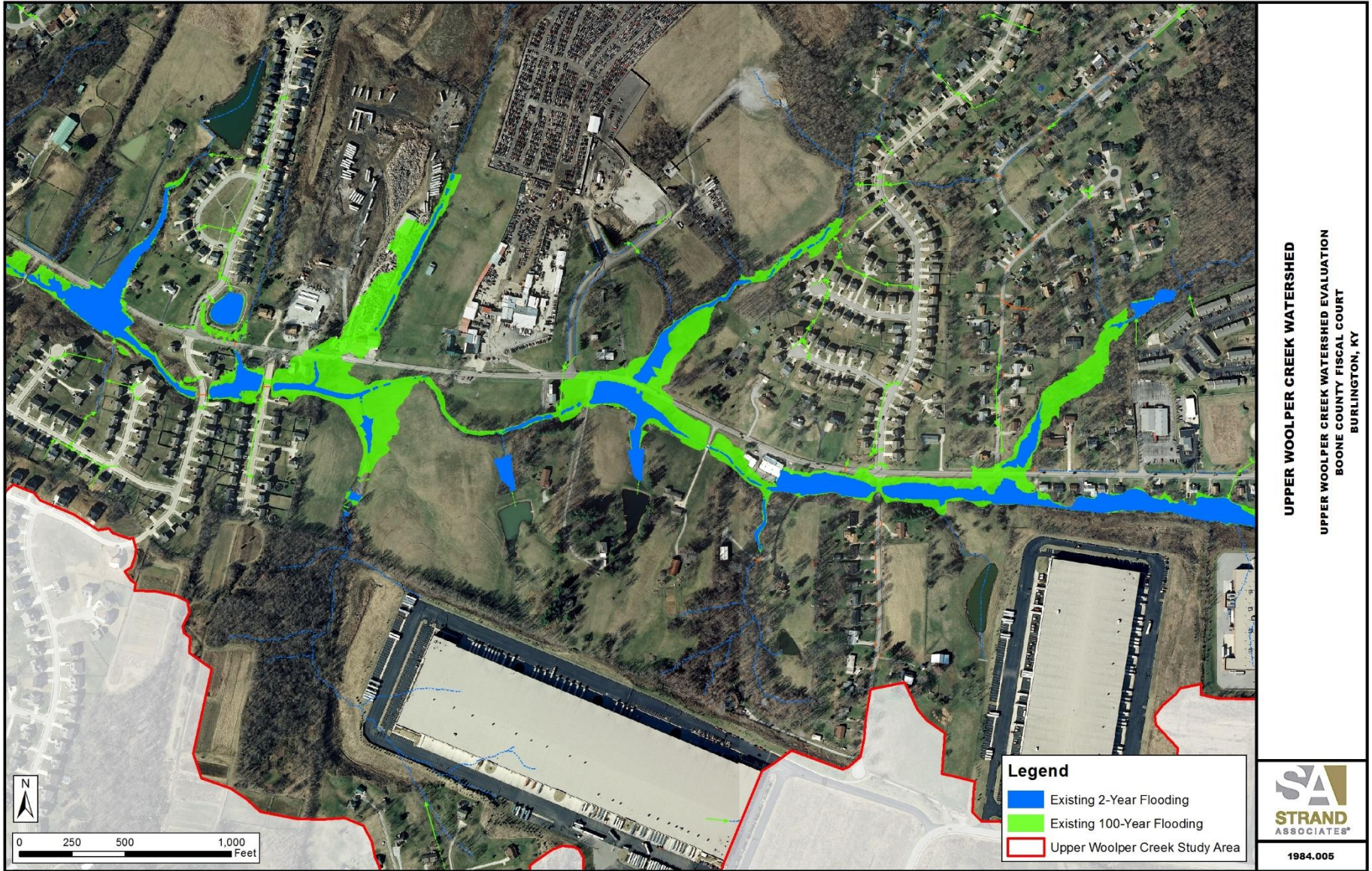
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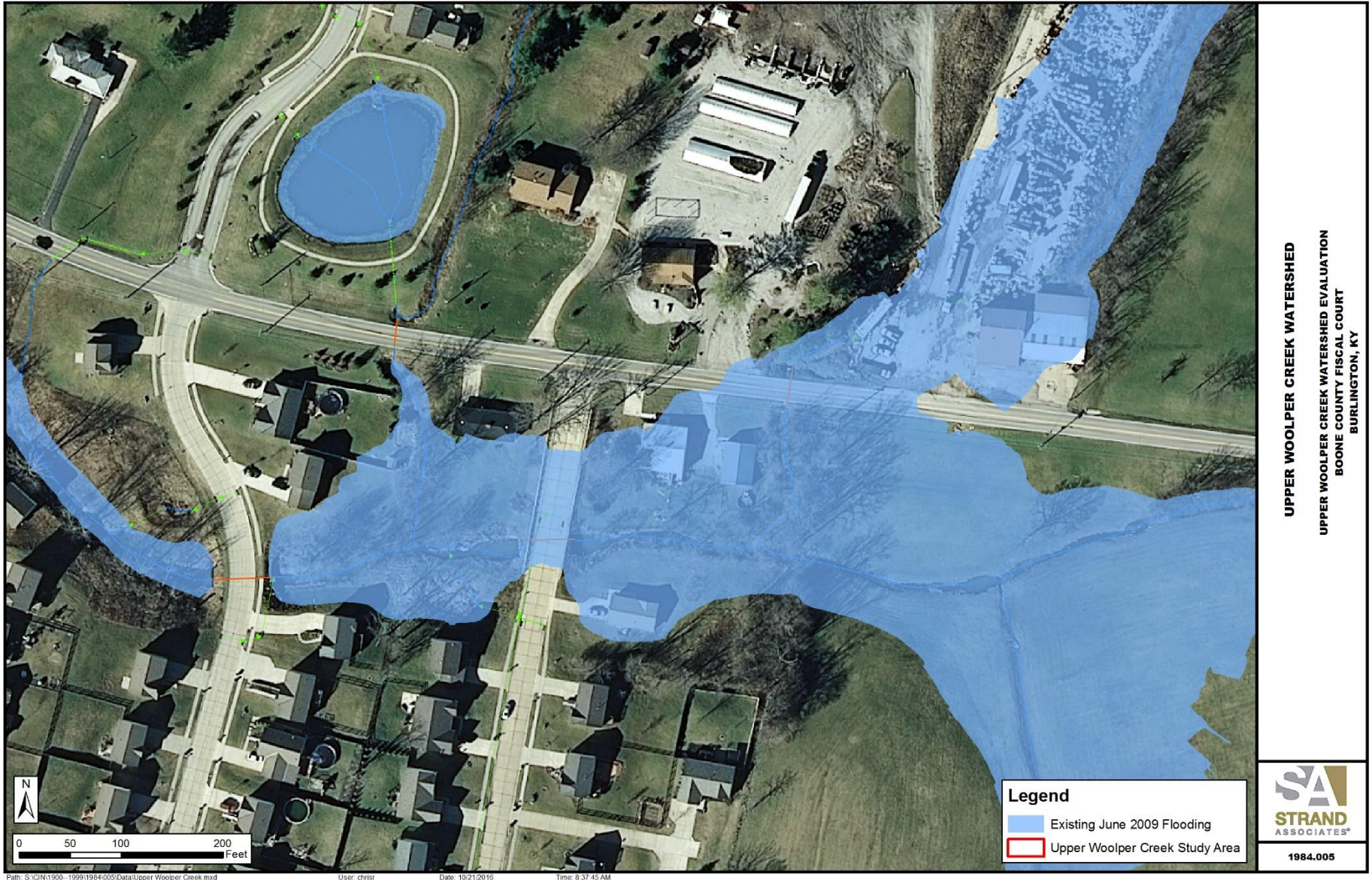
Identifying Opportunities for Detention Basin Retrofits



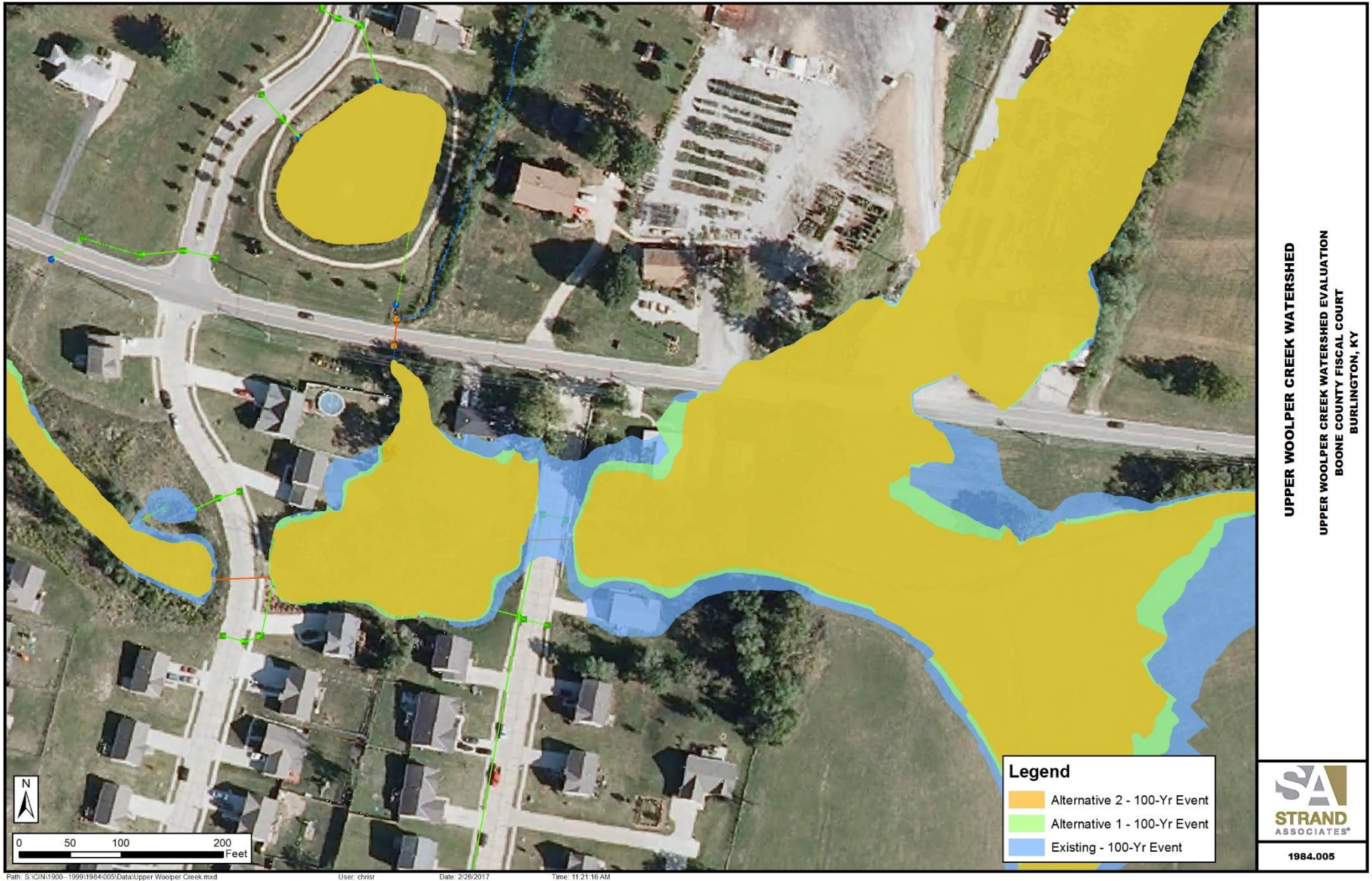
Evaluating Opportunities for Detention Basin Retrofits



Evaluating Opportunities for Detention Basin Retrofits



Evaluating Opportunities for Detention Basin Retrofits



Water Quantity / Flood Reduction Benefits

Culvert Location	Existing Conditions	Alternative No. 1 Culvert Replacement		Alternative No. 2 Culvert Replacement with Detention Basin Retrofits	
	Peak Flow Rate (cfs)	Peak Flow Rate (cfs)	Percent Increase	Peak Flow Rate (cfs)	Percent Increase
Benjamin Lane	351	356	1.4%	314	-10.5%
Lauren Meadows Drive	362	368	1.7%	327	-9.7%
2607 Petersburg Road	376	386	2.7%	346	-8.0%
2903 Petersburg Road	453	464	2.4%	426	-6.0%
2939 Petersburg Road	462	474	2.6%	437	-5.4%
Bullittsville Road	470	481	2.3%	445	-5.3%
Peel Road	1,043	1,049	0.6%	1,023	-1.9%

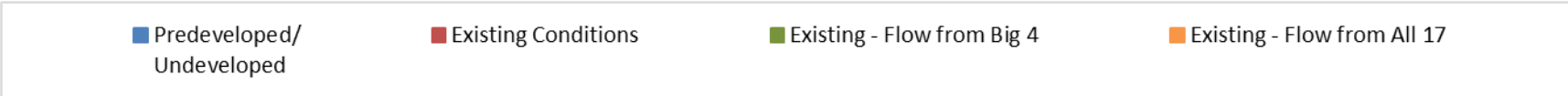
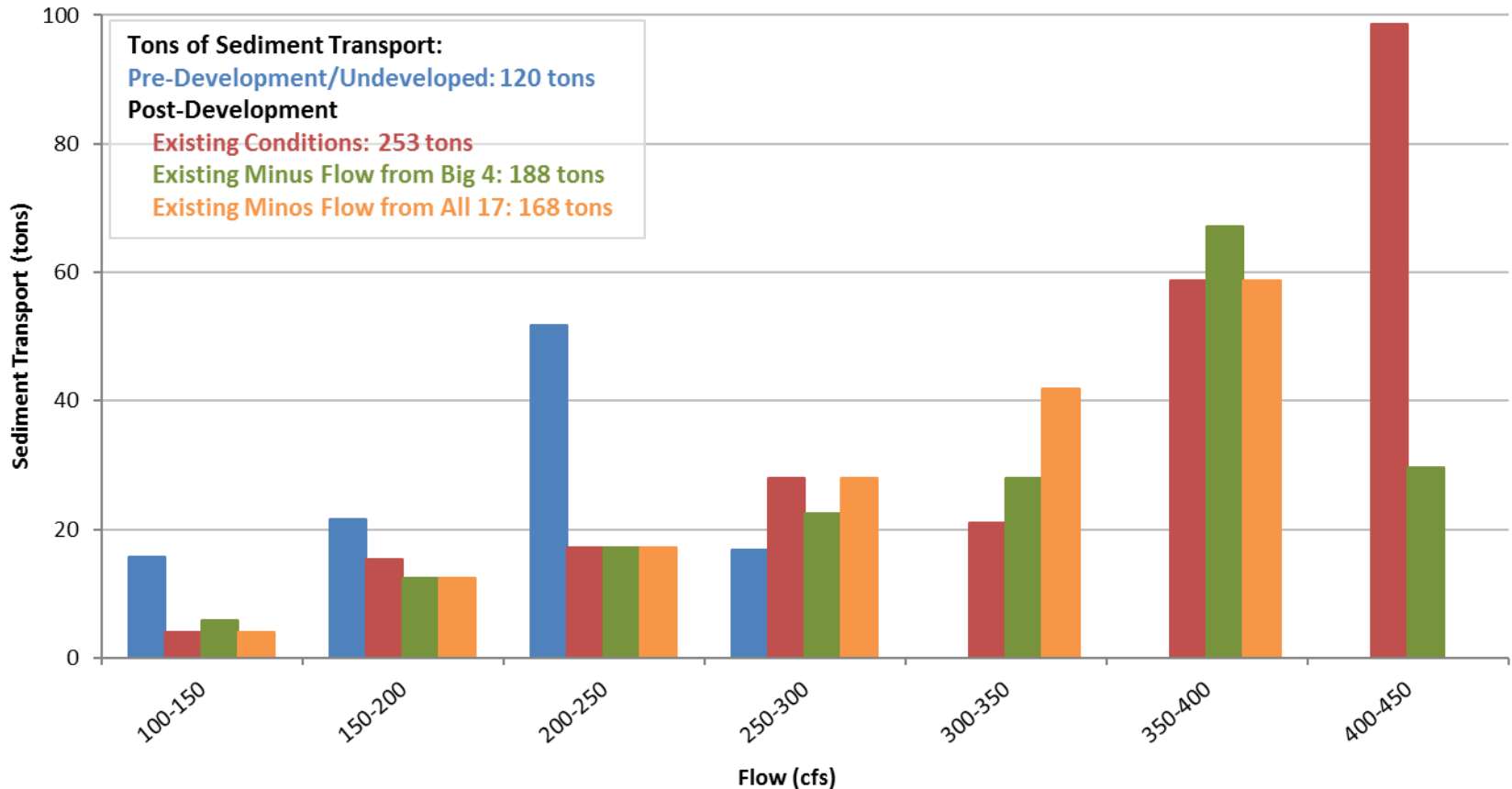
Culvert Location	Existing Conditions	Alternative No. 1 Culvert Replacement		Alternative No. 2 Culvert Replacement with Detention Basin Retrofits	
	WSE (ft)	WSE (ft)	Change (ft)	WSE (ft)	Change (ft)
Benjamin Lane	807.16	805.61	-1.55	805.47	-1.69
Lauren Meadows Drive	804.53	804.56	0.03	804.37	-0.16
2607 Petersburg Road	798.17	798.20	0.03	798.08	-0.09
2903 Petersburg Road	783.78	783.88	0.10	783.57	-0.21
2939 Petersburg Road	780.65	780.68	0.03	780.58	-0.07
Bullittsville Road	776.18	776.26	0.08	775.97	-0.21
Peel Road	757.92	757.94	0.02	757.87	-0.05



Strategic detention basin retrofits can help offset the increased peak flow rates and water surface elevations that would occur if only culvert replacement alternative was implemented.

Water Quality / Hydromodification Benefits

Bullittsville Road - 2-year, 24-hour



Water Quality / Hydromodification Benefits

	Predeveloped/ Undeveloped	Post-Developed		
		Existing Conditions	Existing Minus Flow from Big 4	Existing Minus Flow from All 17
Peak Flow (cfs)	353	538	504	470
Minutes > Q _{critical}	168	180	132	123
Sediment (tons)	120	253	188	168

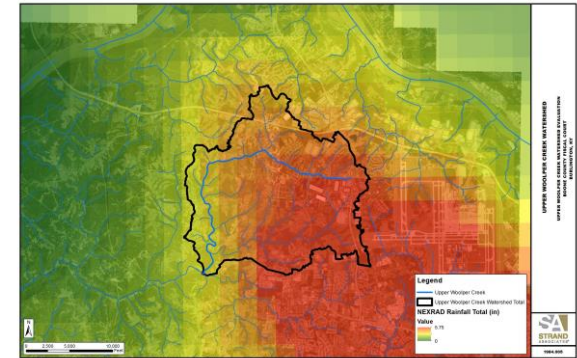
% Change from Pre-Developed	Predeveloped/ Undeveloped	Post-Developed		
		Existing Conditions	Existing Minus Flow from Big 4	Existing Minus Flow from All 17
Peak Flow (cfs)	-	52%	43%	33%
Minutes > Q _{critical}	-	7%	-21%	-27%
Sediment (tons)	-	111%	57%	40%

EXCESS Peaks, Duration, and Sediment Transport	Predeveloped/ Undeveloped	Post-Developed		
		Existing Conditions	Existing Minus Flow from Big 4	Existing Minus Flow from All 17
Peak Flow (cfs)	-	185	151	116
Minutes > Q _{critical}	-	12	-36	-45
Sediment (tons)	-	133	68	48

- Goal: Reduce excess sediment transport by 100%
- Detention basin retrofits at the 4 biggest detention basins = 49% of goal
- Detention basin retrofits at all 17 detention basins = 64% of goal

Upper Woolper Creek Watershed Case Study

- Understanding of magnitude of stormwater management issues is important to guide stormwater master planning initiatives.
- Identification of stormwater management improvements through stormwater master planning can potentially lead to improvements in water quantity (flood reduction) and water quality (sediment transport reduction) improvements.
- Simple modifications at existing detention basins with excess storage capacity can have a big impact downstream.
- Collaboration and partnerships are critical for stormwater master planning evaluations and implementation.



QUESTIONS?

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