



# PUTTING IT ALL TOGETHER

ON A REAL WORLD SITE:  
LESSONS LEARNED

ROBERT W. BAILEY, PE, LEED AP BD+C



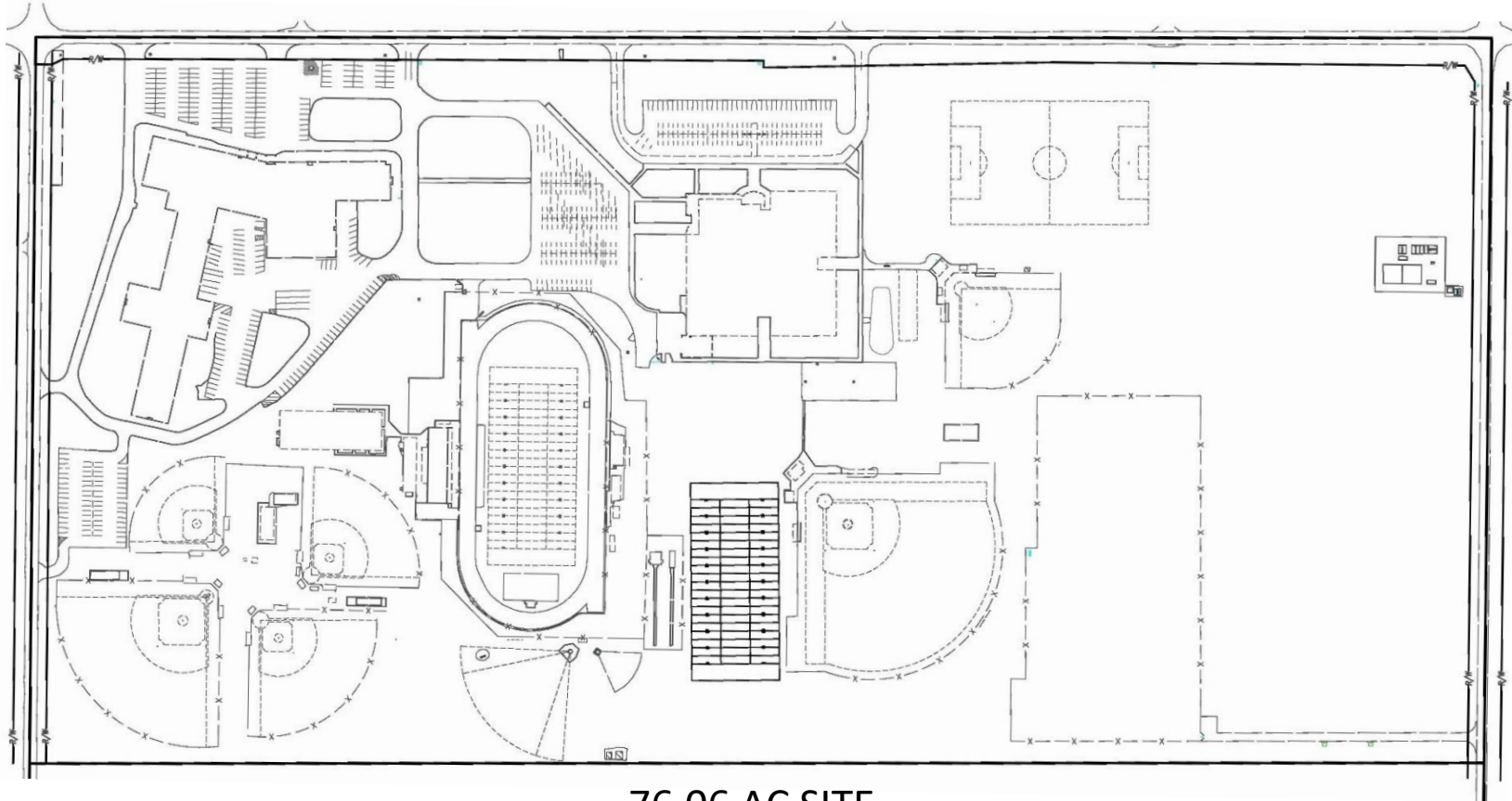
# INTRODUCTION

## TWO ITEMS TO COVER

1. REDEVELOPMENT
2. RUNOFF REDUCTION METHOD



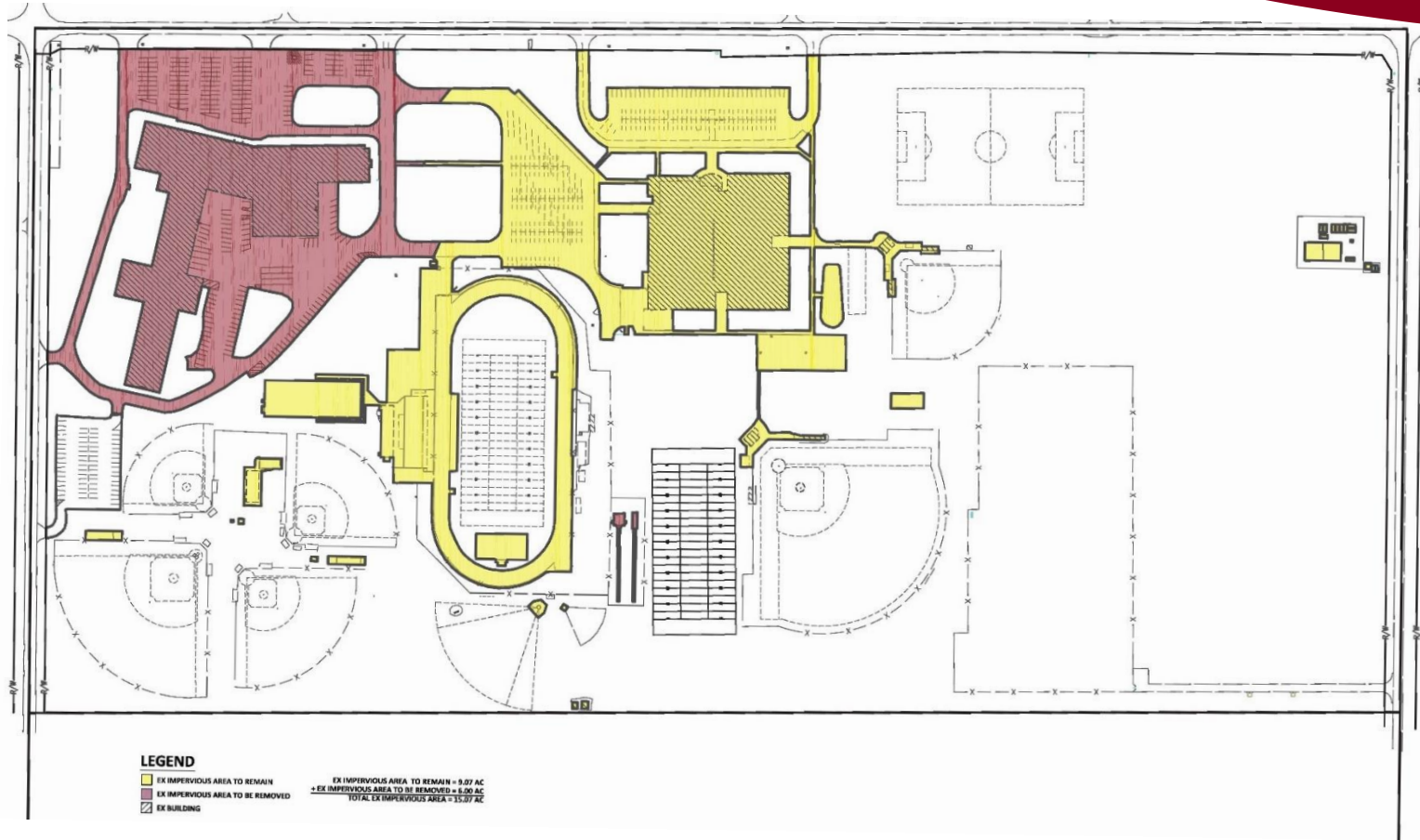
# REDEVELOPMENT



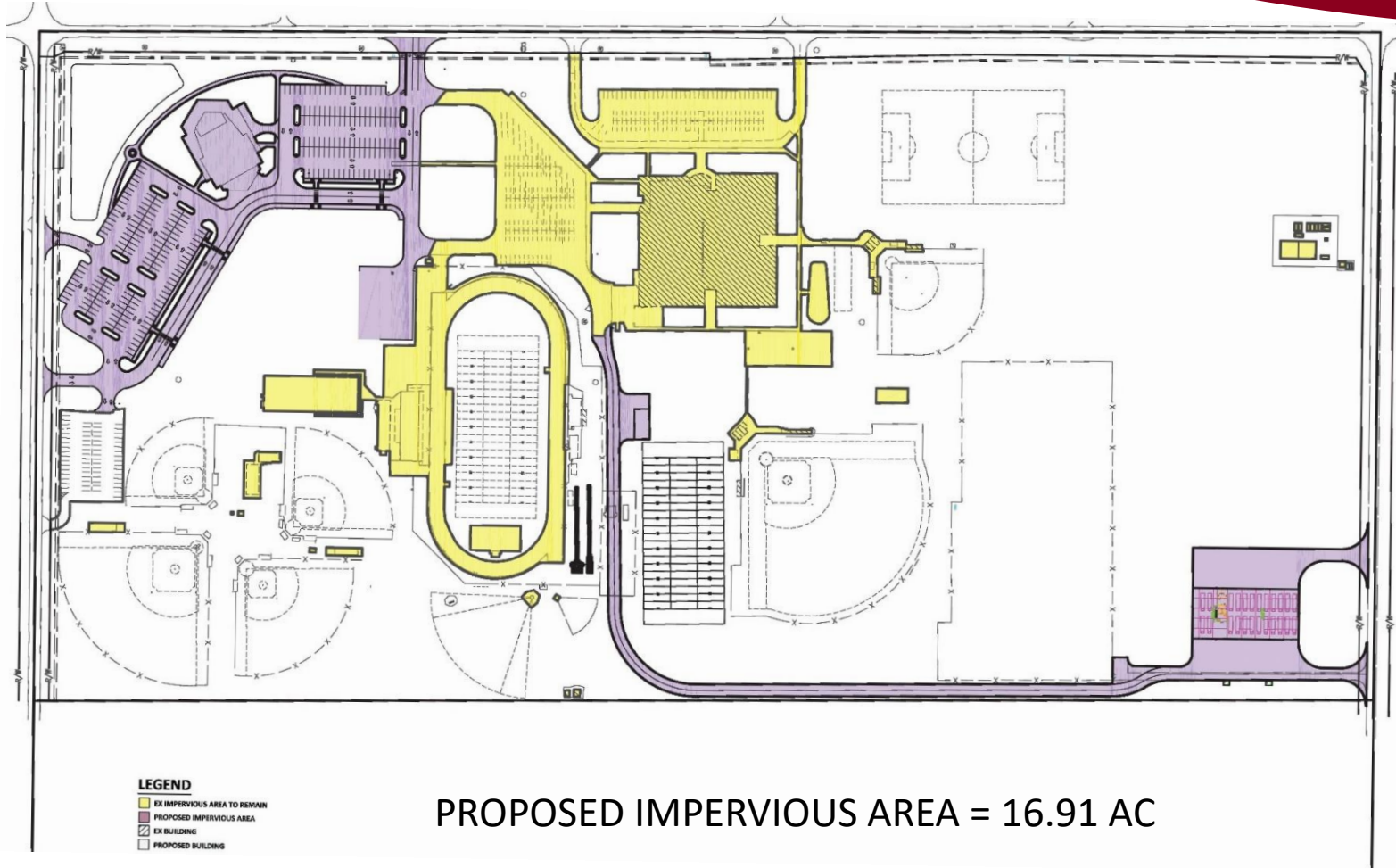
76.06 AC SITE



# REDEVELOPMENT

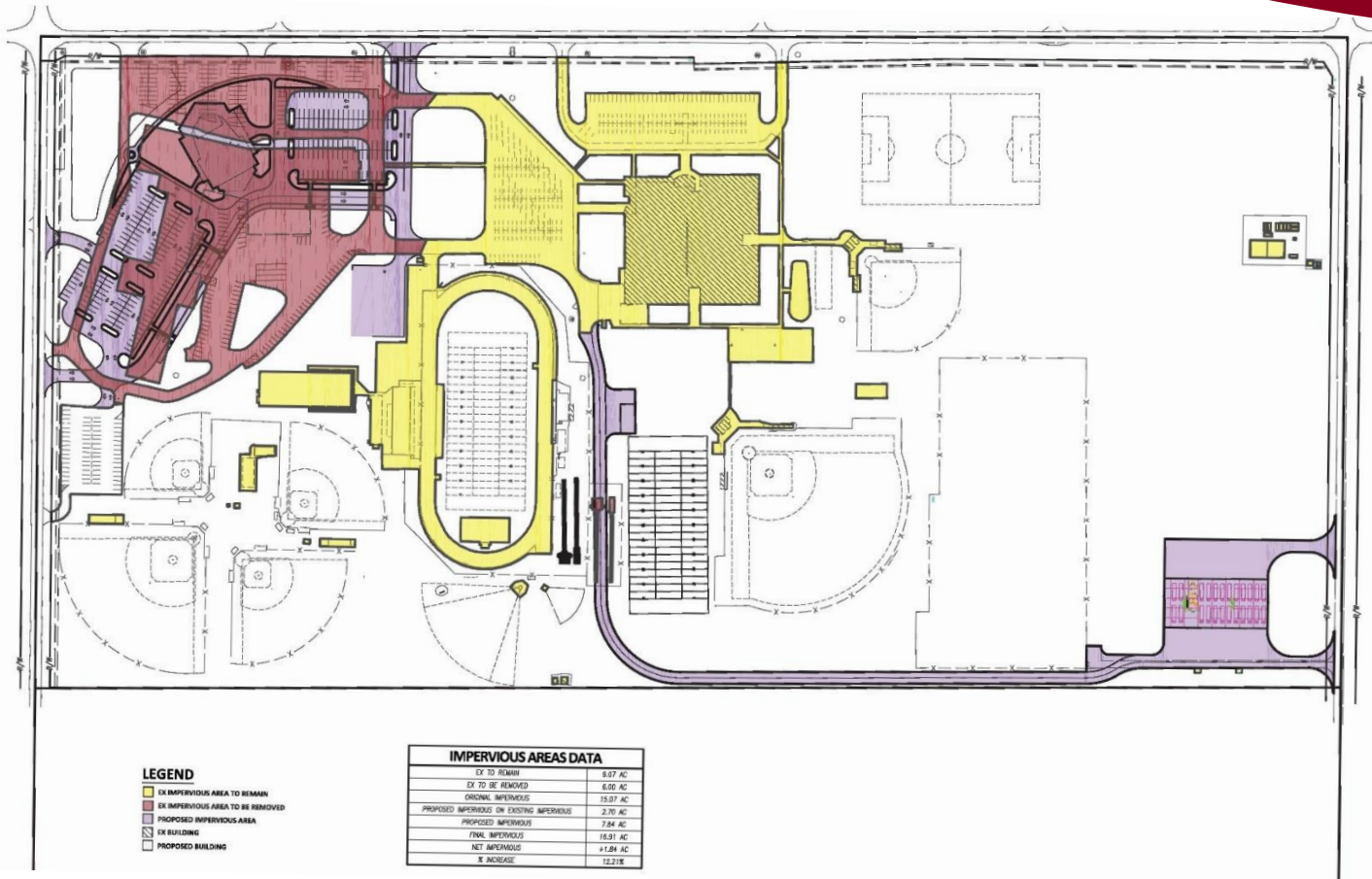


# REDEVELOPMENT



PROPOSED IMPERVIOUS AREA = 16.91 AC

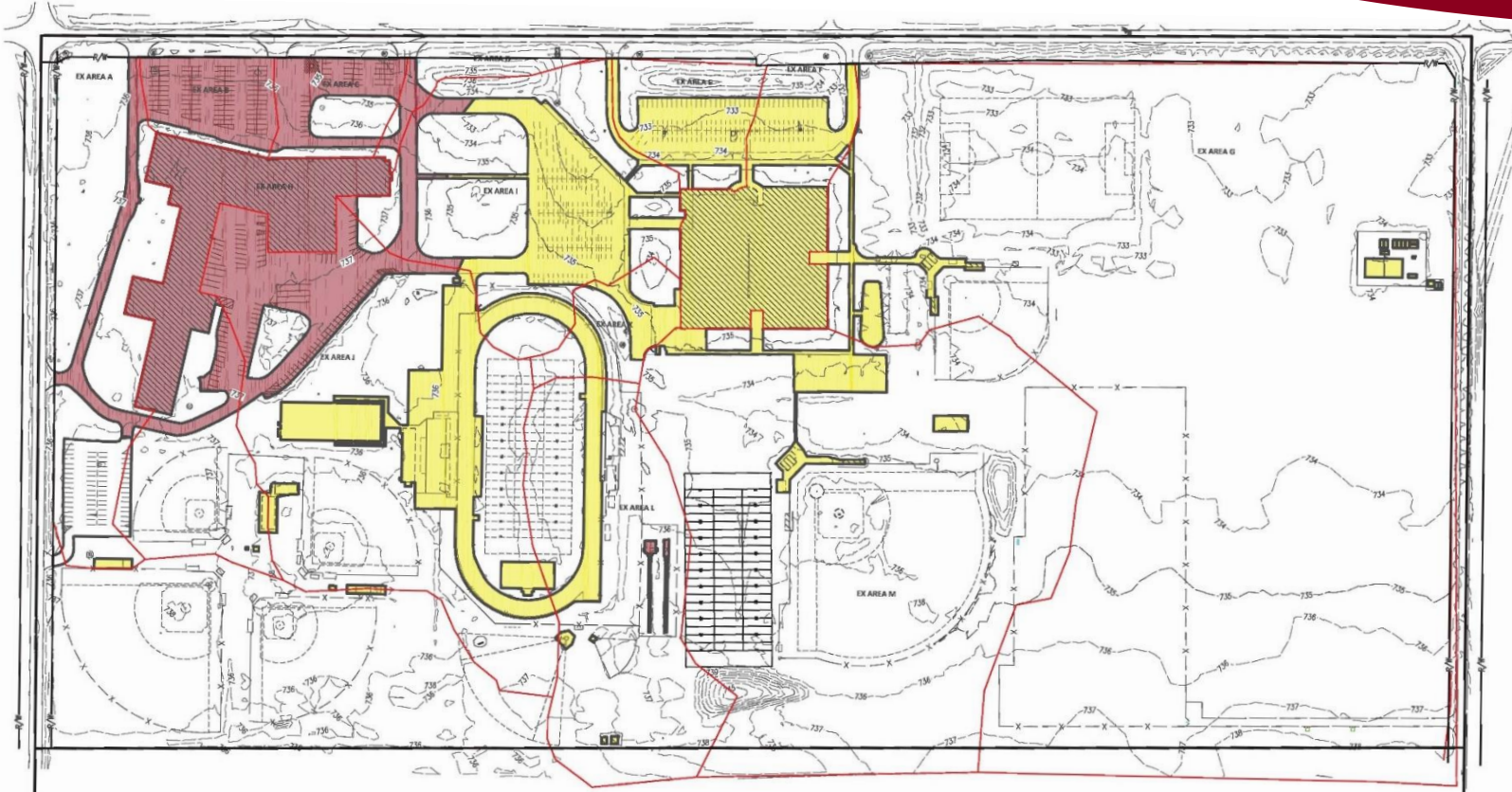
# REDEVELOPMENT



NET INCREASE OF IMPERVIOUS AREA = 1.84 AC



# REDEVELOPMENT



## LEGEND

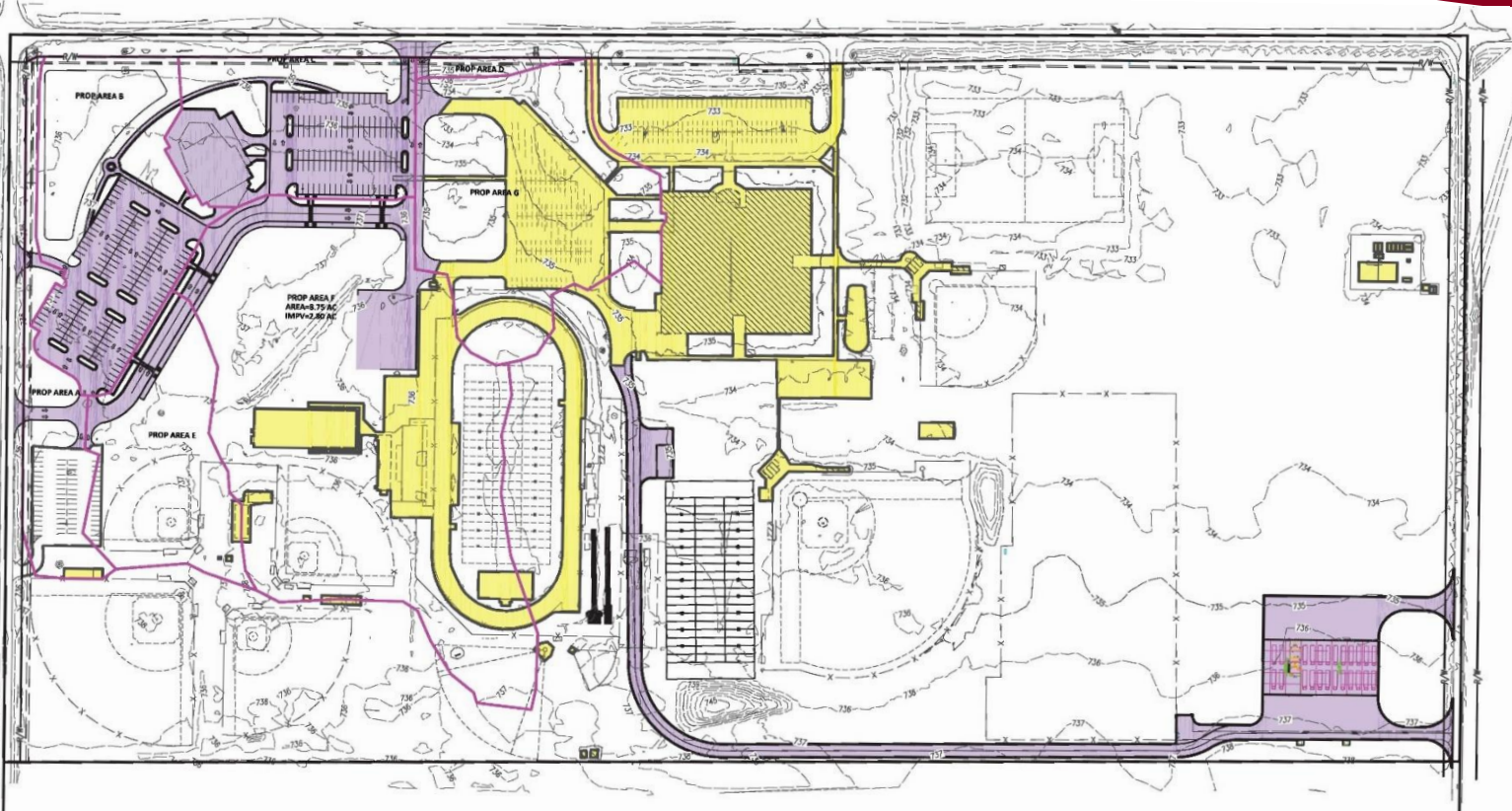
- EX IMPERVIOUS AREA TO REMAIN
- EX IMPERVIOUS AREA TO BE REMOVED
- EX BUILDING

EX IMPERVIOUS AREA TO REMAIN = 9.07 AC  
EX IMPERVIOUS AREA TO BE REMOVED = 6.90 AC  
TOTAL EX IMPERVIOUS AREA = 15.97 AC

80.55 ACRES GROSS  
4.49 ACRES IN R/W  
76.06 ACRES NET



# REDEVELOPMENT



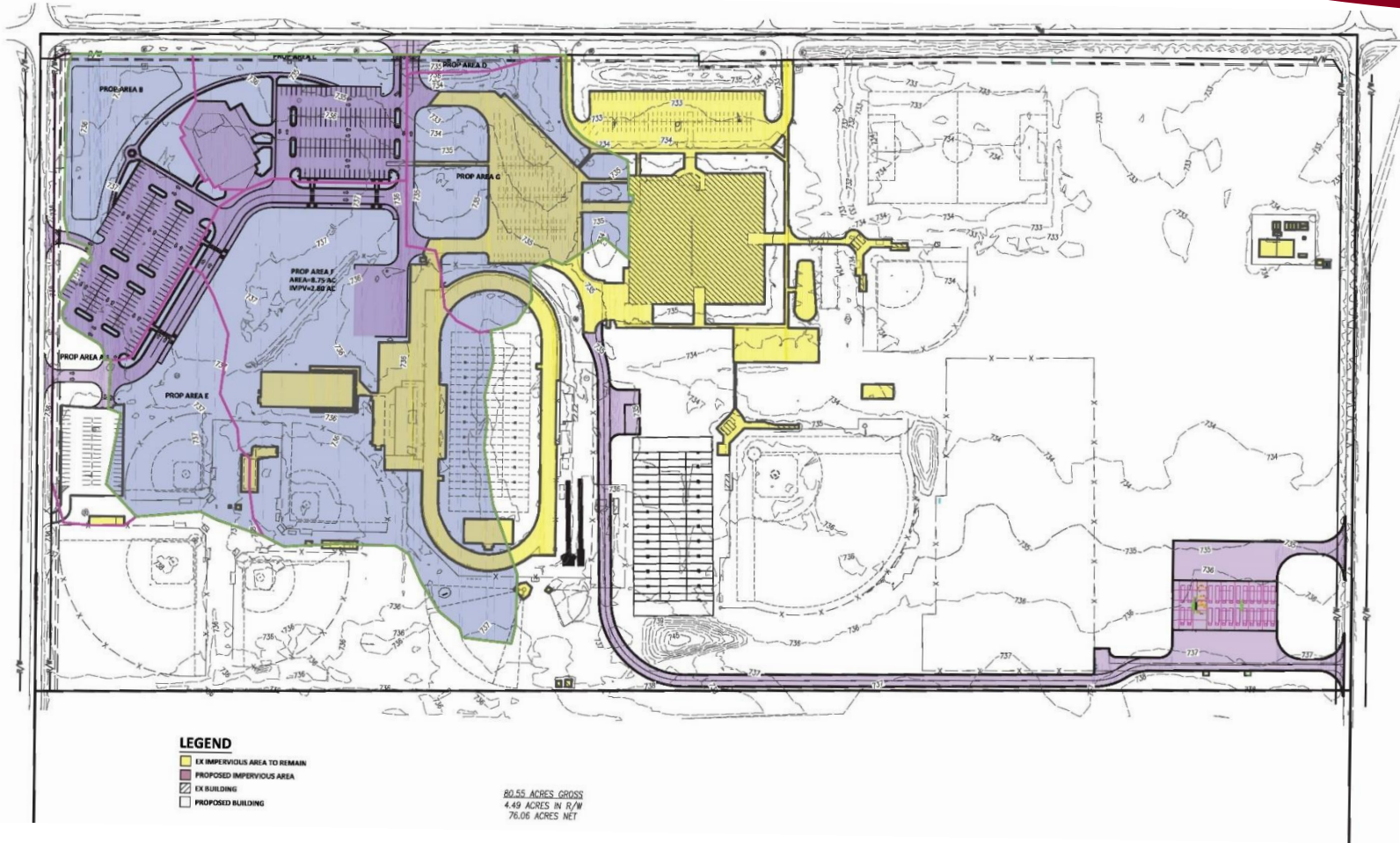
- LEGEND**
- EX IMPERVIOUS AREA TO REMAIN
  - PROPOSED IMPERVIOUS AREA
  - EX BUILDING
  - PROPOSED BUILDING

80.55 ACRES GROSS  
4.49 ACRES IN R/W  
76.06 ACRES NET

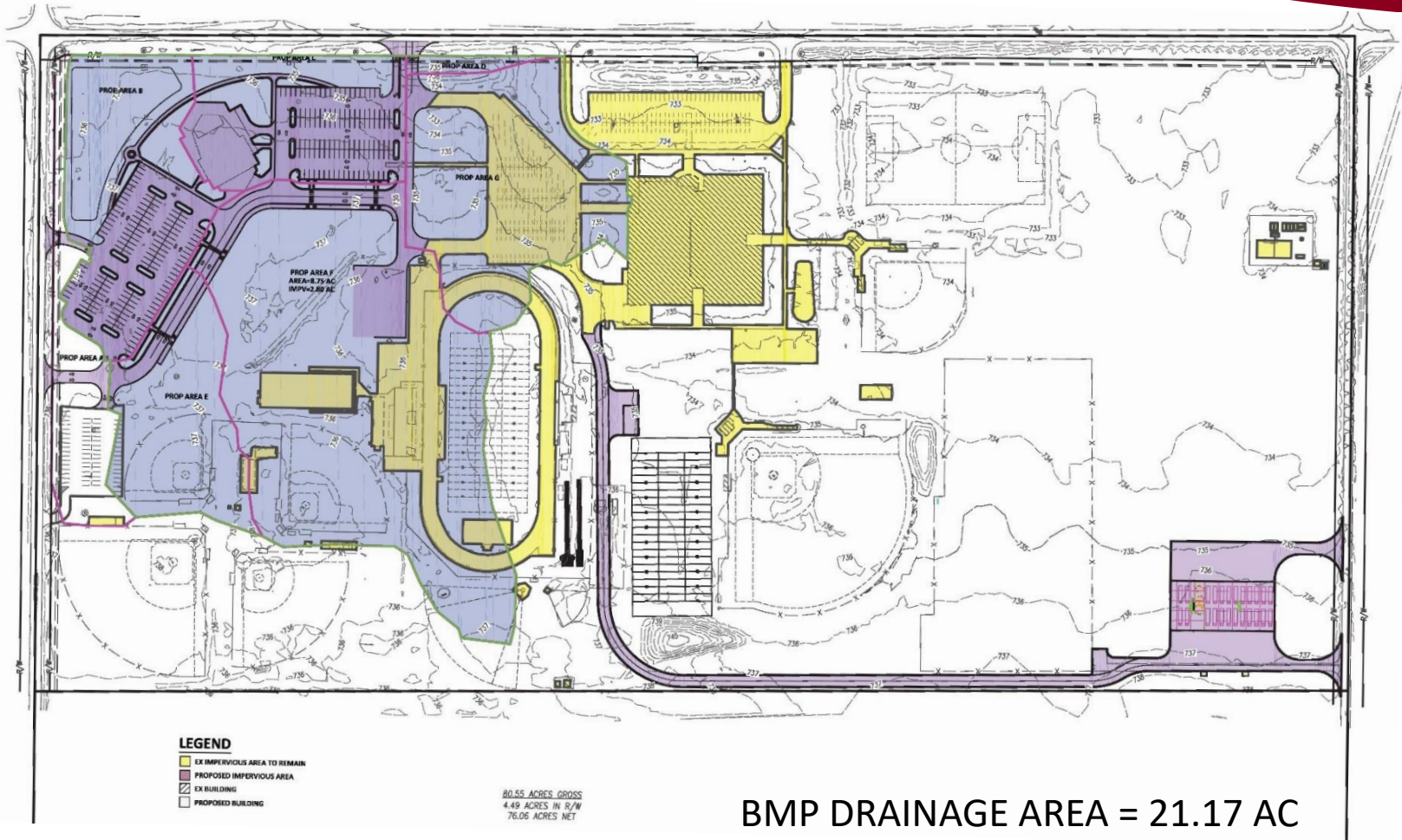




# REDEVELOPMENT

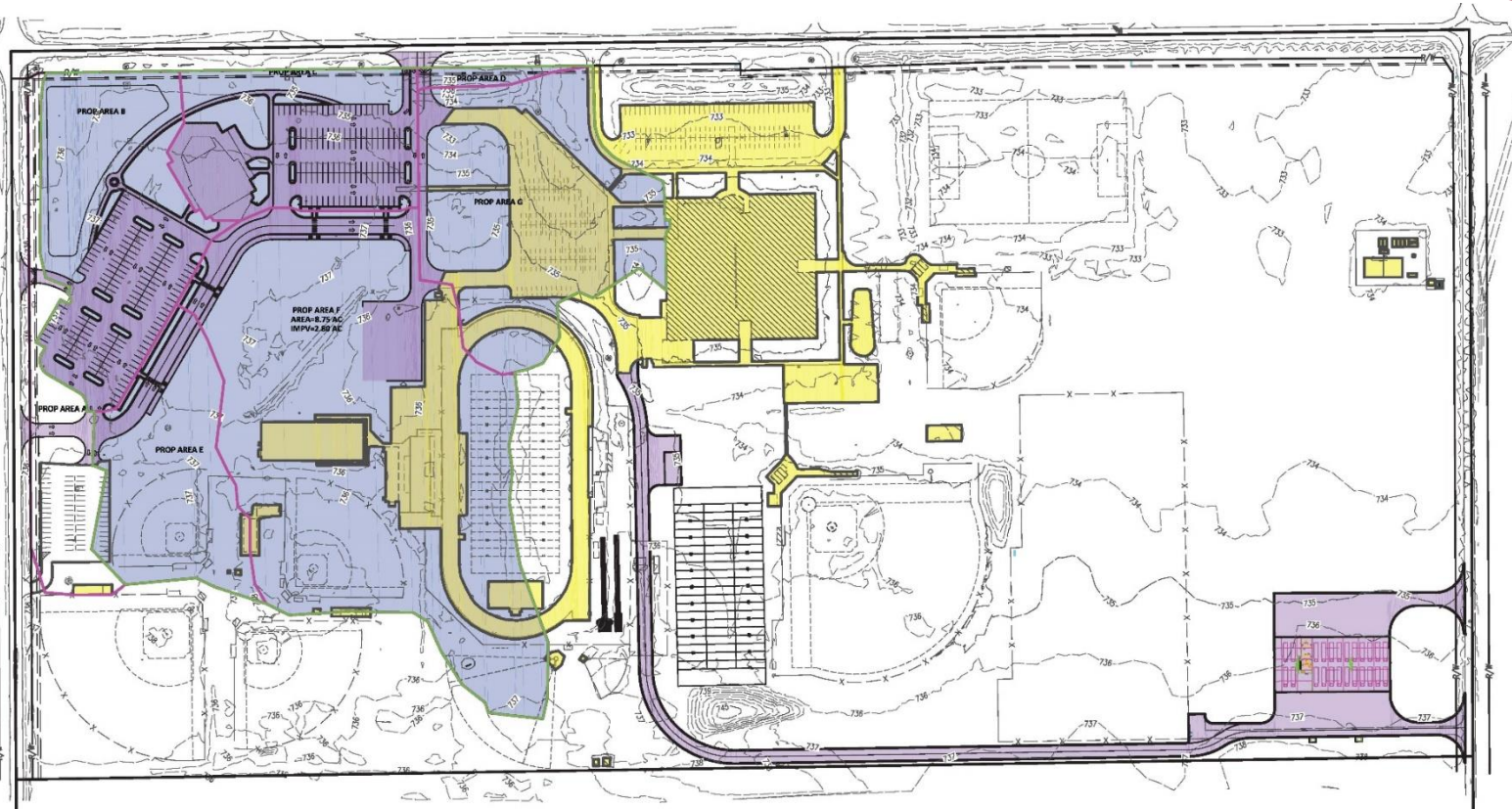


# REDEVELOPMENT





# REDEVELOPMENT



## LEGEND

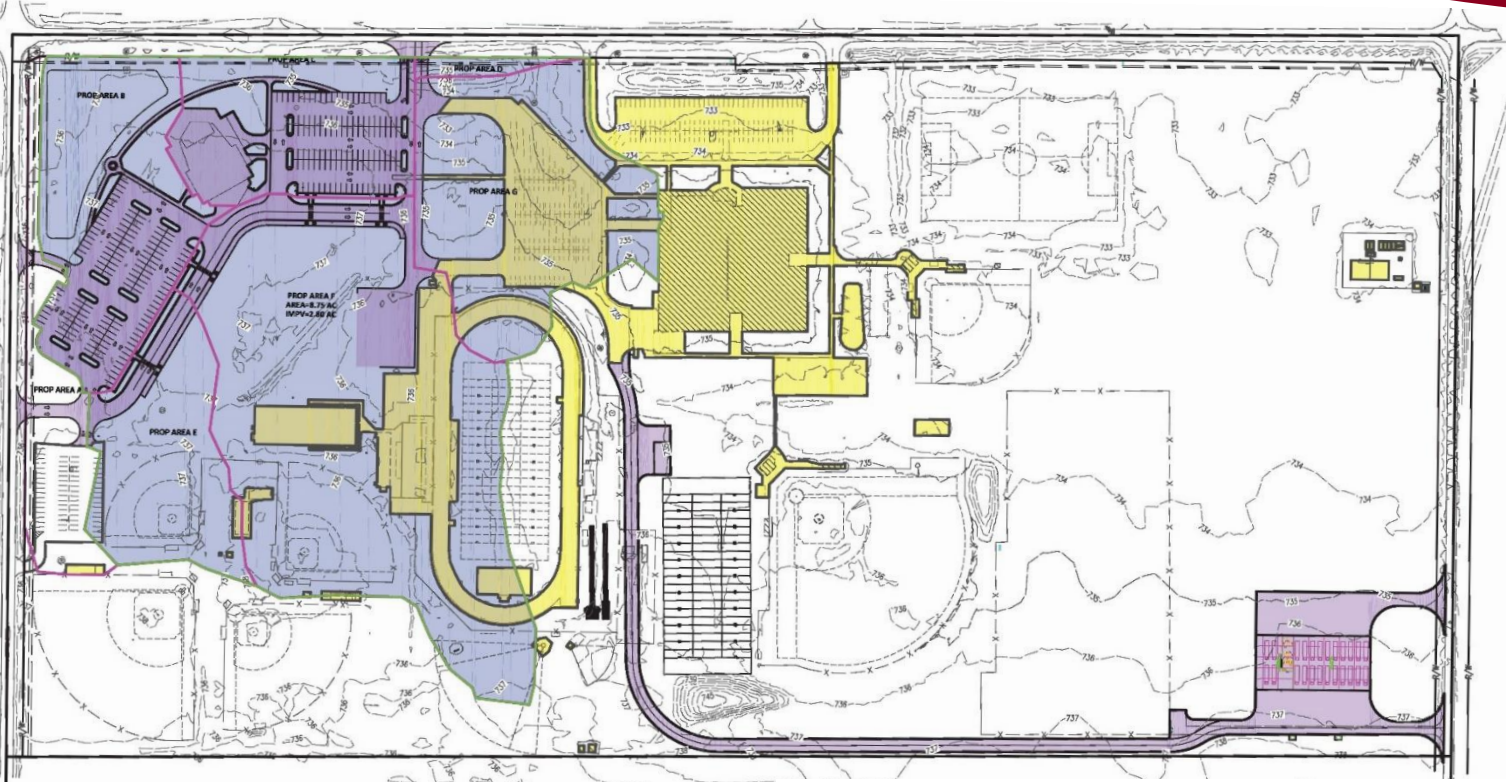
- EX IMPERVIOUS AREA TO REMAIN
- PROPOSED IMPERVIOUS AREA
- EX BUILDING
- PROPOSED BUILDING

80.55 ACRES GROSS  
4.49 ACRES IN R/W  
76.06 ACRES NET

BMP DRAINAGE AREA = 21.17 AC  
EX IMPERVIOUS AREA = 6.75 AC



# REDEVELOPMENT



## LEGEND

- EX IMPERVIOUS AREA TO REMAIN
- PROPOSED IMPERVIOUS AREA
- EX BUILDING
- PROPOSED BUILDING

80.55 ACRES GROSS  
4.49 ACRES IN R/W  
76.06 ACRES NET

BMP DRAINAGE AREA = 21.17 AC  
EX IMPERVIOUS AREA = 6.75 AC  
PROPOSED IMPERVIOUS AREA = 8.59 AC





# REDEVELOPMENT

- Existing Impervious Ratio

$$I1 = 6.75/21.17 = 0.32 = 32\%$$

$$Rv1 = 0.05 + 0.90(0.32) = 0.34$$

- Proposed Impervious Ratio

$$I2 = 8.59/21.17 = 0.41 = 41\%$$

$$Rv2 = 0.05 + 0.90(0.41) = 0.42$$



# REDEVELOPMENT

- Water Quality Volume

$$WQ_v = P A R_v / 12$$

- For Redevelopment

$$WQ_v = P A [0.2 * R_{v1} + R_{v2} - R_{v1}] / 12$$

$$= P A [R_{v2} - 0.8 R_{v1}] / 12$$

$$= 0.90(21.17)(0.42 - 0.8 * 0.34) / 12$$

$$= 0.23 \text{ Ac-ft}$$

$$= 10,236 \text{ cu ft}$$



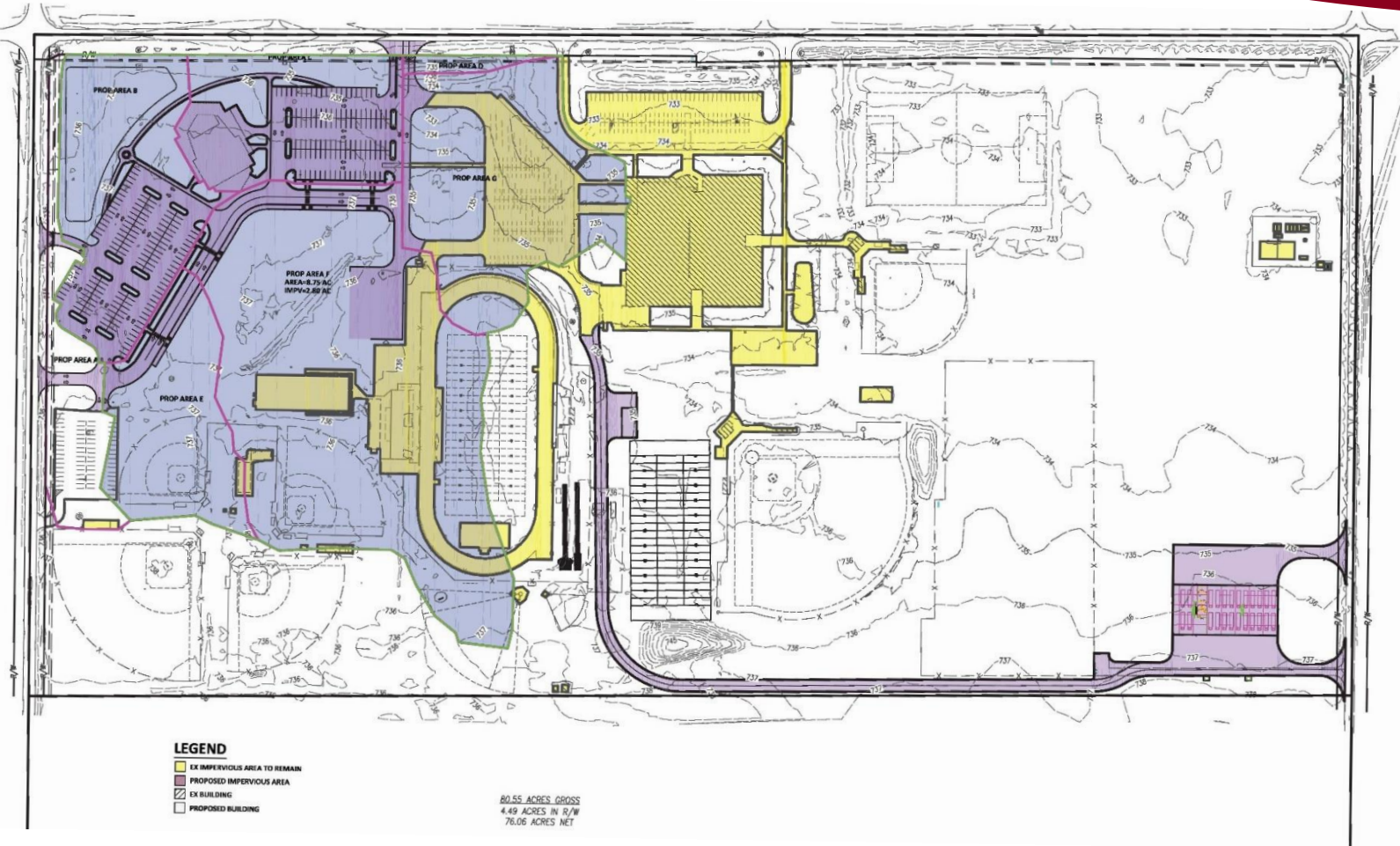
# REDEVELOPMENT

...BUT WAIT

THE BASIN HAS TO TREAT 100% OF THE WATER  
QUALITY VOLUME GOING TO IT



# REDEVELOPMENT





# REDEVELOPMENT

## Water Quality Volume

$$R_v = R_{v2} = 0.42$$

$$A = 21.17 \text{ Ac}$$

$$P = 0.90$$

$$\begin{aligned} \rightarrow WQ_v &= 0.90 * 21.17 * 0.42/12 \\ &= 0.67 \text{ Ac-ft} \\ &= 29,048 \text{ cu ft} \\ &>> 10,236 \text{ cu ft calculated before} \end{aligned}$$

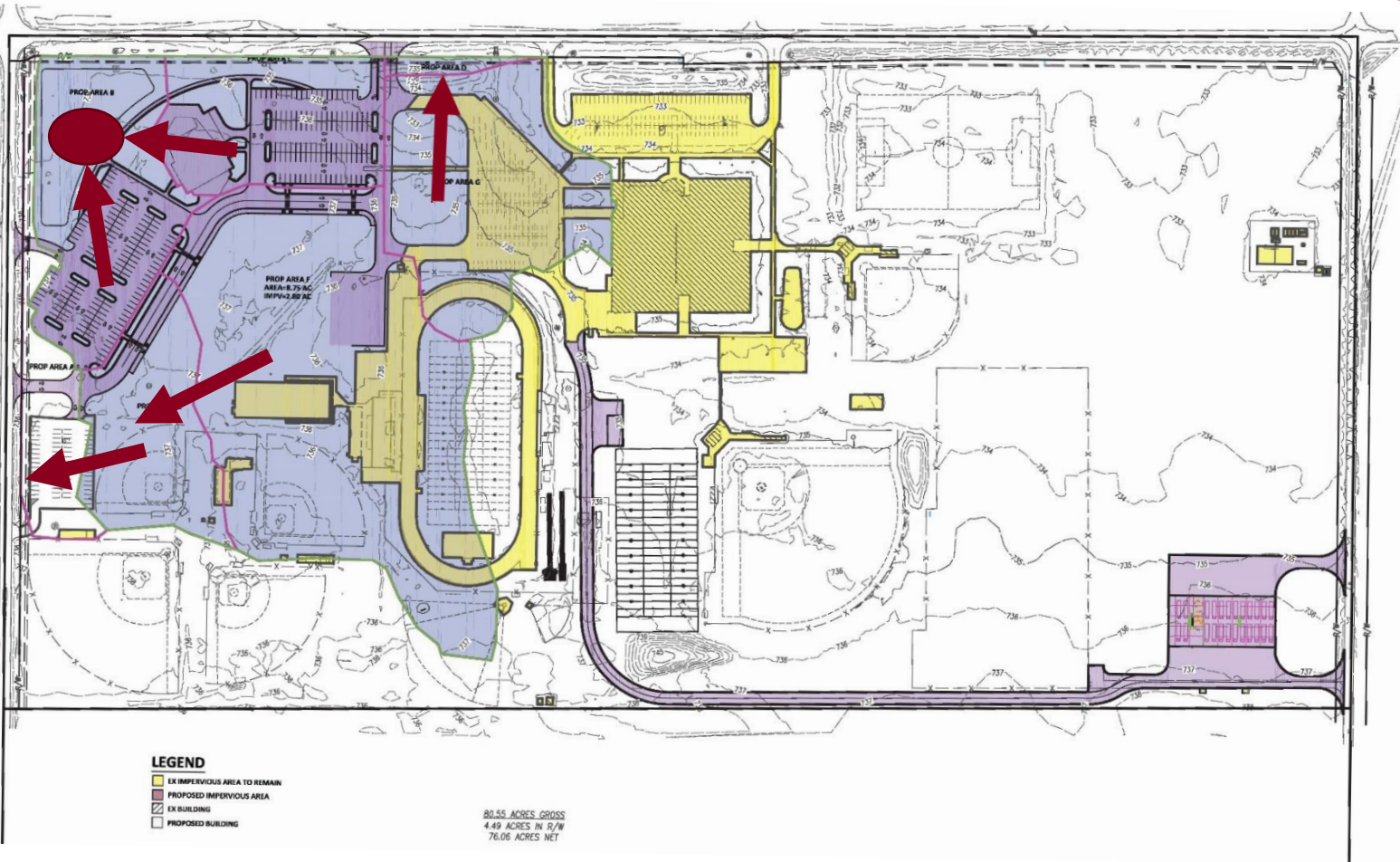


# REDEVELOPMENT

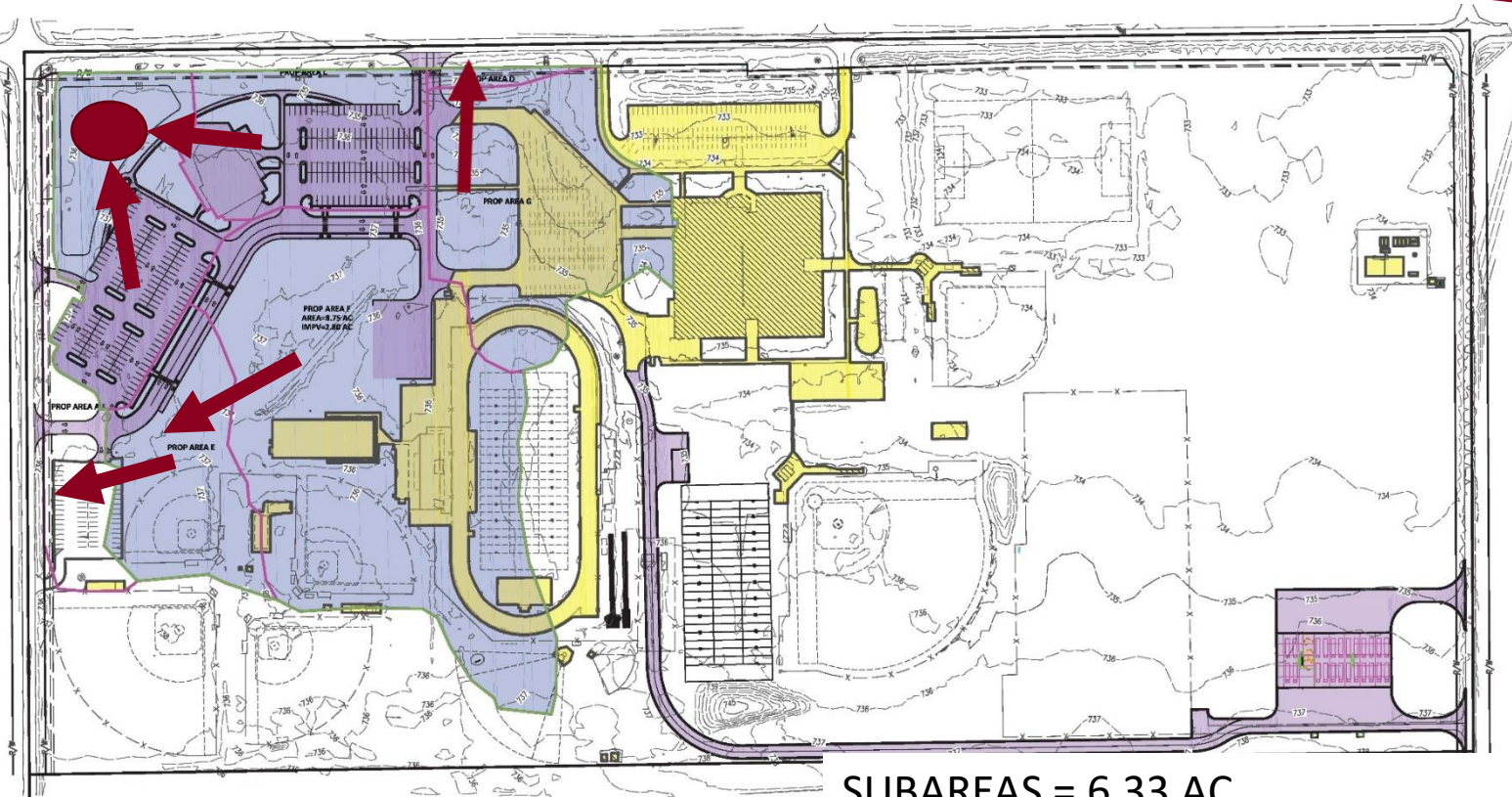
WHAT GIVES???



# REDEVELOPMENT



# REDEVELOPMENT



## LEGEND

- EX IMPERVIOUS AREA TO REMAIN
- PROPOSED IMPERVIOUS AREA
- EX BUILDING
- PROPOSED BUILDING

80.55 ACRES GROSS  
4.49 ACRES IN R/W  
76.06 ACRES NET

SUBAREAS = 6.33 AC

IMPERVIOUS AREA = 3.40 AC

OTHER AREAS BYPASS THE WQ BMP





# REDEVELOPMENT

- Impervious Ratio

$$I = 3.40/6.33 = 0.54 = 54\%$$

$$R_v = 0.05 + 0.90(0.54) = 0.53$$

- Back calculate the area based on the water quality volume

$$\begin{aligned} A &= WQ_v * 12 / (P R_v 43,560) \\ &= 10,236 * 12 / (0.9 * 0.53 * 43,560) \\ &= 5.91 \text{ Ac} \end{aligned}$$



# REDEVELOPMENT

5.91 Ac < Provided Area of 6.33 Acres

→ Good

If calculated acreage required is greater than the provided area, direct more area to the BMP and recalculate



# REDEVELOPMENT

## Actual required Water Quality Volume

$$WQ_v = 0.9 * 6.33 * 0.53/12$$

$$= 0.25 \text{ Ac-ft}$$

$$= 10,960 \text{ cu ft} > 10,236 \text{ cu ft}$$

(required for redevelopment)

10,960 is the design volume for the BMP



BUT WAIT...THERE'S MORE





WHAT ABOUT MY DETENTION REQUIREMENT??

I CAN'T LET THAT MUCH WATER RUN STRAIGHT  
OFF THE SITE WITHOUT DETENTION!!



# RUNOFF REDUCTION

If we include all of the drainage area, we have to hold 100% of the water quality volume.



# RUNOFF REDUCTION

If we include all of the drainage area, we have to hold 100% of the water quality volume.

$$\begin{aligned}WQ_v &= 0.9 * 21.17 * 0.42/12 \\ &= 0.67 \text{ Ac-ft} \\ &= 29,048 \text{ cu ft} \\ &>> 10,960 \text{ cu ft}\end{aligned}$$



# RUNOFF REDUCTION

...or do we?





# RUNOFF REDUCTION

## Project Information & Water Quality Volume Calculation

data input cells
constant values
calculation cells

### Project Information

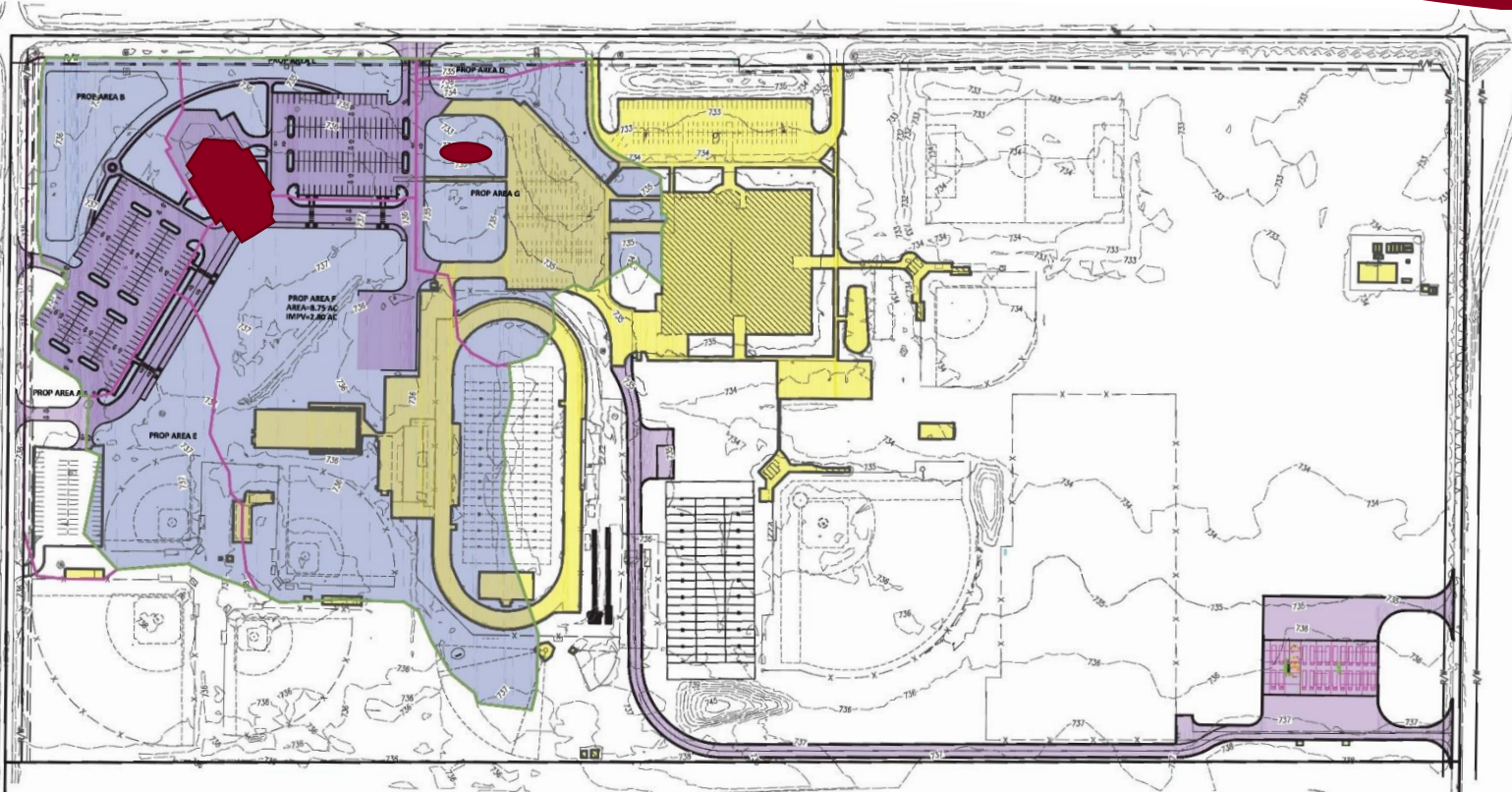
Project Name:	Real World Sample
Project Location:	Bowling Green
Project Latitude:	
Project Longitude:	
NPDES Permit Applicant:	
Spreadsheet Submitted by:	R. Bailey
Date:	9/18/2018
Phone Number:	(419) 535-1015 x230

### Water Quality Volume Calculation

Drainage Area, $A_{total}$ =	21.17 acres	=	922,165 ft <sup>2</sup>
Impervious Area, $A_{imp}$ =	8.59 acres	=	374,180 ft <sup>2</sup>
Imperviousness fraction, $i$ =	0.41	=	41 %
Volumetric Runoff Coefficient, $R_v$ =	0.42		
Water Quality Volume, $WQ_v$ =	28715 ft <sup>3</sup>		



# RUNOFF REDUCTION



## LEGEND

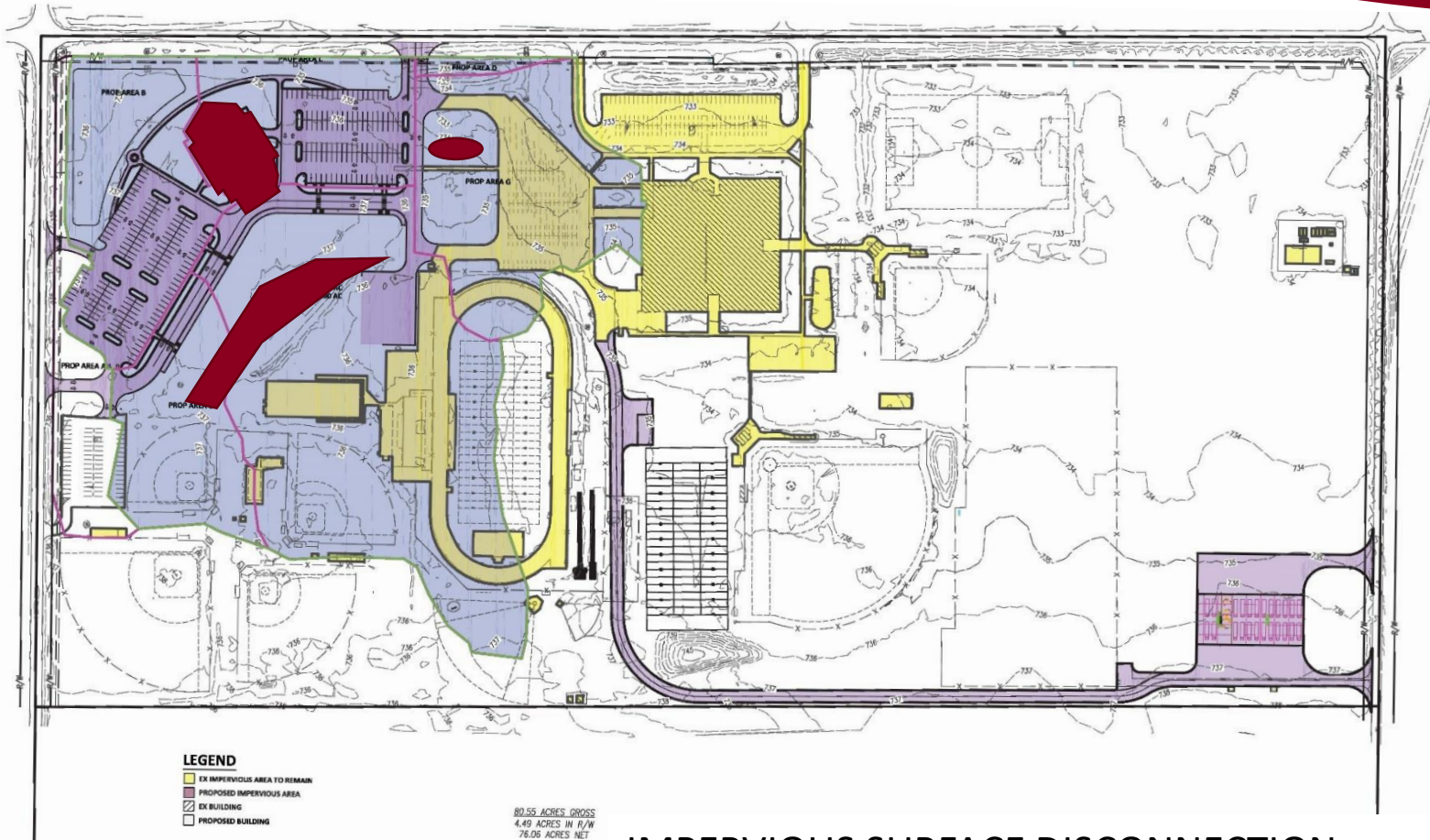
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## BIORETENTION/BIOSWALE/RAIN GARDEN



# RUNOFF REDUCTION



IMPERVIOUS SURFACE DISCONNECTION



# RUNOFF REDUCTION

<b>Apply Runoff Reduction Practices</b>					
<b>Runoff Reduction Practice</b>	<b>Impervious Cover in Contributing Drainage Area</b>	<b>Pervious Cover in Contributing Drainage Area</b>	<b>Volume Received by Practice</b>	<b>Description of Credit</b>	<b>% Credit</b>
	<b>(ft<sup>2</sup>)</b>	<b>(ft<sup>2</sup>)</b>	<b>(ft<sup>3</sup>)</b>		
<b>1. Green (Vegetated) Roof</b>					
Green Roof	20203	N/A	1439	Subtract 100% of the provided storage volume.	100%
<b>2. Rainwater Harvesting</b>					
Rainwater Harvesting		N/A	0	Subtract a % of the provided design volume based on annual beneficial use.	
<b>3. Impervious Surface Disconnection</b>					
Simple Disconnection to A/B Soils or Amended C/D Soils	2475	N/A	176	Reduce volume conveyed to disconnection area by 0.04 cu. ft per sq. ft. of disconnection area.	N/A
Simple Disconnection to C/D Soils		N/A	0	Reduce volume conveyed to disconnection area by 0.02 cu. ft per sq. ft. of disconnection area.	N/A
To Rain Garden(s)	82372	91909	6214	Subtract 100% of the provided storage volume.	100%
To Stormwater Planter(s)		N/A	0	Subtract 100% of the provided storage volume.	100%
<b>4. Sheetflow to Grass Filter</b>					





# RUNOFF REDUCTION

## Project Totals

Drainage Area, $A_{total}$ =	21.17	acres	=	922,165	$ft^2$
Impervious Area, $A_{imp}$ =	8.59	acres	=	374,180	$ft^2$
Imperviousness Fraction, $i$ =	0.41		=	41	%
Volumetric Runoff Coefficient, $R_v$ =	0.42				
Water Quality Volume, $WQ_v$ =	28715	$ft^3$			
Runoff Reduction Volume, $RR_v$ =	7657	$ft^3$			
Remaining Water Quality Volume, $WQ_{vR}$ =	21058	$ft^3$			

The difference in the calculations done previously and those by the spreadsheet is due to round-off error in the hand calculations.





# RUNOFF REDUCTION

OK – So that helps with the Water Quality Volume

What about my detention??



# RUNOFF REDUCTION

		1-year storm	2-year storm	10-year storm			
Target Rainfall Event (in)		2.52	2.60	4.15			
<b>Drainage Area A</b>							
Drainage Area (acres)	38.00						
Storage Volume Provided By Runoff Reduction Practices (cf)	26,174						
<b>Drainage Area B</b>							
Drainage Area (acres)	0.00						
Storage Volume Provided By Runoff Reduction Practices (cf)	0						
<b>Drainage Area C</b>							
Drainage Area (acres)	0.00						
Storage Volume Provided By Runoff Reduction Practices (cf)	0						
<b>Drainage Area D</b>							
Drainage Area (acres)	0.00						
Storage Volume Provided By Runoff Reduction Practices (cf)	0						
<b>Drainage Area E</b>							
Drainage Area (acres)	0.00						
Storage Volume Provided By Runoff Reduction Practices (cf)	0						
Based on the use of Runoff Reduction practices in the various drainage areas, the spreadsheet calculates an adjusted $RV_{Developed}$ and adjusted Curve Number.							
<b>Drainage Area A</b>		<b>A soils</b>	<b>B Soils</b>	<b>C Soils</b>	<b>D Soils</b>		
Forest/Preserved Open Space	Area (acres)	4.0	1.0	2.0	0.0		
	CN	30	55	70	77		
Managed Turf - Natural Profile	Area (acres)	2.0	2.0	4.0	0.0		
	CN	39	61	74	80		
Managed Turf - Graded	Area (acres)	0.0	3.0	6.0	0.0		
	CN	39	61	74	80		
Impervious Cover	Area (acres)	0.0	6.0	8.0	0.0		
	CN	98	98	98	98		
					<b>Weighted CN</b>	<b>S</b>	
					61	6.42	
		<b>1-year storm</b>	<b>2-year storm</b>	<b>10-year storm</b>			
	<b>Runoff Volume<sub>Developed</sub> (in) with no Runoff Reduction</b>	0.20	0.22	0.88			
	<b>Runoff Volume<sub>Developed</sub> (in) with Runoff Reduction</b>	0.01	0.03	0.69			
	<b>Adjusted CN for D.A. A</b>	48	50	57			

Using similar procedure – the runoff coefficient/curve number can be reduced to reduce the volume of detention required.

