Feasibility of Low Impact Developments at NAU's South Commuter Lot
Final Presentation

Sydney Graves, Gabrial Harju, Jessica Hillman

CENE 486C

May 2nd, 2025

PROJECT INTRODUCTION

- Project Purpose
  - Implementation of Low Impact Development (LID) detention basins at P62
  - For decreased flood impacts and stormwater runoff credits from COF
- What is an LID Basin?
  - Designed to capture, slow, and treat stormwater runoff naturally by allowing it to infiltrate into the ground
  - Utilizes the landscape and soils
- Clients
  - Erin Trejo, NAU Facilities Services
  - Dr. Adam Bringhurst

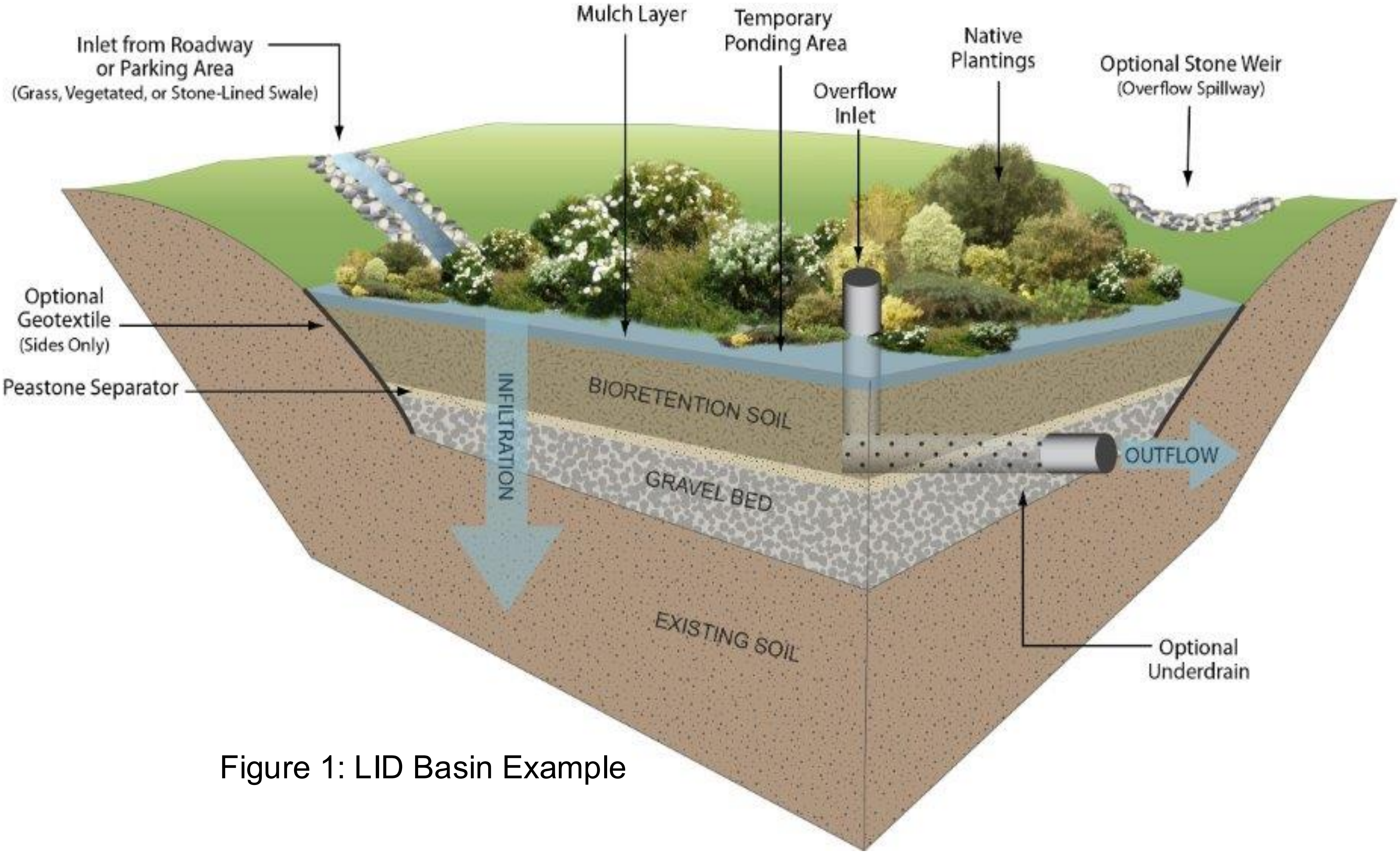

Figure 1: LID Basin Example

PROJECT LOCATION

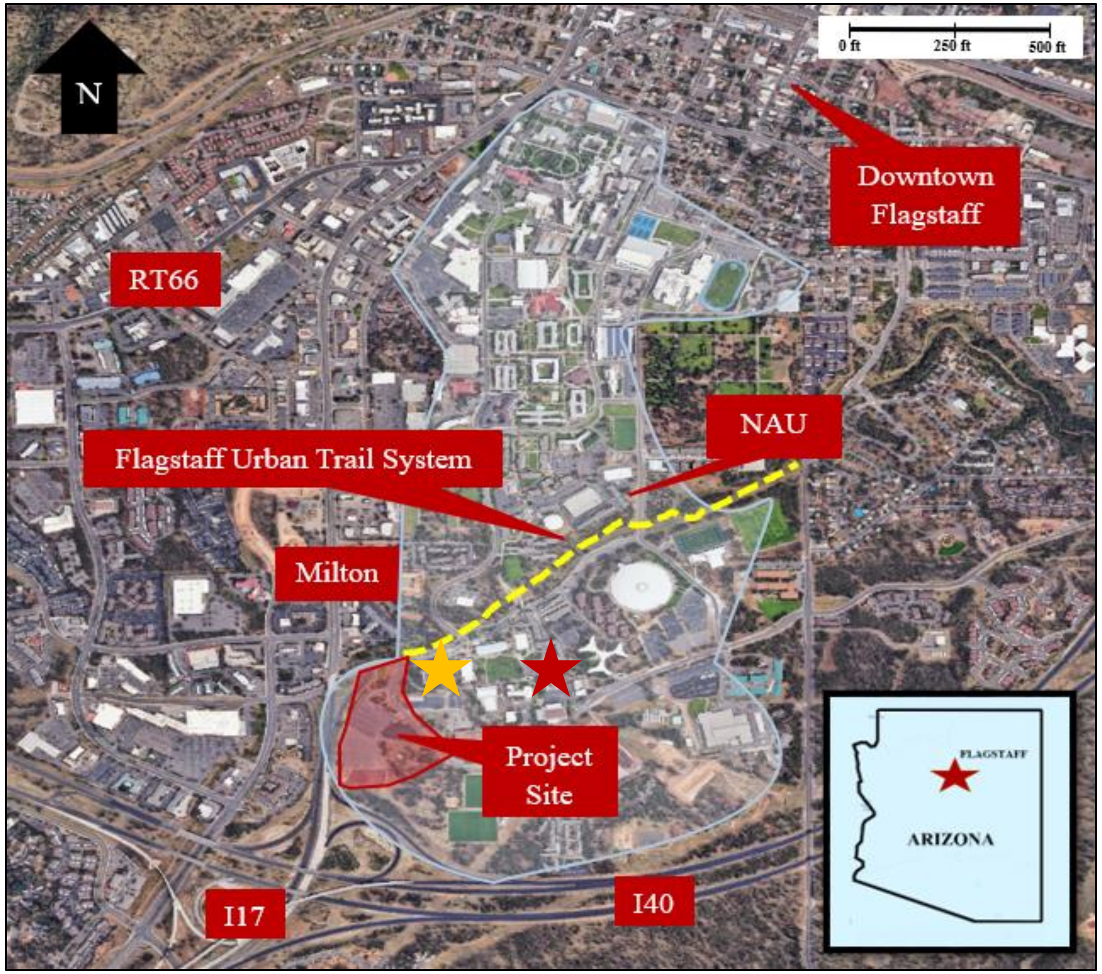

Figure 2: Project Vicinity Map

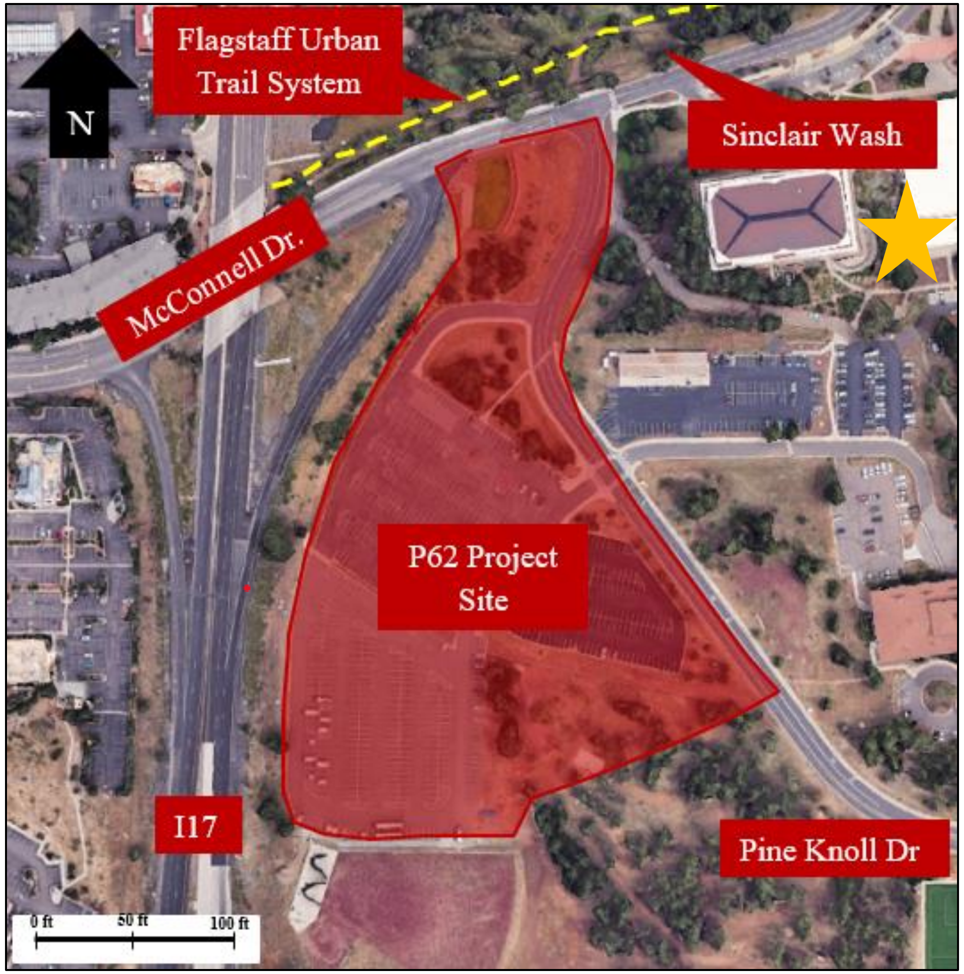

Figure 3: Project Location Map

CONSTRAINTS AND LIMITATIONS: EXISTING VEGETATION

- NAU Tree Bank
  - Cannot construct within the dripline of trees
  - Existing trees, native or non-native, to preserved if healthy
  - Removed - unhealthy - trees must be paid for to tree bank
  - Replace removed trees with native trees

So, this Pork Chop area is largely unusable for upstream storage.

Figure 4: Drip Line and Trees

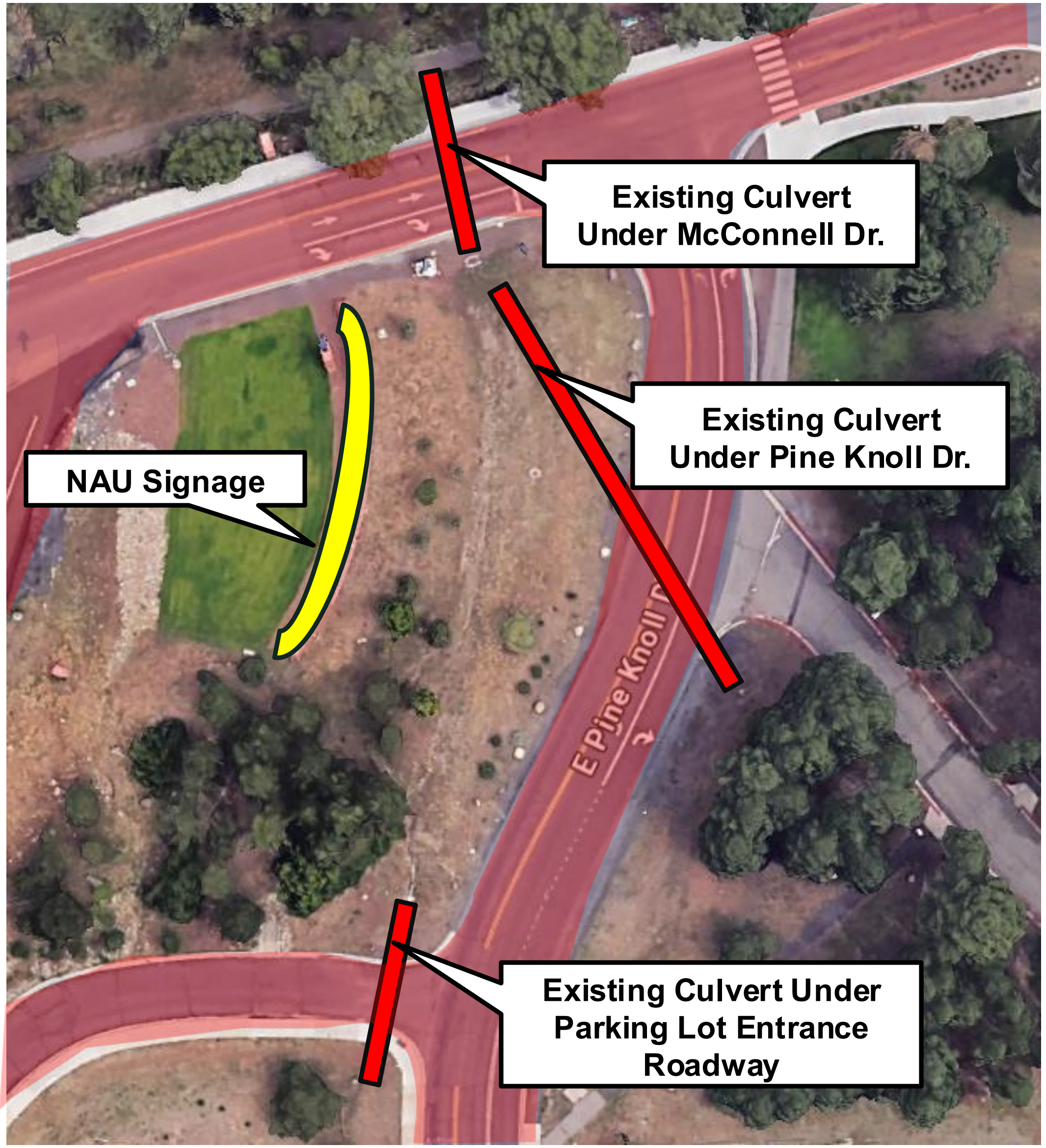

Figure 5: Constraints and Limitations Map

CONSTRAINTS AND LIMITATIONS:

- Existing Roadways
  - McConnell Dr.
  - Pine Knoll Dr.
- Existing Culverts
  - Under Pine Knoll Dr **(Restricts elevation of bottom of basin)**
  - Under McConnell Dr **(Restricts amount of water leaving)**
  - Under Parking Lot Entrance
- NAU Signage

UPDATED AREAS OF OPPORTUNITY:

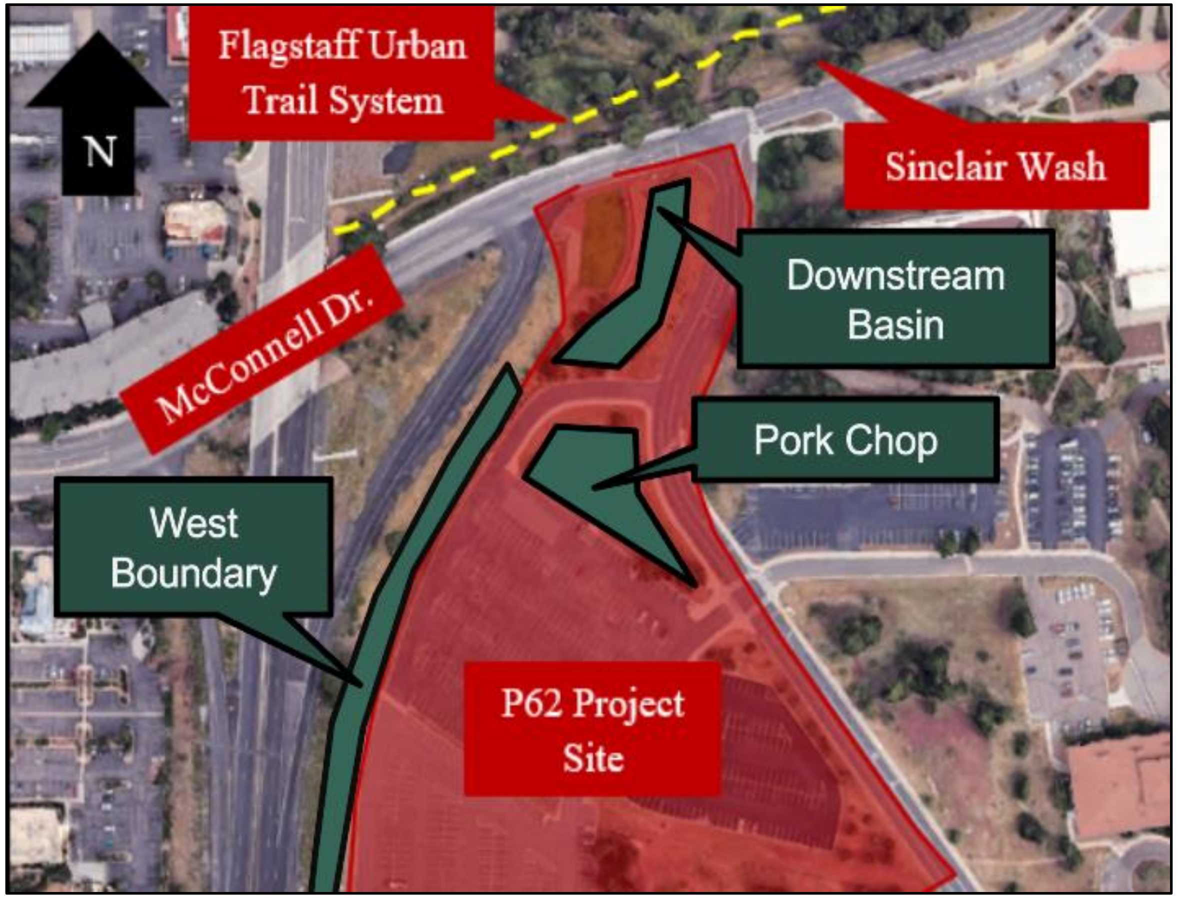

Figure 6: Areas of Opportunity Vicinity Map

- **West Boundary**
- ~~**Pork Chop**~~
- **Downstream Basin**

DESIGN OBJECTIVES

- Proposed improvements will capture the 500yr event storm
  - Thus, improvement is eligible for City of Flagstaff runoff credits
- Improvements will tie into existing infrastructure on sight
  - Curbs, culverts, drains remain as is
- Retain on sight vegetation as much as possible

1.B. Low Impact Development (LID) or Active Rainwater Harvesting (commercial, industrial, multi-family or members of homeowners' associations)

___ My property has been constructed with city-approved LID or active rainwater harvesting that exceeds current minimum standards. The facilities are presently functional, and maintenance is performed as necessary (for homeowners' association, please provide documentation that facilities are inspected and maintained).

Credit is 10% Partial, prorated credits may be applied for varying amounts of LID/Active harvesting.

Figure 7: COF Stormwater Credit Excerpt

TECHNICAL WORK: DATA COLLECTION

- Traditional Topographic Surface
  - Used for analysis of existing conditions
  - Supplemented with drone survey (shown)

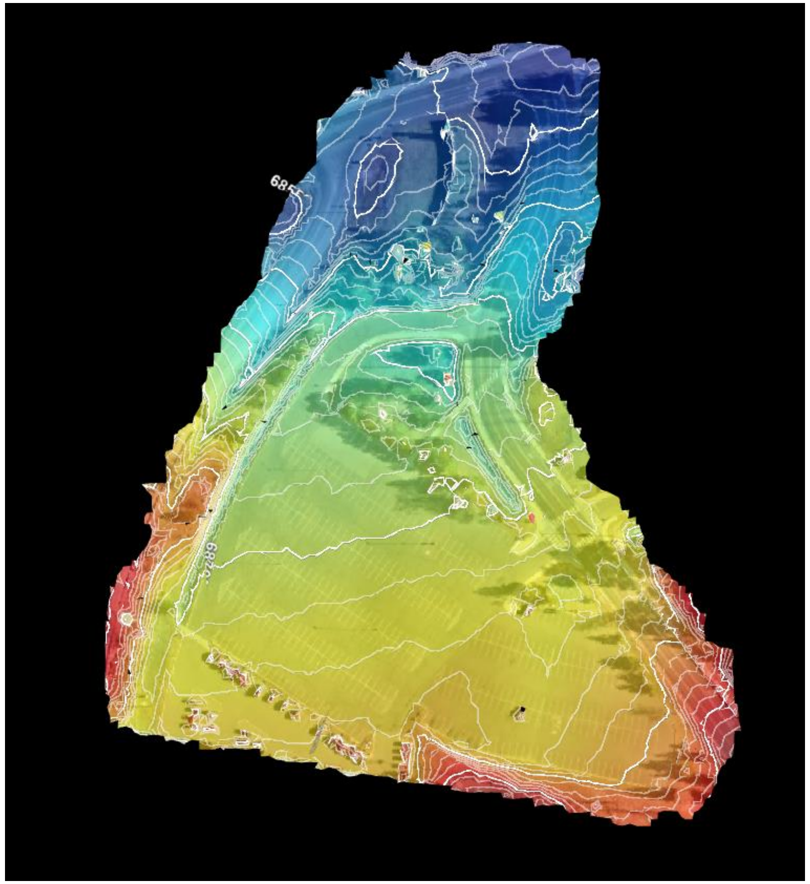

Figure 8: Aerial Topographic Survey

TECHNICAL WORK: HYDROLOGICAL ANALYSIS

HEC-HMS Analysis

- Watershed: 28.5 acres
- Soil: Tortugas – Daze Complex
  - Soil Group D
  - CN values 80 – 85 (Pervious)
    CN values 96 (Impervious – poor grade)
- 1 hr. storm event = greater instantaneous storage

Group D (high % clay)

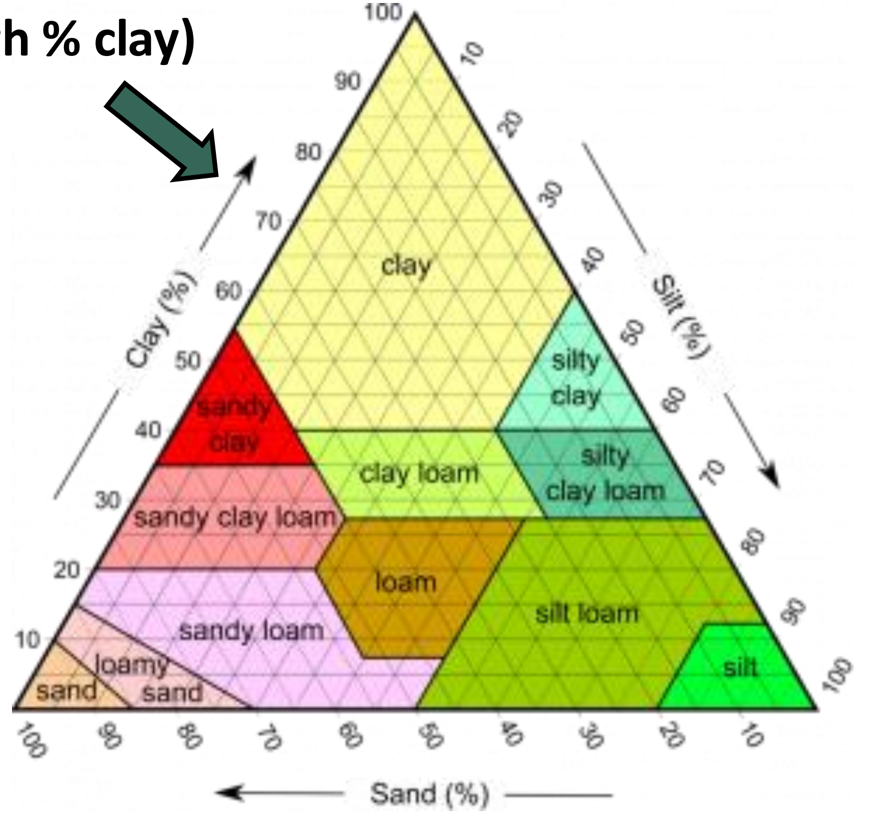

Figure 9: USDA Soil Classification Table

Existing Conditions Model

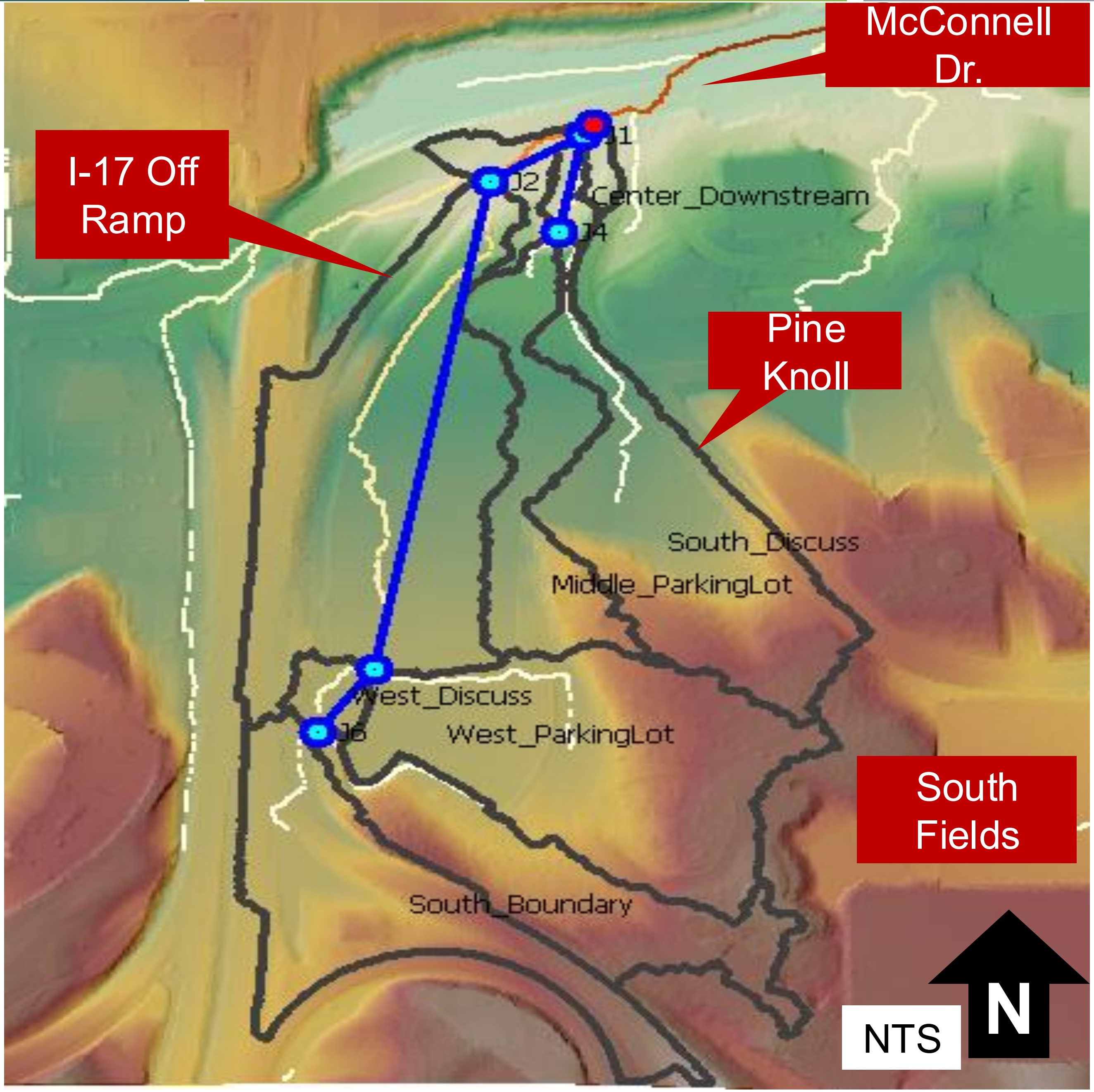

Figure 10: HMS Model Set Up

TECHNICAL WORK: HYDROLOGICAL ANALYSIS CONT.

Rational Method Analysis

- For Watersheds less than 20 acres
- Used to Calibrate HEC-HMS Model
  - Q = Cf*C*i*A
    - Q = Peak Discharge (cfs)
    - Cf = Antecedent Coefficient
    - C = Runoff Coefficient
    - i = Rainfall Intensity
    - A = Watershed Area
- Coefficient of runoff (C) values of 0.72 – 0.95
  - Antecedent Coefficients max out C * Cf = 1.0

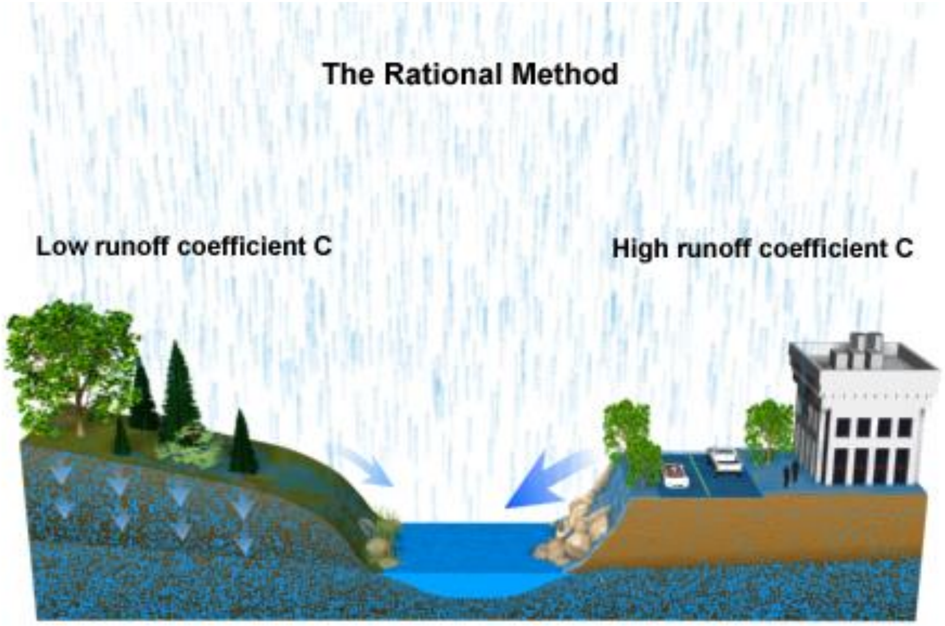

Figure 11: Runoff Coefficient

TECHNICAL WORK: HYDROLOGICAL ANALYSIS

Table 1: Hydrological Analysis Results

Frequency Storm	Intensity (in/hr)	Peak Discharge (cfs)		Downstream Storage Volume (thousands of cf)		Downstream Storage Volume (Acre-ft)		# of Olympic Swimming Pools	
		Rational	HEC-HMS	Rational	HEC-HMS	Rational	HEC-HMS	Rational	HEC-HMS
10 yr 1 hr	1.37	37.2	6	134 K	134 K	3.08	3.08	0.2	0.2
25 yr 1 hr	1.72	48.6	7.7	175 K	171 K	4.02	3.93	0.37	0.26
50 yr 1hr	2	57	9	205 K	199 K	4.71	4.57	0.3	0.3
100 yr 1 hr	2.32	60	10.5	215 K	232K	4.94	5.33	0.33	0.35
500 yr 1 hr	3.16	90	14.4	322 K	319 K	7.39	7.32	0.5	0.48

Volumes are close indicating model is calibrated

TECHNICAL WORK: ALTERNATIVE DESIGN ANALYSIS

- HEC-RAS 2-Dimensional Analysis (Hydraulic Analysis)
  - Using the same terrain LiDAR as Hydrology Model
  - Add in existing culverts, roadway decks, and roughness coefficients (Manning's)
  - Determine appropriate hydrograph locations

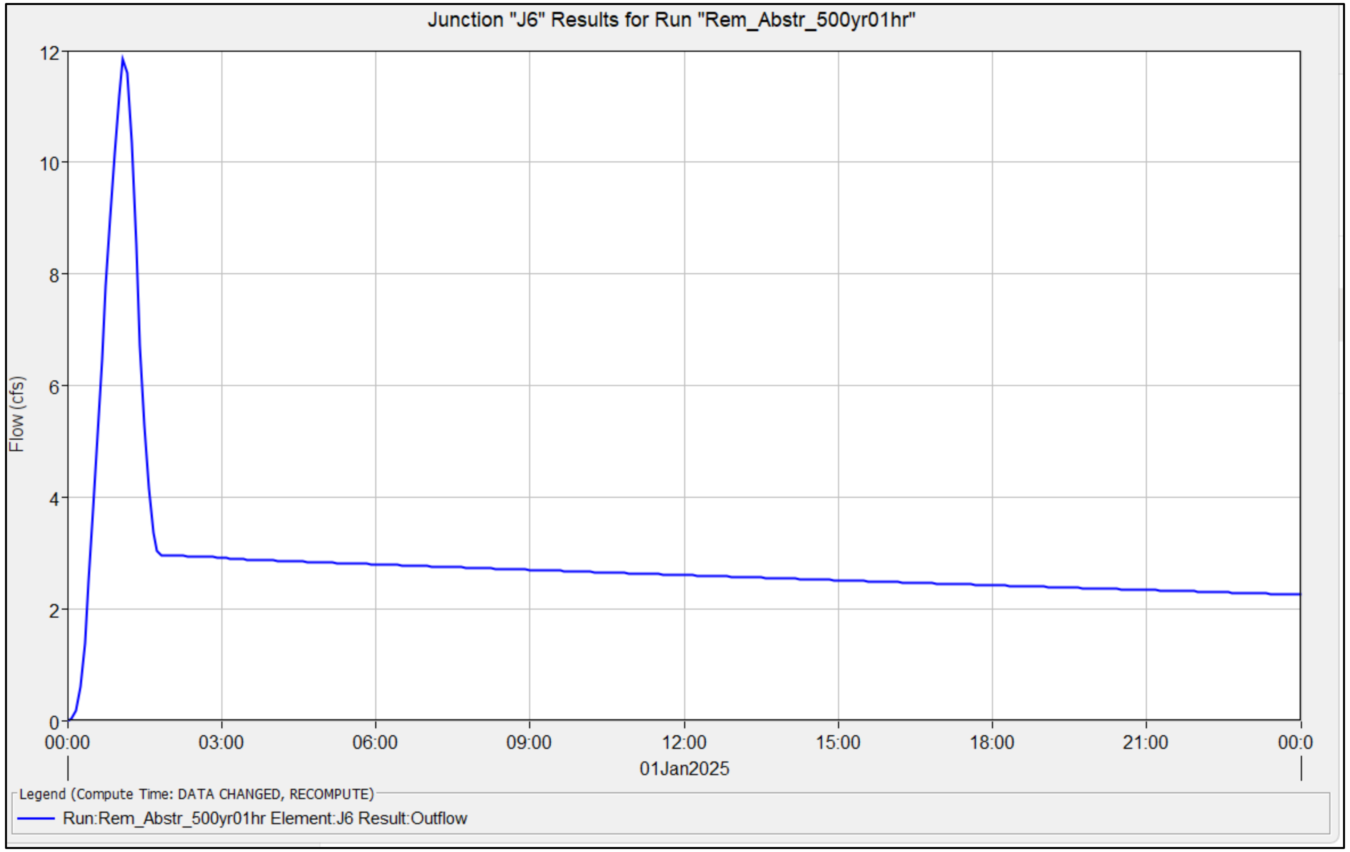

Figure 12: Hydrograph

LEGEND

LiDAR: Red is high, green is low elevation

Grey Rectangles: roadway decks

Black Lines perpendicular to roadway: culverts

Blue lines: internal hydrographs

Model domain in light grey

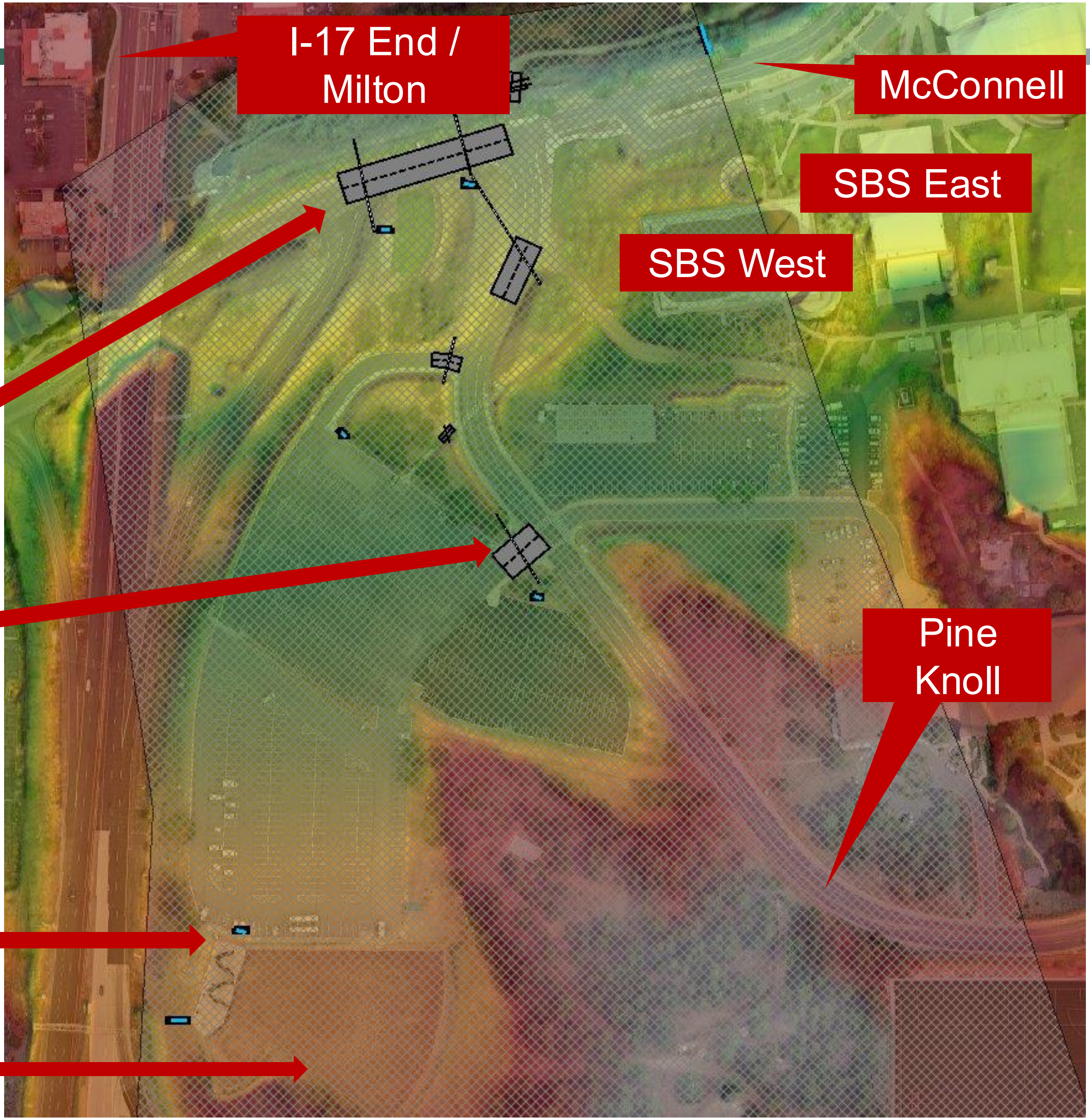

Figure 13: Existing Conditions Model

LEGEND

LiDAR: Red is high, green is low elevation

Grey Rectangles: roadway decks

Black Lines perpendicular to roadway: culverts

Blue lines: internal hydrographs

Model domain in light grey

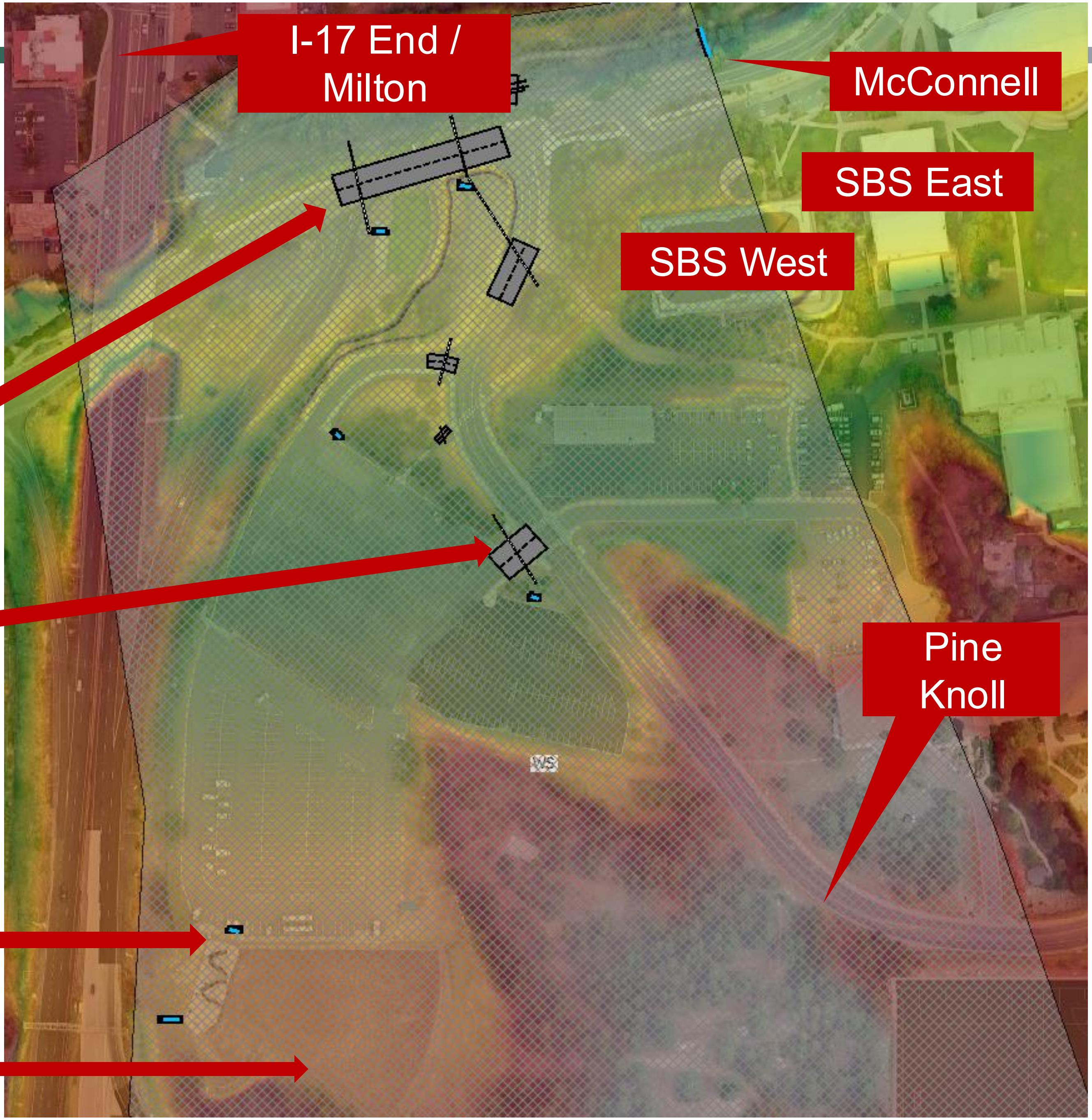

Figure 14: Proposed Conditions Model

Proposed Conditions Model

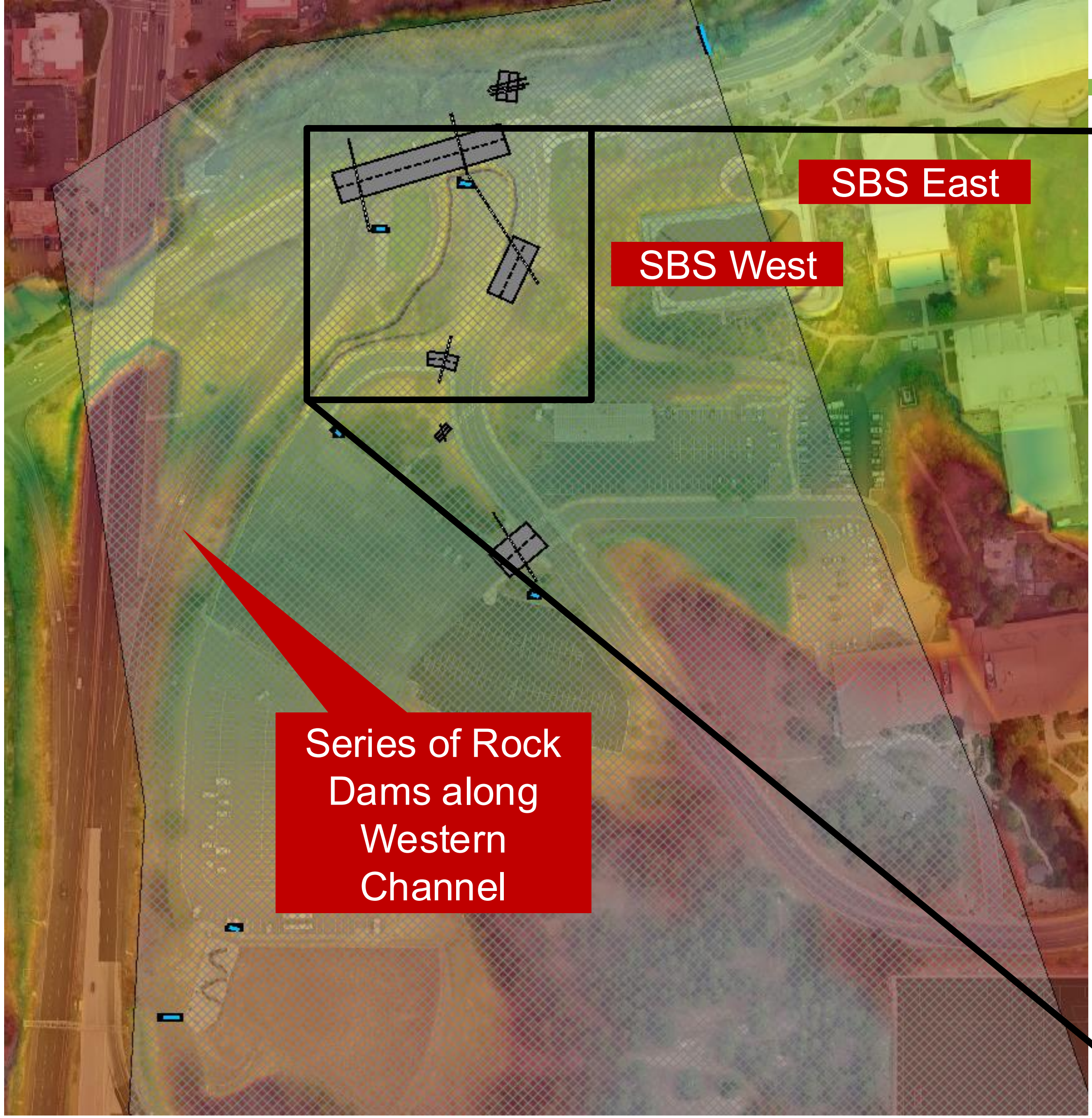

Figure 15: Proposed Improvements

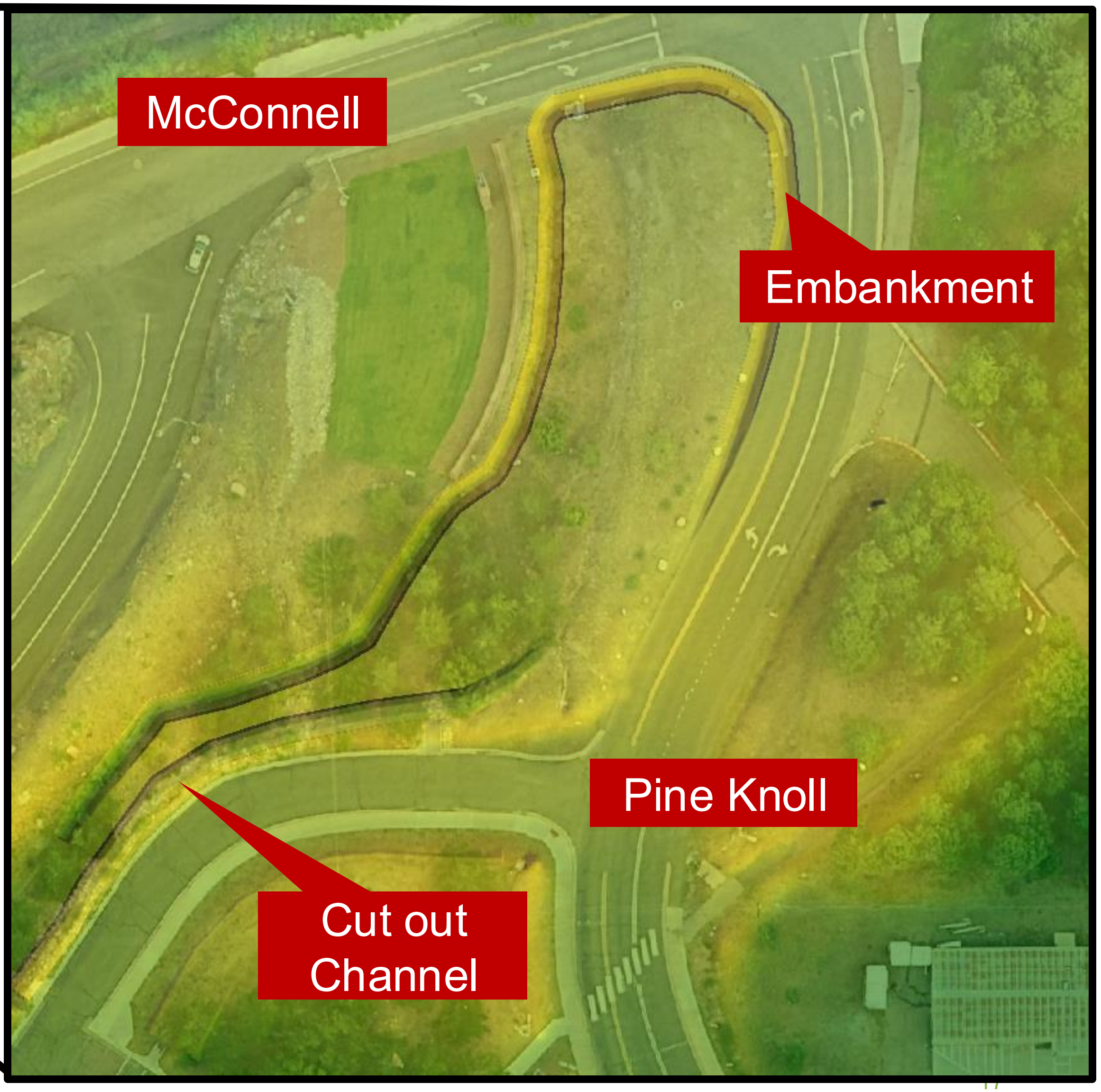

Figure 16: Proposed Downstream Basin

RECOMMENDED IMPROVEMENTS

Existing Conditions vs Proposed Design, 1hr 100yr, Max Depth

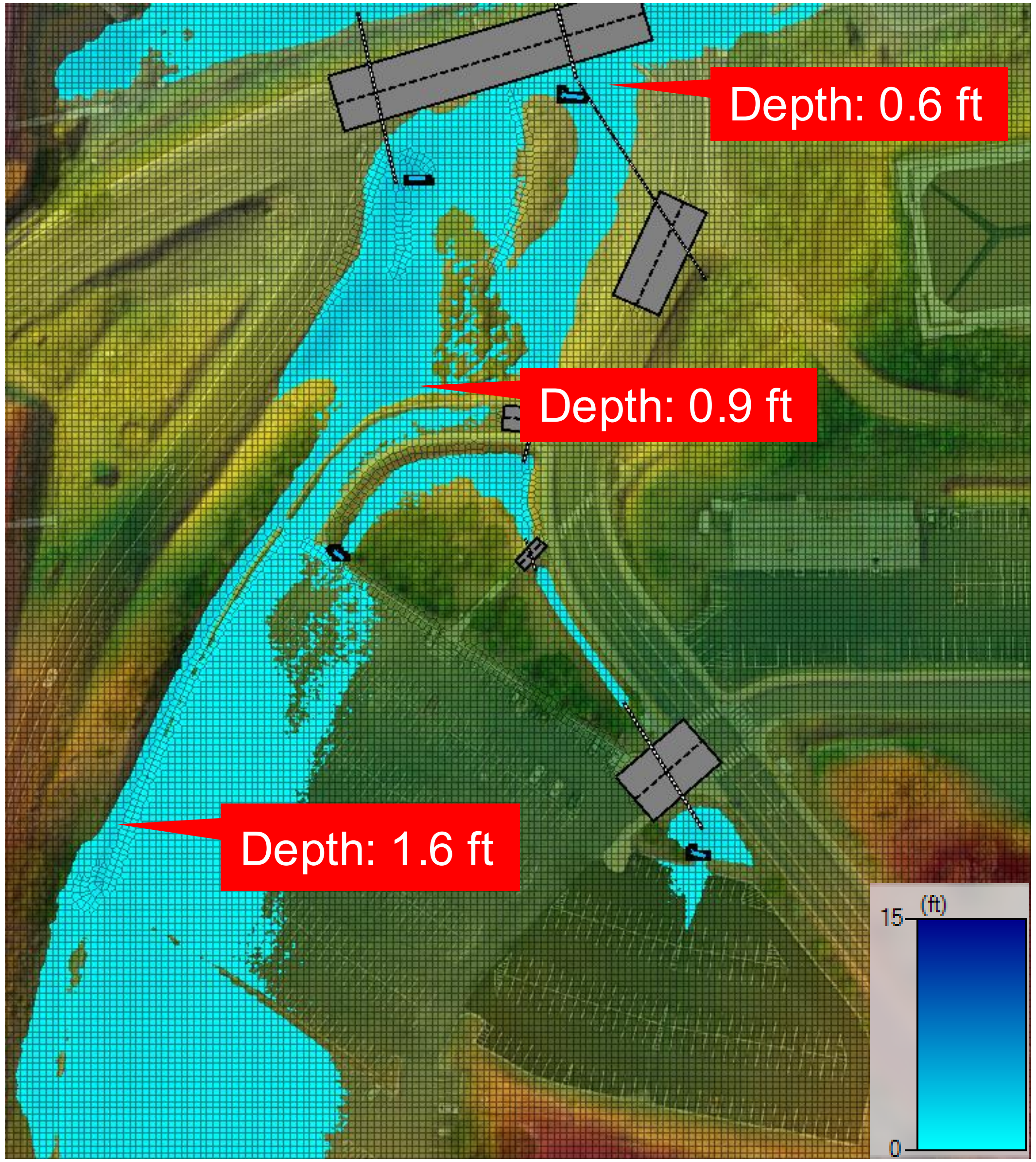

Figure 17: Existing Cond. 1 hr, 100 yr depth

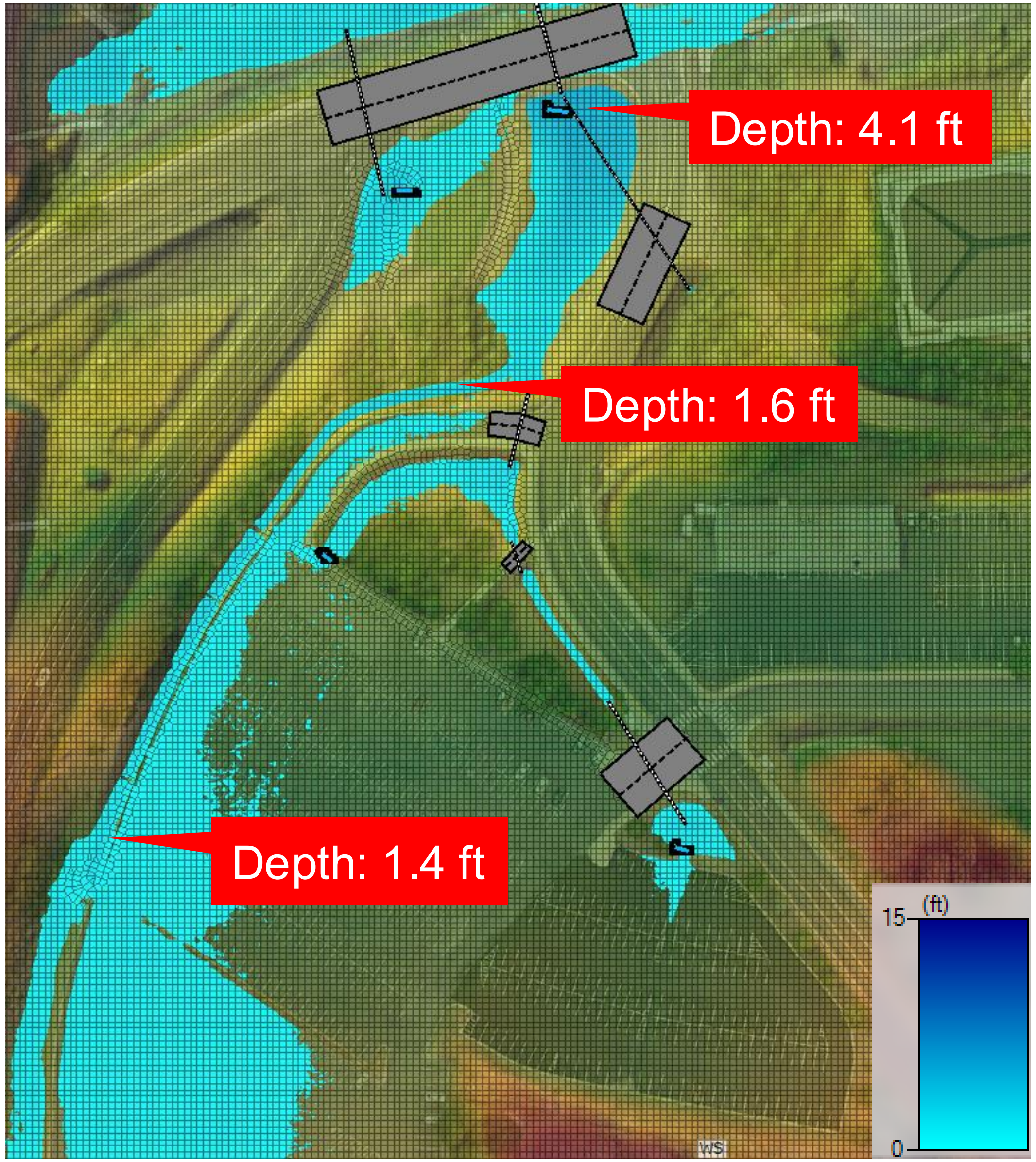

Figure 18: Proposed Design 1 hr, 100 yr depth

Existing Conditions vs Proposed Design, 1hr 500yr, Max Depth

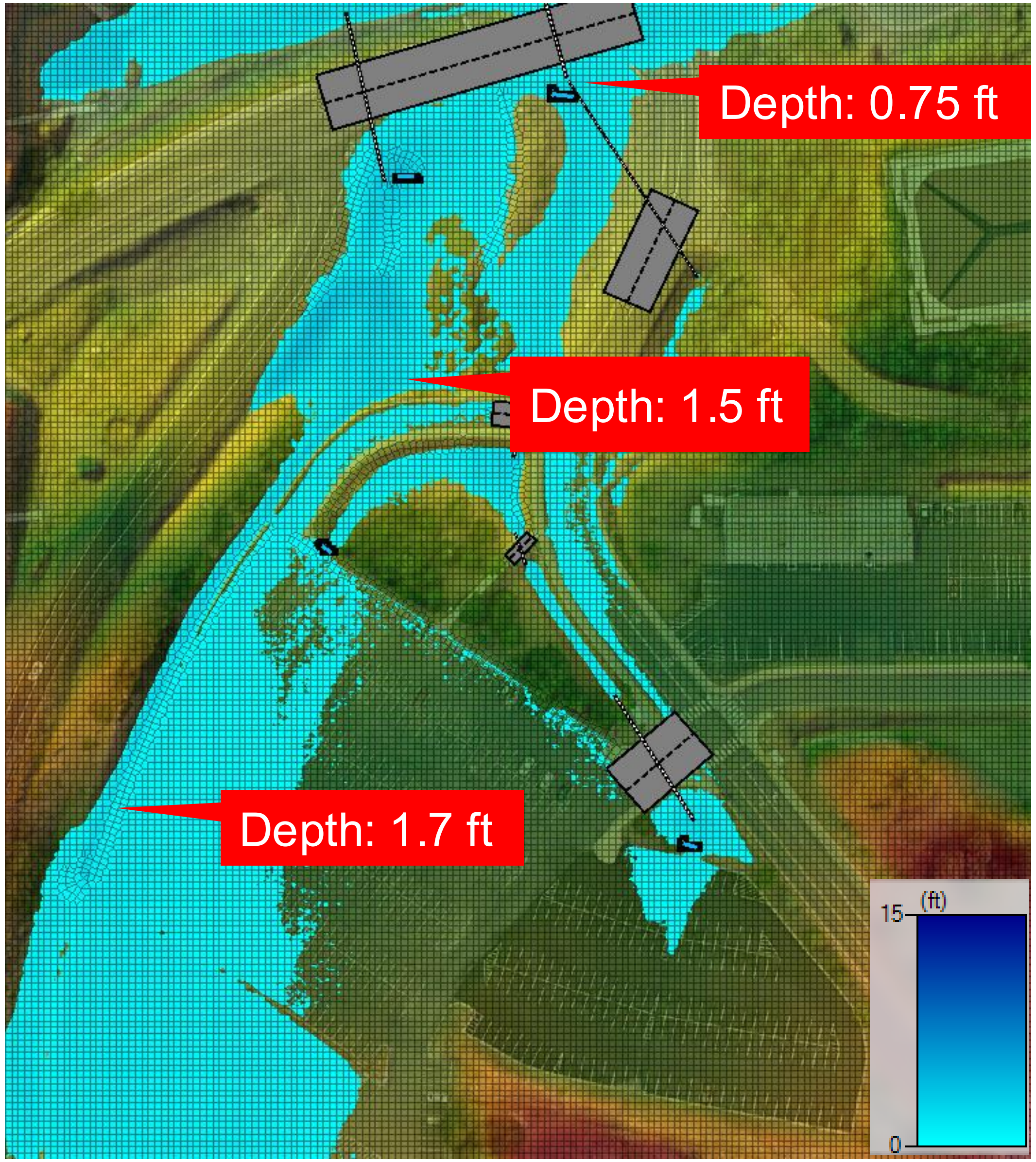

Figure 19: Existing Cond. 1 hr, 500 yr depth

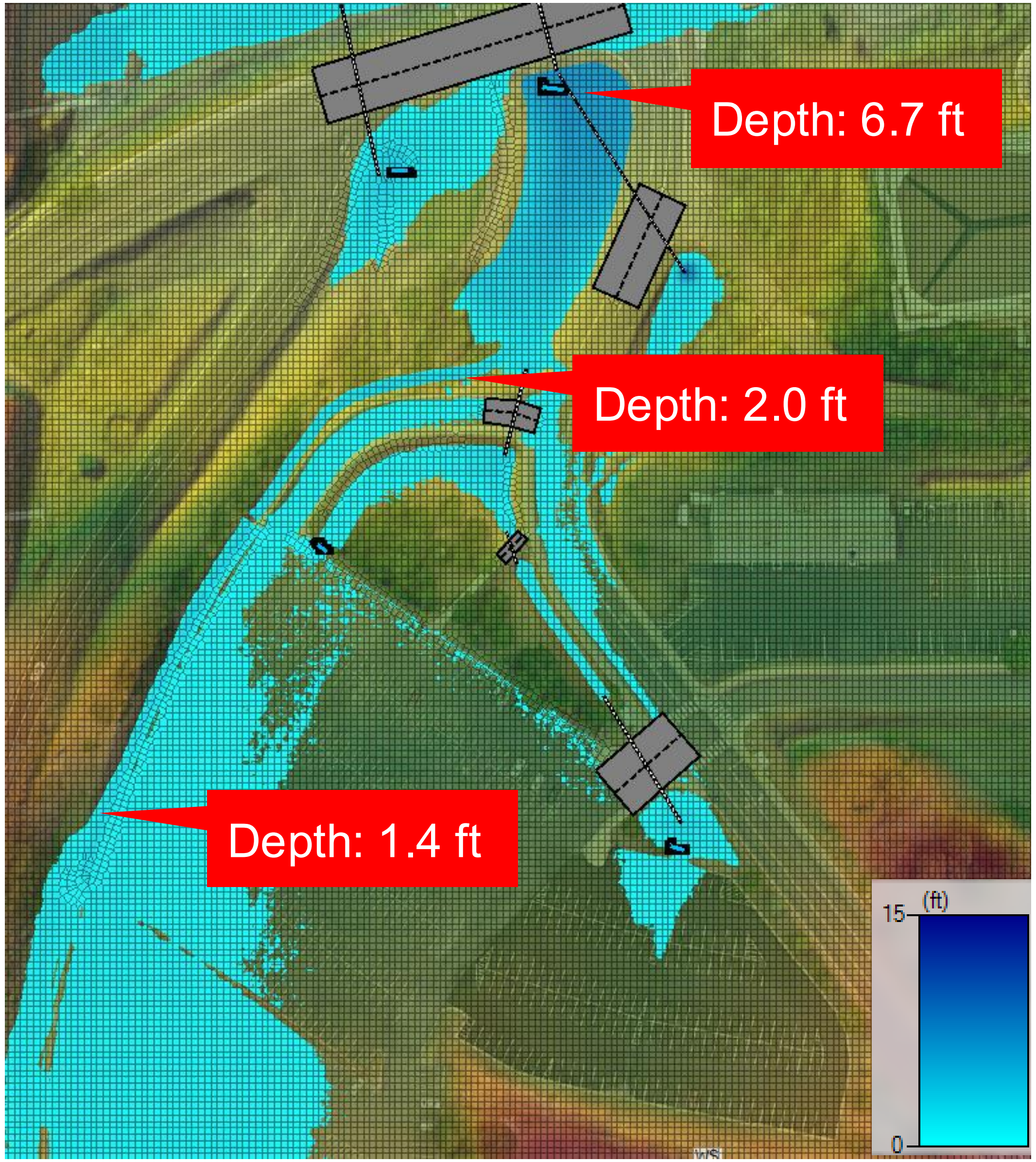

Figure 20: Proposed Design 1 hr, 500 yr depth

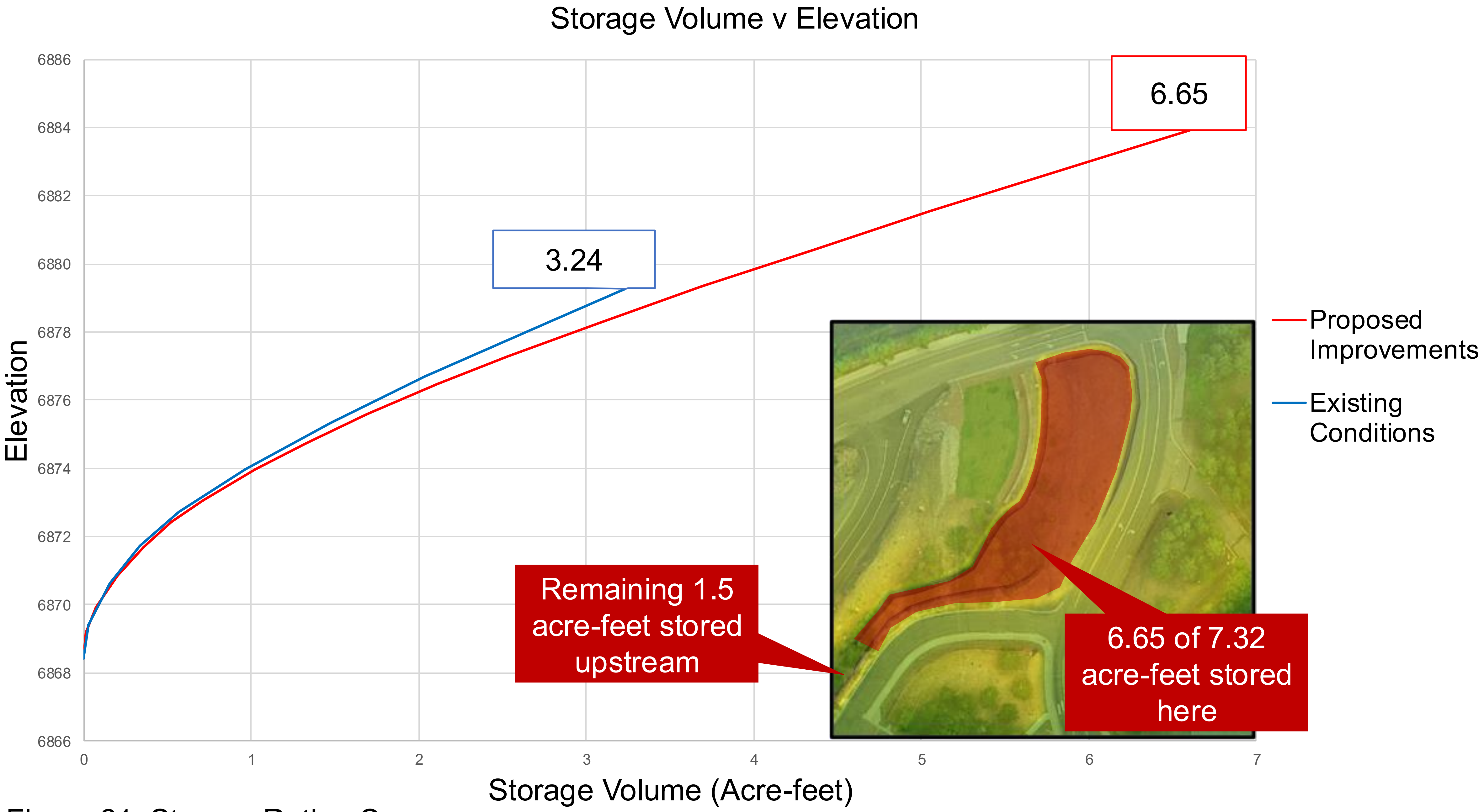

Figure 21: Storage Rating Curve

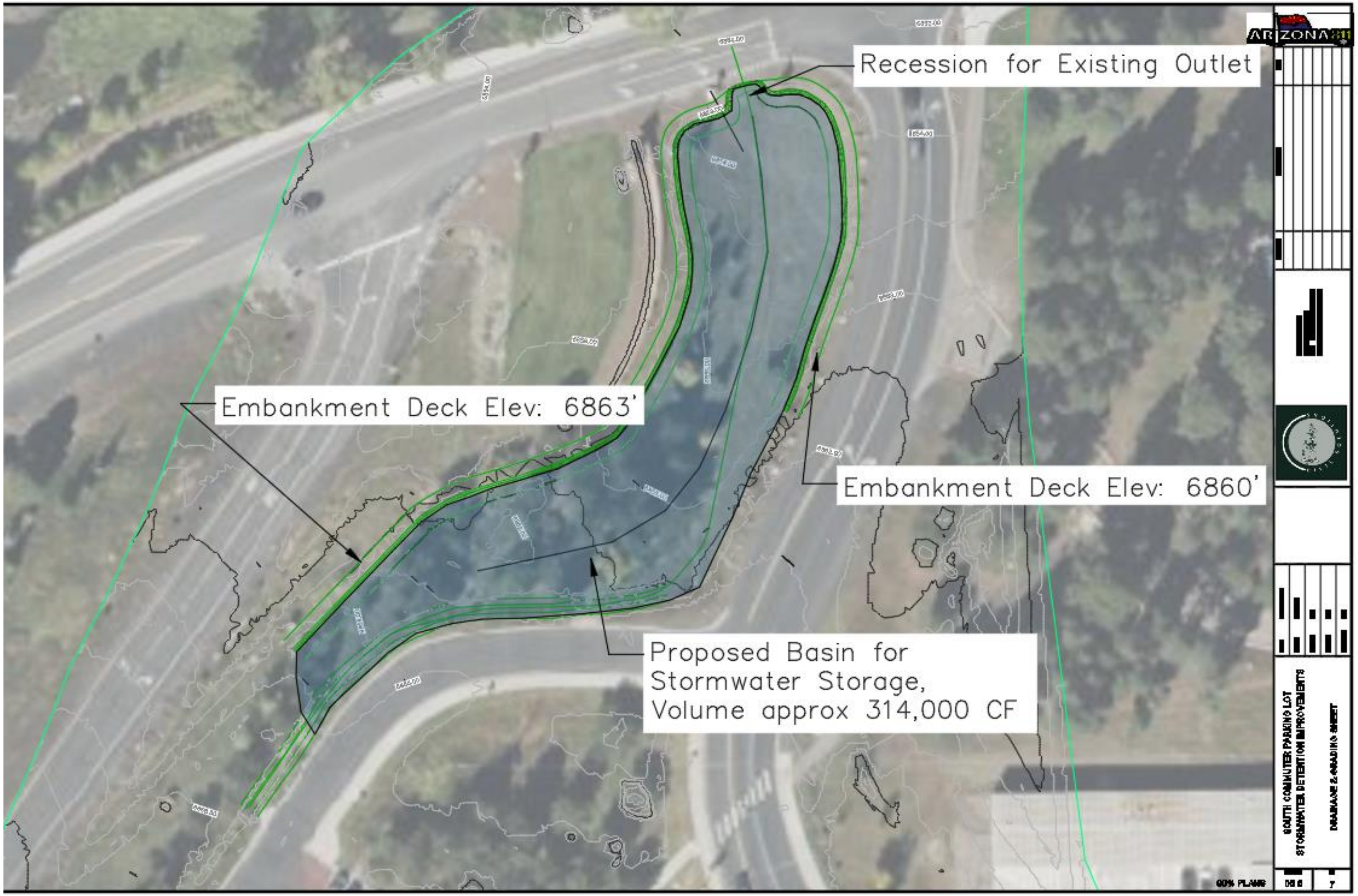

Figure 22: Recommended Final Design, Drainage and Grading Cut-Sheet

ESTIMATED COST OF IMPLEMENTATION

Engineer's Opinion on Probable Costs				
Particulars	**Quantitiy**	**Unit**	**Cost per Unit**	**Total Cost**
Earthwork Cut Quantities				
Channel Cut Volume	93	cy	0	$0
Under Drain Excavation and Refill	33	cy	0	$0
Total Cut	-	-	-	**$0**
Earthwork Fill Quantities				
Clay - Loam Backfill	1511	cy	35	$52,889
Total Fill	-	-	-	**$52,889**
Total Earthwork	-		-	**$52,889**
Materials for Construction				
Large Rock 12-14" Diameter	250	cy	50	$12,500
Under Drains	30	per 10'	50	$1,500
Concrete	2	cy	450	$1,000
Fencing - Rusted Iron Bar	800	lf	75	$60,000
Total Materials	-	-	-	**$75,000**
Service Labor Costs				
Construction Excavation Equipment	1637	cy	25	$40,926
Concrete Equipment and Install	2	cy	200	$444
Rock Dam Install	250	cy	100	$25,000
Fence Install	800	lf	25	$20,000
Total Service Costs	-		-	**$86,370**
PROJECTED TOTAL COSTS				**$214,259**
PROJECTED TOTAL COSTS + 30% Contingency				**$278,537**

Table 2: EOPC

- Cost is heavily dependent on fill material
- Total cost could range from $200k to $400k

PROJECT IMPACTS

Table 3: Triple Bottom Line Table

	People	Planet	Profit
PROS	Added protection from flooding for NAU Students	Increase groundwater filtration and recharge	Qualities NAU for stormwater runoff credits
	Opportunity for educational exhibit	Aligns with NAU Sustainability goals	Potential to avoid expensive from flood damages
CONS	Potential decrease in visual aesthetics from levee and safety fencing	Removal of existing trees for water conveyance	Existing soil needs to be replaced, increasing cost of construction
	May reduce snowplow operations to clear snow due to reduce accessibly to snow storage area	Existing soil will need to be removed, disposed of and replaced.	Maintenance is required to ensure proper infiltration and pollutant removal

Sustainability Index (SI) Formula:
SI = SUM - (MAX-MIN)

SI: 105

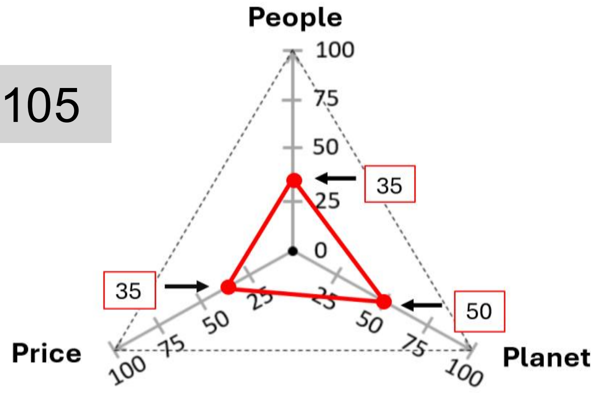

Figure 22: Triple Bottom Line- Existing

SI: 165

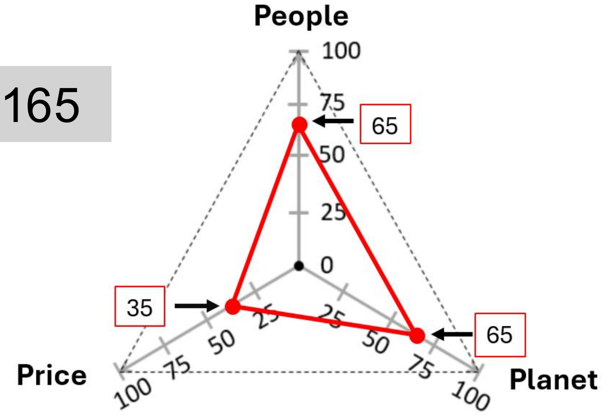

Figure 23: Triple Bottom Line- Proposed

IN CONCLUSION

- Implementation of the proposed design would help with water infiltration, water quality, and stormwater capture (stormwater credits)
  - Stormwater credits of $1,300/year (10% reduction in total costs)
- Due to site constraints – existing trees, culverts, etc. – the design was limited to specific areas
- Although this improvement would benefit the NAU campus, the cost of implementation is high
  - Slow or minimal return on investment (cost of $200k to $400k due to material chosen)
  - Unseen “savings” with flood prevention

1.B. **Low Impact Development (LID) or Active Rainwater Harvesting** (commercial, industrial, multi-family or members of homeowners’ associations)

___ My property has been constructed with city-approved LID or active rainwater harvesting that exceeds current minimum standards. The facilities are presently functional, and maintenance is performed as necessary (for homeowners’ association, please provide documentation that facilities are inspected and maintained).

Credit is 10% Partial, prorated credits may be applied for varying amounts of LID/Active harvesting.

Figure 24: COF Stormwater Credit Excerpt

REFERENCES

[1] N. A. U. F. Services, "Comprehensive Sustainable Smart Campus Master Plan," October 2023. [Online]. Available: https://in.nau.edu/wp-content/uploads/sites/139/2023/11/NAU-Smart-Campus-Master-Plan_11202023_DLR-Group-Part-1.pdf. [Accessed September 2024].

[2] USGS, "Web Soil Survey," USGS, [Online]. Available: https://websoilsurvey.nrcs.usda.gov/app/. [Accessed 8 2 2025].

[3] C. o. Flagstaff, "Stormwater Management Design Manual," 2024. [Online]. Available: https://www.flagstaff.az.gov/DocumentCenter/View/80545/2024-COF-Stormwater-Manual---Draft.

[4] C. o. Flagstaff, "City of Flagstaff GIS," ESRI, [Online]. Available: https://flagstaff.maps.arcgis.com/home/index.html.

[5] A. C. o. Engineering, "HEC - RAS," [Online]. Available: https://www.hec.usace.army.mil/software/hec-ras/.

[6] C. o. F. S. Management, "Stormwater Fees," [Online]. Available: https://www.flagstaff.az.gov/4323/Stormwater-Fees. [Accessed 09 2024].

[7] C. o. F. S. Management, "Stormwater Credit Manual," October 2023. [Online]. Available: https://flagstaff.az.gov/DocumentCenter/View/75459/2023-03-21-Stormwater-Credit-Manual?bidId=. [Accessed September 2024].

[8] E. P. W. R. S. Arizona Department of Transportation, "Stormwater Management Plan," February 2017. [Online]. Available: https://static.azdeq.gov/pn/sm_ms4_pn_swmp_adot.pdf. [Accessed September 2024].

[9] U. S. E. P. Agency, "National Pollutant Discharge Elimination System (NPDES)," 19 10 2023. [Online]. Available: https://www.epa.gov/npdes. [Accessed 10 2023].

[10] Environmental Protection Agency, "National Environmental Policy Act Review Process," [Online]. Available: https://www.epa.gov/nepa/national-environmental-policy-act-review-process. [Accessed October 2024].

[11] O. D. o. Transportation, "Rational Method," [Online]. Available: https://www.oregon.gov/odot/hydraulics/Docs_Hydraulics_Manual/Hydraulics-07-F.pdf.

[12] S. M. City of Flagstaff, "Stormwater Management Rate Adjustments," [Online]. Available: https://www.flagstaff.az.gov/4781/Stormwater-Rate-Adjustment.

QUESTIONS AND COMMENTS?