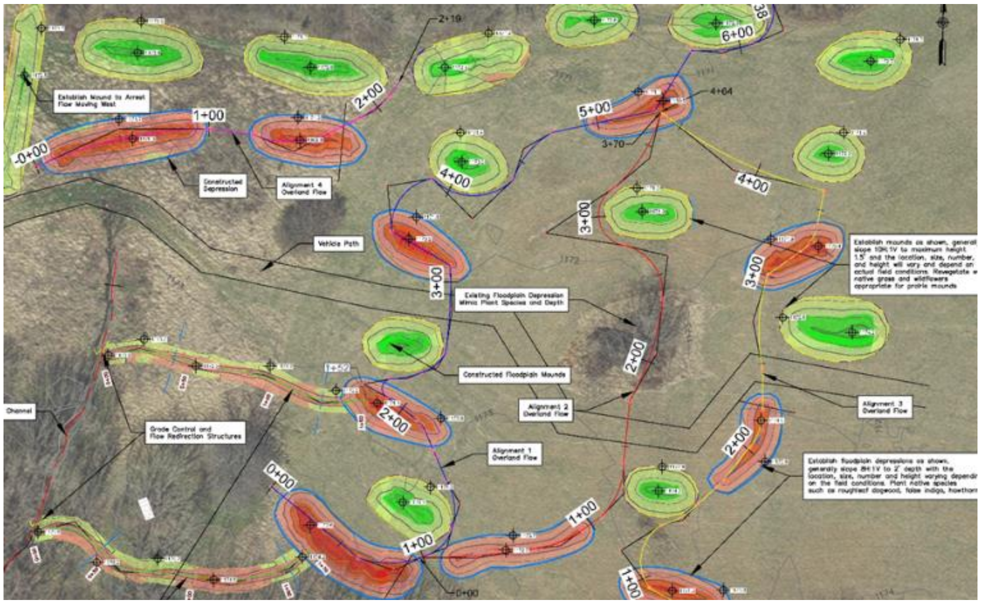
CONCEPT PLAN REPORT

AN ECOLOGICALLY-BASED STORMWATER BMP

FOR THE JOSH BROWN PROPERTY, WEST FORK OF THE WHITE RIVER WATERSHED



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July 28, 2023

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INTRODUCTION

Figure 1. Google Earth image of project site and surrounding landscape

This report describes a plan for an ecologically-based Best Management Practice (BMP) to treat urban stormwater runoff from an existing residential neighborhood. The project will be implemented on land adjacent to the West Fork of the White River (West Fork), in Fayetteville, AR. The BMP design and implementation is a project of the Beaver Watershed Alliance (Alliance) supported by the Walton Family Foundation. Bio x Design and the Watershed Conservation Resource Center (WCRC) collaborated to develop this plan.

It is the mission of the Alliance to protect, enhance, and sustain the high quality of water in Beaver Lake and its tributaries. Implementation of voluntary best management practices, education, and outreach are key activities in support of this goal.

For this project, the Alliance is working with a local landowner and an existing residential neighborhood in east Fayetteville. Stormwater collected from the neighborhood is deposited via a large concrete outfall pipe onto private agricultural land. It flows across a hay meadow and eventually enters the West Fork. The West Fork is tributary to the White River, and thus ultimately contributes to Beaver Lake. Beaver Lake is the water supply for over 550,000 people in Northwest Arkansas, now 1 in 5 Arkansans.

The stormwater treatment plan involves sculpting an existing hay meadow and shallow ditch into a mound-and-swale topography modeled on naturally occurring prairie landscapes of Northwest Arkansas. This new topography will spread and slow the water flowing across the site. This will create extended contact time for the stormwater with site vegetation, reducing sediment and nutrient supplied down gradient. Slower and less channelized flow will reduce stormwater velocities and rejuvenate and protect existing riparian vegetation along the West Fork. Another component of the treatment system is to enhance the channel that has formed from the stormwater outfall. Currently, a head-cut is moving through the channel, but is arrested at a section where tree roots have slowed further incision. Rock structures will be used to hold the channel grade through this section. The structures will also be used to redirect flow at the bankfull elevation to increase treatment of the stormwater through the prairie mound-swale system. Removal of non-native shrubs and planting of native species along the channel and throughout the site will enhance the overall ecology of the site.

A suite of education and outreach activities are also planned. An informational meeting with the residents of the area was held prior to design development, and additional outreach and educational activities are currently underway, including workshops for residents of the subdivision on site and surrounding residents to further learn about low impact development techniques and this specific project.

As development in Northwest Arkansas continues to expand, appropriate treatment of stormwater has become increasingly important. The Alliance intends this project to be a demonstration of possibilities for creative, ecologically-based stormwater management that will be useful for other existing and future developments adjacent to riparian areas and floodplains in the watershed.

SITE DESCRIPTION AND ANALYSIS

The subject property is a 60-acre parcel owned by Mr. Josh Brown. The site is under a conservation easement with the Ozark Land Trust (OLT). The site is located in eastern Fayetteville (Figure 2), zoned for agriculture, and subject to the City's floodplain requirements The site receives stormwater runoff from an existing residential neighborhood that lies between Highway 16 (Huntsville Road) and the West Fork of the White River (Figure 3).

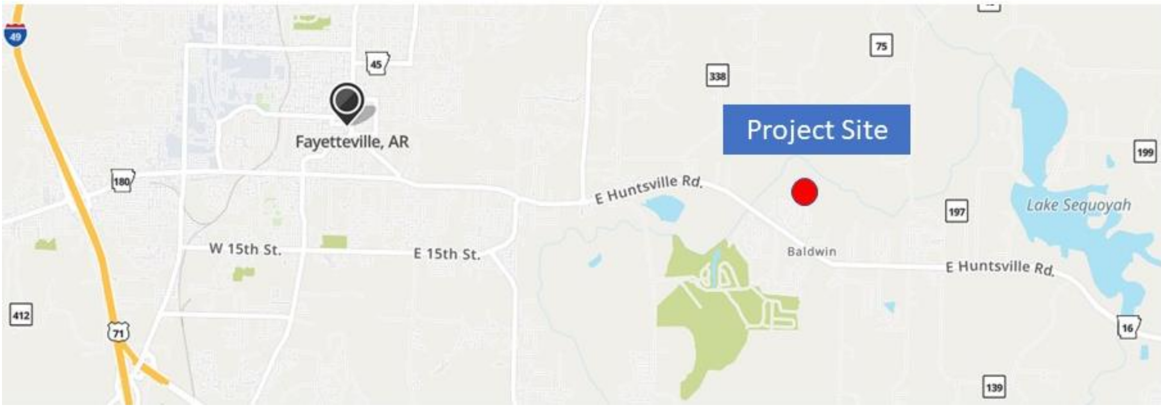

Figure 2. Project Location

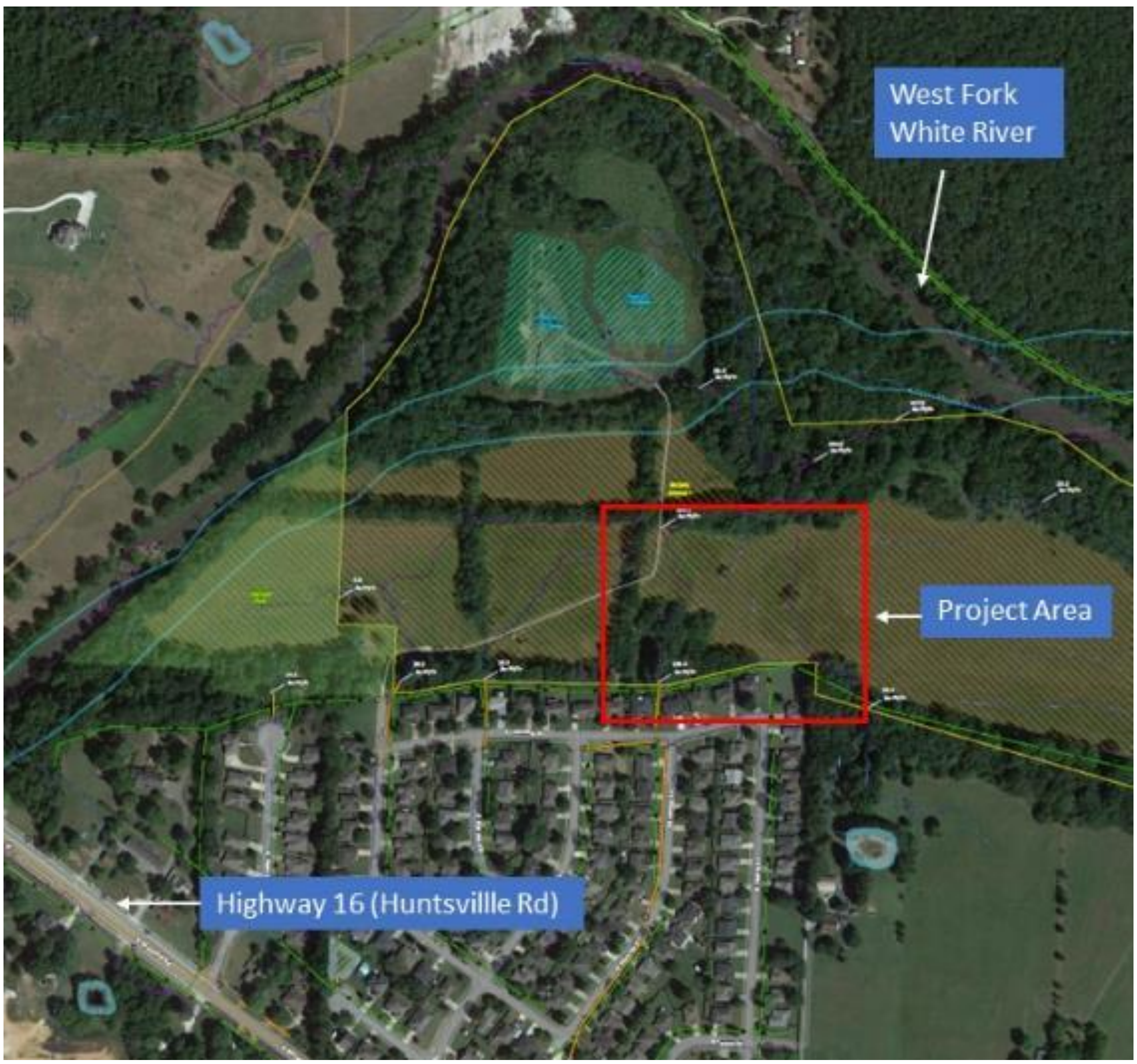

Figure 3. Project site in context

Several stormwater outfalls from the neighborhood exit onto the site; this project will address outfall from the largest of these (Figure 4).

Figure 4. Stormwater outfall. (*Photo: Patterson*).

Mr. Brown is managing the whole of his parcel as a privately owned bird sanctuary. An approximate 4.5-acre shallow wetland and mudflat habitat for shorebirds, aka "Shorebird Stopover," is currently under construction to the north of the stormwater project site, adjacent to the West Fork.

Figure 5. Bird Sanctuary

Stormwater

WCRC conducted an analysis of the hydrology of the site and the contributing stormwater area to understand the volume and flows discharging to the site. The primary stormwater discharge to the project site has a drainage area of 39 acres (Figure 6) and includes pasture and farm properties south of Hwy 16 and the residential neighborhood north of the highway. The residential area includes a detention pond and a network of drainage pipes and inlets.

Flow is discharged during storm events from this drainage area through a 3 ft diameter reinforced concrete pipe. The pipe has a slope of 0.0095, and calculated max discharge and velocity of 70 cfs at 10 ft/s, respectively. Table 1 displays calculations for pipe flow. Discharge from the pipe flows to the north and discharges to a shallow ephemeral drainage that runs through the center of the Josh Brown property.

Full Capacity - Pipe Velocity and Discharge	
Diameter (ft)	3
Slope	0.0095
Manning's n	0.012
Velocity (ft/s) (at maximum capacity)	10.0
Q - Flow (ft^3) (maximum capacity)	70.4

Table 1. Pipe discharge and velocity calculations for the stormwater outlet.

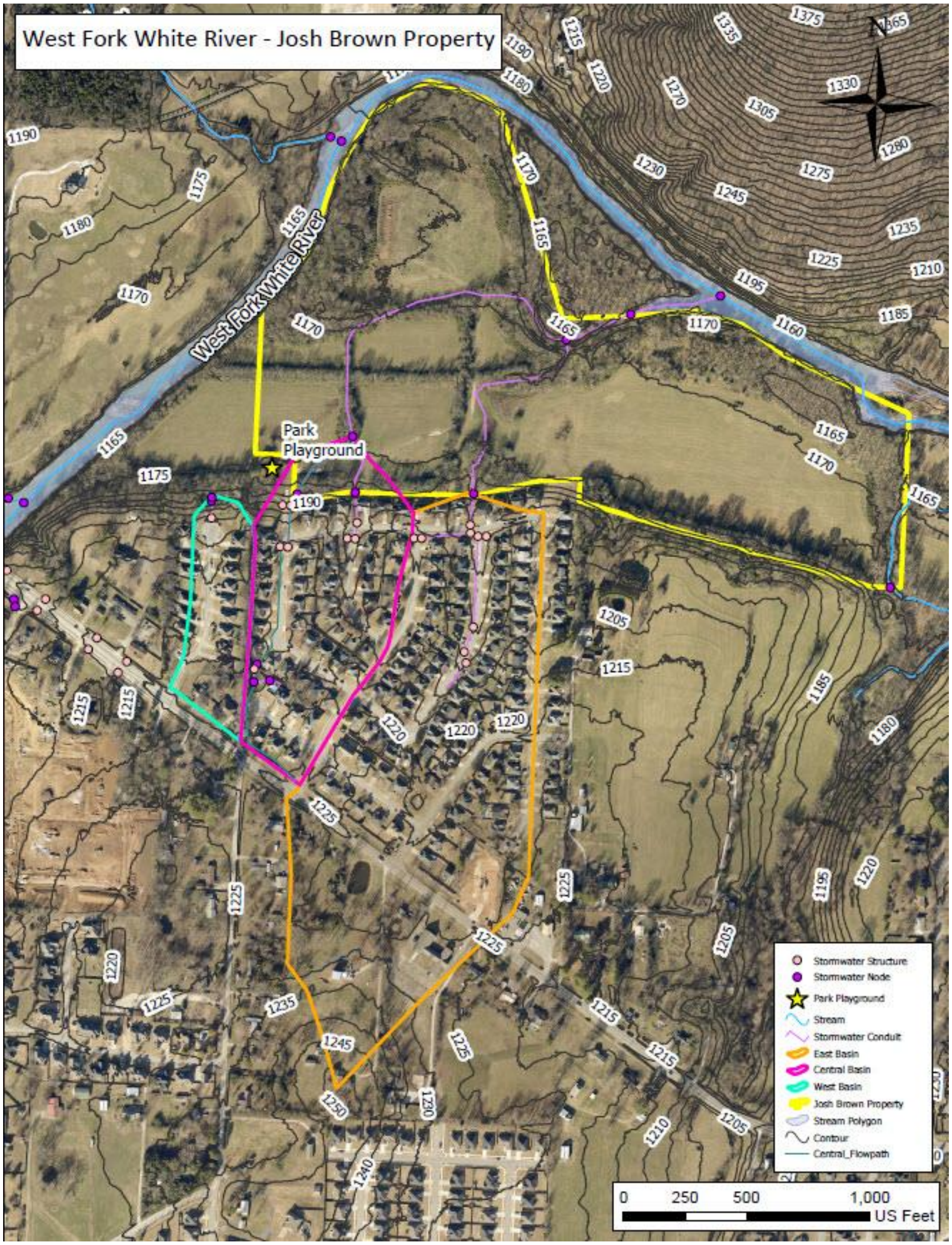

Figure 6. Stormwater basins in the project area. The area outlined in orange is the basin for the stormwater outfall to the project site.

Vegetation

The existing vegetation in the project area and over much of the Brown parcel is non-native, cool season grasses. These grasses are mowed annually for hay. The parcel is transected by several linear treed areas, apparently old fencelines, though some also include shallow ephemeral drainage features (Figure 3).

Much of the site once supported native tallgrass prairie. US Government land surveys conducted in Washington County from 1831-1838 were analyzed by Miller (1972). Miller's maps record the project site property as "lowland prairie" with riparian vegetation along the West Fork.

Site reconnaissance and inventory of current vegetation conducted by Alliance staff, Nate Weston, Sr. Geospatial Ecologist, on October 25, 2022 revealed a significant number and diversity of native plant species that persist on the site and notes habitat types (see Appendix 2.) Examples of findings during the survey include:

- There is a large and healthy tangle of pipevine (*Aristolochia tomentosa*) growing along an old fence line on the western edge of the project area (Figure 7). Pipevine is a host plant for pipevine swallowtail (*Battus philenor*).
- Outside the project area to the north appears to be a small vestige of tallgrass prairie.
- A population of swamp milkweed (*Asclepias incarnata*) was identified in this area.
- Along the northern edge of this prairie patch is a small stand of river cane (*Arundinaria gigantea*).

Figure 7 Pipevine, *Aristilochia tomentosa* on the edge of the treeline on the western edge of the project site *(Photo: Patterson)*.

- A remnant prairie pool is located on the eastern side of the project area.
- In addition to willows, two native hawthorns (*Crataegus* spp.) were observed there. One of them may be a rare Washington hawthorn (*Crataegus phaenopyrum*). Definitive identification awaits confirmation.

Prairie pools are discussed in-depth in the following section.

Prairie mounds

A prairie mound-and-swale topography was a frequent feature of naturally occurring tall grass prairie landscapes in Northwest Arkansas. Prairie mounds and swales are natural phenomena associated with North American prairies found west of the Mississippi River. Explanations for their creation are varied; the two most common are either (1) accumulation of wind-blown material during late-Holocene droughts (Seifert et al., 2009) or (2) through activity of ground dwelling animals (e.g., gopher) activities (Horwath & Johnson, 2006).

However, they were formed, prairie mounds are still seen in scattered locations in northwest Arkansas though many have been removed through farming and development. Mound topography may also be observed on aerial photography or satellite imagery, especially high-resolution LIDAR. Figure 8 shows a LIDAR image with a persisting prairie mound landscape on the left, and where the mounds have been removed by farming on the right.

Figure 8. Northwest Arkansas prairie mound landscape on the left, and farmland where mounds have been removed on the right *(Source: Weston, Beaver Watershed Alliance)***.**

Figure 9 shows this topography in cross-section. The topographic variation helps support a diversity of native vegetation as different heights and depths of flooding support different plant species. Water tends to pool in the areas between these mounds (Figure 10), and in lower areas may support water-loving plants like rushes (*Juncus* spp.), marsh mallows (*Hisbiscus* spp.), and willows (*Salix* spp.). Conversely, dry-tolerant species like bluestems, sunflowers, and sumacs tend to occupy the mounds. Where swales are low enough to hold water for an extended period, these pools can support amphibian and reptile species that prefer wetter conditions, such as salamanders. This is the case in the one existing pool on site.

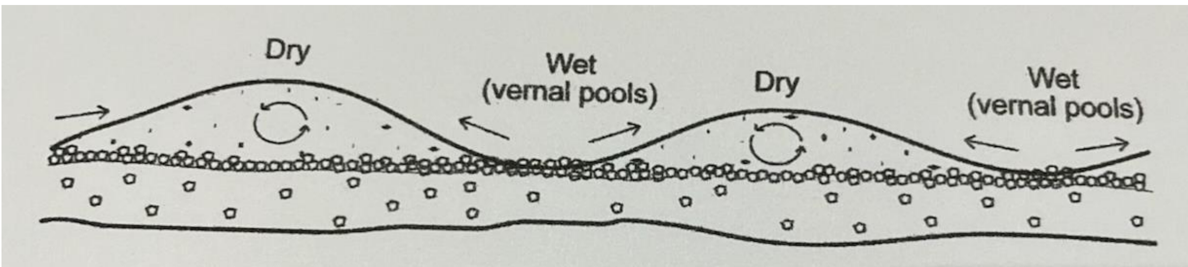

Figure 9. Typical prairie mound and swale topography *(after Horwath & Johnson, 2006).*

Figure 10. Grazed prairie mound landscape after a rain *(Photo: Patterson)***.**

THE PLAN

The design plan for stormwater treatment modifications to the project site is shown in Figure 11. The plan has two main components—grade the site and replant with native species. In addition, the channel that has formed from the stormwater flow will be enhanced with rock structures that will also be used to direct some flow above bankfull to another section of swales and mounds. Other important components including education and outreach activities are also described below. A complete construction plan set is available in Appendix 4.

Reconfigure site topography and plant native species

The site will be recontoured based upon a model of natural prairie mound and swale topography. Shallow excavations will create low-lying areas, and the soil removed will be used to create shallow mounds. The excavated swales will connect with each other to create very low slope reticulated flow paths across the site.

The created mounds will not rise more than one and one-half feet (1.5 ft) above the existing grade in their location (per agreement with the City of Fayetteville). Excavation of swales up to 2 feet in depth means it is likely that more material will be excavated than can be used in the mounds. If so, the extra material will be removed from the site. In this way, there will be no decrease in flood capacity of the site, and there will likely be a modest increase in flood capacity due to material removal.

The mounds and swales will be sculpted with very gentle slopes so that the owner can continue to mow them and make hay; though this will be limited to once a year to minimize impact to native plant and wildlife populations.

Based on this plan, there will be approximately 95,800 square feet of disturbance (2.2ac), or about 36% of the 6-acre site.

Implementation will include specific actions as shown on the construction plan, including:

- Stabilize the construction entrance
- Leave a path across the site for vehicle utility and property right-of-way access
- Consider reinforcing lowest areas of right-of-way vehicle access path with geocell
- Protect and do not disturb existing native vegetation, especially tree areas along west and north edges of project site

- Protect and do not disturb existing pool or its vegetation on the east edge of site

- Enhance stormwater channel with native vegetation and install two grade control structures to protect and reduce down-cutting and improve the ecology.

- Use structures to direct high flows to the east.

- Excavate prairie swales, generally sloping them 4H to 10H:1V. The location and heights may vary depending on the field conditions but will be in the same vein as shown in the construction drawing.

- Make use of existing contour flowlines to route water through swales

- Excavate three of these depressions more deeply to more closely emulate the existing prairie pool.

- Build mounds as shown, generally sloped 10H:1V. The location, size and height may vary depending on field conditions but will be in the same vein as shown in the plan.

- Revegetate mounds with native grass and prairie forbs appropriate for prairie mounds.

- Plant native wet prairie grasses, rushes, and sedges in low lying areas.

- Plant native species such as roughleaf dogwood, false indigo, hawthorn around the three deepest pools.

- Replant disturbed soil areas with native plant species to enhance overall biodiversity and habitat quality

Permissions

The City of Fayetteville required a variance to allow construction of the prairie mounds. The variance was granted on April 10, 2023.

A grading permit application has been approved on July 5, 2023 following submittal to the City of Fayetteville.

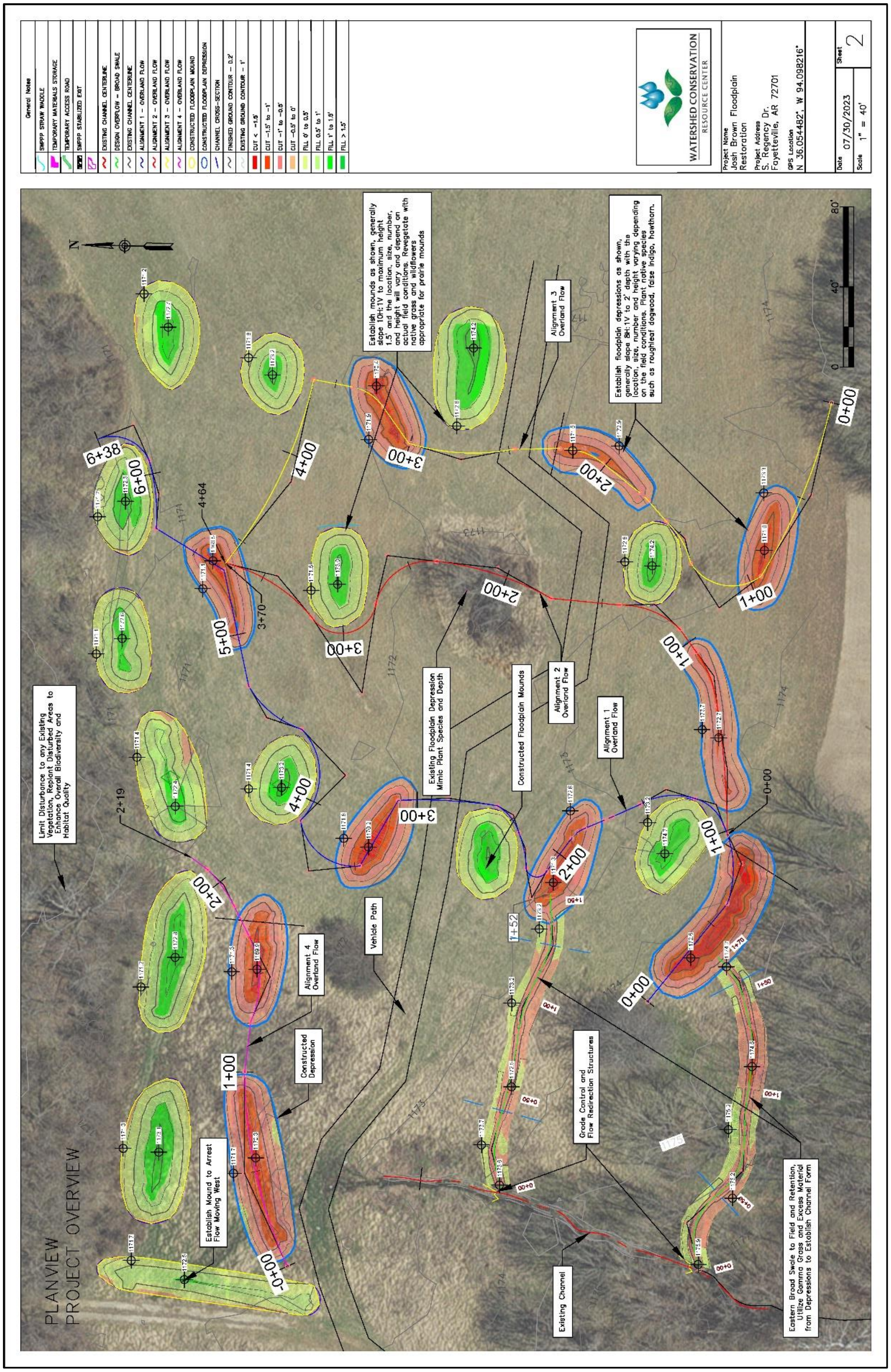

Figure 11. Design Plan for Urban Stormwater BMP

Effectiveness

Table 2 shows discharge and volume calculations based on the Soil Conservation Service (SCS), which is now the Natural Resource Conservation Service's hydrologic model for a single event rainfall-runoff (USDA SCS, 1986) for various size storm events. This method allows for model development to estimate storm runoff volume, peak rate of discharge, and storage volume required for different storm intensities. The estimated percentage of volume retained is shown and acts as small detention ponds. This detention volume is compared to the Water Quality Volume (WQv) and Channel protection Volume (CPv), minimum standards utilized by the City of Fayetteville in categorizing stormwater control.

SCS Method Results for Various Storm Events			
Storm	**Peak Flow**	**Volume**	**Volume Held**
yr	**cfs**	**ft³**	**%**
1	68.9	273,240	4.8
2	79.0	313,203	4.2
10	122.3	488,621	3
100	204.4	833,578	2
Estimated Detention			
Detention Volume	**WQv**	**CPv**	
ft³	**ft³**	**ft³**	
13,196	97,722	245,473	

Table 2. Estimated detention volume & discharge comparisons. SCS volume, discharge, and percentage held by design detention calculations for various size storm events, and the water quality volume and channel protection volume for comparison.

This stormwater BMP project is intended to treat frequent, smaller flows. The project site is in the floodplain of the West Fork and as such at high flows will be flooded, precluding an opportunity for stormwater runoff enhancement under those conditions.

Calculations of effectiveness in treatment wetlands and detention basins assume all the water entering a basin spends the same designed amount of time in the basin. However, these calculations frequently overestimate treatment because flow through the system develops preferential flow paths. This is known as short-circuiting. In an interesting modeling study examining the ability of different surface topographies to reduce short-circuiting the authors found that a set of "islands" in the basin were the best at improving hydraulic performance (Guzman, 2018). The topography of basins with islands closely resembles the prairie mound topography planned for this project. We expect therefore that the project topography will be highly effective at its intended purpose of slowing and treating stormwater inflow.

Estimated sediment and nutrient removal was determined utilizing a compendium of studies measuring effectiveness of nutrient and sediment removal. BMP effectiveness can be variable dependent on a number of factors including; the local hydrology, geology, soil types, incoming pollutant concentrations, volume of runoff reduced through the system, and BMP design. Given the multitude of design factors employed here, such as, native vegetation, short circuiting reduction, low flowpath slope, and geometry and shape of the features, it is the designer's intent to achieve maximum effectiveness. Therefore, estimates here utilize the 75th percentile removal efficiency determined in the study. This being the case, estimated Total suspended Solids reductions are 88%, estimated Total Nitrogen reductions are 41%, and estimated Total Phosphorous reductions are 76% (Fraley-McNeal, et al., 2007). Another study measured the removal efficiency of a constructed wetland for sediment over 18 years of monitoring with yearly average removal efficiency of 39% (Krzeminska et al., 2023).

Invasive plant removal

Invasive plant removal at the project site was conducted from 12/7 - 12/22, 2022. Non-native shrubs including bush honeysuckle were removed from approximately one acre surrounding the stormwater outfall. A mini excavator was used to remove entire plants including the roots. Invasive plants were also removed along the old fencelines surrounding the area where the swales and mounds will be constructed for a total of 2 acres. If needed, WCRC will work with the Alliance to engage volunteers to conduct follow-up treatment in the future.

Trash

Consideration was given to constructing a trash rack to collect trash entering the site with stormwater. Even simple racks are expensive and require regular maintenance to not clog and inhibit stormwater flow. A local Boy Scout troop has indicated a willingness to periodically pick up trash at the site. They have already done so once. Therefore, no trash rack is included in the plan. The City of Fayetteville has indicated a willingness to forgo fees for trash disposal, but that agreement has not been formalized.

Education and outreach

The Alliance will engage neighbors and the wider community in educational events addressing source water protection and riparian rejuvenation. The first neighborhood meeting was held on October 11, 2022. Approximately 20 neighbors attended. Discussions points included:

- the nature and importance of riparian areas for water quality and wildlife
- native and invasive plant management and the relation of these to water quality improvements
- proposed plans for stormwater BMP design on the Josh Brown property

The Alliance followed up with all attendees at this meeting via email and mailed letters. These generated at least one one-on-one meeting with neighboring homeowner. This homeowner is working on adding native plants and rain barrels to their property as a result.

On April 15, the Alliance organized a site visit with a group of Boy Scouts. Approximately 50 Scouts and adults accompanying them picked up trash and had fun finding and identifying bones and other fun things on the site.

NEXT STEPS

The next steps in the project will be to:

- The WCRC will initiate construction of the project in August 2023.
- Education and outreach activities will continue with a second workshop planned for June. This will be a follow-up to the first meeting with all who attended invited and will also be opened and advertised to the general public. This workshop will focus on ways urban and suburban landowners can improve their property with water-smart BMPs such as native plantings, rain gardens, bioswales, no-mow zones, etc. There will also be an update on the Josh Brown project.

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APPENDICES

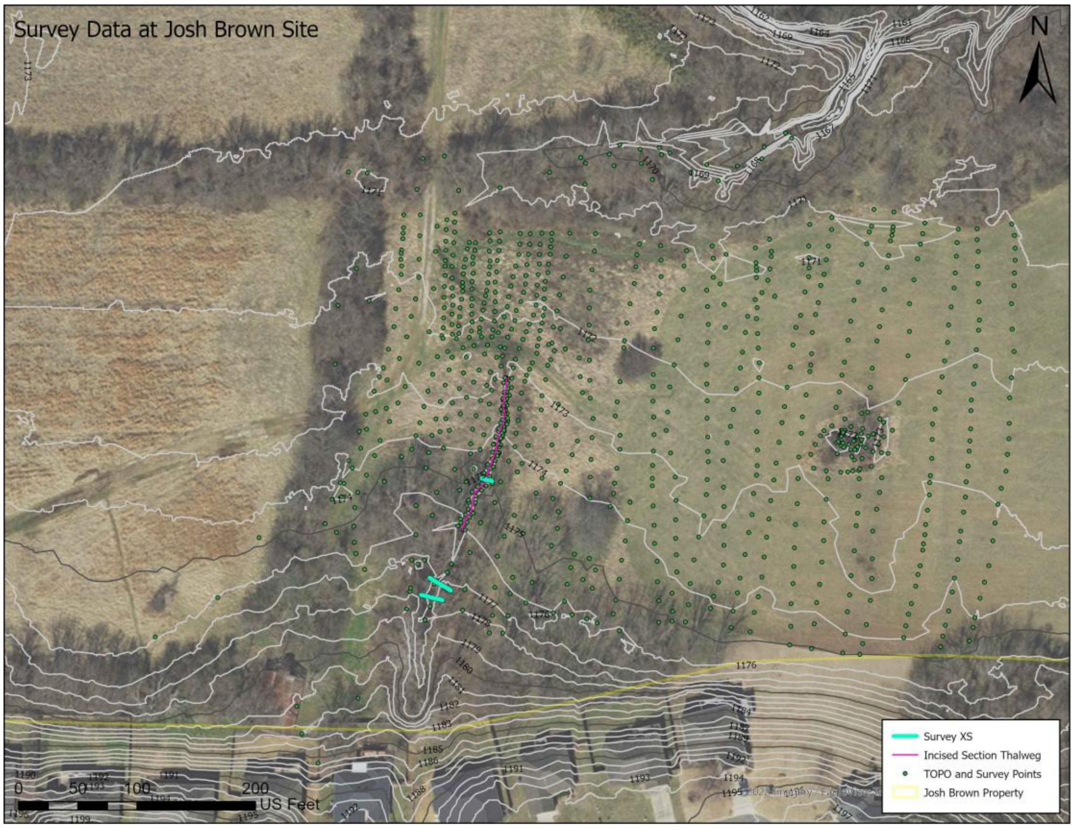
APPENDIX 1 – SITE SURVEY AND STORMWATER CALCULATIONS

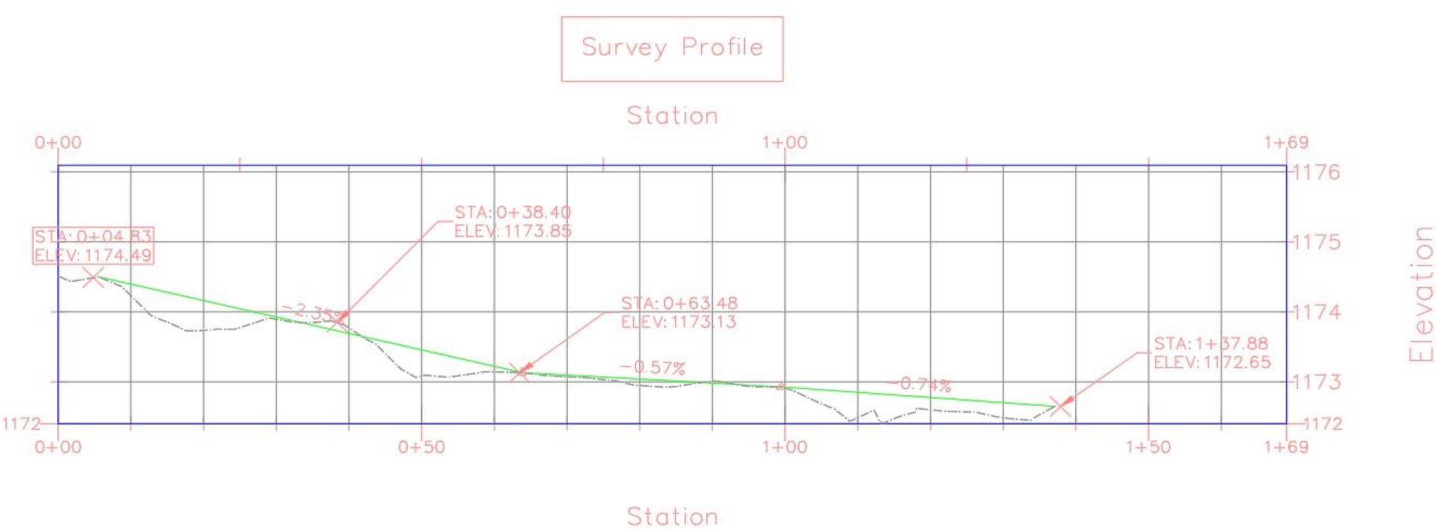
An analysis of the hydrology of the site and the contributing stormwater area was conducted to better understand the volume and flows discharging to the site. The primary stormwater discharge to the project site has a drainage area of 39 acres, and includes pasture and farm properties south of Hwy 16 and an existing residential neighborhood north of the highway. The residential area includes a detention pond and a network of drainage pipes and inlets.

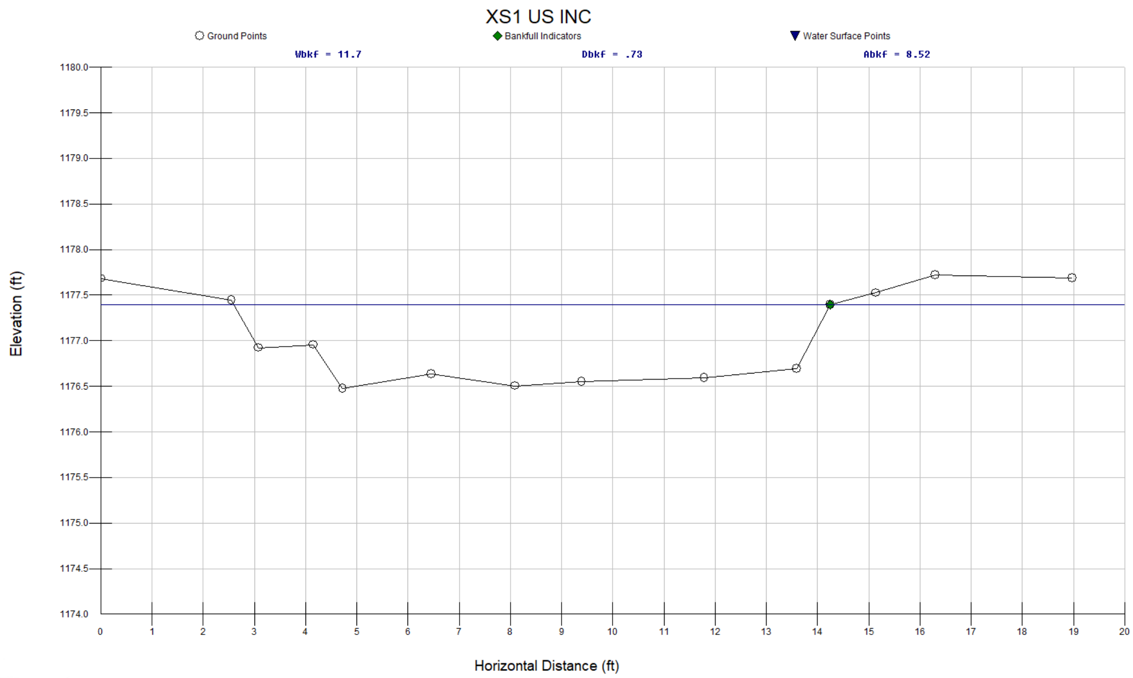
Analysis was conducted in GIS of the flowpath, slope, and time of concentration for sheet flow, shallow concentrated flow, and open channel flow. The drainage area was segmented into different land uses and hydrologic soil groups to develop a curve number to account for the amount of infiltration in a given storm. Precipitation data was utilized for the Fayetteville area typical 24 hour storm events. The drainage network for this area was downloaded from the city of Fayetteville's GIS to facilitate this analysis.

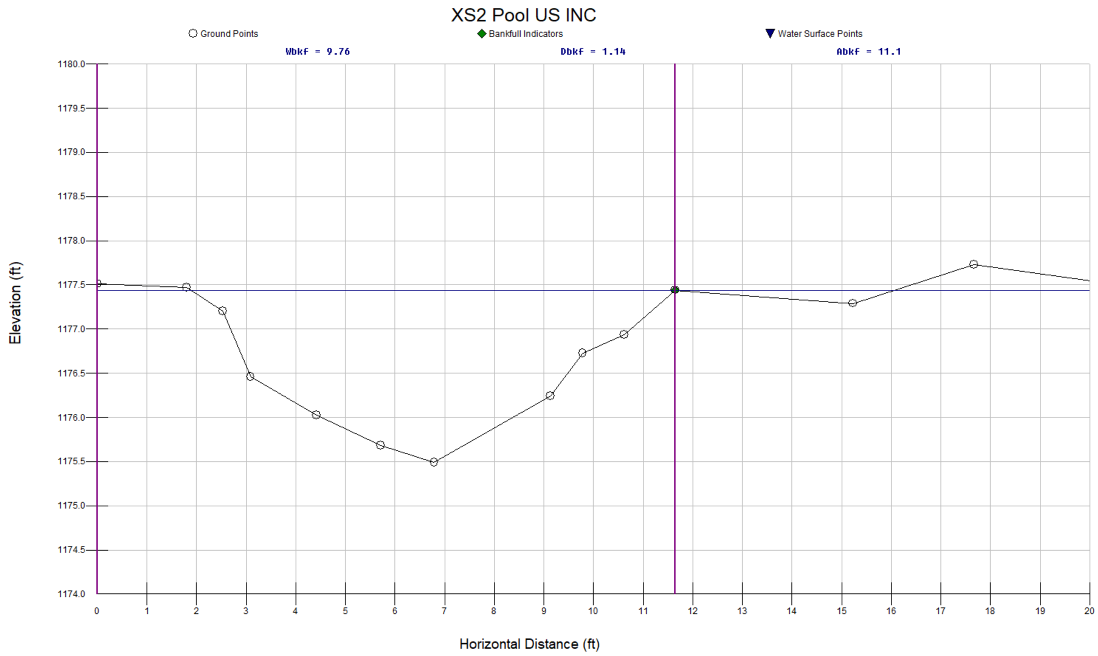
Table 2 shows discharge and volume calculations based on SCS methods (USDA SCS, 1986) for various size storm events. A percentage of volume is shown that is captured as part of the design within the detention ponds. Detention pond volume was calculated based on a design 3-dimensional surface created in civil 3d. This is compared to the Water Quality Volume (WQv) and Channel protection Volume (CPv) minimum standards utilized by the City of Fayetteville in categorizing stormwater control.

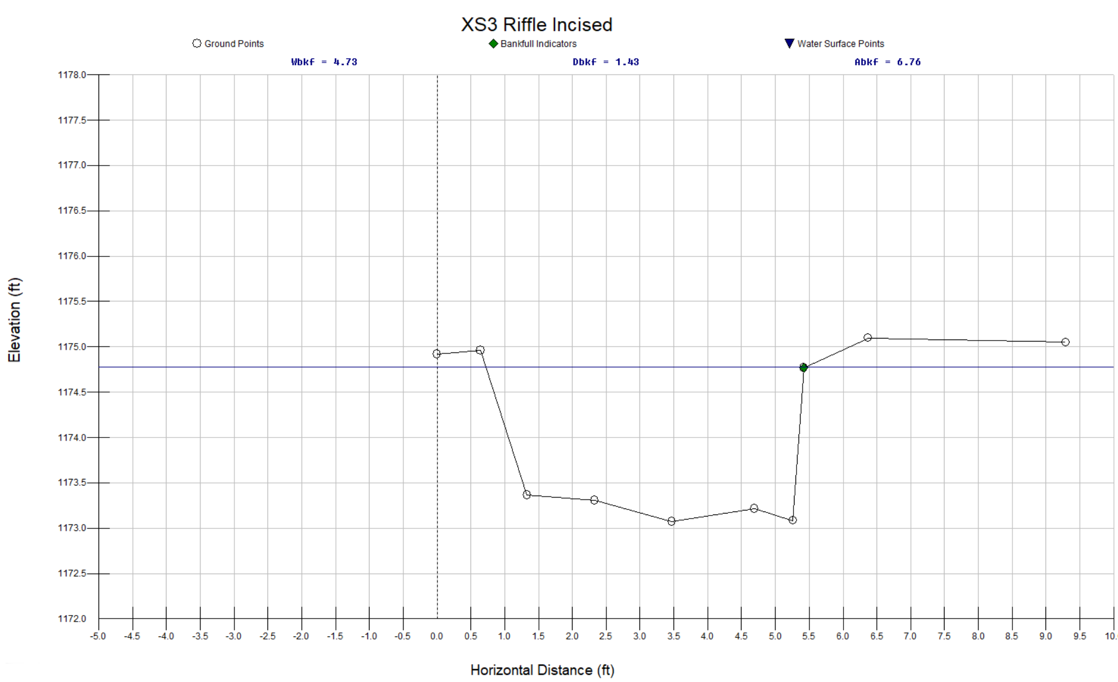
Additional bankfull discharge estimates were conducted for the ephemeral channel collecting runoff from this watershed, shown in the following table. Survey topo data, plotted cross-sections, and the channel longitudinal profile are displayed below as well.


Survey Data at Josh Brown Site
N
Survey XS
Incised Section Thalweg
TOPO and Survey Points
Josh Brown Property
0 50 100 200
US Feet


Survey Profile
Station
0+00
1+00
1+69
Elevation
STA: 0+04.83
ELEV: 1174.49
STA: 0+38.40
ELEV: 1173.85
STA: 0+63.48
ELEV: 1173.13
STA: 1+37.88
ELEV: 1172.65
-2.35%
-0.57%
-0.74%
1176
1175
1174
1173
1172
0+50
1+50
Station


XS1 US INC
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 11.7
Dbkf = .73
Abkf = 8.52
Elevation (ft)
Horizontal Distance (ft)


XS2 Pool US INC
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 9.76
Dbkf = 1.14
Abkf = 11.1
Elevation (ft)
Horizontal Distance (ft)


XS3 Riffle Incised
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 4.73
Dbkf = 1.43
Abkf = 6.76
Elevation (ft)
Horizontal Distance (ft)

Bankfull VELOCITY & DISCHARGE Estimates							
Stream:	East Basin			Location:	Reach - Reach 1		
Date:	10/20/22	Stream Type:	B3c	Valley Type:	VIII		
Observers:				HUC:			

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	8.52	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	0.73	d_{bkf} (ft)
Bankfull Riffle WIDTH	11.69	W_{bkf} (ft)	Wetted PERMIMETER ~ (2 * d_{bkf}) + W_{bkf}	12.38	W_p (ft)
D_{84} at Riffle	70.00	Dia. (mm)	D_{84} (mm) / 304.8	0.23	D_{84} (ft)
Bankfull SLOPE	0.0209	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	0.69	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	3.00	R / D_{84}
Drainage Area	0.061	DA (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	0.681	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log \{ R / D_{84} \}] u^*$	3.76	ft / sec	32.05	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3}*S^{1/2}/n$ *n* = 0.0406	4.13	ft / sec	35.15	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3}*S^{1/2}/n$ *n* = 0.0557	3.01	ft / sec	25.62	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2}/n$ $n = 0.39*S^{0.38}*R^{-0.16}$ **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 *n* = 0.095	1.76	ft / sec	15.00	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Hey)	4.17	ft / sec	35.49	cfs

APPENDIX 2 – PLANT SURVEY DATA

Nate Weston, Beaver Watershed Alliance

Family	Scientific Name	Common Name
Acanthaceae	*Ruellia humilis*	hairy wild petunia
Adoxaceae	*Sambucus canadensis*	elderberry
Alliaceae	*Allium canadense*	wild onion
Anacardiaceae	*Toxicondendron radicans*	poison-ivy
Apiaceae	*Cicuta maculata*	water-hemlock
Apiaceae	*Daucus carota***	Queen Anne's-lace
Apocynaceae	*Apocynum cannabinum*	dogbane
Apocynaceae	*Asclepias incarnata ssp incarnata (S2)*	swamp milkweed
Apocynaceae	*Gonolobus suberosus*	anglepod
Aristolochiaceae	*Aristolochia tomentosa*	pipe-vine
Asteraceae	*Ambrosia trifida^*	giant ragweed
Asteraceae	***Elephantopus carolinianus***	Carolina elephant's-foot
Asteraceae	*Leucanthemum vulgare*	ox-eye daisy
Asteraceae	*Rudbeckia laciniata* var. *laciniata*	wild goldenglow
Asteraceae	*Solidago gigantea*	tall goldenrod
Asteraceae	*Symphyotrichum lanceolatum*	tall white aster
Asteraceae	*Symphyotrichum pilosum* var. *pilosum*	white heath aster
Asteraceae	*Verbesina alternifolia*	yellow-ironweed
Asteraceae	*Vernonia baldwinii*	western ironnweed
Asteraceae	*Rudbeckia triloba var. triloba*	brown-eyed Susan
Brassicaceae	*Alliaria petiolata***	garlic mustard
Brassicaceae	*Barbarea vulgaris**	yellow-rocket
Brassicaceae	*Cardamine hirsuta*	hairy bittercress
Brassicaceae	*Lepidium virginicum*	Virginia pepper-grass
Cannabaceae	*Celtis laevigata*	sugarberry
Cannabaceae	***Celtis occidentalis***	**hackberry**
Caprifoliaceae	*Lonicera japonica***	Japanese honeysuckle
Caprifoliaceae	*Lonicera mackii***	bush honeysuckle
Caprifoliaceae	*Symphoricarpos orbiculatus*	coral-berry
Caryophyllaceae	*Stellaria media*	common chickweed
Celastraceae	*Euonymus fortunei***	winter-creeper
Cyperaceae	*Carex frankii*	Frank's sedge
Cyperaceae	*Carex vulpinoidea*	fox sedge
Cyperaceae	*Cyperus echinatus*	globe flatsedge
Cyperaceae	*Cyperus strigosus*	false nutsedge
Fabaceae	*Albizia julibrissin***	silk-tree
Fabaceae	*Cercis canadensis*	Eastern redbud
Fabaceae	*Gledistia tricanthos*	honey locust
Fabaceae	*Trifolium repens**	white clover

Fagaceae	*Quercus macrocarpa*	bur oak
Fagaceae	*Quercus shumardii*	Shumard oak
Fagaceae	*Quercus velutina*	black oak
Juglancaceae	*Carya alba*	mockernut hickory
Juglandaceae	*Carya illinoinensis*	pecan
Juncaceae	*Juncus effusus*	soft rush
Lamiaceae	*Lamium purpureum*	purple dead-nettle
Malvaceae	*Sida spinosa*	prickly sida
Menispermaceae	*Cocculus carolinus*	Carolina snailseed
Moraceae	*Maclura pomifera*	osage-orange
Moraceae	*Morus alba***	white mulberry
Moraceae	*Morus rubra*	red mulberry
Oleaceae	*Ligustrum sinense***	Chinese privet
Passifloraceae	*Passiflora incarnata*	purple passion flower
Phytolaccaceae	*Phytolacca americana* var. *americana*^	pokeweed
Plantaginaceae	*Plantago lanceolata**	English plantain
Plantanaceae	*Platanus occidentalis*	American sycamore
Poaceae	*Andropogon virginicus var. virginicus*	broomsedge
Poaceae	*Arundinaria gigantea*	river cane
Poaceae	*Cinna arundinacea*	stout wood-reed
Poaceae	*Cynodon dactylon***	Bermuda grass
Poaceae	*Danthonia spicata*	poverty oat grass
Poaceae	*Elymus* spp.	wild rye
Poaceae	*Leersia oryzoides*	rice cut grass
Poaceae	*Paspalum floridanum*	Florida paspalum
Poaceae	*Phleum pratense**	Timothy grass
Poaceae	*Sorghastrum nutans*	Indian grass
Poaceae	*Sorghum halepense***	Johnson grass
Poaceae	*Tridens flavus* var. *flavus*	purple-top tridens
Polemoniaceae	*Phlox paniculata*	perennial phlox
Polygonaceae	*Fallopia scandens*	climbing false buckwheat
Polygonaceae	*Persicaria* sp.	smartweed
Polygonaceae	*Rumex crispus**	curly dock
Ranunculaceae	*Clematis terniflora**	sweet autumn virgin's-bower
Ranunculaceae	*Ranunculus hispidus*	swamp buttercup
Rosaceae	*Crataegus* cf. *phaenopyrum*	Hawthorn
Rosaceae	*Geum canadense*	white avens
Rosaceae	*Prunus monsoniana*	wild goose plum
Rosaceae	*Prunus serotina*	black cherry
Rosaceae	*Pyrus calleryana***	callery pear
Rosaceae	*Rosa multiflora**	multiflora rose
Salicaceae	*Populus deltoides*	cottonwood
Salicaceae	*Salix nigra*^	black willow
Santalaceae	*Phoradendron leucarpum*	mistletoe
Sapindaceae	*Acer negundo*	box elder

Sapindaceae	*Acer rubrum*	red maple
Sapindaceae	*Acer saccharimum*	silver maple
Smilacaceae	*Smilax bona-nox*	saw greenbrier
Solanaceae	*Physalis* sp.	groundcherry
Solanaceae	*Solanum carolinense*	Carolina horsenettle
Ulmaceae	*Ulmus alata*	winged elm
Ulmaceae	*Ulmus americana*	American elm
Ulmaceae	*Ulmus rubra*	slippery elm
Violaceae	*Viola sororia*	blue violet
Violaceae	*Viola striata*	cream violet
Vitaceae	*Vitis vulpina*	fox grape

Notations:

* indicates non-native species

** indicates non-native invasive species

^ indicates native species that can be considered invasive in some habitats

Bold ( ) indicates tracked species (state rank)

Vegetation zones in project area.

APPENDIX 3 – GEOCELL

To stabilize and protect wet crossings on the right-of-way vehicle route, use geocells and gravel, similar to this.

TERRACELL®

CELLULAR CONFINEMENT SYSTEM

TerraCell is an innovative geosynthetic product providing solutions for difficult stabilization, erosion control, slope and retaining wall challenges. TerraCell, generically referred to as a "**geocell**," confines native or select fill materials and is the integral component of a **cellular confinement system.**

TerraCell is a lightweight, flexible mat made of high density polyethylene strips. These strips are ultrasonically bonded together to form an extremely strong, honeycomb configuration. A variety of fill materials can be placed within the TerraCell system: soil, sand, aggregate, concrete, etc. The use of TerraCell and the appropriate fill material create numerous opportunities for versatile and economical solutions for many applications including:

- GROUND STABILIZATION
- SLOPE EROSION CONTROL
- RETAINING WALLS
- STREAM CROSSINGS
- CHANNEL EROSION CONTROL
- EMBANKMENTS

To satisfy the application, TerraCell is available in various heights and three different cell sizes: TerraCell 140 (small), TerraCell 175 (intermediate) and TerraCell 280 (large). It can be supplied in solid wall or perforated (to allow flow between cells) styles. Holes can be made in TerraCell to facilitate a tendoning system for some applications. TerraCell can be manufactured into custom sizes for specific requirements (i.e.; retaining wall fascia).

EXPANDED DIMENSIONS

- TerraCell 140
8.4 ft. x 21.4 ft. x cell height
Panel Area: 180 sq. ft. (nominal)
Cell Area: 10.2" x 8.8"
(44.8 sq. inches nominal)

- TerraCell 175
8.4 ft. x 27.4 ft. x cell height
Panel Area: 230 sq. ft. (nominal)
Cell Area: 12.6" x 11.3"
(71.3 sq. inches nominal)

- TerraCell 280
8.4 ft. x 45 ft. x cell height
Panel Area: 378 sq. ft. (nominal)
Cell Area: 20.0" x 18.7"
(187 sq. inches nominal)

CELL HEIGHT
8", 6", 4", and 3"

COLOR
Black

CUSTOM COLORS
Tan and Green

TERRACELL PRODUCT SPECIFICATIONS

TerraCell is manufactured from High Density Polyethylene (HDPE) to the following minimum standards:

PROPERTY	TEST METHOD	VALUE
Sheet Thickness	ASTM D-5199	50 mils, ± 5%
Density	ASTM D-1505	0.94 grams/cubic cm
Carbon Black Content	ASTM D-1603	1.5%
Environmental Stress Crack Resistance	ASTM D-1693	4000 hours

Cell joints are ultrasonically spot-welded with three (3) welds per inch uniformly spaced across the height of each strip. Seam strengths are the same across the entire height of the cell joint and meet the following minimum seam peel strengths (per US Army Corps of Engineers Technical Report GL-86-19, Appendix A).

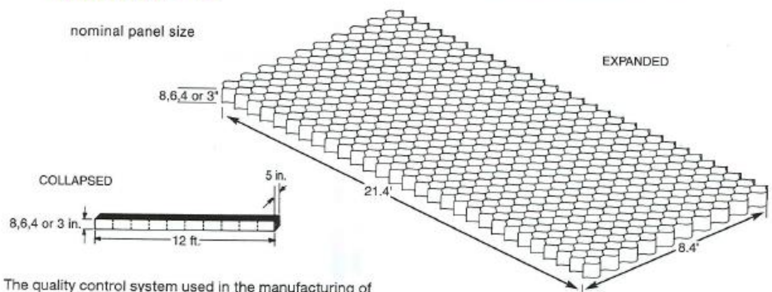
CELL HEIGHT	SEAM PEEL STRENGTH	APPROXIMATE WEIGHT
8 Inch	640 lbs.	114 lbs.
6 Inch	480 lbs.	86 lbs.
4 Inch	320 lbs.	57 lbs.
3 Inch	240 lbs.	43 lbs.

Seam Hang Strength—A 102 mm (4.0 in.) weld joint supporting a load of 72.5 kg (160 lbs.) for 30 days minimum or a 102 mm (4.2 in.) weld joint supporting a load of 72.5 kg (160 lbs.) for 7 days minimum while undergoing temperature change from 23°C (74°F) to 54°C (130°F) on a 1 hour cycle.

Installation Temperature Range: 16°F to 110°F

TERRACELL 140

nominal panel size



The quality control system used in the manufacturing of TerraCell is in compliance with ISO 9001:2000 standards.
TerraCell is licensed from the United States Army under Patent No. 4,797,026.

TerraCell and WEBTEC's broad line of geosynthetic products are marketed through a network of local distributors.

WEBTEC, INC.
P.O. Box 19729 • Charlotte, NC 28219
(800) 438-0027 • (704) 398-0954
Fax (704) 394-7946
E-mail: Info@WEBTECGEOS.com
Website: www.WEBTECGEOS.com

International Erosion Control Association
Corporate Member
GMA Geosynthetic Materials Association

Geocell stream crossing, Lake Wister, OK *(Photo: Patterson)***.**

APPENDIX 4 - CONSTRUCTION DRAWING SET

WATERSHED CONSERVATION RESOURCE CENTER

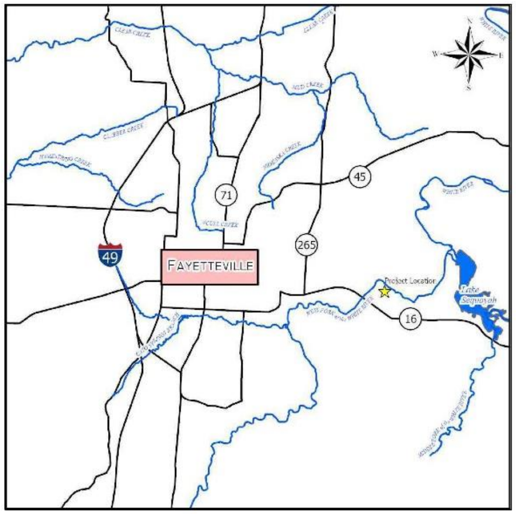
JOSH BROWN FLOODPLAIN RESTORATION

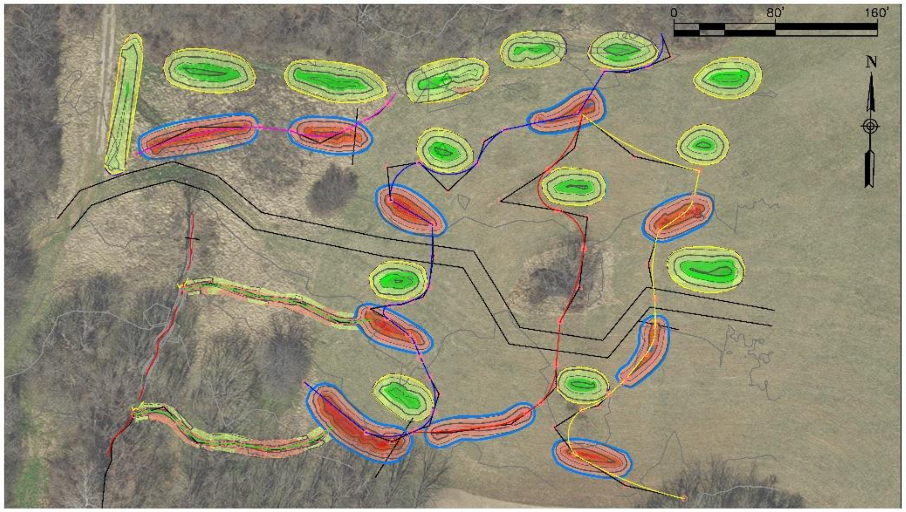
STORM WATER POLLUTION PREVENTION PLAN (SWPPP)

THIS PROJECT REQUIRES A SWPPP. THE OWNER WILL PREPARE THE SWPPP AND OBTAIN THE REQUIRED PERMITS/DOCUMENTATION FROM THE ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO MAINTAIN A COPY OF THE SWPPP ON THE PROJECT SITE. THE CONTRACTOR SHALL FOLLOW PROVISION OF THE SWPPP AND NPDES GENERAL STORM WATER PERMIT NO. ARR150000, INCLUDING BUT NOT LIMITED TO:

- INSTALLING AND MAINTAINING ALL BMPS AND EROSION CONTROL MEASURES
- INSPECTING AND DOCUMENTING INSPECTION OF ALL BMPS AND EROSION CONTROL MEASURES

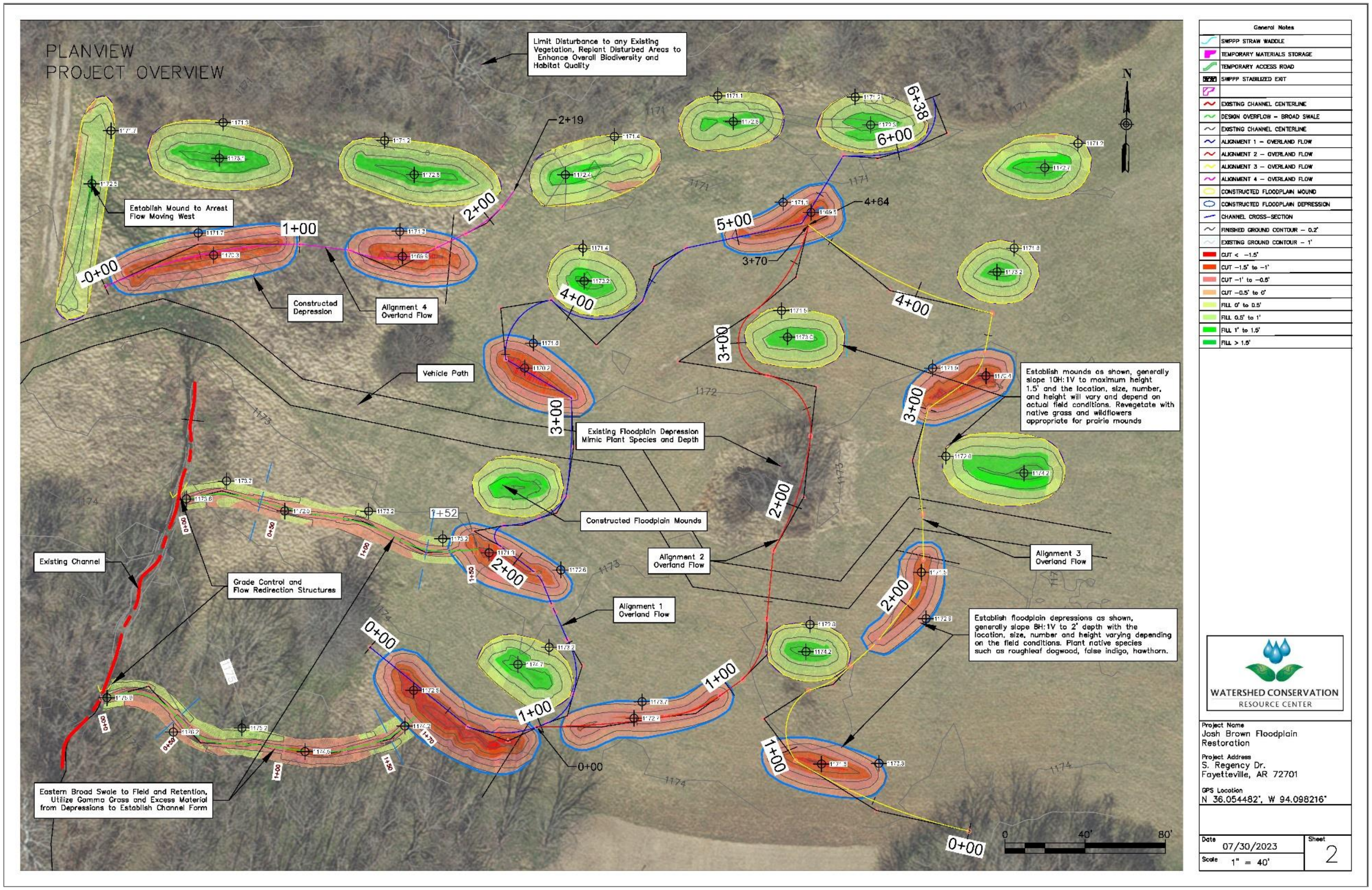
ADDITIONALLY, THE CONTRACTOR SHALL BE RESPONSIBLE OF ANY ENFORCEMENT ACTIONS TAKEN OR IMPOSED BY FEDERAL OR STATE AGENCIES, INCLUDING THE COSTS OF FINES, CONSTRUCTION DELAYS, AND REMEDIAL ACTIONS RESULTING FROM THE CONTRACTOR'S FAILURE TO COMPLY WITH THE PERMIT PROVISIONS.



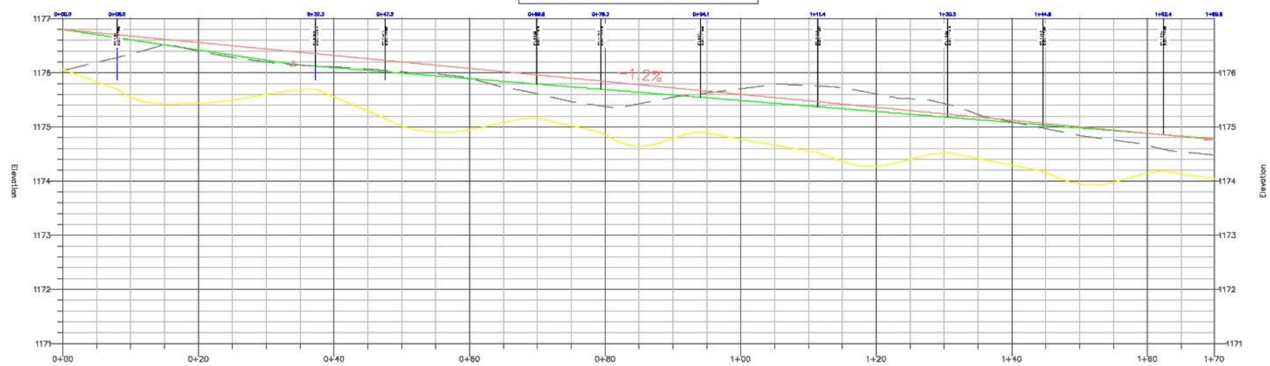


WATERSHED CONSERVATION RESOURCE CENTER

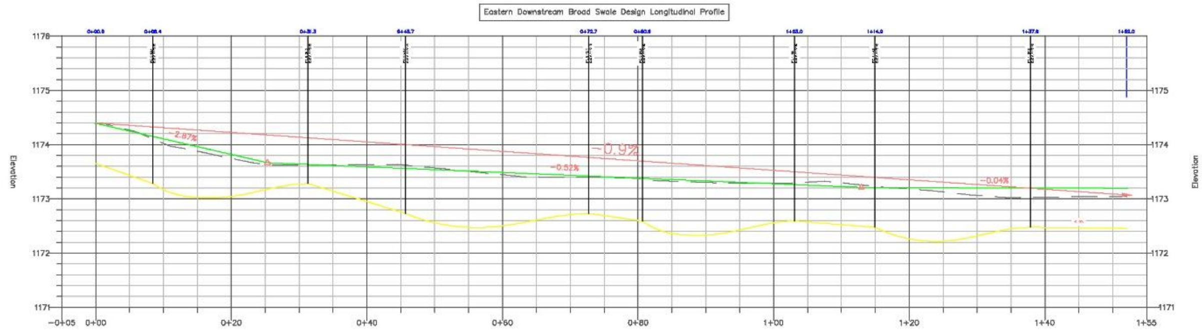
Project Name	Josh Brown Floodplain Restoration
Project Address	S. Regency Dr. Fayetteville, AR 72701
GPS Location	N 36.054482°, W 94.098216°
Date	07/30/2023
Scale	1" = 80'
Sheet	1


PLANVIEW
PROJECT OVERVIEW
Limit Disturbance to any Existing Vegetation, Replant Disturbed Areas to Enhance Overall Biodiversity and Habitat Quality
Establish Mound to Arrest Flow Moving West
Constructed Depression
Alignment 4 Overland Flow
Vehicle Path
Existing Floodplain Depression Mimic Plant Species and Depth
Constructed Floodplain Mounds
Establish mounds as shown, generally slope 10H:1V to maximum height 1.5' and the location, size, number, and height will vary and depend on actual field conditions. Revegetate with native grass and wildflowers appropriate for prairie mounds
Existing Channel
Grade Control and Flow Redirection Structures
Alignment 1 Overland Flow
Alignment 2 Overland Flow
Alignment 3 Overland Flow
Establish floodplain depressions as shown, generally slope 5H:1V to 2' depth with the location, size, number and height varying depending on the field conditions. Plant native species such as roughleaf dogwood, false indigo, hawthorn.
Eastern Broad Swale to Field and Retention, Utilize Gamma Grass and Excess Material from Depressions to Establish Channel Form
General Notes
SWPPP STRAW WADDLE
TEMPORARY MATERIALS STORAGE
TEMPORARY ACCESS ROAD
SWPPP STABILIZED EXIT
EXISTING CHANNEL CENTERLINE
DESIGN OVERFLOW - BROAD SWALE
EXISTING CHANNEL CENTERLINE
ALIGNMENT 1 - OVERLAND FLOW
ALIGNMENT 2 - OVERLAND FLOW
ALIGNMENT 3 - OVERLAND FLOW
ALIGNMENT 4 - OVERLAND FLOW
CONSTRUCTED FLOODPLAIN MOUND
CONSTRUCTED FLOODPLAIN DEPRESSION
CHANNEL CROSS-SECTION
FINISHED GROUND CONTOUR - 0.2'
EXISTING GROUND CONTOUR - 1'
CUT < -1.5'
CUT -1.5' to -1'
CUT -1' to -0.5'
CUT -0.5' to 0'
FILL 0' to 0.5'
FILL 0.5' to 1'
FILL 1' to 1.5'
FILL > 1.5'
WATERSHED CONSERVATION
RESOURCE CENTER
Project Name
Josh Brown Floodplain Restoration
Project Address
S. Regency Dr.
Fayetteville, AR 72701
GPS Location
N 36.054482°, W 94.098216°
Date 07/30/2023
Scale 1" = 40'
Sheet 2

Eastern Upstream Broad Swale Design Longitudinal Profile



Eastern Downstream Broad Swale Design Longitudinal Profile



General Notes

- PROPOSED CHANNEL THALWEG
- PROPOSED BKF
- EXISTING SURFACE

WATERSHED CONSERVATION RESOURCE CENTER

Project Name
Josh Brown Floodplain Restoration

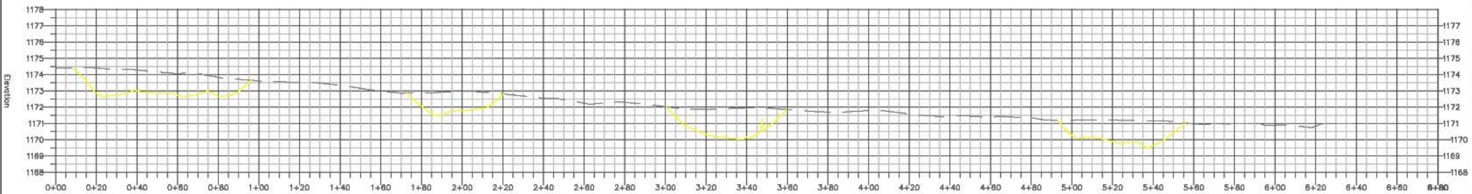
Project Address
S. Regency Dr.
Fayetteville, AR 72701

GPS Location
N 36.054482°, W 94.098216°

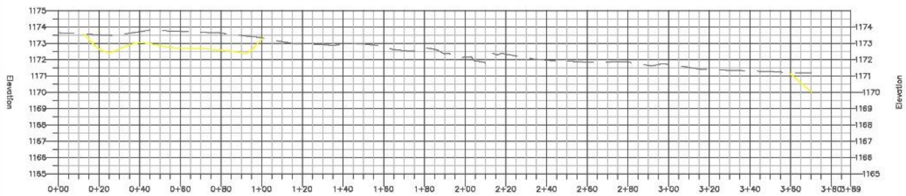
07/30/2023
1" = 15' VE:8

Sheet
3

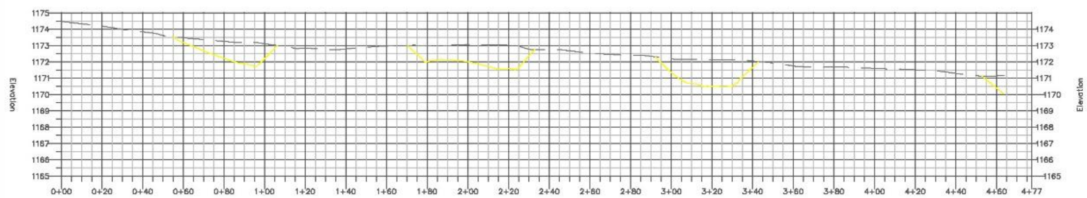
Alignment 1 — Overland Flow Design Longitudinal Profile



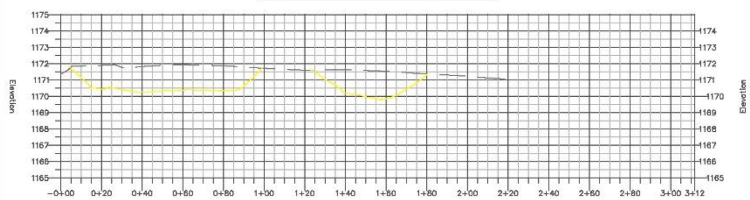
Alignment 2 — Overland Flow Design Longitudinal Profile



Alignment 3 — Overland Flow Design Longitudinal Profile



Alignment 4 — Overland Flow Design Longitudinal Profile



General Notes

PROPOSED SURFACE
EXISTING GROUND

WATERSHED CONSERVATION
RESOURCE CENTER

Project Name
Josh Brown Floodplain Restoration

Project Address
S. Regency Dr.
Fayetteville, AR 72701

GPS Location
N 36.054482°, W 94.098216°

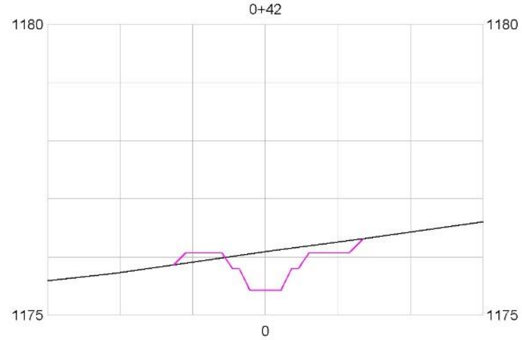
07/30/2023
1" = 50' VE: 8

Sheet
4

CROSS SECTIONS

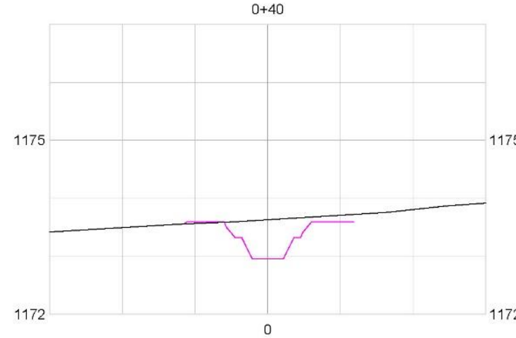
Upstream Broad Swale Overflow XS

0+42



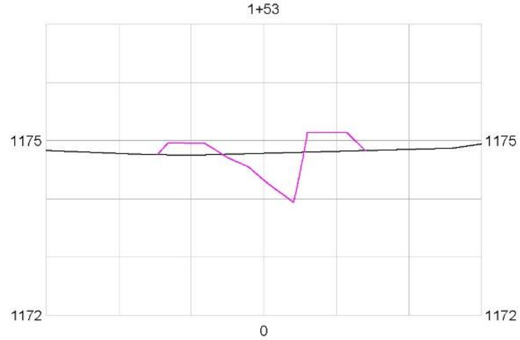
Downstream Broad Swale Overflow XS

0+40



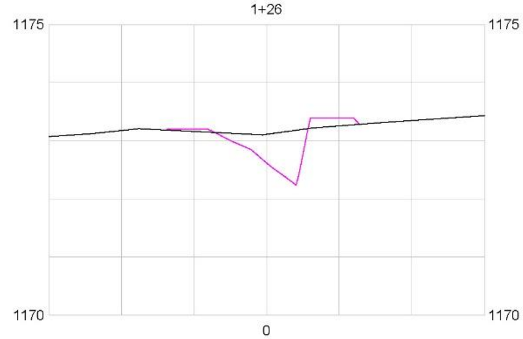
Upstream Broad Swale Overflow XS

1+53



Downstream Broad Swale Overflow XS

1+26



General Notes

PROPOSED SURFACE

EXISTING SURFACE

WATERSHED CONSERVATION
RESOURCE CENTER

Project Name
Josh Brown Floodplain Restoration

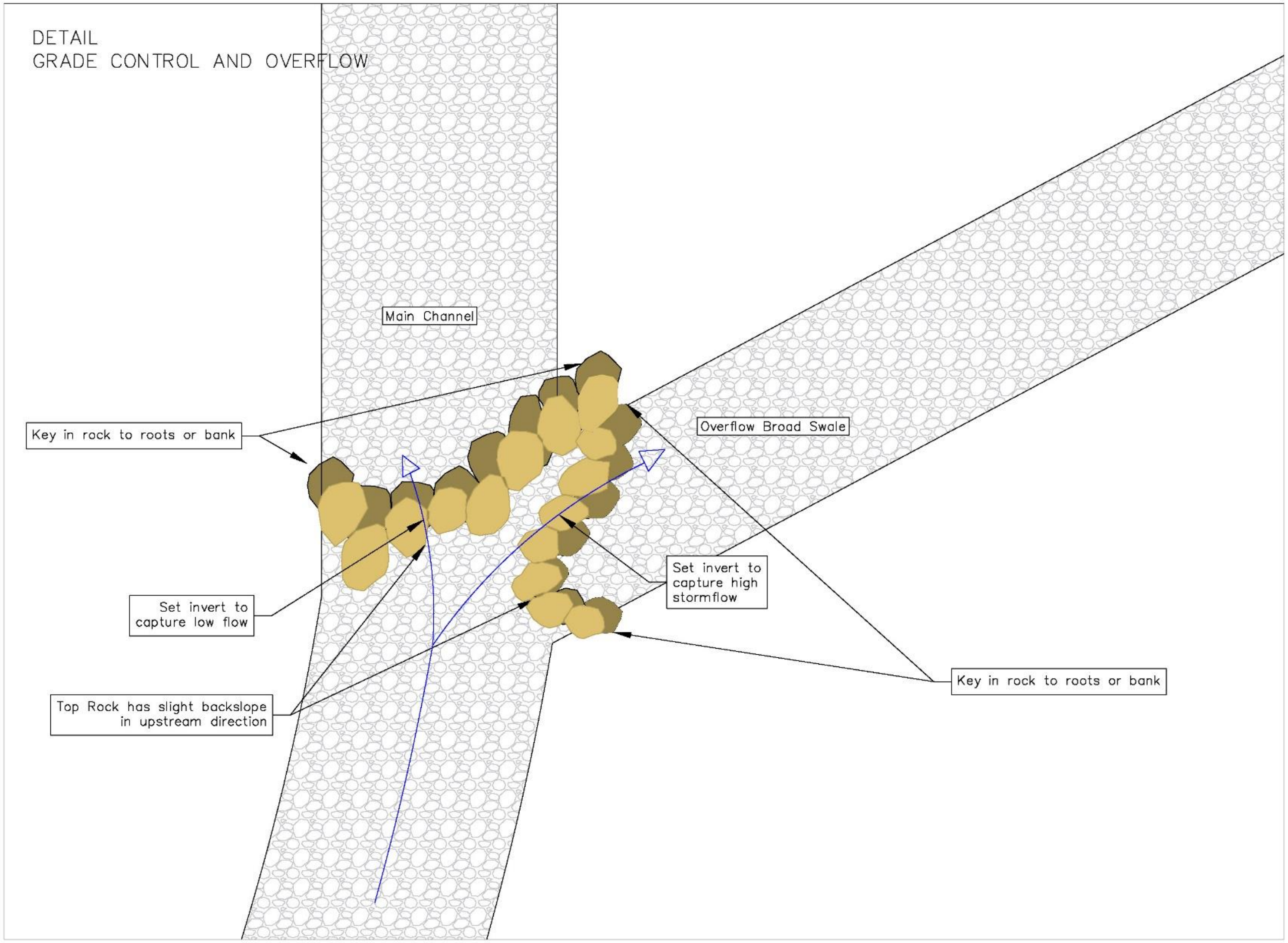
Project Address
S. Regency Dr.
Fayetteville, AR 72701

GPS Location
N 36.054482°, W 94.098216°

07/30/2023

1" = 7'

Sheet
5



WATERSHED CONSERVATION
RESOURCE CENTER

Project Name
Josh Brown Floodplain Restoration

Project Address
S. Regency Dr.
Fayetteville, AR 72701

GPS Location
N 36.054482°, W 94.098216°

07/30/2023
1" = 3'
Sheet 6