Master Plan

Granite Creek Corridor Enhancement
City of Prescott, AZ
WPF1908, Task 5

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City of Prescott, AZ
WPF1908, Task 5

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The City of Prescott has developed this Master Plan for the enhancement of the Granite Creek corridor through downtown. This document provides an assessment of current conditions and conceptual level recommendations and guidelines for actions that will protect and enhance stream function, habitat, and water quality while developing amenities (urban trail, safety, access, and functionality). The City of Prescott has obtained funding for this plan through the Arizona Water Protection Fund.

The riparian corridor is in relatively good condition and contains an urban trail lined with a dense overstory of cottonwoods and other native riparian trees that provide an attractive green space in the heart of downtown. However, the stream is under significant stress from being narrowed and straightened into a highly confined area, invasion by non-native plant species, and water quality concerns from stormwater runoff. Several utility structures cross the channel and serve as grade control, which has helped to prevent deeper incision, but these structures were not built for this purpose. The dense vegetation has helped to maintain the channel's stability by withstanding bank erosion forces. Some of the major issues within the corridor include:

- Water quality impairment from low dissolved oxygen, excessive bacteria, such as *Escherichia coli (E. coli)*, and excessive nutrients primarily due to stormwater runoff
- Exposed utility crossings leading to impaired stream function
- Evidence of channel incision likely due to a narrowed, straightened channel
- Large number of invasive trees (primarily Siberian elm)
- Mature trees growing in channel bed and areas of overly dense vegetation blocking high flows

The Master Plan presents several recommendations for enhancing the Granite Creek corridor. Some of the more important recommendations include:

- Add grade control (cross vane weirs) to protect utility crossings
- Manage riparian vegetation: reduce trees (inflexible vegetation) in active channel and on floodplain, remove invasive tree species, ensure dense root system along banks
- Protect retaining walls from being undermined
- Repair split channels

Three public meeting were held to hear concerns and ideas for improvements. Some of the main interests and suggestions for improvement include:

- Improve sense of safety primarily through added lighting and improved sightlines
- Improve access to trail at all cross streets
- Increase connectivity to other trails and places of interest and add signage
- Retain the sense of a natural setting that is apart from the highly urbanized landscape

Several of these recommended improvements are critically important to ensure that the channel remains stable and the corridor is resilient to future impacts. Suggested improvements

for channel stability recognize the ecological potential and the stressors to the channel in its current form. Increasing green infrastructure (GI) is recommended to improve water quality; however, most GI will need to be added outside the corridor due to a lack of space.

It is important to ensure future projects do not further narrow the active channel or floodplain and the City should consider projects that have the potential to widen the existing floodplain or reduce blockages. There should be a stepped approach to implementation of the recommended enhancements with a priority on undertaking the most important ones first. Many of the recommendations are straightforward but some are more complicated or costly. However, there are multiple potential sources for grant funding to help pay for the improvements. Conceptual costs have been included in this plan.

PROJECT DESCRIPTION

The purpose of this project is to develop a Master Plan for the enhancement of the Granite Creek corridor through downtown Prescott, Arizona. The City of Prescott has obtained funding for this project through the Arizona Water Protection Fund.

Granite Creek has been impacted by urbanization, invasive species, and previous channel rerouting. The City of Prescott desires to enhance this highly valued urban greenspace while retaining its natural functions and aesthetics. This goal is driven in part by citizens and businesses that have requested improvements to the corridor over the years. Prior to development of plans for capital improvements, the City sought dialogue with all partners to determine stakeholders' vision for the corridor, the physical and ecological potential as well as specific improvements to be made, design constraints around private ownership, utility and transportation corridors, and permitting requirements.

This Master Plan is meant to provide a conceptual level document that provides guidelines for future development that will protect stream functions, habitat quality, water quality and other amenities highlighted by the public. The Master Plan should be considered a "road map" to restoring and maintaining stream stability along this reach of Granite Creek. It should be understood that all stream channels are dynamic, changing with large and small flow events. Erosion and deposition will continue along the river. The objective of the Master Plan is to guide development and enhancements in the corridor while minimizing the potential for loss of ecological and physical function of the stream.

LOCATION AND SITE DESCRIPTION

The project area is an approximately 1 mile long, 70 ft wide corridor of Granite Creek that begins at Aubrey Street and ends in Granite Creek Park at Montezuma Street (Figure 1). The reach includes a narrow riparian area, which is relatively unique in that it exists within a rapidly growing urban setting.

This reach of Granite Creek is highly impacted by urban development yet retains an open channel and key vegetation features that the community values. The publicly owned corridor includes a busy urban trail with several public and private access points to businesses and restaurants that directly abut and sometimes encroach into the floodplain and channel. The existing urban trail not only allows access to the de-facto green space but also connects to Granite Creek Park, the downtown area, and surrounding residential areas. The active channel and floodplain face increasing stress from narrowing and straightening, as well as non-native vegetation, and local citizens have voiced concerns about trash, visual impacts, water quality, erosion, maintenance, and safety.

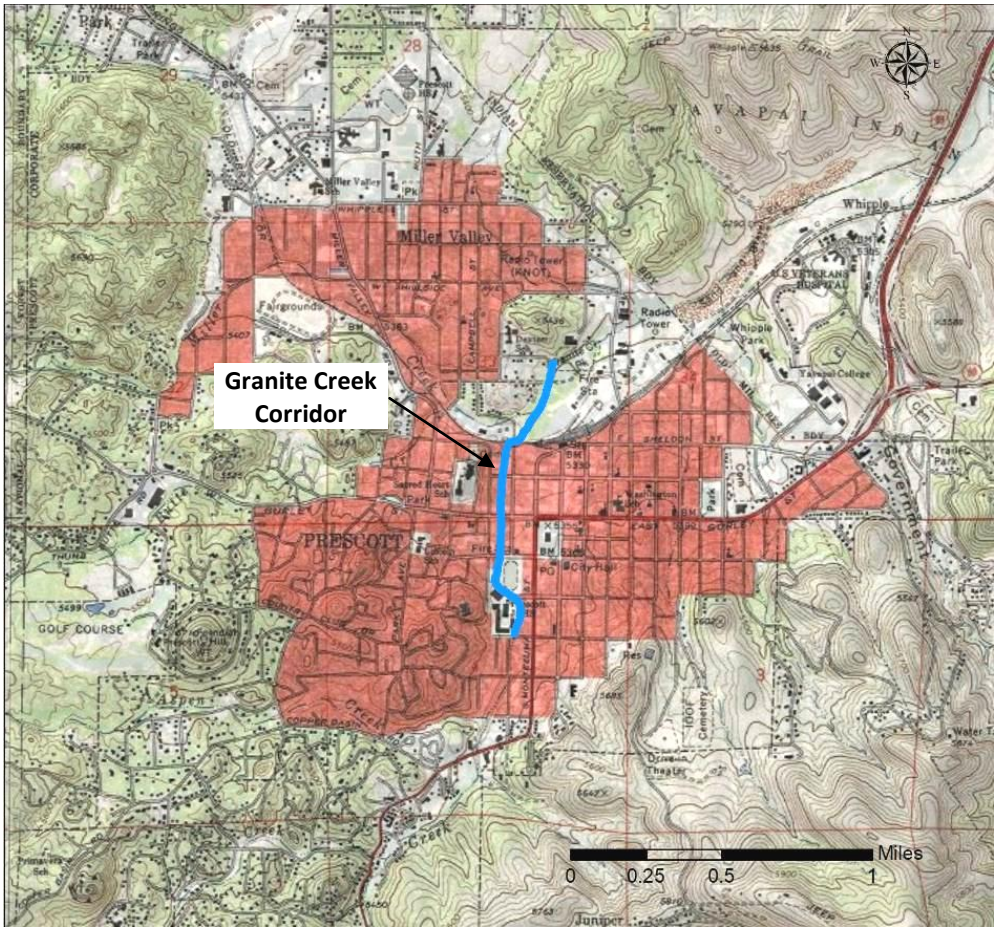


Figure 1. Project location.

PROJECT GOALS

The long-term goals of the project are the stated goals of the Granite Creek Corridor Revitalization Committee.

- Clean up and restore the beauty and native landscape of the corridor, allowing the riparian habitat to thrive and water quality to improve
- Improve the usability of the trail in the downtown corridor, allowing greater access and enhanced safety
- Improve opportunities for interpretation of Prescott history and resources
- Reduce the risk of flood conditions for the properties along the creek

The enhancement of these resources is expected to directly benefit humans and wildlife dependent on river and riparian resources while educating the community about Prescott's waterways and the important role they play in the fabric of the town. The committee expects to utilize input from this proposed project for other reaches of this and other creeks and trails in the near future.

PROJECT OBJECTIVES

Develop a Master Plan for the enhancement of Granite Creek based on the following objectives:

1) Utilize stream and riparian survey data with hydrologic and engineering analysis to determine deficiencies in habitat and function.
2) Develop conceptual plans for improvement of riparian and stream function.
3) Conduct a series of public open houses and comment periods to receive public input and to communicate the issues and potential solutions.
4) Use input from the public forums to finalize a Master Plan for the project area that formalizes the vision for the area and provides a prioritized list of specific tasks.

NATURAL STREAM PROCESSES

Natural alluvial stream channels are composed of a set of distinct features. These include the active or "bankfull" channel, associated geomorphic floodplain, and one or more terrace features. Each of these features is created by the fluvial processes of the river and is characterized by a distinct width and elevation. The bankfull channel carries moderate, frequent flow events and is sized and shaped to carry the stream's sediment load. The bankfull channel commonly carries approximately the 1.5-year return interval flow event and maintains a mean velocity of 3 to 6 cubic feet per second (cfs) adjacent to the bankfull channel, created by the stream in present times, and is overtopped by moderate, frequent flow events. The purpose of the geomorphic floodplain is to spread high flows and dissipate energy.

The cross sectional area of a riffle section of the stream during bankfull flows can generally be predicted by watershed size (Leopold et al., 1964). The width and depth of the stream at this point are important characteristics as well. Greater depth and narrower widths are generally associated with higher shear stress (given equal flow and channel slope) than wider and shallower channels. Higher shear stress allows the stream to move larger sediment sizes. Effects to the stream from changes to width and depth of the bankfull channel can become evident after just a few years since moderate, frequent flood events are responsible for creating the forces in this portion of the channel.

Stream meander, pool depth and frequency, substrate size, and other aspects of stream morphology are directly related to bankfull channel dimensions and are a product of the forces produced by this channel. These aspects of channel morphology are important since they help to dissipate the energy produced by the stream during frequent, moderate flooding events.

Floodplain width is also related to the bankfull or active channel size. The width and elevation of the floodplain helps to determine the shear stress developed by less frequent, more intense runoff events. Wide floodplains that allow flood flows to spread produce lower shear stress than narrowed floodplains. The effects of changes to the floodplain are not usually evident on a year to year basis, but become evident during very large, infrequent flooding events.

Riparian vegetation is an integral part of stream channel stability. In addition to providing important habitat, roots strengthen banks and influence stream width. Ideally, vegetation

types are organized by zones relative to the active channel. Generally short, flexible species are located closest to the channel where shear stress is higher and more frequent. Larger, stiffer species are generally located farther from the active channel where stresses are less and less frequent. Invasive species, changes in flood frequency, and other issues can alter this arrangement and create channel blockage during flood events.

ASSESSMENT OF EXISTING CONDITIONS

Granite Creek is an ephemeral/intermittent stream with some sections that may hold permanent water. The likelihood of permanent water is based on the presence of crayfish and larval salamanders. It is unknown if these more permanent flow areas are fed by shallow groundwater or subsurface irrigation flows and runoff. However, groundwater is thought to be relatively shallow in this reach and is the likely source of surface water.

The corridor is owned by or in easement to the City of Prescott and is designated as a greenway. However, the surrounding high density development leaves very little buffer around the remaining riparian area. Additionally, there are multiple transportation and utility right-of-way crossing the stream through the reach. Consequently, multiple landowners, agencies and utilities would be impacted by actions in the stream corridor.

Businesses, such as restaurants and retail establishments, back directly to the greenbelt corridor and some have direct access to the trail and stream. Consequently, the trail along the stream is utilized for recreation and by pedestrian commuters through the downtown area. The current trail is a dirt or gravel surface. It passes under the Goodwin and Gurley Street bridges at floodplain level, crosses over the street at Carleton and Willis, and crosses the stream on pedestrian bridges at two points.

IMPAIRED WATERS

Granite Creek through the project area is on Arizona's 2018 303(d) List of Impaired Waters for dissolved oxygen. Granite Creek has been listed as impaired for dissolved oxygen since 2004 and was also listed as impaired for E. coli from 2010 to 2014.

The 2016 Water Quality in Arizona 305(b) Assessment Report (ADEQ) also reported high levels of nitrogen and phosphorus in Granite Creek, but stated that it was inconclusive if the stream was exceeding designated limits for these pollutants due lack of adequate samples to assess impairment.

The 2012 Upper Granite Creek Watershed Improvement Plan states that most of the exceedances for the watershed occur during winter storm events that result in overland runoff and high creek flows. The report also lists the following as potential sources of pollution: aging sewer infrastructure, failing or ill-maintained septic systems, water reuse (treated effluent and gray water), horses, cattle and other livestock, wildlife, pets, fire, impervious cover and stormwater, and recreation. According to the Watershed Improvement Plan, the majority of excess nutrient and E. coli sources were related to stormwater drainage, followed by structural and activity impacts to the riparian buffer. The Plan states that the "data points towards urban pollutants carried in stormwater, exacerbated by a lack of adequate riparian buffers along the urban creek reaches" as the source of pollutants.

The Plan's primary recommendation for addressing pollutants in stormwater was the use of Green Infrastructure (GI), specifically "GI is a broad term for features that rely on natural processes such as soil, water, and plants to provide ecosystem services such as clean air, clean water, and temperature regulation. GI encompasses existing forests and green spaces as well as constructed bio-retention features such as rain gardens, wetlands, and filter strips." (Prescott Creeks et al., 2012)

HYDROLOGY

The hydrologic analysis covers the watershed to just past the historic railroad truss bridge, since further downstream no structural enhancements were considered. The watershed above this point is approximately 18 square miles and originates on Prescott National Forest lands outside of the city limits. The majority of the upper watershed remains forested. A small portion of the upper watershed (~ 4 mi^2) is above Goldwater Lakes and runoff from frequent, low intensity storm events may be stored in these lakes rather than allowed downstream. The impact this has on flows can be difficult to quantify, but for the purposes of this analysis, bankfull flow (the 1.5 – 2 yr flow estimates) has been estimated using an effective watershed of 14 square miles, whereas the less frequent, larger flows are estimated using the entire watershed. Stormwater and snowmelt are the main sources of flow with flows extending later in the spring during wet winters. However, for much of the year the creek is dry throughout much of the reach.

Direct stormwater runoff from streets enters the channel at road crossings. Runoff from parking lots or rooftops enters through culverts or overland flow. Local runoff from urbanized areas can produce higher peak flows due to the impervious nature of the local watershed. The lower portions of the study reach retain surface water for longer periods than the upper portion of the reach. Presumably, this is a function of connection with shallow groundwater. Groundwater levels downstream in the Watson Woods area are known to fluctuate seasonally in response to climate.

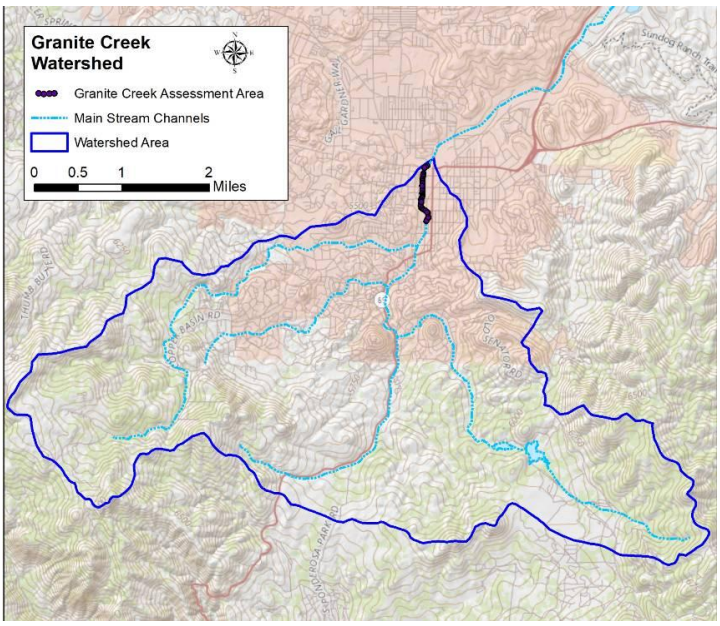


Figure 2. The Granite Creek watershed for the project area.

A flood frequency analysis utilizing the National Streamflow Statistics (NSS) model developed for the USGS to estimate flood-peak discharges, was used to estimate the magnitude of flows through the project area. A tabulation of the 1.5-year through the 25-year recurrence interval is included in Table 1. Bankfull flows are estimated to be closer to the 1.5-year flow.

The two closest USGS stream gages are located downstream of the project area. The first gage is approximately a half mile downstream (~6th Street) with a watershed area of 30 square miles and includes twenty years of data. The second gage is approximately 1.5 miles downstream (Hwy 89) with a watershed area of 36 square miles and 80 years of data. The flows presented in Table 2 are reduced proportionally by watershed size to match the project watershed size.

Table 3 provides the 10 and 25-year peak discharge estimates from the Federal Emergency Management Agency (FEMA) for Granite Creek below Aspen Creek.

Table 1. NSS Flow Estimates at project site

18 sq mile watershed	1.5-year*	2-year*	5-year	10-year	25-year
Discharge (cfs)	210	316	866	1440	2520

**Though the total watershed area of Granite Creek at the project site is 18 square mile, the presence of the Goldwater Lakes in the upper watershed is thought to be large enough to contain bankfull flows, depending on the lake levels when flows occur. The impact this has on flows can be difficult to quantify, but for the purposes of this analysis, bankfull flow (1.5 to 2-yr) has been estimated using an effective watershed of 14 square miles.*

Table 2. USGS Gage Data reduced proportionally by watershed size.

First gage (0.5 mi.)	1.5-year	2-year	5-year	10-year	25-year
Discharge (cfs)	729	985	1553	1937	2428
Second gage (1.5 mi.)	1.5-year	2-year	5-year	10-year	25-year
Discharge (cfs)	411	639	1292	1830	2596

Table 3. FEMA Peak Discharge Estimates

17.5 sq mile watershed	1.5-year	2-year	5-year	10-year	25-year
Discharge (cfs)				3,295	7,310

BANKFULL CHANNEL GEOMETRY

Ten channel cross sections were surveyed throughout the project area to determine bankfull dimensions within the reach and compare with regional data and reference data. The bankfull cross sectional area at the reference site (Cross Section 1, Figure 3) is estimated to be around 45 square feet with the other cross sections approximately the same, depending on slope (Table 3). Cross Section 1, located between Aubrey and Carleton (Figure 4), was chosen as a reference cross section because it is in a stable reach with good bankfull features and a wider floodplain with appropriate riparian vegetation. This cross sectional area coincides with data measured at Granite Creek for a project at Watson Woods and fits the regional curve for the central/southern Arizona region (Moody et al., 2003).

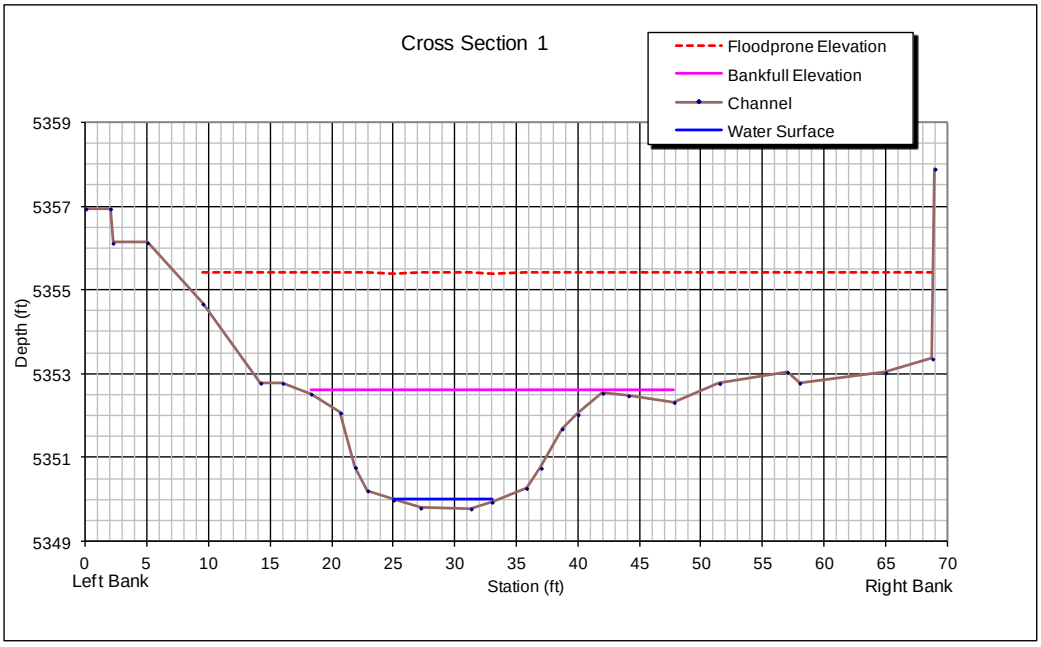


Figure 3. Cross Section 1.

This channel cross section represents a typical cross section, with relatively wide flood-prone area for the study reach.

Table 4. Cross section measurements

Cross Section	XS Area (ft)	Bankfull Width (ft)	Floodprone Width (ft)	Mean Depth (ft)	Entrenchment Ratio	Width-Depth Ratio	Channel Slope	Stream Type	Velocity (fps)	Notes
XS 1	45	24.0	62	1.9	2.6	13.4	0.0048	C4	5.2	reference cross section
XS 2	58	31.3	66	1.9	2.2	15.6	0.0042	C4	4.0	upstream from sewer crossing
XS 3	44	28.0	64	1.7	2.5	15.1	0.0086	C4	5.4	downstream from ped bridge
XS 4	41	24.0	40	1.7	1.7	14.2	0.014	B4	5.8	trail ramp on floodplain
XS 5	37	15.0	35	2.6	2.4	5.5	0.0072	E5	6.3	tall wall on one side
XS 6	42	18.8	39	2.7	2.5	5.8	0.0072	E5	5.5	
XS 7	47	29.4	78	2	3.4	11.3	0.004	E5	5.0	upstream from road, pool
XS 8	37	22.5	90	1.7	4.1	13.1	0.018	C4	6.3	Granite Creek Park
XS 9	40	20.2	85	2.2	4.6	8.5	0.016	E4	5.9	Granite Creek Park
XS 10	49.8	17.6	58	2.8	3.4	5.9	0.0041	E5	4.7	flat pool area

Entrenchment ratio = Ratio of bankfull width to flood prone width (larger ratio indicates larger floodplain)
Width-Depth Ratio = ratio of stream width to stream mean depth at bankfull stage (larger ratio indicates wider, shallower channel)

Cross sections 2, 7 and 10 were taken in pools, not riffles. Pool cross sections are not used as reference.

Figure 4. Location of channel cross sections.

It appears that the stable channel type for the reach is generally a Rosgen 'C', indicating a relatively wide flood-prone width and moderate width to depth ratios (Rosgen, 1996). The stream type through the project area varies from a "C" to an "E" type stream (which is typified by a wide flood prone area with a low width/depth ratio channel) to a "B" type (moderately entrenched, moderate width/depth ratio, but typically steeper slope). The width to depth ratios for the reach are generally low for 'C' type channels and lower than other typical channels throughout the region, indicating that the bankfull width is narrower than typical for the region. The high density of vegetation along the banks strengthens the banks and limits bank erosion. This likely helps to regulate the narrow width of the channel and protects the banks from increased risk of erosion.

These same functions contribute to the formation of the "E" channel conditions in the reach. A natural "E" channel is typically stable in a wide, low slope valley with very high channel sinuosity (Rosgen, 1996). Given the narrow floodplain at the site, an E channel would not be expected to remain stable. Several of the narrower, 'E' type cross sections are controlled by concrete walls and abutments with heavily vegetated banks. The vegetation in combination with grade control structures (roads and utility crossings) are likely contributing to this narrower than normal channel condition.

BED STABILITY

A longitudinal profile was surveyed starting at Aubrey Street and concluding at the trestle bridge (Figure 5). The profile shows an average gradient of 0.77% starting from Carleton Street Bridge down to Granite Street. The profile shows a riffle-pool sequence with utility crossings, bridges, and roads that serve as grade control; lowering the upstream grade and creating pool habitat.

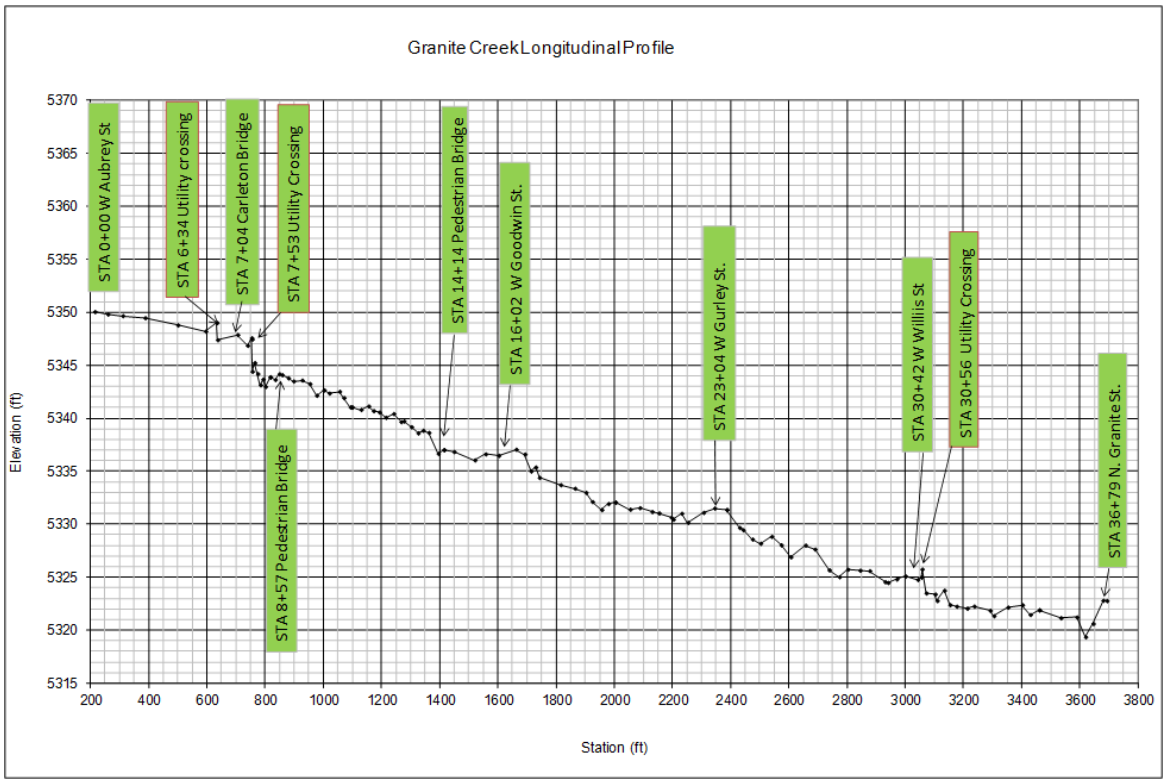


Figure 5. Longitudinal profile through the project site.

Specific channel features are located along the longitudinal profile. Armored utility crossings are currently acting as grade control for the channel rather being buried below the channel bed.

Sediment competency calculations indicate that the stream can move sediment particles up to 134 mm in size at bankfull discharges. This particle size is larger than the D84 (84% of the particles are smaller than this) particle size located at cross section three (the reference cross section). With such a large portion of the bed material prone to movement at relatively frequent flood discharges, the bed is susceptible to destabilizing scour. There is evidence of downcutting below the foundation of some of the retaining walls. Artificial grade control created by concrete utility crossings and roads is undoubtedly helping to stabilize the channel and prevent rapid incision. Further downstream in the steeper riffles, the particle size is larger, with larger boulders providing resistance.

Figure 6. Bed scour undercutting retaining wall where floodplain is overly narrow.

CHANNEL ALIGNMENT AND CONFINEMENT

Channel sinuosity is the ratio of stream length to valley length. It provides an indication of how the stream is able to utilize meanders to reduce potential energy. Granite Creek upstream and downstream of the study reach is generally more sinuous than the study reach. This indicates that the channel was likely relocated and straightened in the past to make room on the old floodplain for development. A consequence of channel straightening is an increase in the slope of the channel since the total channel length has been shortened. With an increased slope, there is an increase in shear stress and competence of the stream to move larger sized materials, which can lead to incision of the stream into its bed. Further evidence of historic channel manipulation is the concrete and stone flood wall running along nearly the entire length of the study area. Much of the wall is historic in nature and creates a floodplain that is generally narrower than would be expected for "C" or "E" type streams in the region. Fortunately, the width of the corridor created by the flood wall is such that the floodplain is still wide enough to alleviate excessive shear stress in most floods (i.e., the low end of the range of variability for the region). While the current walled configuration allows some spreading of flows, larger floods will be prevented from spreading across the entire width of the historically available floodplain. These very large and infrequent flood events may produce higher shear stress as a result. It should be noted that the retaining walls do not contain the FEMA designated 100-year flood. Large areas of the downtown are still within the FEMA floodplain. See FEMA flood maps in Appendix A.

Bridge piers and other hard infrastructure in the corridor generally span the entire corridor, with the exception of middle piers. Consequently their capacity to carry flood flows is near the capacity of the corridor in general. However, there is a pedestrian bridge (upstream or south of Goodwin Street) with a riprap ramp that narrows the floodplain (Figure 7). This situation is ameliorated by the gap on the west side of the ramp which allows flood flows to spread onto

the remaining floodplain. The other pedestrian bridge further upstream in the reach spans the entire floodplain.

Figure 7. Pedestrian bridge upstream from Goodwin Street.

BANK EROSION

Bank stability within the project reach does not appear to be an issue. Though there are several areas where overland flow enters or culvert outfalls cause localized erosion as well as areas with shorter vertical banks, there was no evidence of erosion threatening lateral stability along any of the banks.

It appears that the vegetation along the channel banks (trees, shrubs, and grasses with dense roots) is providing adequate bank protection. High density root mats associated with established trees and shrubs is helping to provide bank armoring within the channel corridor by providing bank protection in the form of roots and roughness. However, if the vegetation encroaches too far into the channel, it can cause a narrowing of the active channel (Figure 8) which can initiate bed scour. Trees and dense shrubs can catch debris causing channel blockages during large floods. There are several areas where the channel runs along retaining walls and scour along the base of the walls is occurring.

Even though the channel has been straightened in the past, there is little indication that the stream is working to reestablish a natural meander pattern. Consequently there is little indication of lateral instability for the existing channel. However, 'E' and 'C' stream types are very susceptible to bank erosion if vegetation is removed. Given the tendency towards greater sinuosity and a greater width/depth ratio for much of the reach, reduction in any type of bank protection could produce bank erosion.

Figure 8. Dense tree roots holding channel shape.

Note the flood debris captured by dense, inflexible species.

BRIDGES AND MAJOR UTILITY CROSSINGS

The depositional bar that has formed below the bridges at floodplain height provides a platform for the urban trail system at Goodwin and Gurley (Figure 9). However, the bottom of the bridge support is around 6 feet from the bar surface. Consequently, headroom for tall pedestrians and bicyclists is minimal. Bar height is a function of the floodplain elevation at each bridge. Lowering the trail elevation to allow headroom will likely create more of an annual maintenance issue as the stream continues to deposit more sediment to rebuild the floodplain. A complicating feature of these depositional bars is that stormwater generated from the roads enters under the bridge and flows across the urban trail. Ditches and culverts are easily covered in debris when the main channel floods, creating maintenance issues on a frequent basis.

Several utilities cross Granite Creek at or above the grade of the channel bed. Most crossings now provide grade control as they have become exposed. The wide, flat cross section creates an overly wide stream channel, eroding banks on both sides and limiting sediment transport (Figure 10).

Figure 9. Gurley Street bridge

The pedestrian trail crosses beneath the bridge on the left. The bar on the left has been deposited by the stream during normal geomorphic activities.

Figure 10. Utility crossing creates an overly wide, shallow cross section.

The overly wide section easily aggrades upstream and creates bank erosion on either side of the stream and bed scour downstream.

RIPARIAN VEGETATION

Riparian plant communities are important to maintaining the stability and function of stream systems. Riparian vegetation provides wildlife habitat while vegetation rooting provides additional strength to erodible banks.

Riparian plant communities are generally distributed by the amount of soil moisture and periodic disturbance and as a result they create a series of zones that run parallel to the stream channel. These zones are called: toe, bank, overbank or floodplain, transition, and upland. The toe zone supports wetland species (sedges, rushes, etc.), the bank and overbank zones are dominated by grasses and small to medium shrubs with flexible stems, and the transition zone supports more arid grasses, shrubs, and trees (Hoag, 1999). Plants with flexible stems and creeping root systems are usually located from the top of the toe zone through the bank zone. The stiffness of vegetation generally increases as it moves away from the central stream channel.

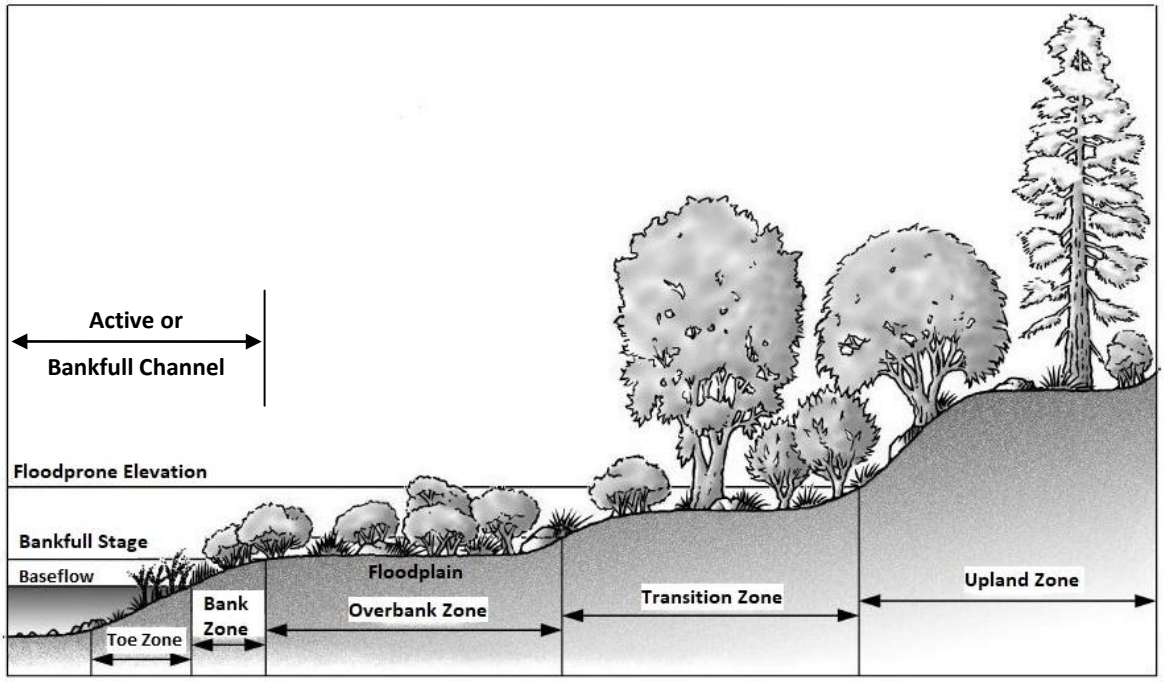


Figure 11. Ideal Riparian Vegetation Zones.

Riparian planting zones can be used to determine where riparian species should be planted in relation to the waterline. This is a general depiction of a riparian zone. In the real world, some of these zones may be absent. (Hoag, 1999)

The vegetation along the Granite Creek corridor consists of a dense overstory of cottonwoods, willows, box elder, velvet ash, and Siberian elm for most of its length. The understory is a mixture of native and non-native grasses, forbs, and shrubs. The relatively healthy riparian area is a major attraction for visitors to the area. Shade, diverse bird life and visual separation from the surrounding urban infrastructure are major resources provided by the vegetation. The dense vegetation also provides protection against scour and bank erosion, but is also probably contributing to the generally narrow and deep active channel.

Granite Creek has many medium and large trees growing in the active channel where we would expect more flexible vegetation. Some of these are beautiful native trees providing shade, habitat and bank protection and should not be removed even though they are in the "wrong" zone. However, many of them are invasive or causing problems including an increase in bank stress, split channels, debris jams, and floodplain blockages and, in these circumstances, should be removed. Additionally, some of the larger trees are in need of maintenance to prevent falling limbs and in some cases entire trees as these trees age. There are also a few areas of very dense vegetation, where small trees and shrubs fill the entire floodplain leaving only a narrow channel.

Figure 12. Split channel caused by trees growing in active channel downstream from Aubrey Street.

Figure 13. Dense vegetation blocking floodplain downstream of Carleton Street.

NATIVE AND INVASIVE CANOPY COVER

Large tree canopy coverage provides desirable shade throughout the project reach. The canopy is composed of native cottonwood (*Populus spp.*), Goodding's willow (*Salix gooddingii*) with lesser amounts of box elder (*Acer negundo*), velvet ash (*Fraxinus velutina*), and Arizona walnut (*Juglans major*). Non-native components are mostly composed of the Siberian elm (*Ulmus pumila*) with minor amounts of tree of heaven (*Ailanthus altissima)*.

Siberian elm is considered an invasive species in Arizona, and is a common overstory species along Granite Creek. This tree is found growing on the upper banks as well as in the channel bottom and amounts to a considerable percentage of the canopy composition through the corridor. The large elm trees provide a large seed supply to the surrounding areas, creating a need to continually remove this rapidly established weed species.

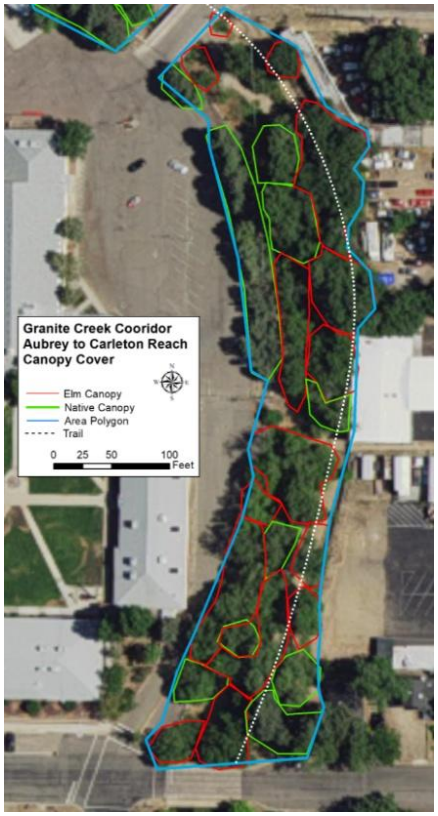
Due to its highly invasive nature, it is preferable to eliminate elm along with tree of heaven. Total and immediate removal of tree of heaven is not likely to change the desired character of the riparian community (i.e. shade). However, removing the elm all at once would result in a considerable loss of canopy and a reduction in habitat quality.

An effort was made to quantify the amount of canopy in each of the five reaches that is composed of either native or elm trees. This information can guide a removal plan by establishing how much shade is being provided by the elms overall and how much the canopy would open up if these trees were removed. These estimates are based on aerial photo interpretation. A more accurate estimate would require an on-the-ground census of the trees, which can be done prior to any tree removal plan.

Table 5. Canopy Cover by Reach

		Siberian Elm (%)	Native Trees (%)	Open (%)
Reach 1	Aubrey to Carleton	50	28	22
Reach 2	Carleton to Goodwin	36	48	16
Reach 3	Goodwin to Gurley	30	61	9
Reach 4	Gurley to Willis	37	52	11
Reach 5	Willis to Historic Bridge	44	26	30

Based on the locations and extents of elm canopy, shade along the trail would be noticeably reduced if they were removed, especially in reaches one, two and five. No effort was made at this time to identify and quantify the number of trees that are growing within the bankfull channel. The general observation is that the majority of trees in the channel are smaller and shorter than adjacent trees higher on the banks. The removal of the elms from the active channel would generally not result in a significant change to the shading of the corridor in most areas.



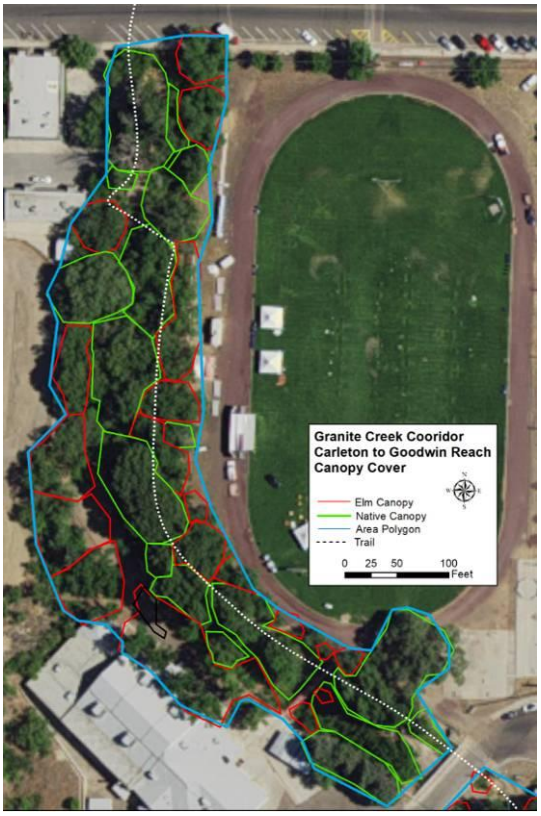
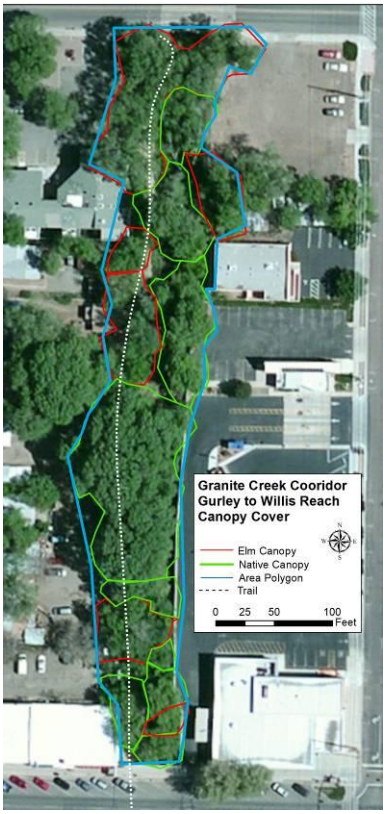


Figure 14. Reaches 1-2 canopy coverage.



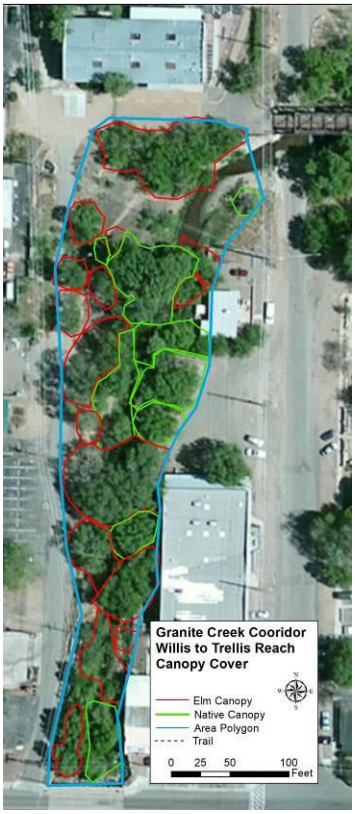


Figure 15. Reaches 3-5 canopy coverage.

TRAIL CONDITIONS AND AMENITIES

Generally, the trail is in good condition with fairly smooth gravel and hard packed dirt surfaces. There are occasional rocks or tree roots interrupting the trail surface. Areas of concern are under the bridges where the surface is uneven due to sediment deposits. There are some areas where the trail surface is directly adjacent to the stream with no buffer to prevent trail runoff from directly entering the stream.

North of Willis Street there is no formal trail connecting to Granite Creek Park and trail users have to walk or bike on the road. There is public access to the trail at every cross street from Aubrey to Willis plus an additional access point at Prescott Mile High Middle School and a private access point between Goodwin and Gurley (at Beach St). The City is currently in discussion with the property owner to obtain an easement to create a public access point at Beach Street.

All public access points provide ramp access except Goodwin where stairs connect to the urban trail. It is likely that some access points do not meet the Americans with Disabilities Act (ADA) requirements. Some appear to be too steep or have slopes that are too long to meet ADA standards. Access at Carleton was recently updated and meets ADA standards.

The trail is used as a non-motorized transportation system through the heart of the downtown as well as connection to the creek for recreational purposes. During the assessment surveys we observed daily commuters on bikes or on foot, lunch break strollers as well as students playing in the stream after school. The assessments were carried out during daylight hours on business days. Accordingly, our informal observations indicated mostly local users. Conversations with Prescott citizens indicated that weekend use by out of town visitors as well as nocturnal use by homeless people was prevalent as well.

The trail connects with Granite Creek Park on the north edge of corridor and ends at Aubrey Street on the south edge. Although other trails connect into Granite Creek Park, there are no designed connections to non-motorized trails in the project area. As noted previously, there are multiple connections with surface streets through the project area. Some of these have created potentially unsafe conditions for pedestrians and bicyclists crossing surface streets.

Currently there is little lighting or signage along the trail within the corridor. Lighting and signage is only available as the trail crosses surface streets, under the Gurley Street bridge, or at businesses with outdoor lighting. There are two murals painted on retaining walls, south of Goodwin Street and at Gurley, and fortunately, only a small amount of graffiti along the trail.

There are numerous utilities, wires, and pipes visible throughout the corridor. Some cross under Granite Creek as mentioned previously and some other major utilities cross over the creek at the bridges. A few smaller installations appear haphazard and not professionally installed and others appear abandoned.

Figure 16. Utilities that may be in need of repair.

There are fences and retaining walls along the outer edge of the corridor throughout most of the project area, including low and high rock walls, chain link fencing, masonry walls, wood fencing, tall concrete retaining walls, and a few are very attractive, historic rock walls (Figure 20). Most are in good repair; however, a few chain link and wire mesh fences that are acting partially as retaining fencing are failing and unattractive (Figure 17).

Figure 17. Two examples of fencing that are deteriorating.

Storm runoff from the streets and parking areas around the corridor is generally routed directly to the channel. Runoff is commonly routed via culvert or pipe, but there are several areas where overland flow is allowed to concentrate and flow across the trail into the stream. In most

areas the width of the corridor is not adequate to contain both the trail and space for vegetated side channels of significant length to provide stormwater retention or treatment.

SUMMARY OF COMMENTS RECEIVED AT PUBLIC MEETINGS

The City held three open house meetings to collect public input on the Master Plan. The first two on June 24 and June 26, 2019 were held to gather scoping information; one of these was primarily directed at the business and property owners along the corridor and the other was geared toward the general public. The purpose of these meetings was to receive input and feedback as well as share ideas and concerns regarding the Master Plan. The last meeting was held October 15, 2019 and was for both the general public and business owners. The City presented a summary of the draft Master Plan that included issues and the findings of the riparian assessment, and then asked for input on specific types of amenities desired, lighting options, accessibility, signage information, and interest in artwork. See Appendix B for the complete notes from the public meetings.

Three major themes came out of the initial public meetings:

- There is great interest in improving the trail as a transportation corridor, especially for bikes. Many people would like to see the trail expanded and to have increased connectivity to other trail systems and places of interest (Yavapai College, the Veterans Administration Medical Center (VA), and other locations), and increased access points and ADA accessibility through downtown. Signage to direct people to places of interest was another common public comment.
- There is a need for an improved sense of safety within the corridor including improved lighting along the trail and underneath the bridges, improved sightlines, and increased policing.
- While there was a desire to utilize the corridor for non-motorized transportation, the public desired that it remain as natural as possible and retain shade, mature trees, water, etc.

Some other comments made during the June meetings include:

- Local residents expressed concerns regarding safety within the corridor and possible misconception regarding crime. There are concerns/issues about the homeless population and how to better integrate them so more people feel comfortable using the trail. Someone asked if there would be a marketing campaign following improvements to help change the public image.
- There are questions on how the project will be funded, whether there are limitations on what can be done due to flooding and regulatory issues, whether the City has the easements they need or if they will be able to get them, and the timeline for the project.
- There is interest in understanding what other projects are located along the corridor (new hotel, farmers market, and work on the historic railroad bridge) and how these projects would integrate with the Master Plan.

- Some expressed interest in augmenting the flow in Granite Creek.

Specific interests mentioned during the October meeting:

- There was a significant interest in adding occasional benches. There was some interest in adding picnic tables, ramadas, and educational information.
- There was a natural theme running through several comments, such as using natural materials for the benches including fallen logs and having a natural theme for any artwork.
- There was a definite interest in adding art but not too much or at the expense of the natural feel of the corridor.
- The interest was fairly equally split among the different styles of lighting. It seemed there was interest in stronger lighting at the access points, moonlighting along the tree-lined trail with the occasional brighter light thrown in for a sense of safety, and good lighting under the bridges.
- There was no clear winner on the type of signage information other than people would definitely like signage. Generally it seemed there was an interest in having information on direction and distance to places of interest (Yavapai College, VA, fairgrounds), access points, major roads, amenities, and other trail systems.
- There was interest in having ADA access at every block.
- There was interest in having a crosswalk at Willis Street. Several people mentioned improving the access along and from Granite Street, south of Aubrey Street.
- The comments were generally supportive of the draft plan at this stage.

RIPARIAN IMPROVEMENT RECOMMENDATIONS

The current condition of the channel and riparian area are providing multiple benefits for habitat, water quality, aesthetics, and open space. However, there are signs that the channel is being impacted by incision caused by encroachment onto its original floodplain, historical changes to its alignment, and gradual changes to vegetation in the riparian zone. These changes are likely exacerbated by increased peak discharges from the urbanized portion of the watershed, inflow of sediment from side tributaries, and other impacts.

While none of these impacts would be significant enough alone to destabilize the stream, all of them together are beginning to have an impact. Increased investment in trails and access to the green space corridor along the creek have the potential to further impact the stream and in turn can be damaged by changes in channel course, erosion, or other flooding induced changes. It will be important to have as stable a channel as possible and to design future improvements to public amenities that will improve the function and stability of the stream. Future development should recognize that the artificially straightened and steepened channel with its narrowed floodplain will not be resilient in the face of additional stressors. Preemptive improvements to prevent further incision and floodplain blockage are highly recommended.

Enhancements aimed at improving inflow water quality and riparian buffer quality are also highly recommended. The quality of the riparian habitat is already relatively high; however, there is a need to maintain the composition and distribution of riparian vegetation in order to promote flood safety and continued riparian health. Given that the corridor is in a densely urbanized area, which is well within the FEMA floodplain, maintenance of the riparian zone to enhance conveyance of flood flows is warranted. Maintenance practices should be designed to both reduce flooding hazard and improve native plant community composition.

Conceptual recommendations for enhancement and maintenance are provided below. Many of these practices will require additional engineering and planning, others can be incorporated into maintenance plans and many of these concepts should be utilized as best management practices for transportation, utilities, drainage, and recreation projects that are part of future development. Conceptual level costs as well as implementation strategy are provided in separate sections. Appendix C provides an overview of the locations of suggested riparian improvements and conceptual level detail drawings of some of the improvements.

ADD CHANNEL GRADE CONTROL

Grade control should be utilized to protect existing utility crossings. Several utility crossings are providing grade control but are not designed for this purpose. These crossings are causing significant scour which can lead to headcutting. Grade control should be installed downstream of the existing utility to protect the utility from being further undermined. Preventing further incision in the active channel is critically important. Reduction in the potential for further incision will improve riparian plant habitat by maintaining a higher water table, prevent the undercutting of utilities, retaining walls, and existing large tree root systems, and will mediate excessive sediment supply to downstream reaches.

Cross vane weirs constructed from large native rock will provide the most useful grade control. The weirs can be constructed to center shear stress towards the middle of the channel, prevent over-widening, and prevent aggradation of the channel. Large boulders sized to resist high flows are aligned in 'V' with the apex pointing upstream. The opening at the downstream end of the 'V' creates the active channel width, while the apex of the 'V' holds the channel grade. The centered flow also helps form pools for wildlife habitat and energy dissipation. Figure 18 provides an example of what a cross vane weir looks like.

The riparian assessment indicates that seven (7) cross vanes should be utilized in the reach to protect existing infrastructure, redefine channel width and depth, and prevent incision of the active channel along retaining walls (Figure 19). Locations for weirs include the utility crossings under Aubrey Street, just up and downstream of Carleton Street, under Willis Street, and under the railroad trestle bridge. All of these crossings are currently creating an over-wide channel and most are directing the flow toward the bank. Placing a cross vane weir below the utility crossings will provide grade control and re-center the flow in the channel helping to ensure that the channel remains stable in these locations. The downstream crossing at Carleton Street has a three-foot drop below the crossing, which will likely require a three-step weir. Cross vane weirs should also be placed at the downstream end of the retaining walls that are being undermined by channel bed erosion.

Cross vane weirs will need to be designed specifically for each location. However, they need not be built all at one time, but can be constructed in smaller groups or singly to provide protection in a shorter reach of stream.

Figure 18. Cross Vane Weir example.

This cross vane weir protects the stream gradient and defines the active channel dimensions.

Figure 19. Approximate locations of cross vane weirs (red) and bank erosion (yellow).

MANAGE RIPARIAN VEGETATION

The riparian vegetation within the corridor is generally in very good condition but vegetation management will be needed to maintain channel stability and help prevent blockages during high flows. High quality riparian vegetation is important to wildlife in the surrounding urban neighborhoods as well as the aesthetic appeal of the corridor. Active management of the vegetation with a plan focused on retaining native vegetation in addition to maintaining high root density for bank stability and flood resilience is necessary to sustain the corridor and protect the valuable urban resources adjacent to the corridor.

There are two reasons to remove trees in Granite Creek:

(1) the trees that are inappropriate for the riparian zone and are, or potentially are, blocking the channel or floodplain causing split channels, debris jams, or erosion;

(2) the trees are invasive species, primarily Siberian elm. In many cases both reasons apply.

Generally, the majority of trees should be removed from the channel bed, banks, and lower floodplain (toe, bank, and overbank zones) where inflexible woody vegetation can cause problems. However, there are many mature, native trees growing in the active channel that should not be removed, particularly willows and cottonwoods that are unlikely to cause problems.

Eventually, all invasive tree species should be removed (mainly Siberian elm and tree of heaven), but currently there are many large elms providing a significant portion of the canopy cover and, therefore, should not be removed all at once. A plan should be developed to selectively remove and replace larger overstory trees with native tree species, which may take a decade or more to complete.

There are few hard and fast recommendations, but we suggest the following as guidelines:

- Remove all the tree of heaven.
- Remove all the Siberian elms in the active channel, all the smaller elms (less than 4"), and all elms that are in the understory. Both tree of heaven and Siberian elm re-sprout when cut, which makes herbicide the most reliable and effective method of killing them. A cut-stump method – cutting the tree and immediately applying an herbicide to the cut stem, is recommended. Smaller trees (up to 2") can be cut with a good brush cutter.
- Remove Siberian elms in stages from the overbank, transition and upland zones without removing more than 20% of the canopy cover in any one area at a time. Plant native species in the canopy gaps to replace the invasive canopy cover.
- Remove or thin most of the smaller, native tree species (<4") from the toe, bank, and lower floodplain to allow unobstructed water flow. Smaller trees need to be replaced with flexible, native vegetation to ensure there are plant roots to provide bank stability.
- Remove larger native trees from the channel bed, toe of bank, and lower floodplain where they are causing or likely to cause an increase in bank stress, bank erosion, split channels, debris jams, and floodplain blockages.

- Remove all trees from the active channel at the start of each split channel.
- Heavily thin areas of overly dense vegetation, focusing on removing tree species while leaving some of the flexible shrub species to protect the streambanks. Supple species, such as coyote or arroyo willow, bend when water flows over them and don't catch larger debris, but have a dense root system that can resist the erosional forces of higher flows.

There will be a need to replace removed vegetation with native, flexible shrub species that provide less resistance to higher flows to ensure that dense root systems maintaining bank stability are not lost. As trees are removed, stumps and root systems should be left intact whenever possible to retain their bank stability function. After removal of woody vegetation from the active channel, there may be a need to reshape the channel to a more stable configuration, such as sloping overly steep banks.

Some suggested native trees and shrubs for replacing invasive species include:

Native Trees

- Cottonwood species (*Populus spp.)*
- Goodding's and Red Willow (*Salix gooddingii* and *Salix laevigata*)
- Box Elder (*Acer negundo*)
- Arizona Walnut (*Juglans major*)
- Arizona Sycamore (*Platanus wrightii*)
- Black Cherry (*Prunus serotina*)
- Velvet Ash (*Fraxinus velutina*)
- Arizona Cypress (*Cupressus arizonica*)

Native Shrubs

- Arroyo and Coyote Willow (*Salix lasiolepis* and *Salix exigua*)
- Redosier Dogwood (*Cornus sericea*)
- Woods Rose (*Rosa woodsii*)
- Golden Currant (*Ribes aureum*)
- Blue Elderberry (*Sambucus nigra ssp. cerulea*)

The shrub willows should be used as the primary shrub species planted along the active channel. They are an excellent bioengineering species due to their ability to provide bank protection by armoring the banks with their strong, dense root system. However, both arroyo and coyote willow are very dense shrubs that can grow more than ten feet tall, which could limit sightlines along the trail and may be a concern for residents. To reduce sightline issues, plant willows on the bank opposite the trail, or on the same bank when the trail is on a higher terrace. There are areas where willows might interfere with sightlines, but they may be the preferred species in locations with high bank stress. In these areas, the willows can be planted in groupings leaving gaps that are planted with shorter species.

Remove Overly Dense Vegetation and Slope Vertical Banks

Immediately downstream of Carleton Street, the vegetation is very dense and is blocking the floodplain providing only a narrow passage for flood flows (Figure 13). The active channel and inner floodplain should be cleared of all trees and enough shrubby species to allow passage of flood flows. The trees along the outer edge of the floodplain should be selectively cleared to prevent blockages or debris jams, but still ensure the area retains a natural feel with native, shade-providing trees. This section also has vertical banks, which should be sloped and then planted with grasses and shrubs to stabilize the disturbed areas and for erosion protection. Many of the small trees in this section are cottonwoods which are a great source of cottonwood poles for replacement of invasive trees.

Add Protection for Rock Wall

The rock wall between Carleton Street and Goodwin Street is being undermined by erosion, which has also resulted in a narrowed channel through this section with an elevated floodplain. This wall is old enough to require clearance with the State Historic Preservation Office prior to work. We recommend adding grade control to prevent further incision as well as placing toe rock protection along the base of the wall and a few rock vanes to deflect flows away from the wall. This will help to preserve the wall in place without damaging it. The floodplain should be lowered through this section, which will also remove the excessive amount of small trees near the bank. And the channel could be pulled away from the wall slightly, which will help relieve some of the stress on the wall. The disturbed bank and floodplain should be planted with grasses and shrubs for erosion protection.

Figure 20. The foundation of the wall is being undermined.

Repair Split Channels

There is approximately 500 feet of channel that is split into two or more channels. This is caused by trees growing in the active channel forcing water to flow around them. This increases

bank erosion, catches debris, which can cause debris jams and reduces the flow capacity of the channel.

The trees at the start of each split should be removed as well as any trees in the channel bed or on the bank. The secondary channels should be filled in and may require some rock sills to ensure they do not reform. The filled channels should be seeded with native grasses and planted with willows and other shrubs to stabilize the filled area.

The native trees growing between the split channels should be thinned, but some can be retained, especially those further from the main channel and any that are unlikely to cause bank erosion or debris jams. In some areas, the main channel can be easily shifted further away from the split channel to allow retention of larger native trees. Native shrubs should be planted along the main channel to provide bank protection.

Lower the Floodplain and Improve Trail Grade

Between Goodwin and Willis Streets, there are sections where the channel is entrenched and the floodplain is too high, which prevents the stream being able to access the floodplain and can lead to excessive bank stress and erosion. The bench that the trail is on should be lowered and/or the bank should be sloped and a lower bench added to increase flow capacity. Increasing the width-depth ratio of the channel from around 6 to closer to the reference ratio of 13 would create a more stable channel.

Where the active channel runs along the retaining wall, grade control should be added to prevent further downcutting. The disturbed areas should be seeded with native grasses and planted with willows and other shrubs. There is also a section where the existing trail is entrenched and during high flows the entrenched trail will channelize flows, which could eventually cause extensive erosion on the trail. The entrenched trail should be repaired to the same grade as the surrounding floodplain.

Prevent Erosion at Stormwater Outfalls

There are several stormwater outfalls along Granite Creek in the project area. Many of them are not problematic, but some are causing excessive erosion. The outfall at Beach Street had significant bank erosion, and the City is currently repairing the outfall and adding a headwall to prevent future erosion.

The outfall in Granite Creek Park (approximately 450 ft downstream of the railroad truss bridge) has a 3+ foot drop off the end of the concrete headwall and the side channel leading to Granite Creek has downcut. A Zuni bowl (a riparian restoration structure for addressing small headcuts or minor erosion) or similar structure should be installed utilizing native rock materials to prevent further downcutting and the potential undermining of the structure. The side channel should be stabilized by adding cross vane weirs, sloping the banks, adding toe rock where the channel ties into Granite Creek, and replanting with appropriate riparian vegetation).

At the outfall downstream of Aubrey Street (approximately 280 ft from Aubrey), two Zuni bowls should be installed, one on each side of the trail, to prevent erosion. A vegetated swale could be added to help filter stormwater before it enters the creek.

There are a few other outfalls that are causing localized bank erosion including the outfall immediately upstream of Willis Street. Building a rock step-pool system in the eroded channel planted with riparian vegetation can prevent further erosion and provide some stormwater filtering.

Under the bridges at Goodwin and Gurley Streets there are two outfalls at each location that discharge across the trail; one each at the upstream and downstream end of the bridges. The outfalls should be reconfigured to prevent stormwater from discharging across the trail to prevent erosion and reduce debris on the trail.

One possible option would be to route the flow into a conveyance along and then under the trail. The upstream outfall could be covered to direct flow down into a drain and then along the wall to the downstream outfall. The stormwater could then be piped under the trail to Granite Creek. A wide, shallow concrete channel covered with removable grates can provide an easy to clean storm drain (see Appendix D). The majority of sediment is deposited by receding flood waters and not stormwater so the best solution should provide an easy to clean and maintain system since sediment deposition on the floodplain is a normal, recurring event.

Reduce Bank Erosion

There are two areas where extended, moderate bank erosion occurs; a roughly 140 ft section north of Goodwin Street and a 1350 ft section north of the historic railroad bridge in Granite Creek Park (Figure 19). These sections of channel have short, vertical banks that are approximately one foot high. The vertical banks should be planted with willows and other native shrubs to help protect the banks and prevent further, more significant erosion.

Increase LID to Improve Water Quality

Low impact development (LID), also called Green Infrastructure, “refers to systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of stormwater in order to protect water quality and associated aquatic habitat” (U.S. EPA, 2018).

Managing stormwater inflows to Granite Creek will help improve water quality. LID structures should be utilized for the retention and treatment of initial stormwater runoff and can include rain gardens, planter boxes, bioswales, vegetated rooftops, rain barrels, and permeable pavements.

Most LID will need to be added outside the corridor due to lack of room; however, there are a few improvements within the corridor that can be added. Step pool systems constructed of natural materials and planted with appropriate riparian or wetland vegetation can help to slow and treat inflow before it enters Granite Creek and should be placed at eroding outfall channels. Opportunities to expand the width of the riparian zone should be undertaken wherever significant inflow areas occur. This will effectively expand the riparian buffer which can help treat pollutants prior to entry into the channel. Parking areas and street runoff should be rerouted away from direct entry into the stream and towards constructed treatment and retention ponds or into buffer areas.

The City of Prescott is using LID in some of its current street projects in the vicinity of the corridor. Work at Carleton and Cortez features curb cuts that allow stormwater to flow into landscaped areas which will intercept first flush pulses. They are also evaluating the use of LID for future street projects, such as tree boxes and using the right-of-way for stormwater treatment.

Utility Improvements

There are several areas where overhead utility lines are running through tree branches. Some lines are hanging quite low and should be restrung or removed if abandoned. In many areas the tree limbs may need to be trimmed to prevent future problems. Tree and limb removal is handled by utility company maintenance, but the city will want to coordinate with the utilities to ensure that the minimum number of trees are removed and any areas of disturbed banks are replanted with shrubs that maintain bank strength and do not grow tall enough to impact overhead utilities.

There are also some abandoned utilities within the corridor that will likely need to be removed. Some may be in the way of future channel and floodplain improvements and others may be removed to improve aesthetics. One possibility includes a sewer line that was recently abandoned because a new connection was created for the Hilton Garden Hotel project. The abandoned line runs parallel with the train trestle bridge and traverses Granite Creek.

Remove Debris in Channel

There are several locations throughout the project area where there is concrete and other debris within the active channel that is unattractive and should be removed.

Figure 21. Concrete debris in channel.

Future Considerations

Efforts should be made to ensure that further narrowing of the active channel and immediate floodplain is avoided. Floodplain use permits are generally aimed at protecting this aspect of

the resource. However, deference should be given to projects that have the potential to widen the existing floodplain or reduce blockages. Full span bridges are advised rather than box culverts (or similar designs) with the potential to catch debris. There are plans to update the FEMA mapping in FY2020/2021. The City should coordinate with the mapping contractor so they are aware of any planned changes to the channel corridor.

Additionally, trails should be placed at grade on the floodplain rather than on elevated floodplain berms. Trails should wander slightly on the floodplain and follow natural undulations to prevent high flows from being captured and channelized on the trail.

Utility crossings should be planned to run deeply under the channel rather than at or above the channel bed. At-grade crossings tend to change the shape of the channel as well as the channel grade, altering channel stability and function. Above grade utilities that are not placed well above flood elevations catch debris and reduce the aesthetic appeal of the channel. If at-grade crossings need to be made, there should be additional work that addresses potential widening of the channel or reduced sediment transport due to slope changes.

The footbridge upstream of Goodwin Street has narrowed the floodplain. If it is replaced in the future it should be replaced with a longer span and the supports and rip-rap narrowing the channel removed or replaced with a vented-ford low-water crossing.

RECOMMENDED TRAIL AND AMENITY IMPROVEMENTS

ADD OR IMPROVE ADA ACCESS TO TRAIL AT ALL MAJOR CROSS STREETS

Build ADA Access at Goodwin Street

Currently, at Goodwin Street there is only stair access into the trail corridor on the north side of the road. However, there is room on the south side to provide trail access that would meet ADA standards. If the access is placed on the far western edge of the corridor, running parallel to the creek, it shouldn't interfere with floodplain function.

Update Gurley Access Point to meet ADA standards

There is a City-owned wooden ramp access into the corridor at Gurley Street on the south side of the road, but this access point requires updating to meet ADA guidelines. There is a step up from the sidewalk on Gurley to access the ramp.

Update Aubrey and Willis Access Point to meet ADA Standards if needed

Both these access points provide a packed earthen ramp from street level into the corridor. The access point at Aubrey Street is likely too steep and sidewalk curbs would need to be cut to accommodate access. The Willis Street access should be assessed to determine if changes are needed.

DEVELOP SECONDARY ADA ACCESS POINT BETWEEN GOODWIN AND GURLEY

There is an access point to the trail between Goodwin and Gurley at Beach Street that is on private property. The City is currently discussing with the property owner the possibility of making this into an ADA compliant public access point.

IMPROVE TRAIL SURFACE

The City of Prescott would like to improve the trail surface to compacted gravel to make it firm and unyielding and ensure that it meets ADA standards. There is a section of trail north of Gurley Street where it is entrenched slightly and should be brought up to the level of the surrounding floodplain. During high flows, an entrenched trail will capture floodwater, which could lead to significant erosion along the trail and the start of a split channel.

The trail under the Goodwin and Gurley Street bridges is problematic for several reasons. The height under the bridges is inadequate, around six feet in some areas. Lowering the trail elevation will only lead to constant maintenance issues as Granite Creek seeks to rebuild the floodplain back to the current, stable geomorphic elevation. Also, normal flooding leaves rocks and debris on the trail surface which cannot be avoided since this is part of the floodplain function. A hardened trail surface under the bridges at the current floodplain elevation would provide an easier surface to maintain, would provide a guide for cleanout, and may prevent larger particles from settling on the trail during floods.

ENHANCE CROSSWALK AT WILLIS AND CREATE TRAIL ACCESS UNDER THE BRIDGE

There are two components needed to create safer conditions at the Willis Street trail crossing. The first component is to maintain and enhance, if needed, the crosswalk located at Willis and the trail intersection. It may be necessary to analyze traffic coming off McCormick Street to identify a potential need to slow traffic. This could potentially be done by adding an all-way stop at the McCormick/Willis intersection. A pedestrian signal crossing may also be appropriate to warn drivers of trail users crossing the street. The second component involves continuing trail access under the Willis Street bridge. This would allow trail users to safely pass under traffic, as it does at Goodwin and Gurley. The trail would continue on the west side of the creek and would be a 6 foot wide sidewalk elevated about 8 inches above the current surface. The crosswalk could be used during times of high water flow.

CREATE DESIGNATED TRAIL NORTH OF WILLIS STREET

The City should create a dedicated trail between Willis Street and Granite Creek Park. There are some utilities located along the road edge that may make this challenging. A potential short-term solution could be to divide the trail from the road using bollards if there is enough room.

ADD LIGHTING AND SIGNAGE

Lighting

In order to enhance safety, two options for lighting were presented – standard streetlights and moonlighting. Some comments indicated a desire to have standard street-lighting throughout the corridor after dark to create safer conditions. After reviewing the feasibility of providing moonlighting throughout the corridor, it was determined that standard lighting at both the access points and throughout the corridor would be ideal. This would include light posts placed near the trail throughout the corridor in a style and color that blend well with the natural corridor. Softer and more natural lighting should be used. Lighting under the several bridges should also be improved. Appendix D provides an overview of amenity improvement locations

and potential options for various amenities including lighting, signage, benches, and retaining walls.

Signage

More welcoming and directional signage will be an important addition to this project. Such signage would ideally indicate the next street, the closest exit, and general amenities that can be found such as food, shopping, and entertainment. They can also show information on connectivity to other trails and parks. Citizens indicated that other signage could include educational elements such as local history, information about the creek health and function, the natural environment found in the corridor, and other information.

Improved signage will raise awareness of the corridor to pedestrians, it will allow for trail users to safely identify the next exit point, and will direct users to amenities that can be found near the corridor. Proposed style for signage includes large stones with relevant information found at access points and other locations along the trail. Educational elements will create attractive information that will be beneficial to residents and visitors as well as highlight important elements of the corridor.

Build Retaining Walls south of Goodwin and between Gurley and Willis

At least 540 feet of new retaining wall is expected at the northern most point in the Carleton Street/Goodwin Street block as well as the Gurley Street/Willis Street block. Current conditions are unfavorable with chain-link fencing in these areas, which is dilapidated and, in some parts, falling towards the trail. Please refer to the picture and rendering for the proposed type of retaining wall in Appendix F.

New retaining walls in these areas will protect the trail and users from harm and deterioration of the uphill slope and will increase floodplain width. New walls will also continue to assist in discouraging unauthorized access through private property along the corridor.

Create Amenity Areas

A commonly expressed desire was to place at least a few benches along the trail. An idea that was shared throughout the feedback was to incorporate natural benches made from wood.

While there is very limited space for amenity areas, most of that space is near the hotel/city park development at the northern end of the corridor. This space could accommodate a small ramada, picnic tables, and benches. While there are currently a number of trash cans placed throughout the corridor, more could be concentrated at the access points as well as mid-block along the trail. These amenities will help keep the corridor clean and create space where users can enjoy the natural elements.

Improve Sense of Safety

Adding lighting and opening the floodplain vegetation by removing invasive tree species and overly dense vegetation will go a long way towards improving the sightlines in the corridor and enhancing public safety.

IMPROVE TRAIL CONNECTIVITY

A long-term goal of enhancing the Granite Creek Corridor is to raise awareness of the connectivity that already exists with other trails as well as continue to promote further connectivity to specific areas. The Greenway Trail through the Granite Creek Corridor currently ends at Aubrey Street to the south. A goal of the City is to gain access via easements from Aubrey Street and going south toward the Prescott National Forest and specifically the Prescott Circle Trail. This involves many dozens of property owners and the Recreation Services Department has been working on this effort for many years.

The Greenway Trail and Granite Creek Corridor currently connect to the Miller Creek Trail, which then travels to the Prescott Rodeo Grounds to the northwest as well as to dining, shopping, and other services. The trail and corridor also connect to Granite Creek Park, a variety of services, and entertainment. The Greenway trail east terminus currently is approximately ½ mile from Granite Creek Park; however, the City will continue to gain access via easements to connect to the City of Prescott's Peavine Trail, which is a designated National Recreation trail connecting the iconic Granite Dells and neighboring communities of Prescott Valley and Chino Valley. When completed, the project would make the Greenway Trail a major connector to most of the city's 106 mile "Mile High Trail System."

There is currently redevelopment of land alongside the Granite Creek corridor and at the intersection of Montezuma Street and Sheldon Street. This is a Hilton Garden Inn Hotel, which will have 100 rooms and other amenities including meeting and a conference space across the historic train trestle bridge. Both the conference space, which is housed in a historic Sam Hill Hardware warehouse, and the train trestle will be refurbished and enhanced while maintaining their historic accuracy and significance. As part of the redevelopment, the City is building a park just to the north of the hotel and directly alongside the Greenway Trail. This park will include the Prescott Farmer's Market, a playground and splash pad for children, and other gathering space. The hotel will allow for public parking in their parking lot, which will create greater access to the park, amenities, and Granite Creek Corridor and Greenway Trail.

These projects and connectivity will greatly impact the Granite Creek Corridor in a positive way. It will generate more use and enjoyment of the trail both from the hotel and the park, and will create more opportunities for citizens and visitors to enjoy the natural corridor as well as enjoy its history.

REGULATORY AND PERMITTING CONSIDERATIONS

All of the proposed work would take place within the city-owned green space corridor. However, access through adjoining private properties may be needed to access the stream for both vegetation management and channel work. Additionally, the public nature of the space will draw lots of attention to major activities and changes. A working relationship with all stakeholders that can provide a forum for concerns and solutions will ensure community support and a successful project.

Work within the project corridor will require two main permits. The first is a floodplain use permit related to FEMA regulations for work in the floodplain. This permit is generally dealt

with through the local floodplain manager. The purpose of the permit is to ensure that any changes to the channel or floodplain do not cause an increase in stage for the 100-year flood event. For some projects, this may require a hydraulic model which shows pre- and post-project flood elevations with an objective of no rise or a lowering of flood stage. All of the practices outlined in this Master Plan are intended to either reduce flood stages or to not change the stage. Early coordination with the local floodplain manager should be included in the project planning to ensure that any requirements for demonstration of a no-rise situation can be met. It should be noted that the City of Prescott will soon begin the process of remapping the extents of the FEMA flood. This is a lengthy process with extensive review. The mapping team should be made aware of the types of projects envisioned for the corridor so that they can include this information in the flood mapping effort.

The second required permit will be the Clean Water Act Section 404 permit. This permit is processed by the Army Corps of Engineers Regulatory Branch for the Los Angeles District (offices in Phoenix). Only projects that take place inside the jurisdictional limits (roughly the bankfull channel) are required to apply for a permit. A preliminary jurisdictional delineation was completed in May 2019 as part of this project and can be utilized for reference and provided to the Army Corps as part of the application package. Additional items in the package include an application showing location, dredge/fill amounts, type of fill, and project purpose. The Army Corps also requires a biological evaluation of the site, explaining any potential impacts to endangered species, and a letter of concurrence from the State Historical Preservation Office (SHPO) that the project will not affect any archaeological resources. Many of the resources in the corridor have been mapped previously, but, in most locations, a field visit by a qualified archaeologist will be needed. It is intended that the major practices envisioned in this Master Plan can be permitted through a Nationwide 27 permit which is designed for stream restoration and improvement practices. This permit usually requires a minimum of 90 days for review and approval and should be in hand prior to any ground breaking activities within the jurisdictional limits.

Other permits that may be required are traffic control permits and temporary construction easements over private lands and right-of-way. The proposed work should also undergo the standard community development review required by the City of Prescott to ensure that discovery of utilities, right of way and drainage are complete and that no unforeseen impacts to surrounding properties occur.

COST ESTIMATES

Below are conceptual level cost estimates for the recommended riparian, trail, and amenity improvements and enhancements (Table 6).

Table 6. Cost estimates for recommended enhancements.

Riparian Area Improvements	
Install Cross Vane Weirs	$48,000
Repair Split Channels	$79,925
Repair Narrowed Channels	$32,230
Lower Floodplain	$83,150
Protect Existing Rock Wall	$60,230
Vegetation for Bank Protection	$13,175
Remove Debris in Channel	$2,600
Mobilization/Demobilization	$25,000
Construction Layout	$10,000
Construction Management	$35,431
Utility Abandonment	$40,000
Construction Contingency (10% of construction costs)	$42,974
Design Services (20% of construction costs)	$94,543
Permitting	$15,000
Estimated Riparian Area Improvements Total:	$582,258

Stormwater Outfall Improvements	
2 Zuni Bowls/LID	$2,880
Rock Chute/Outlet Protection	$14,200
Splash Pad/Riprap Channel at Willis	$6,720
Zuni Bowl, Cross Vane Weirs (Granite Creek Park)	$20,880
Earthwork for Stormwater Improvements	$3,300
Mobilization/Demobilization	$10,000
Construction Layout	$5,000
Construction Management	$6,298
Construction Contingency (10% of construction costs)	$6,928
Design Services (20% of construction costs)	$15,241
Permitting	$15,000
Estimated Stormwater Improvements Total:	$106,447

Trail/Corridor Improvements	
Improve Trail Surface - Aubrey to Willis	**$25,900**
Construct ADA Access at Goodwin	**$57,410**
Replace Access at Gurley	**$15,000**
Concrete Ramp at Goodwin (with handrail)	**$12,000**
Update Aubrey & Willis Access Points to meet ADA	**$57,410**
Retaining Wall	**$148,000**
Enhance Crosswalk at Willis	**$21,200**
Create Designated Trail - Willis to Park	**$8,750**
Mobilization/Demobilization	**$25,000**
Construction Layout	**$10,000**
Construction Management	**$36,867**
Construction Contingency (10% of construction costs)	**$41,754**
Design Services (20% of construction costs)	**$91,858**
Remove Medium to Large Elms	**$72,000**
Estimated Trail/Corridor Improvements Total:	**$623,149**

Amenity Additions	
Lighting - Standard and Under Bridges	**$184,425**
Benches	**$5,400**
Signage	**$6,000**
Amenity Area - at Granite Creek Park (West)	**$70,000**
Amenity Area - near Historic Bridge	**$70,000**
Construction Contingency (10% of construction costs)	**$33,583**
Design Services (20% of construction costs)	**$73,882**
Estimated Amenity Additions Total:	**$443,289**

TOTAL ESTIMATED ENHANCEMENT COSTS:	**$1,755,143**

POTENTIAL FUNDING SOURCES

There are multiple funding sources that can be utilized for implementing the recommended improvements. While none of the sources are likely to fund the entire project, specific funders may be interested in funding certain tasks and goals. We recommend that tasks be split out strategically to target funding sources appropriate for each task. Below is a brief description of some potential funding sources and a summary is provided in Table 7.

The Arizona Water Protection Fund is a grant program that funds the development and implementation of measures that maintain, enhance, and restore rivers, streams and riparian habitats. This grant could help fund work within the channel to prevent erosion and downcutting and to improve channel capacity such as grade control, vegetation management,

and LID. This grant usually has a September deadline. More information can be found at *www.azwpf.gov*.

Heritage Fund grants through the Arizona Game and Fish Department have two programs that could help fund Granite Creek enhancements. One program is the Urban Wildlife/Habitat which funds "projects that conserve, enhance, and establish wildlife habitats and populations in harmony with urban environments, and that increase public awareness of and support for urban wildlife resources." The other program is the Heritage Public Access program to "increase, maintain or reduce public access as needed, for recreational use in cooperation with Federal land managers, local and State governments, private landowners and public users." More information can be found at *www.azgfd.com/wildlife/heritagefund/grantsubprograms*.

Arizona State Parks and Trails provide grant funding under the Motorized and Non-Motorized Trail Project for "projects such as trail development, trail maintenance, pedestrian uses (hiking, running, ADA-accessibility improvements-trails, signs, education), bicycling, equestrian, off-road motorcycling, all-terrain vehicle riding, four-wheel driving, or using other off-road motorized vehicles." This grant has a rolling deadline so grant applications may be submitted at any time. This grant requires a conversation with the program manager to receive permission to apply for the grant and attendance at a grant workshop is highly recommended. The program manager is Mickey Rogers, Chief of Grants and Trails, mrogers@azstateparks.gov, 602-542-6942. More information can be found at *azstateparks.com/grants*.

An Invasive Plant Grant from Arizona Department of Forestry and Fire Management is a possible source of funding for controlling invasive plant species such as Siberian elm and tree of heaven. In 2019, AZDFFM solicited proposals in August for $50,000 to $500,000 to treat invasive plants. More information can be found at *dffm.az.gov/grants/forest-health/invasive-plant-grants*.

The Partners for Fish and Wildlife program, operated by the U.S. Fish and Wildlife Service provides technical and financial support to private landowners (non-federal or state lands) who want to improve fish and wildlife habitat on their land. This grant could help fund the removal of non-native plants and the planting of native species. The Arizona Partners program is particularly focused on protecting, restoring, and/or enhancing wetland and riparian habitats. Up to $25,000 is available for each project. We recommend contacting the state or field coordinator at the Arizona Ecological Services Field Office at (602) 242-0210 for more information. More information can also be found at www.*fws.gov/southwest/es/arizona/Partners*.

Arizona Department of Environmental Quality has a Water Quality Improvement Grant (WQIG). The WQIG Program funds projects that address polluted runoff, also known as non-point source pollution, in watersheds with documented water quality impairments. This grant requires a 40% match. This could be a source of funding for Low Impact Development/ Green Infrastructure. More information can be found at *www.azdeq.gov/node/3102.*

The Arizona Department of Housing receives Community Development Block Grants funds from the U.S. Department of Housing and Urban Development to develop viable urban communities by providing decent housing and a suitable living environment, and by expanding economic

opportunities, principally for low- and moderate-income persons. These grants may provide funds for open space amenities, fencing, and traffic crossings.

Table 7. Summary of potential funding sources.

Grant or Agency Name	Type of Projects Funded
AZ Water Protection Fund	This grant funds measures that maintain, enhance, and restore rivers, stream, and riparian habitats. *www.azwpf.gov*
Heritage Fund AZ Game and Fish Department	Urban Wildlife Habitat funds projects that conserve, enhance, and establish wildlife habitats in urban environments. Public Access funds projects that increase, maintain or reduce public access for recreational use. *www.azgfd.com/wildlife/heritagefund/grantsubprograms*
Land and Water Conservation Fund AZ State Parks and Trails	Provides funding for the acquisition and development of public outdoor recreation areas and facilities. *azstateparks.com/grants*
Motorized and Non-Motorized Trail Project AZ State Parks and Trails	Provides funding for projects such as trail development, trail maintenance, pedestrian uses (hiking, running, ADA-accessibility improvements, signs, and education), bicycling, and others. *azstateparks.com/grants*
Invasive Plant Grant AZ Dept of Forestry and Fire Management	Provides funding for controlling invasive plant species. *dffm.az.gov/grants/forest-health/invasive-plant-grants*
Partners for Fish and Wildlife U.S. Fish and Wildlife Service	Provides support to private landowners who want to improve fish and wildlife habitat on their land, especially wetland and riparian habitats. *www.fws.gov/southwest/es/arizona/Partners*
Water Quality Improvement Grant AZ Dept of Environmental Quality	Funds projects that address polluted runoff, also known as non-point source pollution (LID/GI), in watersheds with documented water quality impairments. *www.azdeq.gov/node/3102*
Community Development Block Grants AZ Dept of Housing	Funds development of viable urban communities by providing decent housing and a suitable living environment.

PRIORITY RECOMMENDATIONS

Several recommendations have been made for the enhancement of the Granite Creek Corridor. Some of these recommendations are especially important to ensure channel stability and to improve habitat and water quality. These recommended actions should be the top priority for future enhancements and include:

- Add grade control: the channel is under stress and grade control will help ensure relatively stable channel morphology
- Protect retaining walls from being undermined
- Remove Siberian elm (and tree of heaven). This can help accomplish several goals since there are such a large number of elms; removing elms will significantly thin the overly dense vegetation helping to improve sightlines and a sense of security as well as reduce channel blockages and increase channel capacity. Removing the invasive plants and replacing them with native species will improve riparian habitat. Staged removal of the elms is important to avoid reducing too much overstory at one time.
- Clear overly dense vegetation and trees in active channel to help decrease bank stress, debris jams and floodplain blockages, and increase channel flow capacity.
- Improve floodplain and trail grade so that drainage and stream access to the floodplain is improved.
- Improve drainage under bridges to alleviate maintenance issues.
- Increase Low Impact Development/ Green Infrastructure. LID will help improve water quality; however, most improvements will be addressed outside the corridor since there is little room for LID within the corridor.

Three public meetings were held to find out what enhancements residents were looking for and to receive feedback on the draft Master Plan. The following improvements appear to be the highest priority for residents.

- Improve ADA access to the trail.
- Improve sense of security in the corridor primarily through lighting and improved sightlines.
- Increase connectivity to other trails.

IMPLEMENTATION STRATEGY

Given the extent and expense of the total project, it is likely to require implementation in stages to fit within budget and timelines that work around construction seasons. If all construction was scheduled as quickly as possible the project might take two years to complete. However, a successful project could also be implemented in stages over a decade or more. During that time period, products, construction methods, and priorities may change. Accordingly, this document should be considered a guidance tool that outlines the objectives and goals rather than the details of the work to be done. Individual projects should be planned

so that they fit within the overarching goal of the project and recognize the need to preserve and enhance the resources and functions identified by the working group and public during the concept development period.

Specific tasks outlined in this Master Plan are likely to be executed as funding becomes available or other related projects outside the Granite Creek Corridor are implemented. While this strategy is an expedient way to implement many of the tasks in the project (street crossings, retaining walls, and access points), there is a need to implement several of the larger, widespread tasks as standalone projects that provide a framework for peripheral projects. Among these larger projects are major stream stabilization work or removal of larger trees that requires mobilization of machinery into the corridor. These two tasks should be considered the keystones of the project and likely should occur prior to or in coordination with other aspects of the project.

The primary tasks can be divided into specific reaches of the project area and implemented within an individual reach. In regard to removal of larger elm trees in the project area, this is a preferred strategy since it is not desirable to remove a large percentage of trees from the entire reach all at once. Reaches can be implemented in any order since there are no planned grade or alignment changes to the stream that require systematic implementation from one direction to another. Consequently, the primary tasks can be implemented in a reach wise fashion independently of peripheral projects or in the reach surrounding a peripheral project.

Given the climate of the Prescott area, construction work can be accomplished during most any period. However, construction timing for in-stream work and tree removal should be guided by specific seasons most amenable to the work. With tree removal, it is recommended to work during fall and winter to avoid interference with bird breeding season. With in-stream work, periods of low, steady flow are best. Early summer, post monsoon periods, and early fall are the best time to avoid precipitation events occurring during a construction period as winter and spring are prone to heavy precipitation and runoff.

It will be important to identify in-stream projects well ahead of the implementation date. Work within the jurisdictional limits will require a Clean Water Act, Section 404 permit, which can require several months to obtain from the Army Corps of Engineers. Ensuring that an application is in at least 90 days prior to construction start up is recommended.

A conceptual sequence for implementation of a reach-based project is provided below. It should be noted that each reach will have unique aspects that will affect the timing and type of tasks involved. This description is a very generalized form.

1. Identify the reach limits and associated peripheral projects.
2. Identify funding source(s).
3. Identify affected neighboring properties, determine potential effects, and coordinate with land owner.
4. Develop preliminary plans that can identify impacts within the CWA jurisdictional limits.
5. Apply for CWA 404 permit at least 90 days in advance of scheduled construction.
6. Finalize design plans and specifications.

7. Contract(s). May require several construction contractors to accomplish specialty items.
8. Construction
    a. Clear vegetation
    b. Construct channel stabilization
    c. Construct peripheral projects (trail, drainage, utilities, lighting, walls, etc.)
    d. Revegetate
9. Monitor and evaluate project effectiveness.
10. Repeat as needed.

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