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<u>Memorandum</u>

Reference Reach Evaluation for Cottonwood Creek Reclamation Project

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This memorandum documents an evaluation of reference reach conditions to guide the reclamation of a reach of Cottonwood Creek near Cherry Creek Reservoir southeast of Denver, Colorado. Water use issues, including evapotranspiration of riparian vegetation along the reclaimed creek, are addressed. The objective is to show that the proposed reclamation project is appropriately designed with respect to water use, with the intent that the State Engineers Office will view the project as acceptable without an augmentation plan.

Project Background and Location

The Cherry Creek Basin Water Quality Authority (CCBWQA) has undertaken a project to reclaim a reach of Cottonwood Creek within Cherry Creek State Park to reduce water quality impacts to Cherry Creek Reservoir. The intent of the project is to stabilize the eroding creek and create a healthy riparian system to reduce the loading of phosphorus, sediment, and other pollutants to the reservoir. Phosphorus is a critical nutrient with respect to algal productivity in the lake and is delivered to the lake via soil erosion and rainfall washoff processes.

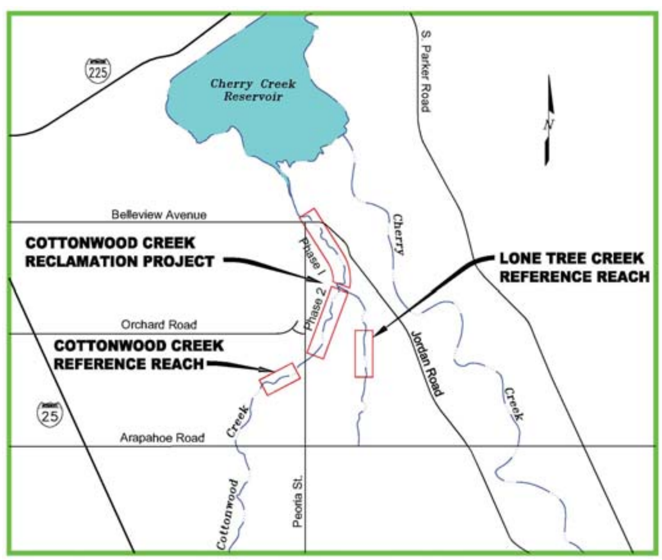


Figure 1. Location Map.

Figure 1 shows Cottonwood Creek in relation to Cherry Creek Reservoir and the reach being improved in the Cottonwood Creek Reclamation Project.

In

Streams as Responsive Systems

Cottonwood Creek, like any natural stream, has shown itself to be a dynamic system, adjusting its character in response to a changing flow regime. The Cottonwood Creek watershed has undergone extensive urbanization over the last several decades, resulting in significant increases ~~the~~ volume, peak discharges, frequency, and duration of stormwater runoff from impervious surfaces. Baseflows have increased also.

Figure 2. Wetland and Riparian Vegetation Associated with Increased Flows along Cottonwood Creek.

which has occurred without human intervention

Two major responses to increased flows are evident along reaches of Cottonwood Creek near the project location. First, there has been an increase in wetland and riparian vegetation along the creek, particularly within about two to three feet (measured vertically) above the streambed. Figure 2 shows a photograph of the increased vegetation that has developed along Cottonwood Creek. The increase in flow and vegetation in these reaches has generally had a positive effect with respect to stream stability, habitat, and water quality. Cottonwood Creek in these reaches emulates the healthy stream corridor illustrated in Figure 3.

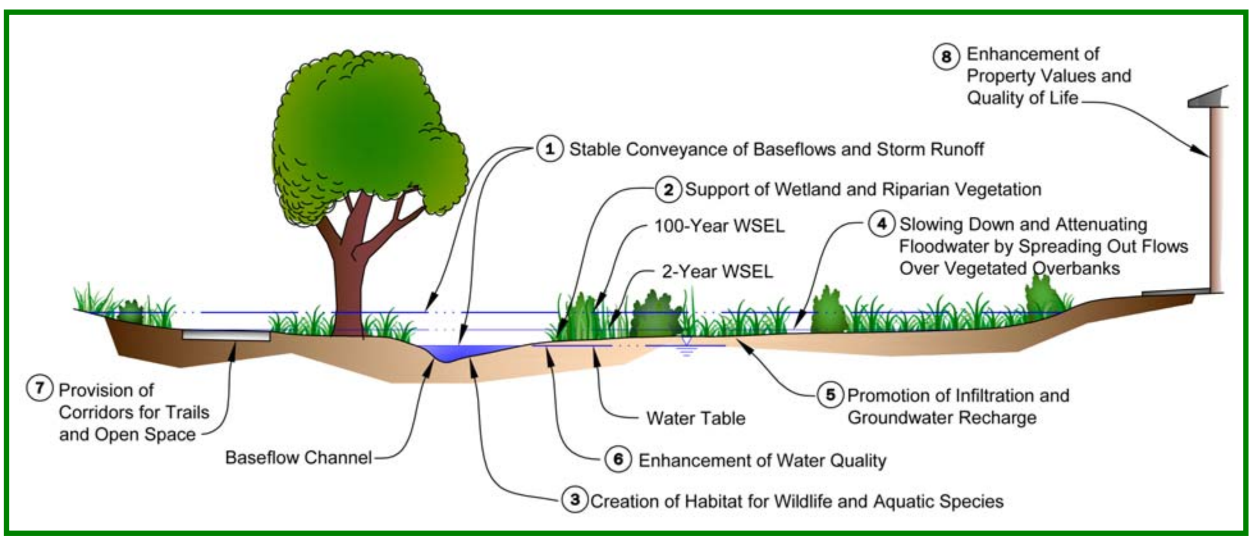


Figure 3. Functions and Benefits of Healthy Streams.

The second type of response to increased flows evident in less-stable reaches of Cottonwood Creek is degradation, a downcutting of the channel invert through headcutting and erosion. Figure 4 shows a degrading reach of Cottonwood Creek. Degradation is normally associated with a significant short-term loss of stream benefits, as discussed below and illustrated in Figure 5.

Figure 4. Degraded Reach of Cottonwood Creek.

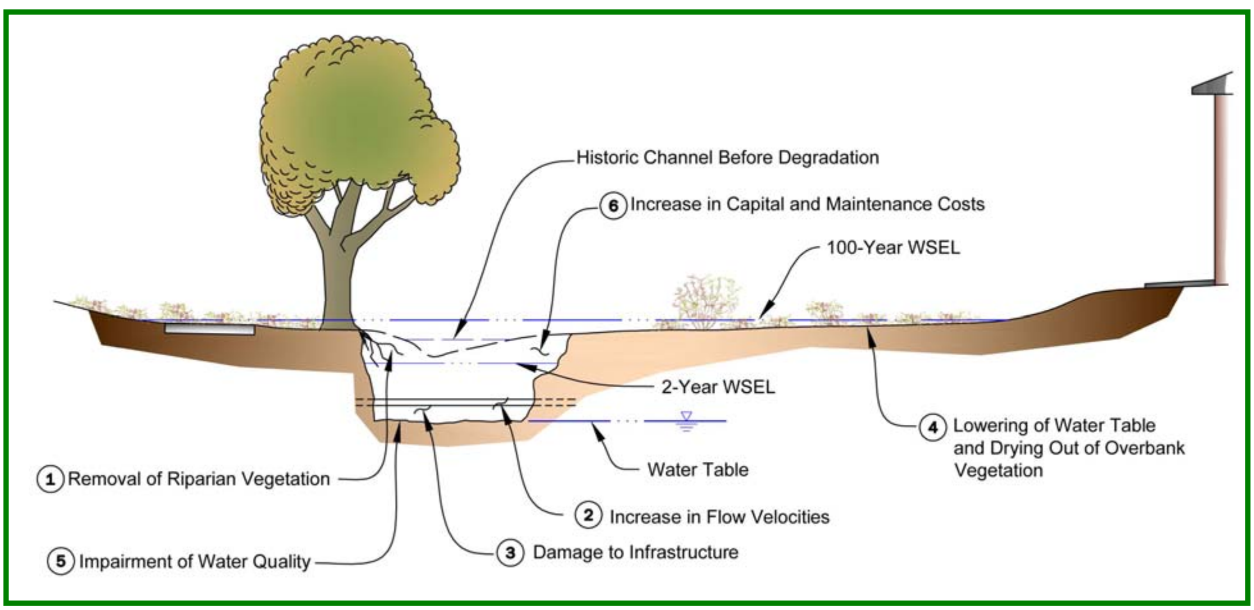


Figure 5. Impacts of Stream Degradation.

1. Removal of Riparian Vegetation. Erosion typically strips natural vegetation from the bed and banks of drainageways. This disrupts habitat for aquatic and terrestrial species and leaves the channel exposed to further erosion damage.

2. Increase in Flow Velocities. An incised channel concentrates runoff and increases flow velocities. It is not unusual for channel velocities to more than double during high runoff in an incised condition, leading to further channel erosion.

3. Damage to Infrastructure. Channel erosion can threaten utility lines, bridge abutments, and other infrastructure. Utility pipelines that were originally constructed several feet below the bed of a creek often become exposed as the bed of a channel lowers. Damage to the utility lines can result as the force of that water and debris come to bear against the line. Channel degradation can expose the foundations of bridge abutments and piers, leading to increased risk of undermining and scour failure during flood events. Erosion and lateral movement of channel banks can cause significant damage to properties adjacent to drainageways, especially if structures are located close to the top of the bank.

4. Lowering of Water Table and Drying-out of Overbank Vegetation. In many cases, lowering of the channel thalweg and baseflow elevation leads to a corresponding lowering of the local water table. Besides the loss of storage volume, lowering the water table can “dry-out” the overbanks and can effect a transition from wetland and riparian species to weedy and upland species. This can have a striking effect on the ecology of overbank areas.

5. Impairment of Water Quality. The sediment associated with the erosion of an incised channel can lead to water quality impairment in downstream receiving waters. One mile of channel incision 5-feet deep and 15-feet wide produces almost 15,000-cubic yards of sediment that could be deposited in downstream lakes and stream reaches. Along the Front Range of Colorado, these sediments contain phosphorus, a nutrient that can lead to accelerated eutrophication of lakes and reservoirs. Also, channel incision impairs the “cleansing” function that natural floodplain overbanks can provide through settling, vegetative filtering, wetland treatment processes, and infiltration.

6. Increase in Capital and Maintenance Costs. Typical stabilization projects to repair eroded drainageways require significant capital investment; the more erosion, generally the higher the cost.

It is these negative impacts associated with degradation, especially in the area of water quality, that the Basin Authority intends to mitigate through the Cottonwood Creek Reclamation Project.

Stream Evolution Model

Stream channels will typically evolve beyond the initial degradation shown in Figure 5. Higher flood velocities within the narrow, incised channels tend to further erode the channel banks. Bank erosion leads to a progressive widening of the channel over time and the re-establishment -- at a lower elevation -- of a baseflow channel flanked by a wellvegetated hydraulic floodplain. This channel evolution model is illustrated in Figure 6 (Interagency Working Group, 2001). An expanded discussion of stream evolution from the Environmental Protection Agency's Watershed Assessment of River Stability and Sediment Supply, including representative photos and diagrams, is provided in Appendix A. A similar discussion taken from the Kansas River and Stream Corridor Management Guide is shown in Appendix B.

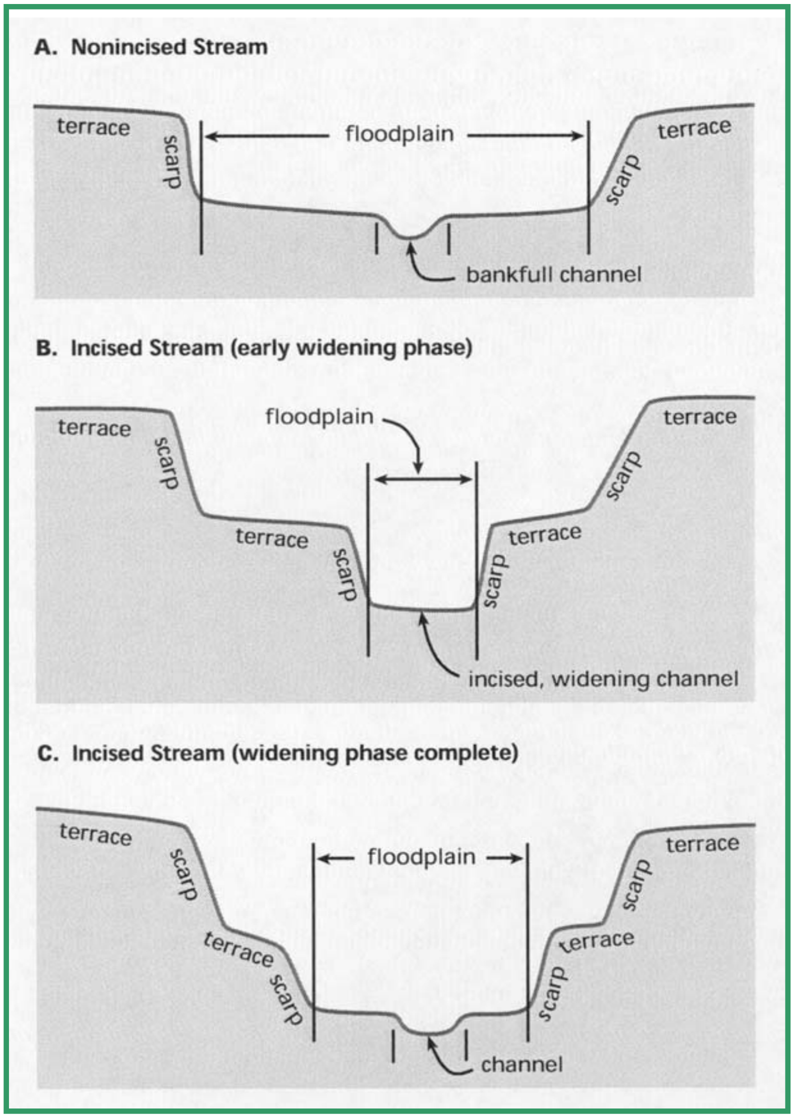


Figure 6. Typical Channel Evolution (Interagency Working Group, 2001).

Applying these channel evolution models to Cottonwood Creek means that *even the degraded reach of the creek will eventually develop a corridor of wetland and riparian vegetation supported by increased flows from urbanization*. The reclamation project will simply accomplish this in a shorter time frame and without the water quality impairment associated with letting the stream system erode and widen on its own.

Reference Reach Concept

The Federal Interagency Stream Restoration Working Group has published an excellent guidance document on stream restoration (Interagency Working Group, 2001). In it, the concept of a *reference reach* is promoted. A reference reach on the same or a similar stream is representative of what the degraded reach might look like had it remained relatively stable, and also represents the desired restored or reclaimed creek. The designer, by emulating desirable characteristics of the reference reach (cross-sectional geometry, slope, vegetation), increases the likelihood that the completed stream reclamation project will become successfully established.

A reference reach on Cottonwood Creek upstream of the project was used as a design model for Phase 1 of the reclamation work, which was completed several years ago. The same reach and another similar reach on Lone Tree Creek are being evaluated as reference reaches for Phase 2 of the Cottonwood Creek Reclamation Project, currently being designed. The location of the two reference reaches and Phase 1 and 2 of the reclamation project are shown in the Location Map on page 1.

With respect to water use, it is important that the evapotranspiration losses associated with the reclaimed channel not exceed the losses associated with the reference reaches, and that no artificial impoundments or controlled diversions be created. With the goal of ensuring that the completed project does not result in any increase in evapotranspiration along the riparian corridor compared to the reference reaches, the types and average widths of wetland and riparian vegetation along the reference reaches were assessed.

Evaluation of Riparian Vegetation Corridor Width

Recent (July, 2006) aerial photography was obtained for the project area showing the reference reaches and the Phase 1 and Phase 2 project reaches. The summer growing conditions allowed wetland and riparian vegetation to be identified on the photography and a two-day field reconnaissance ensured that the delineation accurately represented field conditions. Two basic categories were established. Open water, wetland grasses, sedges, rushes, and cattails were classified as *herbaceous wetlands*. Woody riparian vegetation such as shrub willows and cottonwood and willow trees were classified separately. These are the two main types of riparian vegetation associated with elevated evapotranspiration along the streams; vegetation outside these categories consisted of upland grasses hydraulically disconnected from the stream channels. Figures 7 and 8 show representative categories of riparian vegetation along the two reference reaches in plan view and Figure 9 shows a photograph of typical vegetation.

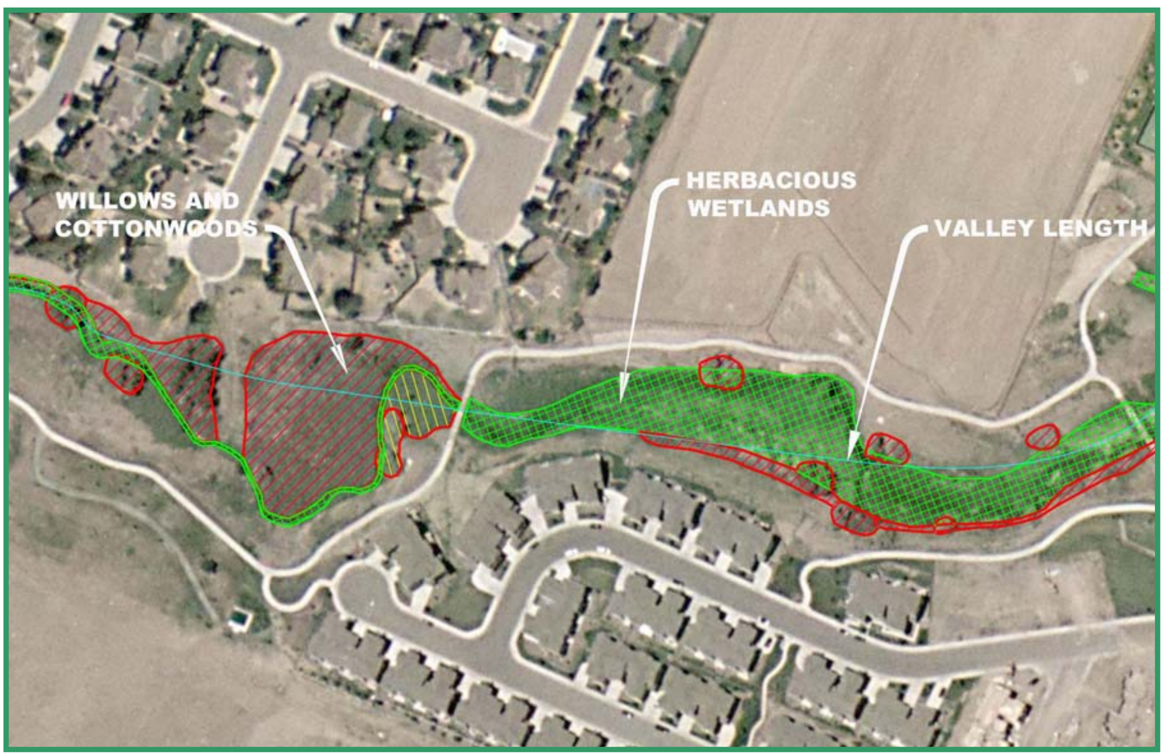


Figure 7. Cottonwood Creek Reference Reach.

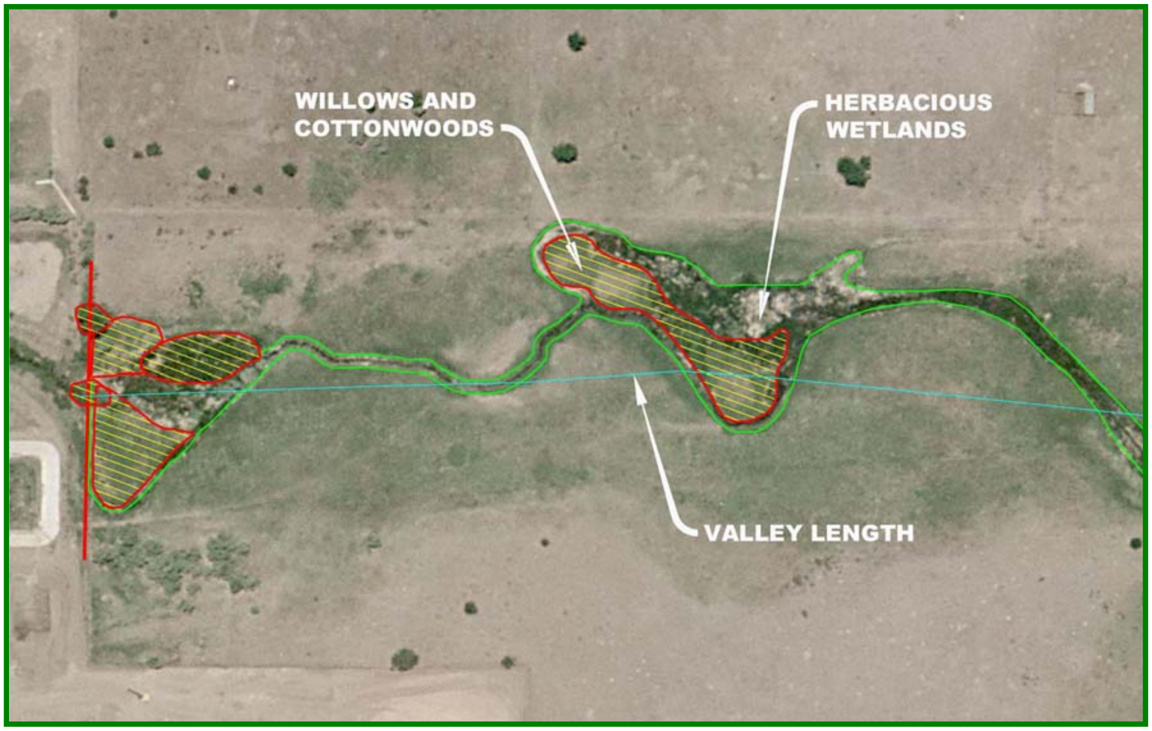


Figure 8. Lone Tree Creek Reference Reach.

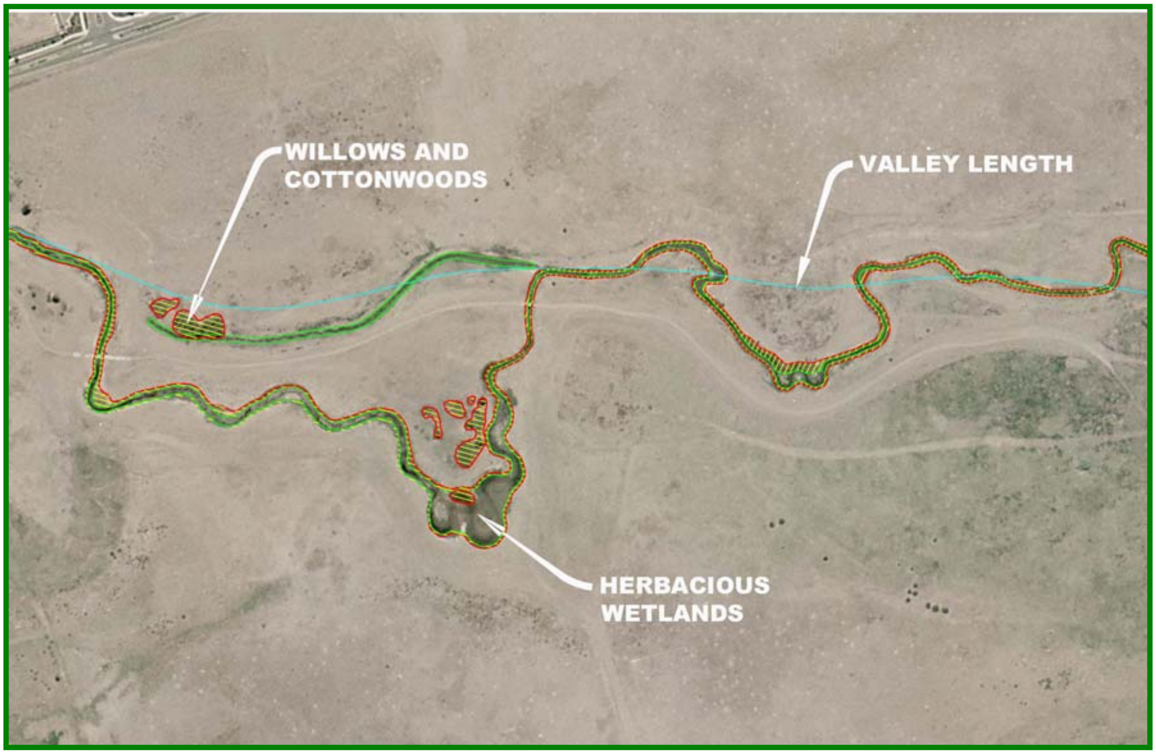
As a comparison, the same two categories of vegetation established along Phase 1 of the Cottonwood Creek Reclamation Project were assessed. Figure 10 shows a representative reach of the Phase 1 project in plan view and Figure 11 shows a photo of the completed reclamation work. Vegetation widths along the stream channel, even if associated with two channel branches or tightly meandering stream alignments, were averaged over the length of the stream valley (represented by a blue line on Figures 7, 8 and 10), providing a uniform means of comparing the widths of vegetation.

The bar charts in Figure 12 show that the wetland and woody riparian vegetation widths for the Phase 1 reclamation project are well within the limits of vegetation established in the two reference reaches. *It follows that the evapotranspiration associated with the reclaimed*

Figure 9. Representative Wetland and Riparian Vegetation in Reference Reaches.

which creek?

channel, although greater than in the degraded pre-project conditions, is certainly not in excess of nearby reference conditions. Further, given the tendency for degraded channels to naturally widen over time, the evapotranspiration associated with the reclaimed channel is not expected to be greater than the evapotranspiration that could develop in the future even if the channel were never improved.



Phase 1 of Cottonwood Creek reclamation Project.

Figure 11. Typical Phase 1 Channel Reclamation.

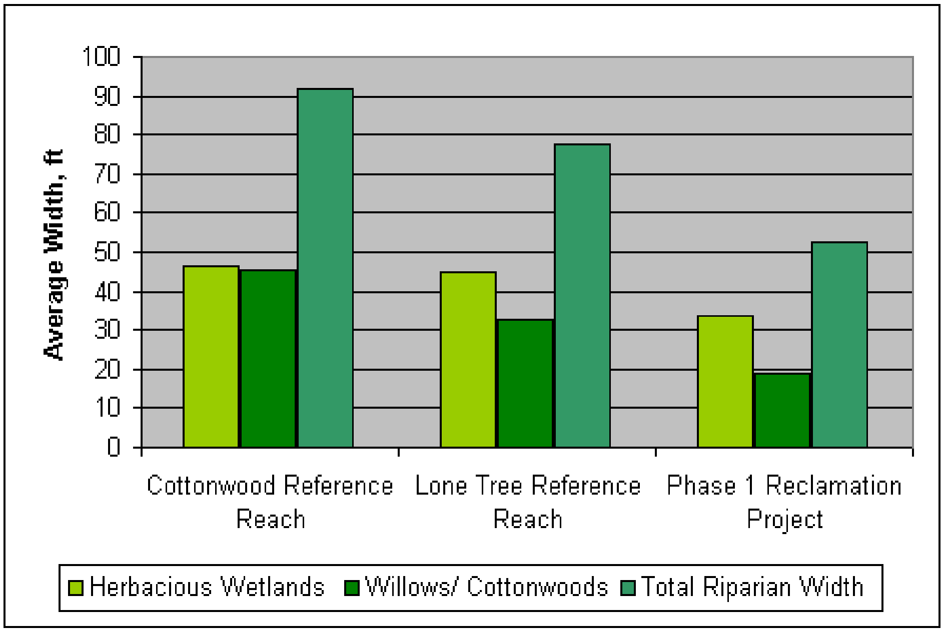


Figure 12. Comparison of Average Widths of Wetland and Riparian Vegetation.

Water-use Criteria for Phase 2

It is anticipated that Phase 2 of the Cottonwood Creek Reclamation Project will establish similar average widths of wetland and riparian vegetation as Phase 1, and will not exceed the widths of the reference reaches. In addition, the design will only create features that are typical of natural stream systems, such as rock riffle grade-control structures and meandering stream reaches. The design will not include artificial impoundments and controlled diversions of flow.

Conclusion

This memorandum has described how the Cottonwood Creek channel has responded to increased runoff from urbanization by establishing wider corridors of wetland and riparian vegetation in stable reaches and degrading the less-stable reaches, leading to water quality impacts to Cherry Creek Reservoir. Based on the typical channel evolution model, a corridor of wetland and riparian vegetation is eventually expected along the degraded reaches of Cottonwood Creek via natural channel widening, even if the reclamation project is not undertaken (although the CCBWQA would not be inclined to allow the negative water quality impacts to continue under this scenario).

An evaluation of two nearby reference reaches shows that the average width of wetland and riparian vegetation (and associated evapotranspiration) in the completed Phase 1 Cottonwood Creek Reclamation Project is less than similar vegetation and losses in the reference reaches. Phase 2 of the project will also be designed so that the average width of wetland and riparian vegetation and associated losses will be less than in the reference reaches, and will not include artificial impoundments and controlled diversions of flow.

Phase 2 of the Cottonwood Creek Reclamation Project will be designed to have lower evapotranspiration losses than nearby reference reaches with the intent that the State Engineers Office will view the project as acceptable without an augmentation plan.

References

(Interagency Stream Restoration Working Group, 2001). *Stream Corridor Restoration – Principles, Processes, and Practices,* by The Federal Interagency Stream Restoration Working Group. Published October, 1988, revised August, 2001. Adopted as Part 653 of the National Engineering Handbook, USDA – Natural Resources Conservation Service.

(WARSSS, 2006). *Channel Processes: Stream Channel Succession*, by the US Environmental Protection Agency's Watershed Assessment of River Stability and Sediment Supply. Published on USEPA's web site @ http://www.epa.gov/warsss/sedsource/successn.htm

(Kansas State Conservation Commission). *Kansas River and Stream Corridor Management Guide*, by The Kansas State Conservation Commission. Undated.