A STREAM RESTORATION PLAN FOR THE CITY OF DAVENPORT

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REFERENCE: *Proceedings of the 2011 Georgia Water Resources Conference*, held April 11–13, 2011, at the University of Georgia.

Abstract. The City of Davenport, Iowa, is drained by two major stream systems - Duck Creek and Blackhawk Creek – and a network of smaller streams and open channels. As urbanization increases these streams are experiencing significant and continued erosion due to extreme swings in storm flows. These flows have caused stream bank failures and channel head cutting, resulting in sediment and brush in the channel, loss of park land and residential property, threats to infrastructure such as park trails, and bridge and culvert plugging. It is expected that future water quality impairments such as turbidity and biotic impairment in the creeks will have to be addressed by the City as the MS4 permit holder.

Davenport is located in the eastern side of Iowa on the Mississippi River in the Quad Cities area, which has a combined population of about 380,000. This project developed a stream restoration plan for 18 miles of public and private stream channel using standardized construction details to develop construction level plans and project priorities for the entire channel length.

The project was completed using a rapid visual assessment of all channel reaches. The channels were walked by a team who recorded conditions and estimated channel bank recession rate according to a method developed by the Natural Resource Conservation Service. The team compiled a photographic record and field records of proposed remedial actions. At selected locations, a Rosgen Bank Erosion Hazard Index was calculated, bank pins and channel chains were installed and a cross section measured using a GPS unit. A hydrologic/hydraulic model was also constructed using the EPA SWMM model to estimate channel velocities and shear stress and to assist in developing planning standards for undeveloped land.

INTRODUCTION

Davenport, Iowa, is a city of just over 100,000 residents in eastern Iowa. The city is bounded by Bettendorf, Iowa, to the east, agricultural land to the north and west and the Mississippi River to the south. Across the Mississippi River lie Moline and Rock Island, Illinois. The four cities are commonly referred to as the Quad Cities. Figure 1 shows the project location.

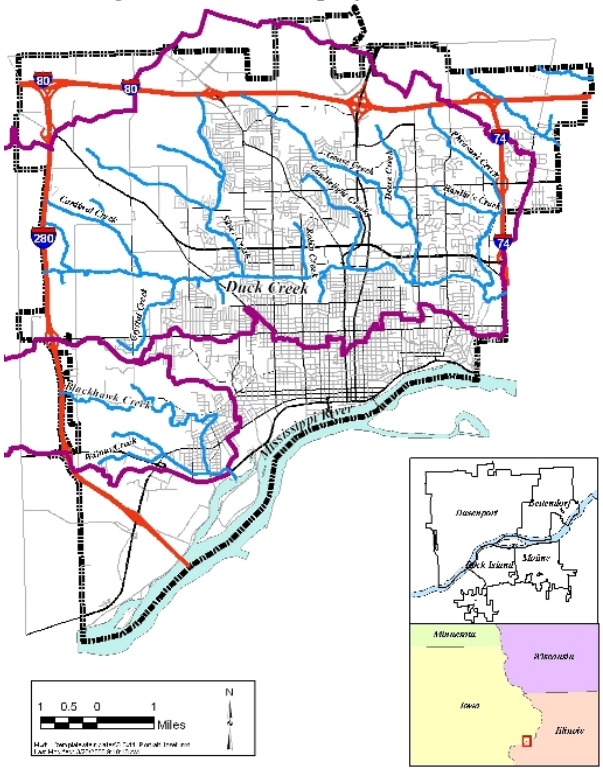


Figure 1. Project location.

Two major stream systems - Duck Creek and Blackhawk Creek – drain most of the city through a network of smaller streams and open channels. Duck Creek is deeply incised and has been rerouted and straightened from its historic channel. Some channelization has occurred on Blackhawk Creek, but much of the upper stream is relatively unaltered. As urbanization continues these streams are experiencing significant and continued erosion due to extreme swings in storm flows. These flows have caused stream bank failures and channel head cutting, resulting in sediment and brush in the channel, loss of park land and residential property, threats to infrastructure such as park trails, and bridge and culvert plugging. The City goals are primarily bank stability and a reduction in sediment transport. Secondary goals are mollusk habitat creation and better aesthetics. Nutrient reduction and fish passage, although

important for the ecosystem, are not a focus of this work.

In response, the City proposed to develop a comprehensive stormwater management and stream restoration plan. The purpose of this plan is to mitigate existing stream issues as well identify best management practices and zoning and regulatory requirements to implement as the upper watershed develops.

STUDY APPROACH

Due to the length of stream miles to assess and a limited budget, the study team developed a rapid assessment approach that was scientifically sound but oriented to the preparation of biddable documents for stream restoration projects. The selected methodology consisted of:

- Assembling high-quality aerial photos, topography, parcel, and soils GIS data as well as historical aerial photos for an initial desktop assessment.
- Preparing an EPA SWMM model of the watershed for current and build-out conditions to generate water surface elevations and discharge rates, velocities and volumes. Velocities and channel shear stress for the 2-year event were used to represent the bankfull condition.
- Conducting an on-ground site assessment consisting of:
  - Walking the channels and recording channel conditions and making a photographic record;
  - Completing a Rosgen Bank Erosion Hazard Index (BEHI) assessment and taking channel cross sections by reach or subreach (Rosgen, 1996);
  - Installing bank pins and channel chains at selected locations to measure actual rescession and scour; and
  - Assembling field notes of obstructions, current and impending bank failures and other features requiring short and long term maintenance.
- Developing a palette of standardized restoration techniques, applying those to the 18 miles of assessed streams, creating a GIS shapefile that overlaid those recommendations on aerial photos, and estimating the cost of restoration of each reach by priority project.
- Channel reaches for restoration were prioritized using the NRCS, Wisconsin Field Office Technical Guide for Average Annual Lateral Recession Rate. This methodology, although subjective, provides a uniform scale across which multiple viewers over different time periods can assess channel bank erosion rates.

DESK ASSESSMENT

Duck Creek and Blackhawk Creek are the two main stream systems under study, as well as a Duck Creek tributary named Candlelight Creek. The 65 square mile watershed encompasses most of the city of Davenport as well as a large area of rural Scott County.

Duck and Blackhawk Creeks discharge to the Mississippi River after flowing down a bluff area. The most downstream reaches flow through older residential and industrial areas. The upstream reaches of Duck and Blackhawk Creeks are in agricultural use. Candlelight Creek flows through a residential area. Figure 2 shows the land use for the project area.

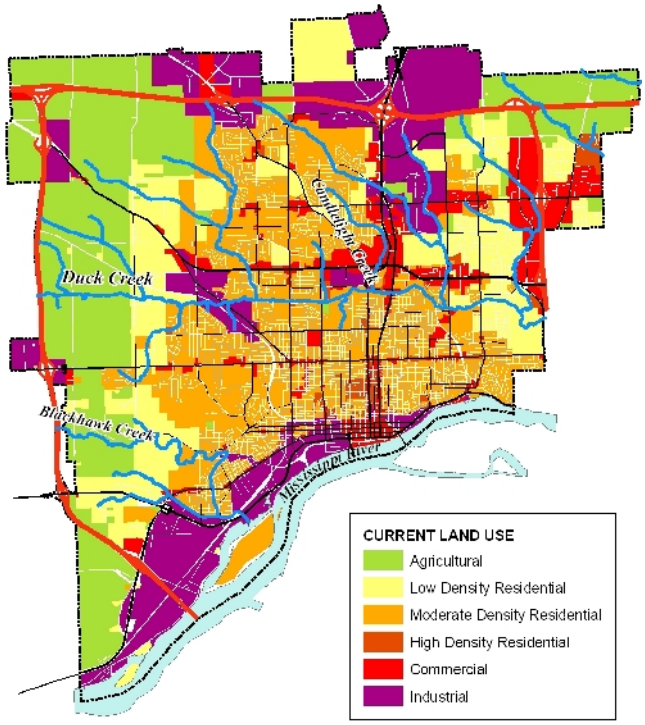


Figure 2. City of Davenport current land use.

Topographic mapping showed the project area to be relatively steep in the upper reaches and then flatter in the Mississippi River floodplain (Figure 3). This shows the necessity of controlling runoff rates and velocities in the undeveloped upper reaches and areas proposed for redevelopment to minimize future erosion impacts to the channel. The agricultural lands in the upstream portion of the watersheds are adequately drained for farming practices. When this land use changes there is the opportunity to add storage and volume management practices that can result in less run-off volume and lower discharge rates. The more downstream reaches tend

to be fixed in their location due to development occurring adjacent to the channel banks.

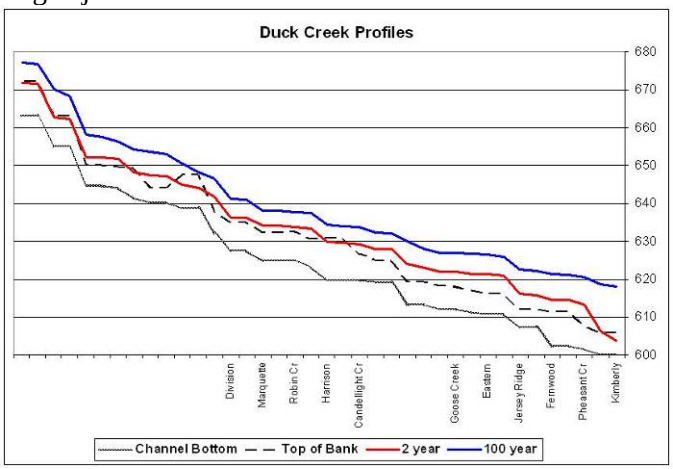
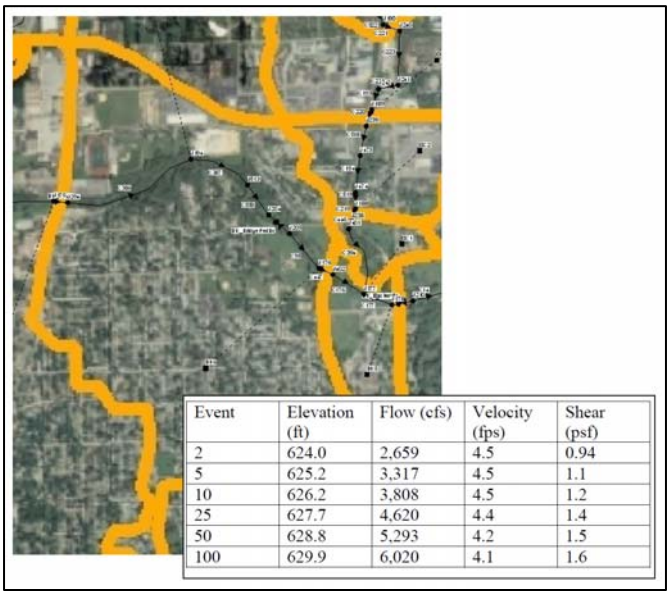


Figure 3. Duck Creek profiles showing channel bottom, top of bank, and 2- and 100-year depths.

Hydrologic/ Hydraulic Modeling. EPA SWMM was used to develop hydrologic/hydraulic models of the watersheds for both the existing and build-out conditions. This model was used to identify flow velocities and shear stress conditions in the streams for a number of rainfall events (Figure 4). The 2-year event was used to represent the bankfull condition. Storm recurrence intervals were determined by the Huff and Angel Frequency Atlas of the Midwest. Watershed characteristics were obtained from City supplied LIDAR data and field surveys of road crossings.



Event	Elevation (ft)	Flow (cfs)	Velocity (fps)	Shear (psf)
2	624.0	2,659	4.5	0.94
5	625.2	3,317	4.5	1.1
10	626.2	3,808	4.5	1.2
25	627.7	4,620	4.4	1.4
50	628.8	5,293	4.2	1.5
100	629.9	6,020	4.1	1.6

Figure 4. Subwatershed and elevation, flow, velocity and shear stress data for the modeled Duck Creek segment.

The models were also used to identify stream segments that are currently or which are predicted to experience higher than desirable bankfull velocities both on the main stem and on the many tributaries and channels in the watersheds. Desirable bankfull velocities were set at no more than 2.5 fps for firm loam and 3.0 fps for clay stream banks. Figure 5 shows the modeled velocities for build-out conditions in a part of the Duck Creek watershed.

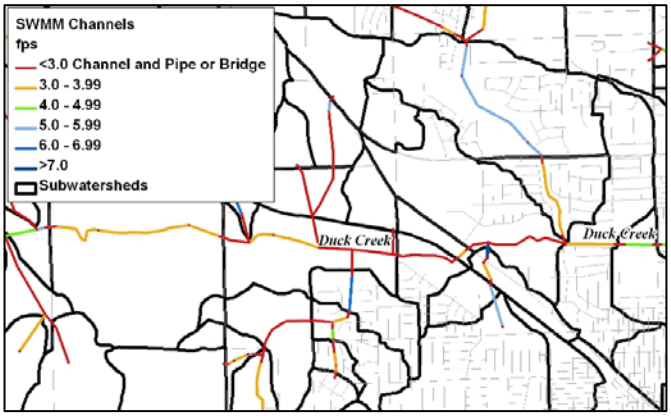


Figure 5. Modeled build-out velocities for Duck Creek and tributaries.

Historic Data. Historically a meandering stream, Duck Creek has been straightened and channelized. Aerial Photography from the 1930s compared to today (Figure 6) show that stream realignment has occurred throughout the city. This was a common practice among many counties and municipalities throughout the United States as the typical water management philosophy was to remove the water off the land as soon as possible and maximize the amount of land for agriculture or development. This change in stream alignment has steepened the channel slope and therefore the water velocity and shear stress. As a result much of Duck Creek is incised 12-15 feet, as verified through topographic maps and field reconnaissance.

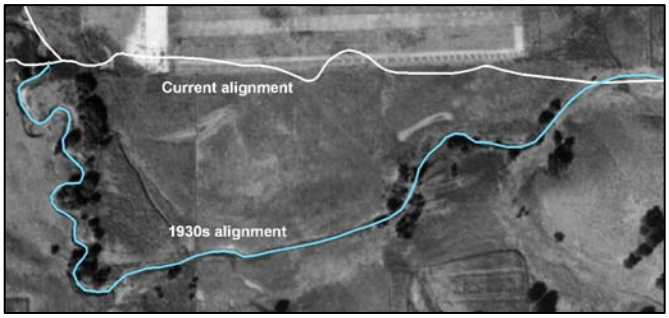


Figure 6. 1930's aerial of Duck Creek showing the original meandering alignment compared to the mostly straightened current alignment.

Other Data. Other data was also assembled during the desk assessment. Scott County Soil Survey data indicates that most of the corridor contains fine-loamy soils. This information correlates to the field assessment that the watershed has a Soil Type B or C, according to the National Resource Conservation Service soil classification system, runoff characteristics and somewhat erodible channel banks.

Ownership of riparian properties often determines the nature and extent of improvement options. The City of Davenport owns much of the Duck Creek corridor and maintains it as park land, although the upper agricultural reaches are in private ownership. Much of the Blackhawk Creek corridor is in private ownership.

FIELD ASSESSMENT

The field assessment was conducted by two two-person teams for Duck Creek and one two-person team for Blackhawk and Candlelight Creeks. The field teams carried field books of high-quality aerial photos of the corridors with stream stations marked at 10-foot intervals. The teams made a photographic record, notes on channel stability and general condition, channel substrate, and channel recession. They also recorded observations on the type of stream restoration techniques that would be appropriate at each location. The notes were made directly on the field books.

Visual assessment details noted lateral recession rates, head cutting, pipe outfill conditions, tree root exposure, fence post or other man-made structure susceptibility to failure, trash and debris in the channel, vegetation on the banks and overbanks according to the 2003 Wisconsin NRCS Field Office Technical Guide.

One of the Duck Creek two-person teams surveyed cross sections on each of the fourteen reaches, and conducted a Rosgen Bank Erosion Hazard Index (BEHI) assessment. That team also installed bank pins and scour chains at various locations so that city staff could monitor actual bank rescession rates and headcutting.

STREAM RESTORATION PLAN

The desk top information, model results and field assessment provided the information necessary to develop stream restoration management practices. The study's goal was to find the best fit of bio-engineering practices and hard physical features that could be installed and maintained by city staff. Corps of Engineers papers on bio-engineering practices with associated allowable ranges for velocity and shear stress were screened by the design team and city staff. (Fischenich, 2001)

One notable design element became apparent during the screening and field assessment process. The Quad Cities area is rich in limestone and dolomite but poor in the availability of metamorphic or igneous rock. Possibly due to the abundance of limestone, cement plants have a ready supply of concrete rubble. In fact concrete rubble had been used in several locations on the streams with poor results. The large pieces that were used meant there were significant void spaces where fines could wash through the material.

Selected Treatment Methods. The stream restoration plan identified a palette of treatments that were applied to the entire stream corridor depending on existing condition or current or modeled future velocity and shear stress. (Fischenich 2001) These treatments included:

- In the areas of greatest stress, or where public infrastructure was threatened by an eroding or meandering streambank, vegetated riprap was proposed to provide an immediate toe and bank stabilization, increase in strength as vegetation grows, provide some limited habitat and be aesthetically more pleasing than a rock embankment alone.
- Areas of lower stress that were in poor conditions, as defined by sloughing banks, exposed roots and damage to infrastructure, were recommended for brush bundles supplemented by live stakes. The brush bundles will stabilize the streambanks until the live stakes mature.
- Live stakes would be added to provide streambank structure for those areas such as outside bends that may be stressed but are currently stable and eroding at less than 0.06 ft/yr.
- Significant segments of the corridors are heavily wooded, and the streambank and riparian areas are heavily shaded and bereft of understory vegetation. Canopy thinning to open up the riparian area and streambank revegetation with native seed and erosion control fabric is needed in many reaches. Much of stream corridor is overshaded, limiting ground cover and desired root density. Therefore, tree thinning and replanting is prescribed for many stream segments. Presettlement stem density was estimated at 0.5 to 47 trees per hectare for savanna and 4.8 to 9.9 trees per hectare for woodland according to research of vegetation patterns of the Upper Mississippi in the Midwest. (Nelson, J.C., et al, 1999)

- Most of the riparian area of Duck Creek is maintained as park land with a bicycle and pedestrian trail providing views of the Creek. Except for the heavily wooded areas, the riparian zone is typically mowed to the streambank. The stream restoration plan calls for planting a native buffer at least ten feet wide from the top of the bank. Where a large open area is maintained as turf, the plan recommends converting some or all of that area to native vegetation.

Implementation Plan. For each reach of Duck and Blackhawk Creeks, an implementation plan was developed that details the types of improvements recommended, their priority for implementation, and the estimated cost. The plan also includes maintenance recommendations. Figure 7 shows the implementation plan for about 1,400 linear feet of Duck Creek. Stream reaches were characterized as low, medium and high priority, depending on potential damage to public and private infrastructure and lateral recession rates between 0.1 -0 0.5 ft/yr – low, 0.06 to 0.2 ft/yr medium, and >0.3 ft/yr as high.

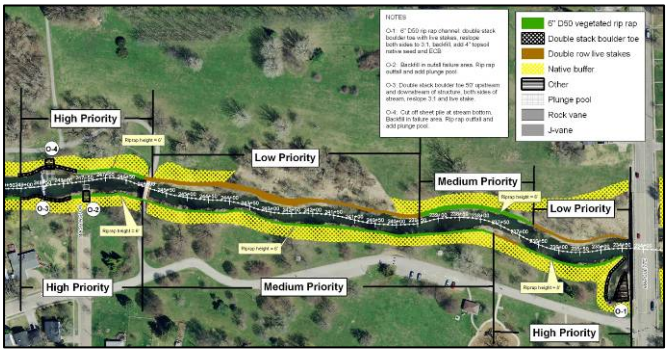


Figure 7. Stream restoration plan for a segment of Duck Creek.

The stream restoration recommendations were compiled into a GIS shapefile and overlaid onto aerial photos of the streams by reach. The restoration plan also includes standard detail plates developed for each of the treatment methods. These plans and details can form the core of construction bid documents, or can provide guidance to city crews that may be undertaking portions of the restoration.

The final report provides a master plan for the ultimate restoration of degraded channel reaches and a protection plan for reaches that are relatively untouched.

SUMMARY

The rapid stream assessment process was ideal for efficiently evaluating stream conditions and developing a management plan for the streams. The combination of initial desk study using best available information on topography, soils, land use and parcel data combined with current and historic aerial photos provided a first cut at identifying problem areas. Field work confirmed initial observations and provided new insights into the reasons for degradation and potential solutions. City staff further verified the problem reaches and the most likely potential solutions that would work on a local level.

The report detailed specific projects for each stream segment needing stabilization and activities for those areas that need protection from future degradation, along with priorities for action and estimated cost. The final result is a long-term action plan so that the City of Davenport can protect and improve these valuable water resources.

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