Section 7
Fluvial Geomorphic Evaluation

7.1 Introduction

Fluvial geomorphology is the process of how moving water shapes the land. Fluvial relates to flowing water and geomorphology refers to the systematic examination of land forms. Combined, fluvial geomorphology is the systematic examination of land formed by flowing water either through erosion or deposition. Correspondingly, the fluvial geomorphic processes are examined in relation to dynamic equilibrium. This equilibrium is the balanced movement of water and sediment under dynamic (variable) flow conditions typically inherent in a natural environment.

The purpose of the Deadmans Run geomorphic investigation was to determine the geomorphic conditions of three stream segments, including two unlined stream segments of the main stem and one unlined tributary segment. By understanding the geomorphic conditions of the watershed, the locations and prioritizations of interventions can be determined for managing the main stem and tributary. Primary elements of this investigation included a field reconnaissance and classification of the current condition of the waterways along the following segments of the Deadmans Run Watershed (Figure 7-1):

- Segment 1: Tributary upstream of Sycamore Drive Extension to Skyway Road
- Segment 2: Main channel downstream of Wedgewood Lake to Corporate Drive
- Segment 3: Main channel extending from Cornhusker Highway to the confluence with Salt Creek

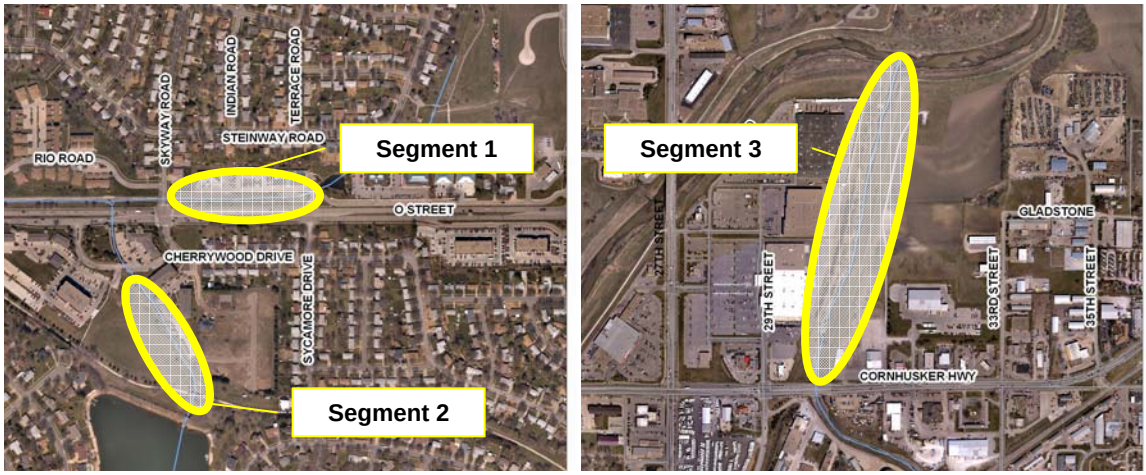

Figure 7-1
Geomorphic Evaluation Stream Segments

7.2 Geomorphic Field Reconnaissance

Detailed field reconnaissance was conducted in June 2006. The approach to the field reconnaissance for the Deadmans Run Watershed was to observe geomorphic conditions and indicators currently present in the watershed. Each of the identified waterways was walked and pertinent geomorphic observations were recorded with a Pocket PC equipped with ArcPad Version 7.0 and a GPS unit. The City provided topographic contour, street, and stream alignment shapefile layers to locate features.

The data recorded in the field were grouped into suites including:

- Bars
- Channel dimensions
- Crossings
- Erosion and mass wasting
- Material
- Notes (miscellaneous)
- Outfalls
- Photographs
- Profile features
- Vegetation

The shapefiles for these field notes, as well as photographs taken during field reconnaissance, are included in the electronic files of Appendix A. Typically, at a minimum, two photographs, one looking upstream and the other looking downstream, were taken at each chosen location.

7.3 Evaluation Results

Reach description summaries for the stream sections evaluated by the project team are provided in Appendix E. These reach summaries include an interpretation of historical data reviewed and the conclusions from the geomorphic assessment completed by the project team.

7.3.1 Historical Background

The archived aerial photographs for Segments 1 and 2 are presented on Figure 7-1 while Figure 7-2 shows the historical photos for Segment 3. The following descriptions are based on a review of available aerial photographs and historic maps provided by the City/NRD or obtained by the project team.

Segment 1: Sycamore Drive Extension to Skyway Road: In 1959, the alignment along the north side of O Street was straight, indicating channelization with only a few isolated trees along the channel in a rural setting. The channel remained relatively unchanged through 1965 and nearby areas did not show signs of urbanization until 1999. By 1999, the Dialysis Center detention pond at the Sycamore Drive extension was present and the channel was lined with concrete upstream and downstream of this reach. Further, more trees are seen along the channel and signs of active meandering were visible along the upstream half of the channel. By 2002, many of the trees appear removed and the signs of remeandering along the channel are more pronounced, encroaching on O Street, especially along the east portion. By 2005, the channel meanders were essentially graded out of the channel and the channel is reasonably straight. The banks are essentially turf grass with isolated trees and brush as seen today.

Segment 2: Wedgewood Lake to Corporate Drive: As depicted on Figure 7-1, the main channel shows meanders in 1959 with a single row of isolated trees along the banks in a rural setting. The present day trail is a railroad alignment. By 1965, Wedgewood Lake and its dam are present and the channel has been straightened. Residential development is beginning to appear at a distance away from the main channel.

The railroad alignment was changed to a pedestrian/biking trail by 1999. Residential and commercial developments have fully encroached around the channel to the east and plans have recently been submitted to the City for development on the west (left descending) bank.

The channel shows some deviation along its straight alignment seen in 1965, but the overall alignment is straight. A scour pool, as seen today, is downstream of the spillway. Field investigations revealed current conditions are similar to the 1999 photograph.

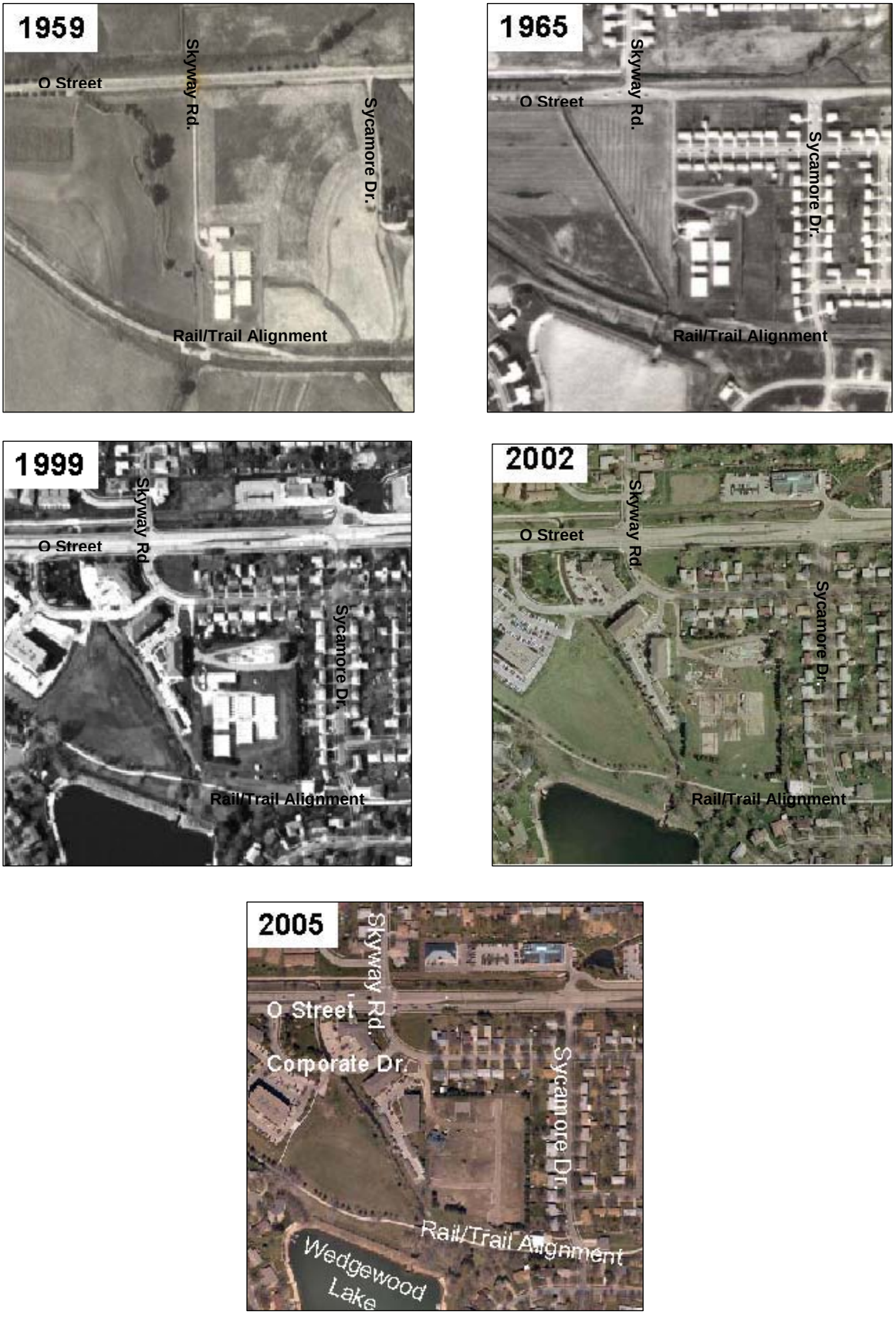

Figure 7-2
Segments 1 and 2 - Historical Photographs

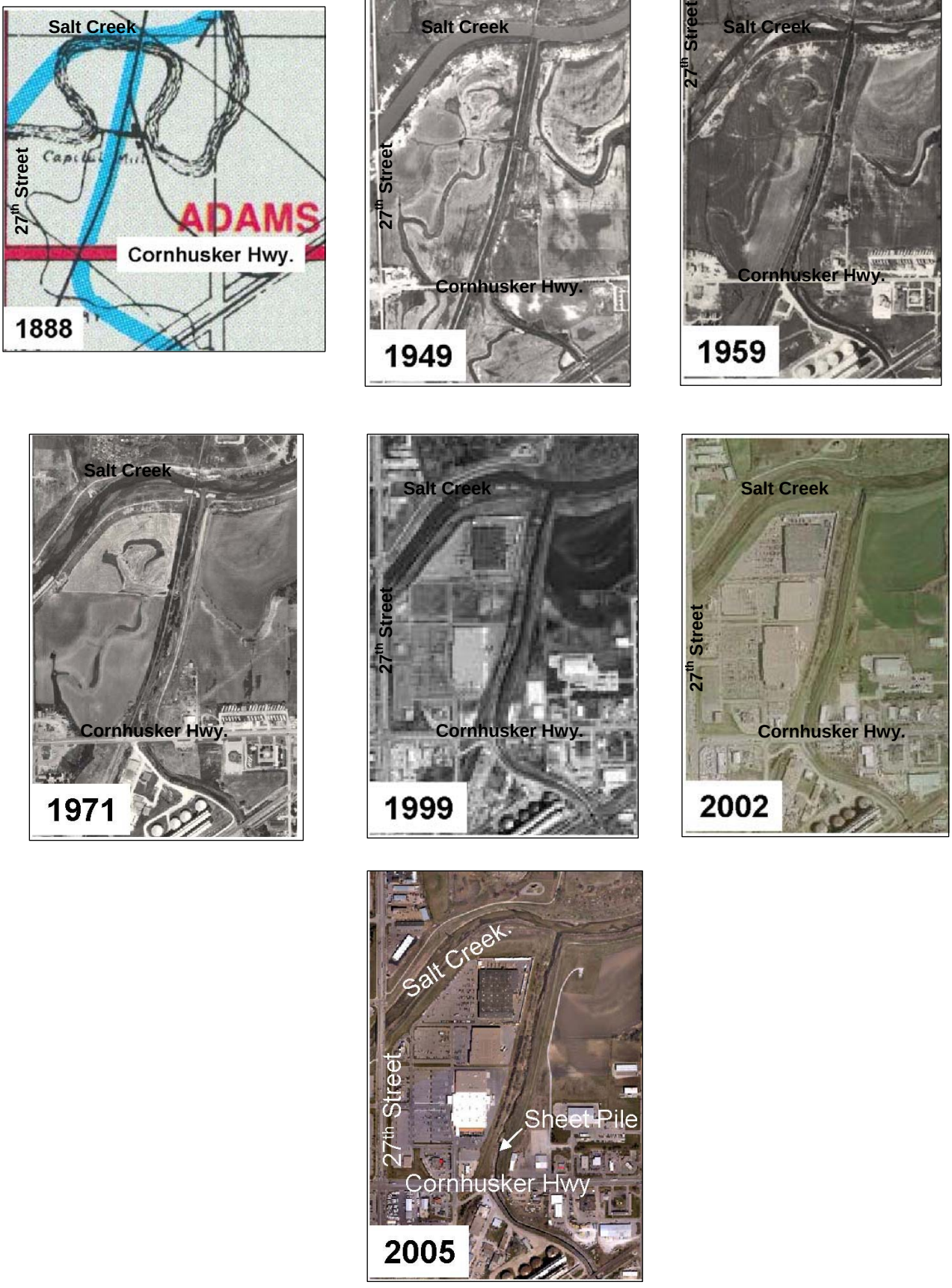

Figure 7-3
Segment 3 - Historical Photographs

Segment 3: Cornhusker Highway to Salt Creek Confluence Main Stem: Since 1888, the Deadmans Run and Salt Creek channels have been straightened and shortened. Deadmans Run, downstream of Cornhusker Highway, was shortened by approximately 15 percent (Figure 7-2). More importantly, the channel was straightened. Scroll marks, seen in the aerial photographs dating to 1949, indicate meandering radii for Deadmans Run in the order of 75 to 150 feet. As seen in 1949, the railroad had been aligned along the west side of the channel. Land use around the channel was rural. In 1971, the channel exhibited some meandering, but by 1999 the channel was again straightened. Between 1971 and 1999, the channel upstream was lined with concrete and the sheet pile wall was placed at the upstream end of the study reach. By 1999, the railroad was gone and commercial development encroached the channel along the west side and near the channel along the east upstream half. Further, by 1999, bank erosion is evident along the 650 feet of the upstream portion of the left bank, and becomes prominent by 2002, and even more prominent through 2005. It was not until 2005 that the erosion downstream of the storm sewer acting as a flow vane appeared. In 2007, corrective action is planned by the City's Wastewater Division to mitigate the erosion at the flow vane, as well as upstream of the area. Sheet pile walls are planned to be constructed in two sections to armor the low flow banks on each side of the stream with the intention of avoiding additional erosion in the area.

7.3.2 Stream Stage Classification

As summarized above, one of the key objectives of the evaluation was to evaluate the current conditions of the stream system. Schumm (1984) and Simon (1989) have classified the process of how streams reestablish equilibrium after a disturbance to the channel or the watershed. Simon classifies this reestablishment into six stages: I) Pre-Disturbance, II) Disturbance, III) Incision, IV) Widening, V) Deposition, and VI) Recovery and Reconstruction. Figure 7-4 schematically depicts each of these stream stages.

Segment 1: Sycamore Drive Extension to Skyway Road: The creek along this reach is primarily a trapezoidal channel with turf-grass-covered banks. Medium-sized trees are located along the left descending bank crest and more brushy-type woody vegetation is near the crest along the right descending bank crest. The nominal flow at the bottom of the channel is from flow overtopping and leaking through the stoplog weir located immediately upstream of the Sycamore Drive crossing and potentially from groundwater base flow. Rushes line the edges and are growing in the bottom channel at several locations, indicating a typical low energy waterway.

Evidence of incision and active meandering as seen in the historical aerial photographs was not observed. The 6- to 8-inch diameter pieces of crushed limestone in the channel have apparently abated incision since repairs to the banks and channel. However, current practices of mowing the shallow-rooted grass as close as possible to the waters edge (including rushes) and close to the ground have seriously reduced the potential of filtering surface water before it reaches the channel and of the roots reinforcing the banks. Several areas of the banks were scalped to bare ground, thus eliminating the potential for the turf grasses from reinforcing the near surface and providing a stormwater buffer. The combination of shallow-rooted grasses along the banks and current mowing practice may have initiated the bank instabilities in the past. Using Simon's Classification for urban channel evolution as seen on Figure 7-4, this reach is classified as Stage V/VI.

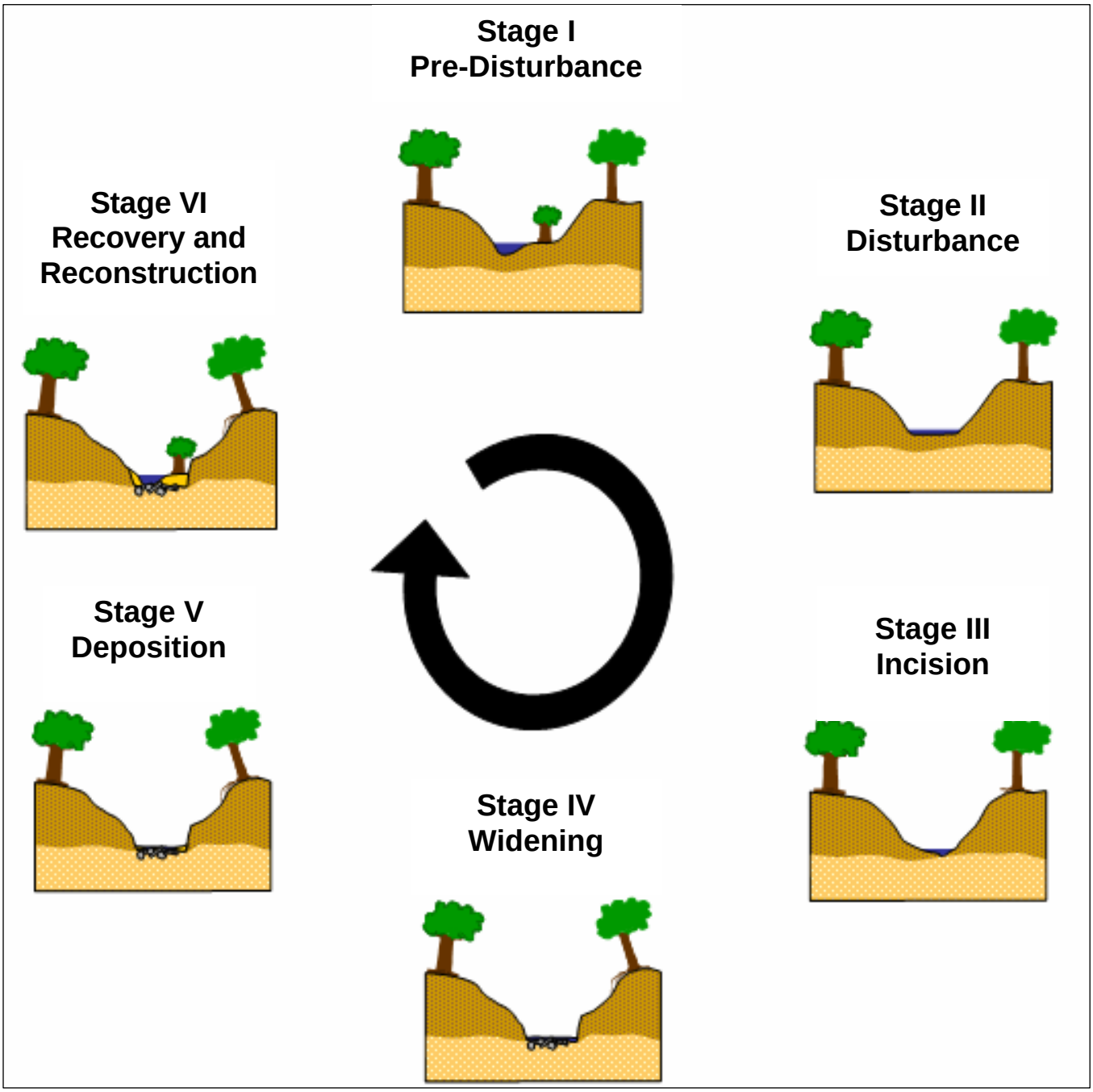

Figure 7-4
Channel Evolution Model (Simon 1989)

Segment 2: Wedgewood Lake to Corporate Drive: From the spillway of Wedgewood Lake to the pedestrian trail bridge, this tributary is reasonably stable with a two-stage channel and good bank reinforcement from existing woody vegetation. There is a knickpoint at the end of the concrete slab leading from the spillway, but the channel appears to have adjusted to the grade change and large broken slabs of concrete armor the bottom.

Downstream of the pedestrian bridge, the tributary is wider and appears to form a backwater condition upstream of the Corporate Drive crossing. Erosion is not a factor for this portion of the stream reach and sedimentation is less of a concern because of the limited sediment source along the banks and the upstream sediment sink of Wedgewood Lake. The main limiting factor for this portion of the reach is the narrow vegetative buffers along either side of the tributary. Algae and duckweed were of limited presence, but the potential for both species thriving following the loading of nutrient-rich surface waters flowing to the channel was apparent. Using Simon's Classification for urban channel evolution, this reach is classified as Stage V/VI.

Segment 3: Cornhusker Highway to Salt Creek Confluence: The sheet pile wall located near the Cornhusker Highway crossing and at the end of the lined trapezoidal channel remains an effective grade control, abating migration of the headcut upstream. The scour pool downstream of the sheet pile wall appears to have sized itself accordingly to the drop and flow from the sheet pile wall. Immediately downstream of the sheet pile wall is a 48-inch corrugated metal pipe (CMP) along the left descending bank, labeled Outfall 1 in Figure 7-5. The flow during rainfall events from this outfall appears to direct the flow of the main stem over to the right descending bank, resulting in localized scour along this bank. This directing of flow also appears to set up the meandering front, such that the left descending bank shows erosion downstream.

The erosion continues along the left descending bank for approximately half the distance between the sheet pile wall and the confluence with Salt Creek. The right descending bank may not show as much scour because it was regraded. The creek is undergoing active re-meandering from Outfall 1 and Outfall 3. Outfall 3 is a destroyed 36-inch CMP along the left descending bank, approximately 1,000 feet downstream of Cornhusker Highway.

When Outfall 3 was installed, the outside bend of the meander was likely along the right descending bank. During higher flows, which overtopped the CMP outlet frame, the bank behind the frame scoured, exposing the fine glacial outwash sand that underlies the loess. The overtopped pipe became a flow vane, directing the flow perpendicular to the pipe alignment. Water flows over the pipe until the sand is eroded under the pipe and the undermined pipe collapses. This sequence is repeated along the inclined pipe and the erosion migrates to the left bank.

Between Outfall 3 and Outfall 6, localized bank degradation is observed, where the flows have acted as turning vanes. Sedimentation through bar deposition is prevalent along the entire unlined portion of this reach. The bars within the remeandering segment are irregular, which would be expected. Downstream of Outfall 6, the bars become somewhat more regular-shaped. Closer to the confluence with Salt Creek, submerged ripples and megaripples of sand along the channel bottom are prevalent. Using Simon's Classification for urban channel evolution, this reach is classified as Stage IV/V.

Figure 7-5
Segment 3 - Existing Outfalls

7.3.3 Summary Discussion

Segments 1 and 2 appear reasonably stable. The knickpoint downstream of the Wedgewood Lake's spillway (Figure 7-6) appears abated by the armoring in the channel. Segment 3 is undergoing a combination of widening and remeandering with mobile bar deposition. The knickpoint and zones in this area are depicted on Figure 7-6.

Figure 7-6 also presents the shear in the channel at the bankfull height (depth), which should be the stage of the channel-forming flow. These figures depict shear along the channel, which was calculated using the slopes from topographic contours provided by the City. Although Segments 1 and 2 are reasonably stable, higher shear values were calculated in these areas ranging from 0.9 to 1.7 pounds per square foot (lb/ft^2). This is an indication that these reaches show a significant potential for erosion should the flows scour under the shallow-rooted and stressed bank vegetation or if current channel armoring such as the 6- to 8-inch diameter rocks are removed. This mechanism of scour became evident in the 2002 aerial photograph of the upstream reaches. Although the shear values (0.3 to 0.6 lb/ft^2) in Segment 3 are less than those of the upstream reaches, the threshold shear of the silty/sandy bank

material (shear less than 0.1 lb/ft²) is less than the calculated shear. Thus, when scour is concentrated around structures such as the culvert outfalls, the underlying bank material provides little resistance to erosion under the back cover.

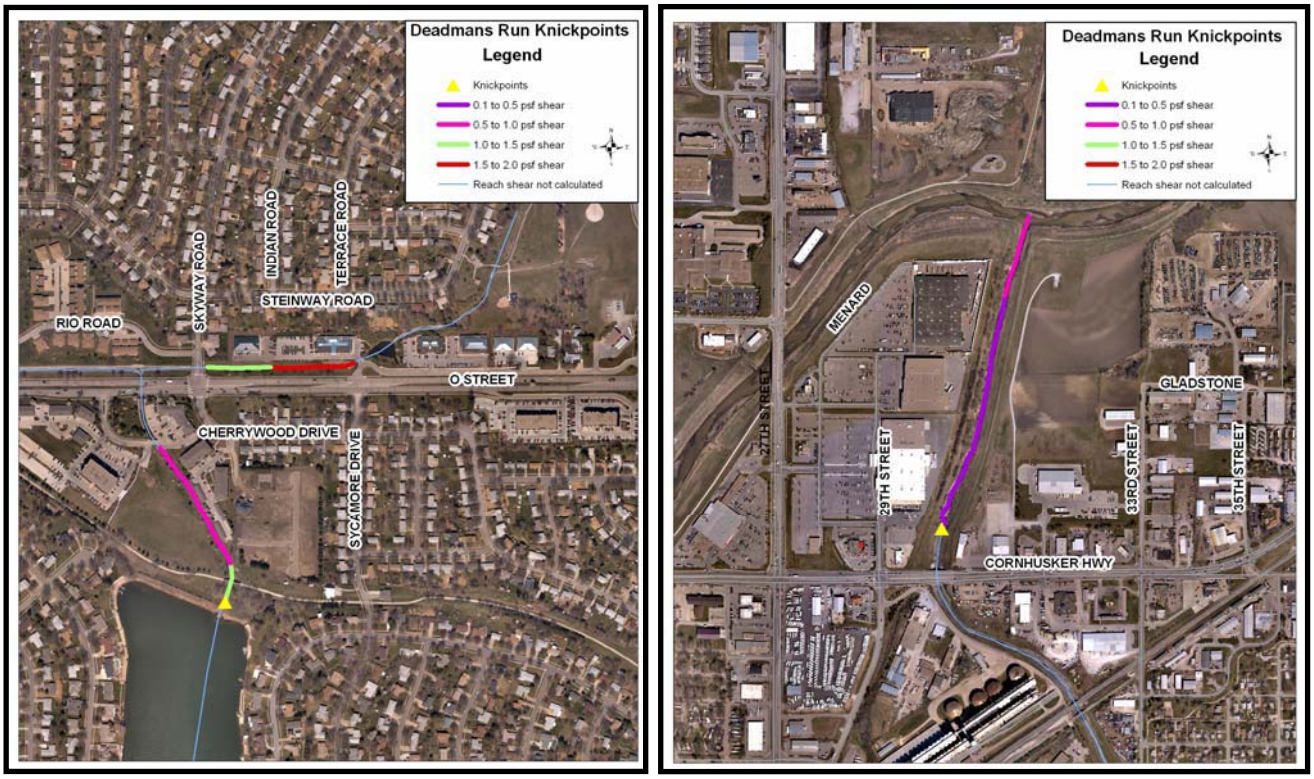

Figure 7-6
Deadmans Run Knickpoints

7.4 Stream Improvements

Segment 1 appears reasonably stable at this time; however, enhancements to the stability of the channel can be achieved by planting deeper-rooted woody and mesic prairie vegetation along the banks and placing several grade controls to maintain the channel slope. For Segment 2, establishing a wider vegetative buffer downstream of the pedestrian bridge will provide stormwater quality filtering. Each reach is encountering localized issues that should be addressed during routine maintenance activities. The severities of these issues are not critical and do not warrant inclusion in the recommended Master Plan improvement projects.

For Segment 3, current conditions are endangering utility and building infrastructure along the left (west) bank, requiring stream improvements focused at abating the extensive active meandering. To assist the creek in its attempt to reach dynamic equilibrium, the following is recommended:

- Remeandering the entire reach with a two-stage channel that will also facilitate flood conveyance
- Reconfiguring the left descending bank and right descending bank
- Raising the channel bed downstream of the sheet pile wall with grade controls

Further details regarding the recommended Segment 3 stream improvements are provided in Section 8 of this report.