Section 5
Capital Improvement Projects

5.1 Problem Identification

The results of the hydrologic, hydraulic, and geomorphic evaluations discussed in the previous sections of this report formed the foundation for identifying problem areas in the watershed. Problem areas were classified as primary or secondary.

Primary problem areas are those that pose a serious public safety concern with respect to frequent building flooding, stream instability, or severe maintenance conditions. In addition, primary problem areas include sites where stream degradation or instability exist, which creates a clear influence elsewhere in the watershed. Secondary problem areas include sites where stream degradation or instability exist but are not likely to propagate to other areas of the watershed. Secondary problem areas also include infrequent flooding of habitable buildings.

Three major categories were used to evaluate potential primary and secondary problem areas: (1) drainage infrastructure, (2) habitable buildings, and (3) natural streams. For primary problem areas, a prioritized list of recommended improvements was developed to form the basis of the CIPs, which is presented in Section 5.2. Secondary problems are described in Section 5.3.

The following subsections provide the methodology used to identify primary and secondary problems within each of the three major categories.

5.1.1 Drainage Infrastructure

Because of the rural nature of the watershed, a significant number of unimproved roads are located throughout the study area. As development continues in the watershed, it is anticipated that drainage infrastructure (e.g., culverts and bridges) will be replaced or retrofitted at the same time the road is improved. Therefore, for the purposes of this study, the approach was to provide the necessary design data for each modeled drainage structure to be used during detailed design at the time the roadway is upgraded. The design data for each modeled drainage structure, as determined by USGS, is provided in Appendix D.

Drainage structures in need of immediate structural repair were considered a primary problem. Routine maintenance needs required to maintain the capacity of the drainage system were classified as secondary problems. Applying these criteria resulted in no primary or secondary problem areas under this category.

5.1.2 Habitable Buildings

The hydrologic and hydraulic computer models developed by USGS (Phase 1) included the estimation of the 2-, 5-, 10-, 50-, 100-, and 500-year peak stormwater flow rates and resultant water surface elevations (WSEs). For the purposes of this study, frequent habitable building flooding (2- and 5-year design storms), typically caused by an altered drainage system, was considered a primary problem. Applying these criteria resulted in

one primary habitable building problem area located along the south tributary and adjacent to Bobcat Circle.

Habitable buildings being impacted from the 10-, 50-, and 100-year design storms occur much less frequently, and therefore were classified as secondary problems. Secondary problems are typically associated with deficiencies within the adjacent altered drainage system, which is identified as the cause of the flooding.

Habitable buildings located in the natural 100- and 500-year floodplains were not considered primary or secondary problem areas. However, under unique circumstances, buildings located within the natural (rural) floodplain could be considered a secondary problem. For the Cardwell Branch study area, one secondary problem area was identified that addresses habitable buildings located within the natural floodplain. Because improvements designed to remove habitable buildings from the natural floodplain are cost-prohibitive, identifying low cost options is the preferred approach, which is further discussed in Section 5.3.

5.1.3 Natural Streams

The geomorphic evaluation discussed in Section 4 was used to identify primary and secondary stream instability problems. Each stream instability problem was assigned a category based on the descriptions below.

- **Category 1 – Hazard.** These stream conditions pose a near-term threat to public safety or significant infrastructure and should be repaired promptly. Sites exhibiting clear evidence that a long delay in treatment will potentially lead to a permanent loss of property or a dramatic increase in the cost of treatment directly associated with the progression of the problem receive a Category 1 rating.

- **Category 2 – Systemic.** These sites, while not posing an immediate public hazard, are fundamentally unstable with clear influence elsewhere in the watershed. The series of knickpoints mentioned above is an example of this case. While the knickpoints may pose no immediate threat if left untreated, the incision migrating throughout the watershed will. As the bed elevation drops, bank heights increase and consequently so does the risk of mass wasting, the generation of massive sediment, and the risk of bridge and culvert sedimentation. Category 2 problem areas are not emergencies but should be addressed as soon as funding permits.

- **Category 3 – Supporting Systemic.** Like the Category 2 problems, these sites include ongoing channel adjustment conditions. However, either because of location in the watershed or particularly robust channel conditions, propagation of the problem is less likely or is proceeding relatively slowly.

- **Category 4 – Localized.** These problems are distinct from the two previous categories in that the cause is local rather than systemic. Examples of this type of problem include overbank drainage, removal of riparian corridor, and debris dumping.

- **Category 5 – Preservation.** These are opportunities to protect the higher quality reaches of Cardwell Branch. In addition to the aesthetic, water quality, and habitat

benefits, protecting the better functioning reaches provides a reference point for reclaiming the damaged areas. Moreover, the presence of self-managing reaches buffers some of the effects of stream degradation.

- **Category 6 – Enhancements.** These are opportunities to prevent future problems, reduce water and sediment conveyance stress on the stream system, or to otherwise improve stream performance. This category includes improvements that increase infiltration, dissipate or direct energy, or reestablish a normal grade for streambanks.

Categories 1 and 2 are considered primary problem areas. In addition, Category 3 areas located within the City of Lincoln's Tier 1 growth area were also considered primary problem areas, due to the near-term growth potential. Category 3 areas located outside of the Tier 1 growth area were considered secondary problems, as were all Category 4, 5, and 6 locations.

None of the problem areas were given a Category 1 designation, while 7 problem areas were assigned as Category 2 and 1 problem area was assigned as Category 3 (within Tier 1 growth area), for a total of 8 primary problem areas. A total of 27 secondary problems was identified that received a priority of 3 (outside of Tier 1 growth area), 4, 5, or 6.

5.2 Primary Problem Area Improvements

Conceptual recommended improvements were developed to address each primary problem area, which form the basis for the CIPs. For the Cardwell Branch study area, nine primary problems were identified and are shown on Figure 5-1. Eight of the primary problems were classified as stream instability problems, while one was classified as a habitable building flooding issue. A brief description of each CIP is provided below, followed by the results of applying the City's prioritization process to these projects.

5.2.1 Capital Improvement Projects

The total estimated conceptual level cost estimate for the nine CIPs is approximately $3.2 million. Detailed cost information is presented in Appendix E. All costs are in 2007 dollars. The cost estimates do not include costs for easements or land rights, hazardous waste remediation, utility relocation, or rehabilitation. The nine CIPs are described on the following pages.

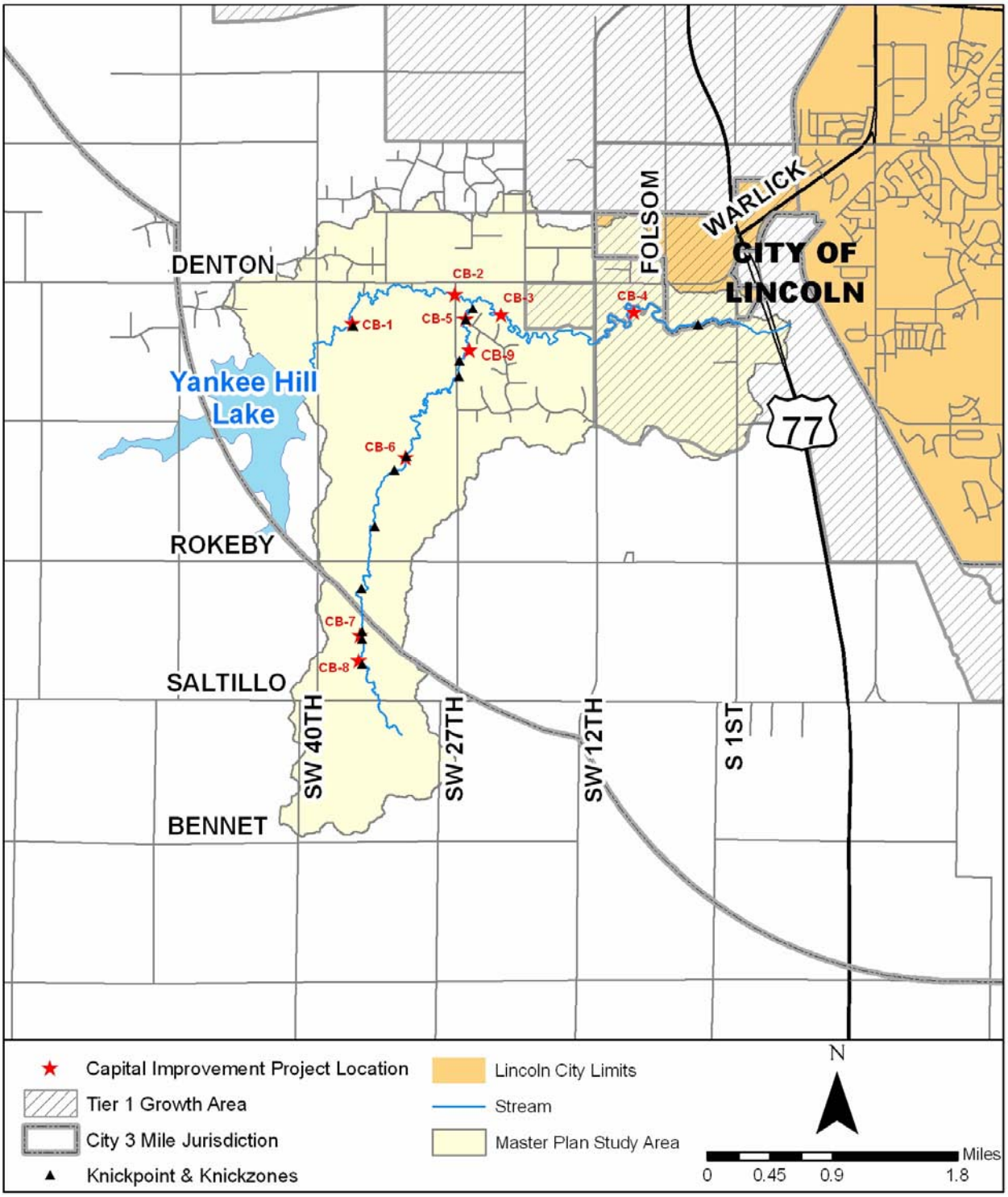


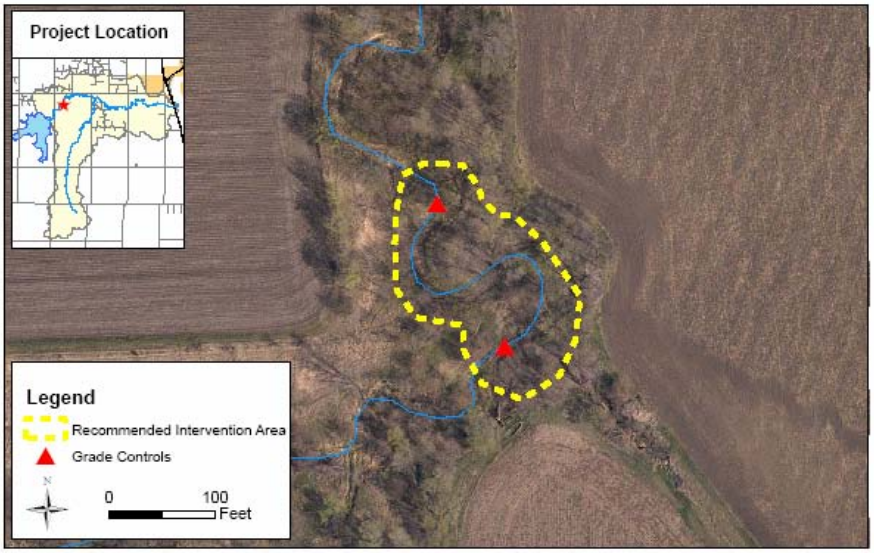
Figure 5-1
Cardwell Branch CIP Locations

Project CB-1: Main Stem, Station 319+50 to 322+80 – Grade Control Incising Channel (Category 2)

Project CB-1 location area, looking upstream

Problem Description: Extensive downcutting, a relatively narrow lower channel and at least one knickpoint was observed in this segment. Accumulations of woody debris apparently have slowed the rate of incision; but, through the presence of the knickpoint in the bare channel, incision has not been abated. Continued incision will generate more woody debris, as well as generate significant sediment. Further, the upstream migration of incision will erode the channel and degrade the banks upstream and along this segment. Further accumulation and raising of woody debris along existing locations of the main stem may contribute to backpooling behind the debris and thereby lead to uncontrolled flooding.

Recommended Interventions: Placing several grade controls to arrest incision and direct flows along the fairly tight meanders. The grade controls should be Newbury-type rock structures with gently sloping tailwater ramps. The grade controls should be shaped to direct flows through the tight meanders as well as manage meander migration. Other than vegetating the transitions upstream and downstream of the grade controls, the current condition of the banks does not warrant further stabilization.



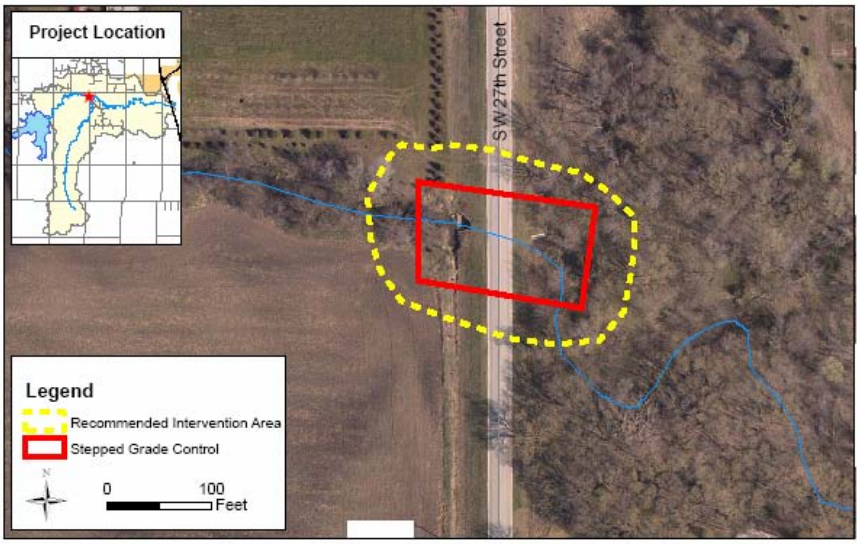
Estimated Project Cost: $228,900

Project CB-2: Main Stem at SW 27th Street Crossing, Station 241+60 to 242+80 – Grade Control Headcut at Road Crossing (Category 2)

Project CB-2 location area, looking downstream from SW 27th Street culvert

Problem Description: The headcut underneath and downstream of the crossing is currently stabilized by ongoing armoring of the channel. The channel bed elevation difference upstream and downstream of the crossing is 4.0 feet for a channel slope in excess of 0.03 ft/ft, indicating the presence of a knick zone. This slope is highly unstable for the natural bed and bank soils and will cause significant degradation of the channel under the crossing and downstream of the crossing. Should the knick zone under this crossing be allowed to migrate upstream, the channel will incise as deep as 4 feet, thereby causing bank instability and significant generation of sediment and woody debris. In particular, this woody debris could block the crossing.

Recommended Intervention: Stabilizing the knick zone more permanently with a stepped-grade control structure immediately downstream of the crossing with a scour pool. The grade control structure shall be constructed of crushed stone with a cross-sectional shape that directs the flow toward the center of the channel. The scour pool shall be sized to properly dissipate energy at the end of the stepped structure. The current condition of the banks does not necessitate extensive bank stabilization other than what would be required for the installation of the stepped-grade control and scour pool.



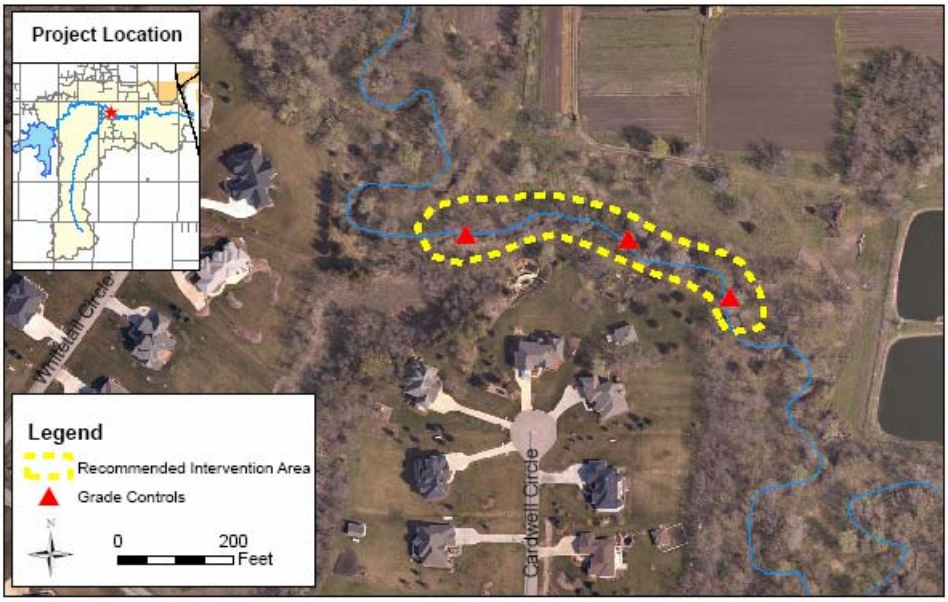
Estimated Project Cost: $349,300

Project CB-3: Main Stem, Station 206+50 to 212+00 – Grade Control Flanked Check Dam (Category 2)

Problem Description: The 2-feet high check dam, which crosses the channel near the upstream portion of this segment, was flanked along the right descending bank. It is no longer controlling the grade in the channel and is manifesting itself into a headcut. If left unabated, this headcut will migrate upstream. The eroded channel will raise the banks, exposing bare ground below the root zone. This erosion could potentially lead to bank instability, accelerated generation of woody debris, and toppling of trees and significant sediment generation.

Project CB-3 location area, looking upstream at check dam

Recommended Intervention: Replace the lost function of the check dam with a series of rock grade controls. The grade control structures should be the Newbury-type structures with gentle slope tailwater ramps. Vegetating the transitions from the grade controls to the adjacent banks would provide a more robust and flexible connection between the grade control and natural banks and additional energy dissipation.



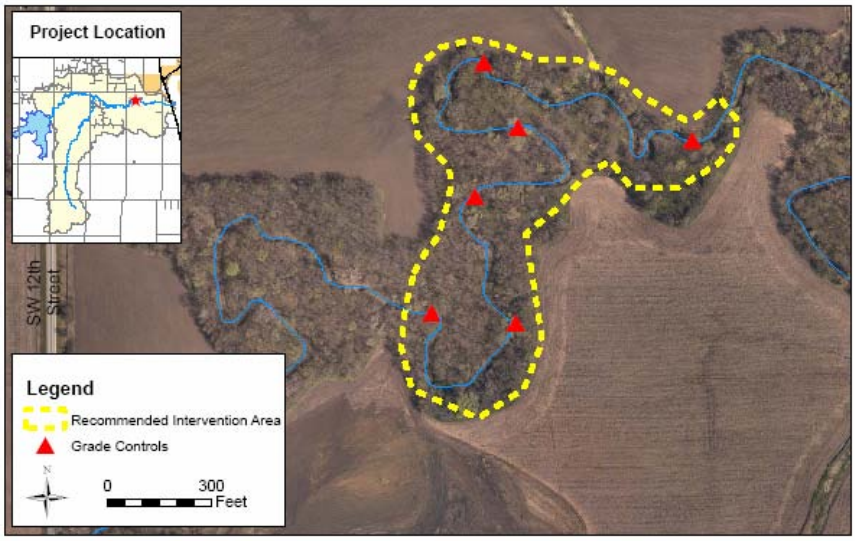
Estimated Project Cost: $275,500

Project CB-4: Main Stem, Station 74+90 to 103+50 – Grade and Flow Control Active Meanders (Category 2)

Project CB-4 location area, looking downstream

Problem Description: This segment shows active meandering as indicated by alternating scoured and bare banks. This active meandering is progressing in the downstream direction. Typically, the scoured banks were bare to nearly bare, and the grass and tree root zones are undercut, leaving overhanging to imminently overhanging trees. If left unabated, this active meandering will continue, scouring the banks over a large scale, generating great volumes of woody debris and sediment. Further, the continuance of this active migration could potentially cut off meanders, shorten the channel length, and cause incision in a location where incision is currently not a process.

Recommended Interventions: Arrest the active channel meandering by fixing select locations of current riffles with rock grade controls. The grade controls should be Newbury-type structures with gently sloping tailwater ramps and a cross-sectional shape to direct flow. Because of the existing tree and other vegetation cover in place, the installation of more robust bank treatments would disrupt the riparian environment more than it would improve it. The diversion of the flow away from the bank would reduce the shear force on these banks and allow them to mend. Further, vegetating the transitions from the grade controls to the adjacent banks would provide a more robust and flexible connection between the grade control and natural banks and provide additional energy dissipation.



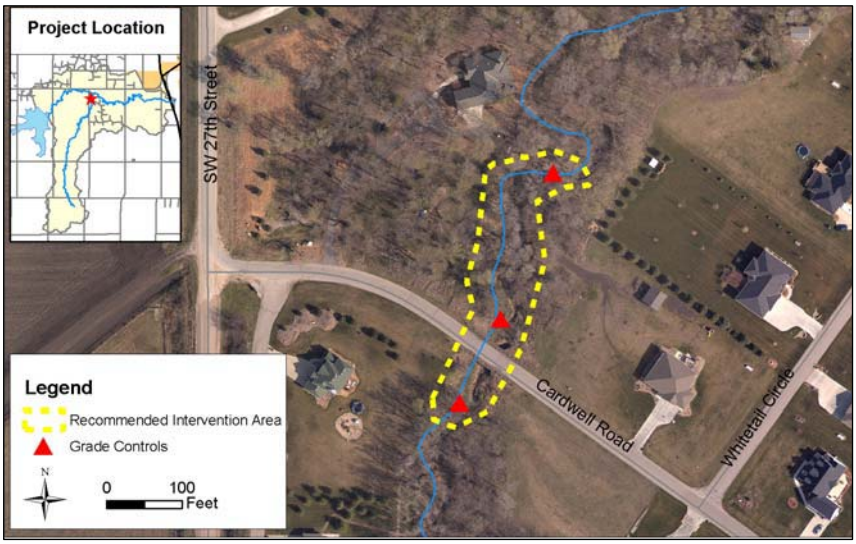
Estimated Project Cost: $703,600

Project CB-5: Tributary, Station 7+50 to 11+50 – Grade Control Incising Channel (Category 2)

Project CB-5 location area, downstream of Cardwell Road

Problem Description: Extensive downcutting with steep banks are present along this segment. At least two knickpoints were found in this segment. The sanitary sewer, encased in concrete, is exposed immediately downstream of the crossing at Cardwell Road and forms one of the knickpoints. Continued incision could undermine the concrete encasement of the sanitary sewer, potentially leading to a line break. The continuation of incision will also generate more woody debris that could block either the tributary or Cardwell Branch. Further, the upstream migration of incision will erode the channel and degrade the banks upstream and along this segment. Additional accumulation of woody debris along existing locations of the tributary may contribute to backpooling behind the debris and thereby lead to uncontrolled flooding.

Recommended Interventions: Placing grade controls to arrest incision and direct flows toward the central portion of the channel. The grade controls should be Newbury-type rock structures with gently sloping tailwater ramps. The grade controls should be shaped to direct flows through the tight meanders as well as manage meander migration. Other than vegetate the transitions upstream and downstream of the grade controls, the current condition of and location of the banks does not warrant further stabilization.



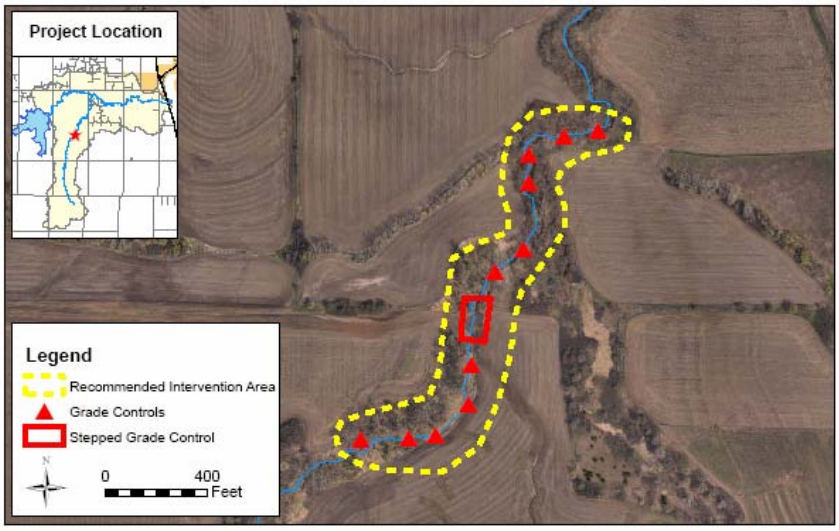
Estimated Project Cost: $237,300

Project CB-6: South Tributary, Station 101+30 to 129+80 – Grade Control Straightened and Incising Channel (Category 2)

Project CB-6 location area, looking upstream at check dam

Problem Description: This segment of the tributary is incised with steep-sided banks and a channel slope approaching 0.007 ft/ft. In addition, the flows at the bankfull/dominant discharge stage exert the highest shear stress on the channel over this segment than any other in the study area. A knick zone approaching 850 feet long is upstream of and through a culvert crossing located in the center of the problem area. The culvert crossing is in poor condition and will likely be flanked or a headcut will propagate through the corroded bottom, thus potentially creating a 4.5-foot high headcut that will ultimately migrate upstream. The banks, with little or no deep root reinforcement from woody vegetation, will slough and erode and generate significant volumes of sediment. This sediment will accumulate downstream in Cardwell Branch and Salt Creek. Further, continued degradation of the banks and lack of stream energy management will continue until the channel slope flattens and the channel widens after it incises.

Recommended Intervention: Several rock structures in conjunction with a stepped-grade structure and scour pool will manage the channel slope, abate migration of the knick zone, and provide longer-term stabilization than the existing culvert. The grade controls should be Newbury-style structures, which are hydraulically rough with gentle tailwater slopes. The stepped-grade control structure with a scour pool should be placed in the area of the existing culvert crossing. The grade control structure shall be constructed of crushed stone with a cross-sectional shape that directs the flow toward the center of the channel.



The scour pool shall be sized to properly dissipate energy at the end of the stepped structure. Currently, the banks are in good enough condition not to warrant bank stabilization other than vegetated transitions upstream and downstream of each structure and around the scour pool. Further, the installation of the grade controls should provide a stabilizing influence through diverting flows away from the banks and thereby reducing the stress on the banks. However, the current bank vegetation is the invasive reed canary grass. Augmenting the stability of the banks with deeper rooted vegetation along the banks near construction access points would prove fortuitous.

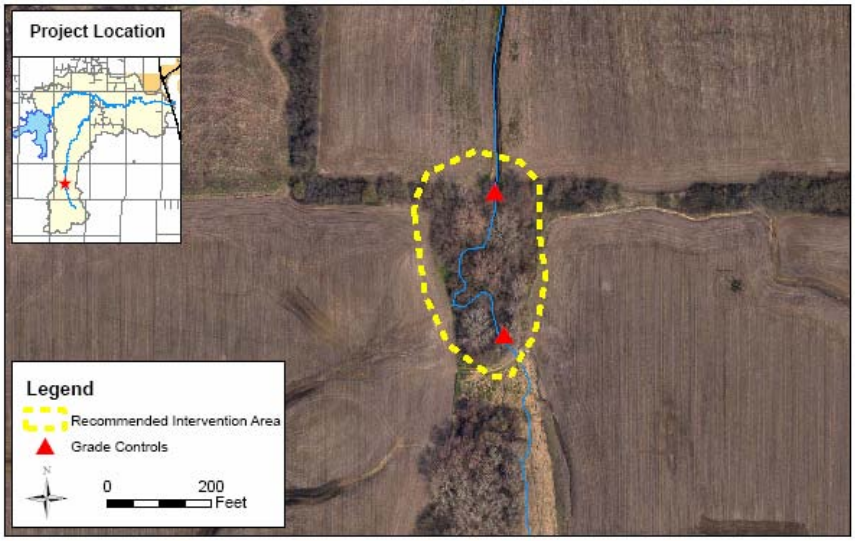
Estimated Project Cost: $890,100

Project CB-7: South Tributary, Station 202+30 to 208+30 – Grade Control Incising Channel (Category 2)

Project CB-7 location area, looking upstream at knickpoint

Problem Description: This segment of the tributary shows signs of incision through steep banks and at least two knickpoints. Currently one of the knickpoints is abated by tree roots that are being undermined such that there are little or no mechanisms to prevent incision from migrating upstream. Unless the headcuts are more permanently arrested, the upstream channel will downcut and the banks will erode and generate significant volumes of excess sediment that will accumulate downstream in the Cardwell Branch main stem and Salt Creek. Further, the stable channel upstream of this incised segment will not be preserved.

Recommended Intervention: Several rock structures will abate migration of the knickpoints or headcuts and will provide long-term preservation of the upstream stable channels. The grade controls should be Newbury-style structures with hydraulically rough surfaces and gently sloping tailwater slopes. Currently, the banks are in good enough condition not to warrant bank stabilization other than vegetated transitions upstream and downstream of each structure. Further, the installation of the grade controls will provide a stabilizing influence through diverting flows away from the banks and thereby reducing the stress on the banks.



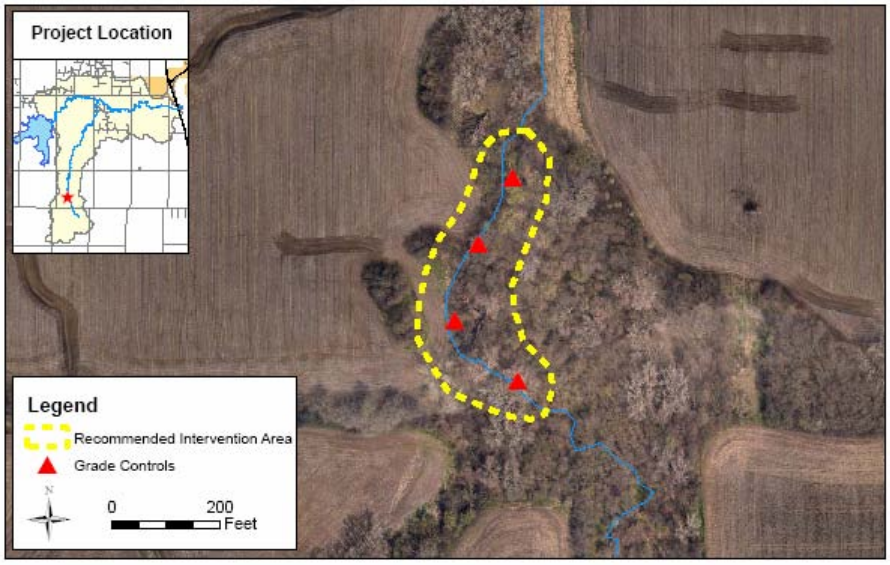
Estimated Project Cost: $216,300

Project CB-8: South Tributary, Station 213+40 to 218+70 – Grade Control Incising Channel (Category 2)

Problem Description: This segment of the tributary shows signs of incision through steep banks and at least one knickpoint. Currently, there are no mechanisms to prevent incision from migrating upstream. Unless the headcuts are arrested, the upstream channel will downcut and the banks will erode and generate significant volumes of excess sediment that will accumulate downstream in Cardwell Branch main stem and Salt Creek. Further, the stable channel upstream of this incised segment will not be preserved.

Project CB-8 location area, looking upstream at knickpoint

Recommended Intervention: Several rock structures will abate migration of the knickpoints and will provide long-term preservation of the upstream stable channels. The grade controls should be Newbury-style structures with hydraulically rough surfaces and gently sloping tailwater slopes. Currently, the banks are in good enough condition not to warrant bank stabilization other than vegetated transitions upstream and downstream of each structure. Further, the installation of the grade controls should provide a stabilizing influence through diverting flows away from the banks and thereby reducing the stress on the banks.



Estimated Project Cost: $226,600

Project CB-9: South Tributary, Station 25+30 to 27+09 – Local Earth Berm

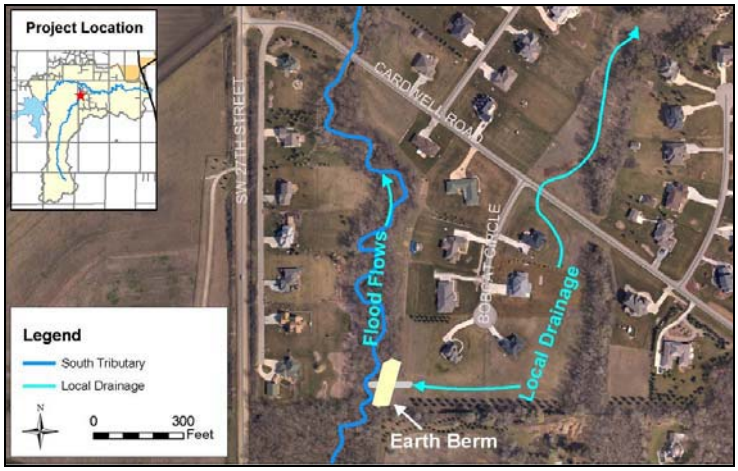
Problem Description: During a severe rainstorm (5-year storm and greater), floodwaters are diverted from the south tributary into a side channel through a "notch" along the streambank. The streambank notch is located just upstream of Bobcat Circle. Once the flow is diverted through the streambank notch, the floodwater is conveyed within a side channel located along the backyards of several buildings along Bobcat Circle, which has the potential to cause flooding. As discussed in Section 2.2, this flooding situation was observed by USGS staff during a recent rainstorm that occurred on May 5, 2007.

Project CB-9 Cardwell Woods Existing Drainage Pattern

Recommended Intervention: This improvement project consists of constructing an earth berm that extends across the "notch." The earth berm extending across the notch would be approximately 6 feet high with 3:1 side slopes, and designed to retain floodwaters within the channel during most flooding conditions. A pipe with flap gate would need to be constructed as part of the earth berm for local drainage back to the tributary. The pipe and flap gate would require regular maintenance. A potential alternative to the pipe and flap gate would include regrading the side channel so that local drainage would flow to the east and then north to Cardwell Road. The earth berm would provide flood protection for buildings along Bobcat Circle; however, the berm would not meet FEMA standards to remove buildings along Bobcat Circle from the floodprone area.

Flooding at "notch" on May 5, 2007

The proposed implementation plan for this project would involve shared responsibility between the public and private sectors for design, construction, right-of-way, and long-term maintenance.



Estimated Project Cost: $45,200

5.2.2 Prioritization

The prioritization of Cardwell Branch CIPs was completed according to the prioritization system that was developed for the City and NRD by a peer review committee to set priorities for the implementation of watershed master planning projects. The peer review committee consisted of local consultants along with City, State, and NRD staff who provided input and suggestions regarding the prioritization criteria and appropriate weighting of the selected criteria. The prioritization system was specifically developed for CIPs that are part of the ongoing watershed master planning efforts.

The prioritization system contains five major categories as summarized below:

- Flooding Impacts – This category identifies the impact of floodwater encroachment on structures, public or private property, parking lots, public utilities, or other infrastructure. The flooding potential can be identified through hydrologic and hydraulic analysis, study of topographic maps, field investigation, and recorded historic problems. This category is further divided according to the frequency of the flooding – flooding that occurs at a more or less frequent rate than the 10-year storm event. Projects primarily intended to address structural or nonstructural flooding will usually incorporate a high or low risk safety factor and may, if applicable, incorporate stream stability or water quality benefits.

- Stream Stability – This category identifies the impacts of channel erosion – the transport and undermining of soil by stream flow or overland flow. Channel erosion can threaten structures, public property, parking lots, public utilities, or other public infrastructure. Channel erosion can also endanger streams, wetlands, lakes, conservation easements, buffer zones, or other natural resources. The stream stability and erosion threat may be identified through basic visual observation, not strictly using a fluvial geomorphic assessment. This category is further divided according to the nature of the erosion, aggressive channel downcutting as compared to gradual channel widening. Projects primarily intended for stream stability typically will not incorporate flooding impact benefits, though will incorporate water quality benefits.

- Water Quality – This category identifies the impacts of water quality. A number of geomorphic mechanisms can adversely affect water quality through increased pollutant loading. The water quality benefits broken down in this category reflect the types of projects developed during watershed master planning efforts. This category is further divided according to the perceived scope of the project benefits, with greater emphasis placed upon projects with broad based impacts. Projects primarily intended for water quality typically will not incorporate flooding impact benefits, though may incorporate stream stability benefits.

- Safety Factor – This category identifies benefits to the potential threat to public health and safety. The potential for loss of life or bodily injury may include individuals trapped in structures during flooding or vehicles being swept away by floodwater. A safety factor is generally associated with projects addressing structural or nonstructural flooding, though may be associated with stream stability or water quality projects.

- Miscellaneous Factors – This category identifies various other miscellaneous factors and additional considerations that have not been addressed in the previous four categories. Examples of other factors include but are not limited to: project location, development status, adjacent projects, complaints, and outside funding opportunities.

For each project, a ranking worksheet was used to assign points under each category, with the goal of developing an overall score. The projects with the highest point score are considered a higher priority. Appendix F provides a copy of each ranking worksheet. Table 5-1 lists the results of the ranking scores for the eight CIPs within the Cardwell Branch study area. For projects with the same overall score, engineering judgment was used to finalize the ranking.

Table 5-1
Cardwell Branch Priority Ranking Results

Project No.	Overall Score	Project Ranking	Project Cost
CB-1	170	9	$228,900
CB-2	205	2	$349,300
CB-3	190	5	$275,500
CB-4	205	3	$703,600
CB-5	205	4	$237,300
CB-6	190	6	$890,100
CB-7	185	7	$216,300
CB-8	185	8	$226,600
CB-9	245	1	$45,200
		Total	$3,172,800

As implementation begins on the Cardwell Branch CIPs, the priority of these projects will need to be reviewed and weighted against other projects included in adopted watershed master plans.

5.3 Secondary Problem Area Improvements

The majority of the secondary problem areas consists of stream instability problems. In addition, there is one location where habitable buildings are located within the natural floodplain, which was identified during the floodplain mapping update process conducted by USGS. The secondary problem area locations are illustrated on Figure 5-2 and summarized below.

5.3.1 Habitable Building

As discussed in Section 1.1, the Cardwell Branch watershed planning process is being conducted using a two-phased approach. Phase 1, called the Cardwell Branch Watershed Assessment was recently completed by USGS (Section 2.2). One of the major outcomes of the Phase 1 planning process was updated floodplain mapping, which is being reviewed by FEMA. In the interim, the City has adopted the study floodplain maps for the purposes of locally regulating the floodprone areas until the FEMA approval process is finalized.

During the Phase 1 public participation process, property owners along Bobcat Circle expressed their concern about residences being shown within the study floodprone areas that are not currently shown within the existing published FEMA floodplain. In response to these public concerns, the City and NRD evaluated feasible low cost solutions as part of the Master Plan effort to reduce the width of the floodprone area along this tributary reach. A potential feasible low cost solution is described below.

5.3.1.1 Potential Feasible Low Cost Solution

The goal of this evaluation was to identify a feasible low cost solution to reduce the width of the floodprone area along the Cardwell Branch south tributary that drains parallel to Bobcat Circle.

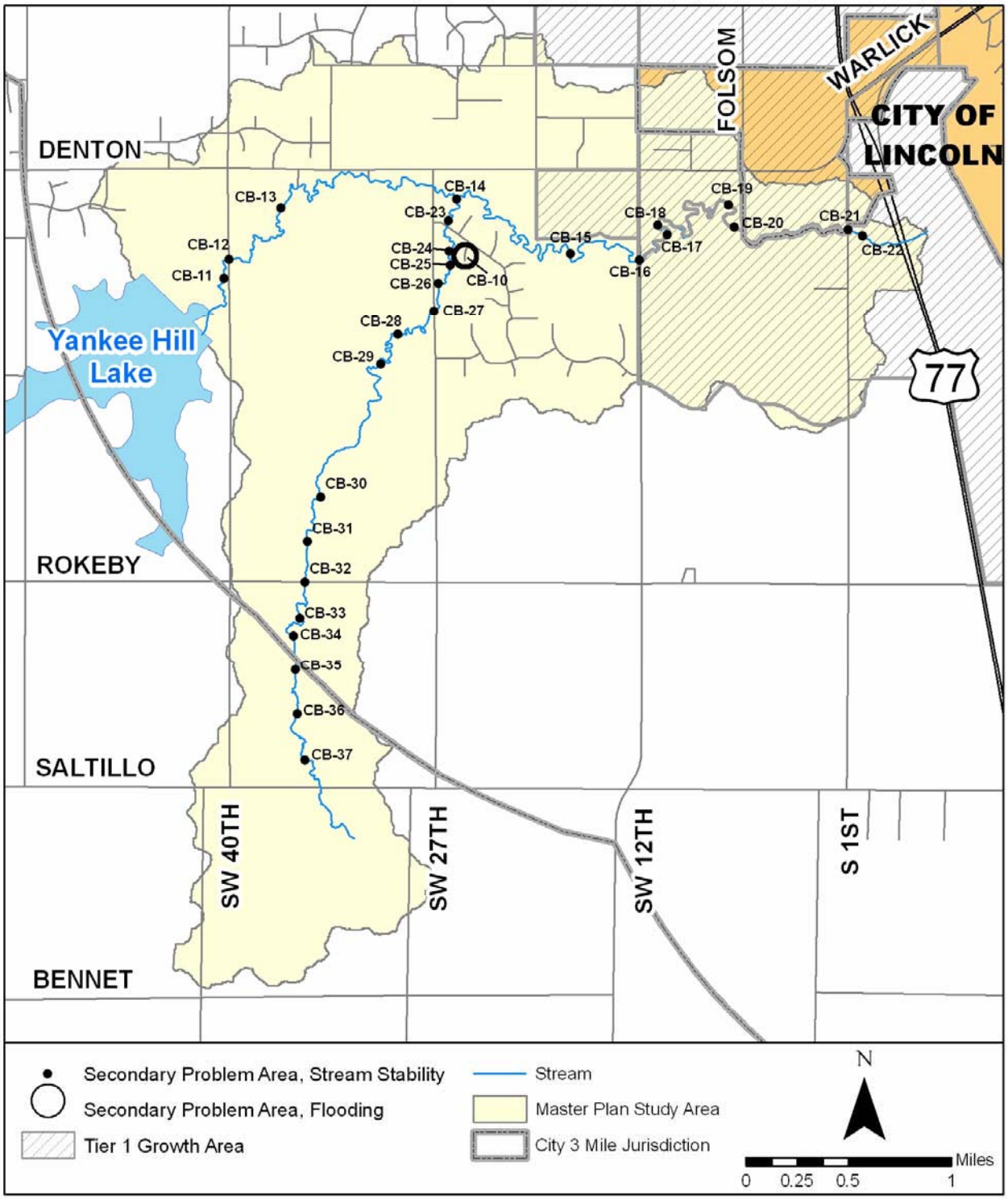


Figure 5-2
Cardwell Branch Secondary Problem Area Locations

To achieve the goal of floodplain reduction, various watershed improvements were considered as potential solutions: grading modifications, multi-use detention, natural channel modifications, and diversion channels. However, only one alternative, grading modifications, was determined to be both low cost and provide flood reduction benefits to the affected property owners. A brief description of the recommended solution is provided below, while Section 5.3.1.2 describes the other alternatives that were considered. The recommended solution is provided as a response to the concerns of local residents and could be completed as a private project.

Project CB-10: Grading Modifications

The recommended improvement project consists of regrading the properties located adjacent to the stream by placing fill in the rear of the properties. The placement of fill would require the buildings to have traditional basements, thereby eliminating the walk-out basement feature. These modifications would elevate the low-flow opening of the building, thus providing additional flood protection to the structure. The estimated project cost per property ranges from $15,000 to $25,000, which would be funded by the property owner. A list of advantages and disadvantages for this alternative follows:

Advantages

- Provides 100-year flood protection for individual buildings along Bobcat Circle.
- Removes individual buildings from the FEMA floodplain, if the grading modifications are completed prior to FEMA adopting the study floodplain.

Disadvantages

- The property owner will need to retain the services of a professional surveyor to fill out the necessary FEMA documents (MT-EZ Form) verifying the low-flow opening of their building.
- The placement of fill and elimination of the walk-out basement feature will affect the functionality and appearance of the property.

5.3.1.2 Other Alternatives Examined

Several other alternatives were evaluated to address the future flooding potential along Bobcat Circle. A brief description of each alternative is provided below.

Regional Detention Basin

This alternative includes the construction of a regional detention basin shown on Figure 5-3. The basin would control the stormwater runoff from the upstream tributary area. The regional detention basin would provide downstream flood control benefits by reducing the 100-year peak flow rates by approximately 90 percent immediately downstream of the basin and approximately 50 percent near SW 27th and Cardwell Road. The basin would also lower 100-year floodplain elevations almost 2 feet in portions of the Cardwell Woods homeowners' association near SW 27th and Cardwell Road. However, the magnitude of this flow reduction is not enough to provide 100-year flood protection for all of the buildings located along Cardwell Road and Bobcat Circle. The estimated project cost for this alternative ranges from $500,000 to $750,000, which does not include costs to acquire land rights. If this alternative is further pursued, additional analysis should be performed to compare cost/benefit ratios

with other alternatives, as well as determine public acceptance of a regional detention facility. A list of advantages and disadvantages for this alternative follows:

Advantages

- Reduces the potential magnitude of flooding along Bobcat Circle and Cardwell Road.
- The detention basin could be designed as a multiuse facility with potential water quality features, recreational features, and long-term stream stability benefits.

Disadvantages

- The detention basin does not provide 100-year flood protection for all of the buildings along Bobcat Circle.
- Requires land rights for 80 to 90 acres.

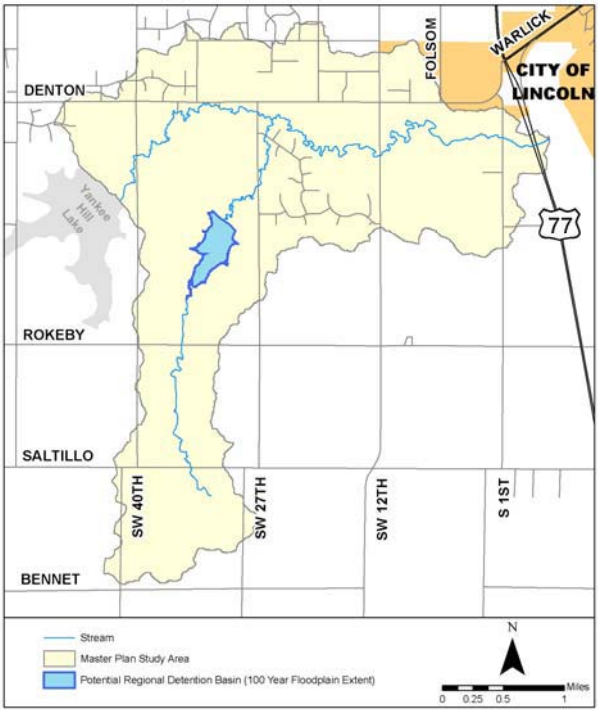


Figure 5-3
Cardwell Branch Potential Regional Detention Basin

Channel Modifications

This alternative includes modifying the stream segment adjacent to Bobcat Circle by constructing approximately 150-foot-wide flood benches on each side of the creek to increase the conveyance capacity of the stream. The flood benches would be constructed to maintain the low flow channel configuration (2-year design storm or bank full stage), while maintaining positive drainage towards the main channel. The flood benches would transition back to existing grade with 2:1 side slopes stabilized with bioengineering methods.

The proposed channel modifications would reduce the magnitude of future flooding along this reach, but would not provide enough additional conveyance capacity to provide 100-year flood protection for buildings along Bobcat Circle. The estimated project cost for this alternative ranges from $500,000 to $700,000. A list of advantages and disadvantages for this alternative follows:

Advantages

- Reduces the potential magnitude of flooding along Bobcat Circle.

Disadvantages

- The channel improvements do not provide 100-year flood protection for buildings along Bobcat Circle.
- The riparian vegetation and habitat adjacent to the stream will be eliminated during channel construction.
- Flood benches would have significant use and aesthetic impacts on the yards of the adjacent residences.

- Will require land rights and cooperation from several landowners, which costs are not included in this estimate.

Channel Modifications with Overflow Swale

This alternative includes the channel modification described above and provides a supplemental overflow swale to provide additional conveyance capacity during flooding conditions. During a severe rainstorm, once the maximum capacity of the channel is achieved, the overflow swale would divert excess floodwaters from the channel to minimize future flooding potential. The overflow swale would be designed to eventually drain back into the main channel of Cardwell Branch at a location north of Bobcat Circle. The estimated project cost for this alternative ranges from $600,000 to $800,000. A list of advantages and disadvantages for this alternative follows:

Advantages

- Provides 100-year flood protection for buildings along Bobcat Circle and would remove residences along Bobcat Circle from the FEMA floodplain through a Letter of Map Revision process.

Disadvantages

- The construction of the overflow swale would require modifications to the local drainage paths in the neighborhood.
- The riparian vegetation and habitat adjacent to the stream will be eliminated during channel construction.
- Flood benches would have significant use and aesthetic impacts on the yards of the adjacent residences.
- Will require land rights and cooperation from several landowners, which costs are not included in this estimate.

Regional Detention with Overflow Swale

This alternative combines the regional detention facility and the supplemental overflow swale concept as described above. The estimated project cost for this alternative ranges from $700,000 to $900,000. A list of advantages and disadvantages for this alternative follows:

Advantages

- Provides 100-year flood protection for buildings along Bobcat Circle and would remove residences along Bobcat Circle from the FEMA floodplain through a Letter of Map Revision process.
- The riparian vegetation and habitat adjacent to the stream will be preserved.

Disadvantages

- The construction of the overflow swale would require modifications to the local drainage paths in the neighborhood.
- Costs do not include land rights, which would be significant.

5.3.2 Natural Streams

The majority of secondary problem areas are associated with natural stream instability areas. These problem areas are not as serious as the stream instability problems classified as primary problems, but should be addressed in conjunction with other infrastructure projects occurring in the watershed. For example, many of the secondary stream instability problems could be addressed at the same time roadways are improved and water and wastewater pipelines are installed, if they are located in the same general vicinity. In addition, many of these secondary problems could be combined with routine maintenance activities. Secondary problems could also be addressed as a private project; however, close coordination with the City, County, and NRD would be required.

Project CB-11: Main Stem, Station 350+00 to 354+30 - Grade control straightened channel (Category 6)
Problem Description: This segment of the main stem is widening.
Recommended Intervention: Install several rock structures to direct flow, keep the stable upstream segment intact, and provide longer-term stabilization than debris jams.

Project CB-12: Main Stem, Station 345+60 to 346+70 - Further stabilize SW 40th Street channel crossing (Category 6)
Problem Description: The crossing is recognized as an existing grade control along the main stem.
Recommended Intervention: Place rock grade controls to protect the crossing.

Project CB-13: Main Stem, Station 247+00 to 327+20 - Manage channel grade and stabilize woody debris grade controls (Category 6)
Problem Description: Accumulations of woody debris at numerous locations have apparently acted as *de facto* grade controls.
Recommended Intervention: Install several rock structures to provide longer-term stabilization than debris jams and maintain channel grade.

Project CB-14: Main Stem, Station 227+00 to 234+90 - Manage channel upstream and downstream of confluence with Main Tributary (Category 6)
Problem Description: Any lowering of this channel could also trigger a headcut or accelerate headcuts along the main tributary.
Recommended Intervention: Install several rock structures to provide longer-term maintenance of the channel grade.

Project CB-15: Main Stem, Station 140+40 to 185+60 - Manage channel grade and stabilize woody debris grade controls (Category 6)
Problem Description: Accumulations of woody debris at numerous locations apparently have acted as grade controls.
Recommended Intervention: Install several rock structures to provide longer-term stabilization than debris jams and maintain channel grade.

Project CB-16: Main Stem, Station 131+60 to 130+40 - Further stabilize SW 12th Street channel crossing (Category 6)
Problem Description: The crossing is recognized as an existing grade control along the main stem.
Recommended Intervention: Place rock grade controls to protect the crossing.

Project CB-17: Main Stem, Station 110+70 to 128+80 - Manage channel grade and stabilize woody debris grade controls (Category 6)
Problem Description: Accumulations of woody debris at several locations apparently have acted as *de facto* grade controls.
Recommended Intervention: Install several rock structures to provide longer-term stabilization than debris jams and maintain channel grade.

Project CB-18: Main Stem, Station 116+60 to 114+00 - Bank toe projection and flow vanes and grade control (Category 4)
Problem Description: The full height of the left descending bank is bare with little or no root reinforcement.
Recommended Intervention: Divert flow from the left descending bank toward the center of the channel using large rock along the toe of the bank and the use of flow vanes and a grade control.

Project CB-19: Main Stem, Station 24+10 to 71+70 - Manage channel grade and stabilize woody debris grade controls (Category 6)
Problem Description: Accumulations of woody debris at several locations apparently have acted as *de facto* grade controls.
Recommended Intervention: Install several rock structures to provide longer-term stabilization than debris jams and maintain channel grade. In areas of sparse woody vegetation, we recommend augmenting tree and brush plantings.

Project CB-20: Main Stem, Station 57+40 to 62+80 - Bank toe projection and flow vanes and grade controls (Category 4)
Problem Description: The right descending bank is bare with little or no root reinforcement along its full height.
Recommended Intervention: Divert flow from the left descending bank toward the center of the channel using large rock along the toe of the bank and the use of flow vanes and grade controls.

Project CB-21: Main Stem, Station 22+60 to 23+20 - Further stabilize South 1st Street channel crossing and beaver dam grade control (Category 6)
Problem Description: The crossing and beaver dam are recognized as an existing grade control along the main stem.
Recommended Intervention: Place rock grade controls to protect the crossing.

Project CB-22: Main Stem, Station 9+50 to 20+30 - Manage channel grade and stabilize woody debris grade controls (Category 6)
Problem Description: Accumulations of woody debris at several locations have apparently acted as *de facto* grade controls.
Recommended Intervention: Install several rock structures to provide longer-term stabilization than debris jams and maintain channel grade. We also recommend particular monitoring for channel adjustments.

Project CB-23: Tributary, Station 0+00 to 5+40 - Grade control incising channel (Category 3)
Problem Description: Downcuttings with steeper banks are present along this segment with at least two knickpoints found in this segment.
Recommended Intervention: Place grade controls to arrest incision and direct flows toward the central portion of the channel.

Project CB-24: Tributary, Station 19+50 to 20+30 - Bank toe projection and flow vanes and grade control (Category 4)
Problem Description: The full height of the left descending bank is bare with little or no root reinforcement.
Recommended Intervention: Divert flow from the left descending bank toward the center of the channel using large rock along the toe of the bank and the use of flow vanes and a grade control.

Project CB-25: Tributary, Station 11+50 to 27+00 - Further stabilize channel between Category 3 grade controls (Category 6)
Problem Description: Although knickpoints were not found along this segment, the channel slope merits monitoring and potential interventions.
Recommended Intervention: Place several rock grade controls to protect and maintain grade between Category 3 grade controls.

Project CB-26: Tributary, Station 27+00 to 43+40 - Grade control incising channel (Category 3)
Problem Description: Incision and the presence of several knickpoints were observed along this segment.
Recommended Intervention: Place several rock structures to manage the channel slope and abate migration of the knickpoints or headcuts and to provide longer-term stabilization than debris jams or roots crossing the channel.

Project CB-27: Tributary, Station 42+30 to 53+40 - Further stabilize SW 27th Street channel crossing and in between Category 3 grade controls (Category 6)
Problem Description: The crossing is recognized as an existing grade control along the main stem.
Recommended Intervention: Place several rock grade controls to protect the crossing and maintain grade between Category 3 grade controls.

Project CB-28: Tributary, Station 50+80 to 64+10 - Grade control incising channel (Category 3)
Problem Description: Extensive downcutting and relatively narrow lower channel was observed with at least one knickpoint found in this segment.
Recommended Intervention: Place grade controls to arrest incision and direct flows along the fairly tight meanders in the upstream portion of this segment.

Project CB-29: Tributary, Station 66+60 to 97+00 - Manage channel grade and stabilize woody debris grade controls (Category 6)
Problem Description: Accumulations of woody debris at several locations have apparently acted as *de facto* grade controls.
Recommended Intervention: Install several rock structures to provide longer-term stabilization than debris jams and maintain channel grade.

Project CB-30: Tributary, Station 121+60 to 146+00 - Manage channel grade between Category 2 and 3 interventions (Category 6)
Problem Description: The channel has been manipulated to varying degrees over the years.
Recommended Intervention: Install several rock structures to provide longer-term stabilization to maintain channel grade.

Project CB-31: Tributary, Station 146+00 to 158+20 - Grade control straightened and incising channel (Category 3)
Problem Description: This segment of the tributary was straightened and most of the deep-rooted riparian vegetation was removed.
Recommended Intervention: Place several rock structures to manage the channel slope and abate migration of the perceived headcut.

Project CB-32: Tributary, Station 162+90 to 164+30 - Further stabilize Rokeby Road channel crossing (Category 6)
Problem Description: The crossing is recognized as an existing grade control along the main stem.
Recommended Intervention: Place rock grade controls to protect the crossing.

Project CB-33: Tributary, Station 166+80 to 181+60 - Grade control incising channel (Category 3)
Problem Description: Extensive downcutting and relatively narrow lower channel with at least one knickpoint were found in this segment.
Recommended Intervention: Place grade controls to arrest incision and direct flows along the fairly tight meanders in the upstream portion of this segment.

Project CB-34: Tributary, Station 184+80 to 192+80 - Manage channel grade and stabilize woody debris grade controls (Category 6)
Problem Description: Accumulations of woody debris at several locations have apparently acted as *de facto* grade controls.
Recommended Intervention: Install several rock structures to provide longer-term stabilization than debris jams and maintain channel grade.

Project CB-35: Tributary, Station 194+60 to 201+00 - Grade control straightened and incising channel (Category 3)
Problem Description: This segment of the tributary was straightened and most if not all of the deep-rooted riparian vegetation was removed.
Recommended Intervention: Place several rock structures to manage the channel slope and abate migration of headcuts and to provide longer-term stabilization than debris jams.

Project CB-36: Tributary, Station 204+50 to 212+30 - Manage channel grade between Category 2 interventions (Category 6)
Problem Description: Accumulations of woody debris at several locations apparently have acted as *de facto* grade controls.
Recommended Intervention: Install several rock structures to provide longer-term stabilization than debris jams and maintain channel grade.

Project CB-37: Tributary, Station 220+60 to 241+70 - Manage channel grade at the Main Tributary headwaters (Category 6)
Problem Description: The potential exists for headcuts to form along this segment and migrate upstream through stable channels.
Recommended Intervention: Install several rock structures to provide longer-term stabilization to maintain channel grade.