Insert Figure I-i
Flood Prone Area Map - Existing Conditions

# EVALUATION SUMMARY

Urban Planning Zones S-1, S-2, S-3 and a portion of S-5 have been identified as part of the Tier I growth area by the Lincoln-Lancaster County Comprehensive Plan (LLCCP). This means they are expected to become developed within the next 25 years. These Urban Planning Zones compose the Southeast Upper Salt Creek (SEUSC) Watershed.

.

## STORMWATER QUALITY

### Urban Runoff

Water quality samples collected by the City at five urban sites indicate that stormwater quality within the City appears to be relatively good compared to national runoff quality data. The five monitoring sites are located in basins in Lincoln selected by the Public Works and Utilities Department to collect runoff data from typical watersheds.

Two sites are in predominately residential watersheds, two are in watersheds with predominately industrial land use, and one is in a predominantly commercial watershed. The commercial site and one of the residential sites are located in the adjacent Beal Slough watershed. There does not appear to be any trend indicating an improvement or impairment of stormwater quality. The City has not collected data from large acreage residential development.

Current threats to stormwater quality in the SEUSC Watershed are runoff from adjacent crop ground, sediment from stream bed and bank erosion and potential runoff from failed or poorly maintained individual sanitary septic systems.

### Erosion and Sedimentation in Streams

Some channel bed erosion and bank sloughing is occurring near the mouth of the S-1 watershed west of 14$^{th}$ Street and is evident in S-5 in the two artificial channels between South 38$^{th}$ Street and the BNSF Railroad ditch. The channel has scoured several feet in the southern channel. Stream velocities are at or above erosive velocities for existing and projected conditions. Development in the S-3 watershed has not caused significant stormwater impacts on downstream reaches. Some channel bed erosion and bank sloughing is occurring near the mouth of the S-2 watershed west of the BNSF Railroad.

Erosion caused by increased flow rates, and increased occurrence of bankfull conditions due to projected development, will increase if not adequately addressed. Land disturbance activities associated with projected development could also adversely affect surface water quality if appropriate Best Management Practices (BMPs) are not installed and maintained.

### Erosion and Sediment from Land Disturbance Activities

Construction sites in the basin can be a significant source of erosion and sediment. Development in the upper portion of S-1 is currently underway. Erosion and sediment control plans have been prepared and should be implemented. Joint City and NRD education and enforcement efforts have increased citizen and developer awareness. Citizen and developer awareness has improved compliance with city, state, and federal erosion and sediment control regulations for development. Increased City and NRD staffing will help education, compliance and enforcement activities required by the Municipal NPDES Permit.

## STORMWATER QUANTITY

### Flooding Along Streams and Channels

The SEUSC Watershed is approximately 50% developed. New and pending developments near South 27$^{th}$ Street and Yankee Hill Road have been designed according to the 2000 Lincoln Drainage Criteria Manual (DCM), significantly reducing the flood hazard to adjacent property.

Acreages in the eastern portion of the basin (S-3) were developed prior to adoption of the DCM. Many of the homes are out of the 100-year flood prone area. In general, flooding occurs in open space along the channel; however, several homes appear subject to being flooded based on inspection of aerial photography and topographic contours. Low building openings and lowest floor elevations would need to be confirmed to accurately determine flood hazard exposure.

Flooding in S-2 is currently confined to commodity crops on adjacent agricultural land and to overtopping at South 40$^{th}$ Street, Rokeby Road, South 27$^{th}$ Street, and the BNSF Railroad.

Flooding in S-5 is currently confined to commodity crops on adjacent agricultural land and overtopping at South 38$^{th}$ Street. South 38$^{th}$ Street crosses the northern and southern tributaries in the portion of the S-5 watershed included in this plan. The roadway is overtopped by floods greater than the 5-year event along the north tributary and by floods greater than the 2-year event of the south tributary. Saltillo Road is inundated by floods greater than the 2-year event. The Salt Creek floodplain controls water surface elevations in the lowlands west of 38$^{th}$ Street.

The Salt Creek floodplain has been delineated by FEMA near the lower (west) end of the S-2/S-3 Urban Planning Zones, but the limit of detailed study is at South 27$^{th}$ Street. The FEMA delineated floodplain between the BNSF Railroad and South 27$^{th}$ Street is based on the flooding effects of Salt Creek. The Salt Creek floodplain delineated by FEMA at the lower (west) end of the S-1 watershed is based on approximate methods, so no base flood elevations were determined in this area by FEMA. The City and the NRD sponsored a study by the U.S. Army Corps of Engineers (COE) of the Salt Creek Floodplain in Wilderness Park (Salt Creek at Wilderness Park Hydrologic Study, June 1999). The water surface elevations from that study were used as starting water surface elevations for the hydraulic models of the S-1, S-2/S-3, and a portion of S-5 watersheds evaluated in this study.

The upper part of S-3 and all of S-1 are at or near ultimate built-out conditions. Significant land use changes are not projected to occur in these areas. Land use changes are projected to occur in S-2. Urbanization increases the peak flow rates for all storms evaluated. Upstream of the South 48$^{th}$ Street alignment, the flow rates may decease slightly because of the projected development of agricultural ground into large lot rural residential land uses near 70$^{th}$ Street and Rokeby Road. The 2-, 10-, and 100-year events are projected to decrease by approximately 10%, 6%, and 4%, respectively. This is due to the acreage development tending to have large, permanently grassed areas and preservation of drainageways in natural or nearly natural configurations. Downstream of the South 48$^{th}$ Street alignment, the 2-, 10-, and 100-year events are projected to increase by approximately 45%, 22%, and 17% on the mainstem, respectively. Without intervention by application of stormwater management practices, the mainstem water surface profiles between BNSF Railroad and 40$^{th}$ Street would increase by 3 to 5 ft, which could result in significantly higher road and bridge replacement or upgrade costs. On the tributaries in the subbasins that are projected to become urban residential, peak flow rates could increase by up to 80%, 63% and 54% for the 2-, 10-, and 100-year storms,

respectively. Tables I-10, I-11, and I-12 list the comparison of the 2-, 10-, and 100-year storms at selected locations for existing and projected land use conditions in S-2/S-3 and a portion of S-5. Refer to Appendix C for a complete summary printout of the hydrologic models. This scenario is based on land uses projected in the LLCCP and the lack of a delineated floodplain to preserve floodplain storage capacity in this watershed. Development is assumed to allow encroachment to the limits of the minimum flood corridor in areas that do not have a delineated FEMA floodplain.

**If the existing 100-year flood prone area were to be preserved, there would be no significant increase in peak flow rates in the mainstem below 40th Street**. This is due to two conditions; (1) the floodplain storage helps attenuate increased peak flow rates; and (2) the increased peak flow rates from the northwest tributary arrive at the confluence and are accommodated in the channel before the mainstem peak flow rates arrive.

**MASTER PLAN RECOMMENDATIONS**

The master plan is intended to provide a solution developed through a public involvement process that addresses the identified issues in a manner that is acceptable to the public and governmental agencies. Components considered must be up-to-date, cost-conscious, effective, practical and meet the unique current and foreseeable community needs of Lincoln, while being responsive to applicable provisions of regulatory requirements.

Capital project components identified in the master plan are generally included in order to meet City of Lincoln design standards and/or to accommodate future urban growth projected for the basins in the SEUSC Watershed. In some cases, the magnitude of the project also reflects the results of more detailed hydrologic and hydraulic modeling completed with HEC-1 and HEC-RAS. It is recognized that prior to areas within the watershed being annexed into the City, the county may have a need to construct improvements in these locations, and that these improvements may not reflect the standards identified in the master plan. In these cases, it is anticipated that such components would be upgraded in the future by the City of Lincoln.

# Southeast Upper Salt Creek Watershed Stormwater Master Plan

**Urban Planning Zones S-1, S-2/S-3 and a portion of S-5**

## PURPOSE

The Lincoln Stormwater Basin Planning Project is being undertaken to provide stormwater master planning for the entire City and future growth areas over a period of years. This project is targeted at continuing to implement the recommendations of the November 1994 Mayor's Stormwater Task Force Report. The report recommended comprehensive planning for stormwater management using a basin-wide approach driven by local needs and a collaborative effort among existing agencies to meet those needs. Proactive planning rather than reactive planning allows consideration of options that may no longer be feasible after development occurs. The City of Lincoln Public Works and Utilities Department and the Lower Platte South Natural Resources District (NRD) have completed master planning for the first basin, see "Beal Slough Stormwater Master Plan, May 2000".

The Public Works and Utilities Department and the NRD are jointly preparing stormwater master planning for areas in Lincoln in anticipation of development. This Stormwater Master Plan is for the Southeast Upper Salt Creek (SEUSC) Watershed known as Urban Planning Zones (UPZ) S-1, S-2/S-3, and a portion of S-5 (refer to Area Map, Figure I-1). The SEUSC Watershed includes three distinct drainage areas that collect into ephemeral streams, which discharge into Salt Creek and several smaller drainage areas that outlet directly into Salt Creek.

The purpose of this report is to present hydrologic and hydraulic characteristics of the watershed for existing and projected land use conditions and identify current and potential future stormwater issues.

**Location**

UPZ S-1 generally is bounded by the Burlington Northern and Santa Fe (BNSF) Railroad tracks to the west, 33rd Street to the east, Pine Lake Road to the north, and Rokeby Road to the south. This watershed is largely developed, and it contains the Wilderness Ridge Development and Golf Course, and the Pine Lake Heights South Development. These subdivisions, and the property between them, are being developed by the same owners. Stormwater facilities for these subdivisions were designed to accommodate the projected conditions.

The UPZ S-2/S-3 watershed is bounded on the west by the BNSF Railroad tracks, to the east by 70$^{th}$ Street, to the north by Pine Lake Road, and to the south by Saltillo Road (see Figure I-2). Land use in the eastern portion of this watershed is dominated by rural residential acreage development. Land use in the western portion is largely agricultural with farmsteads and scattered residential acreages. A sanitary sewer trunk line is being extended along the east side of Salt Creek that is intended to serve further urbanization in this watershed. Existing and future land use, as well as stormwater issues, are discussed in detail in the Stream Segment Evaluation section of this report.

The portion of UPZ S-5 studied in this master plan is the watershed generally bounded by Saltillo Road and Bennet Road, and by Salt Creek and South 54$^{th}$ Street. Land use is agricultural with scattered rural residential development near South 54$^{th}$ Street and Saltillo Road.

Insert
Figure I-1 Area Map
Southeast Upper Salt Creek Watershed

Insert
Figure I-2 Watershed Boundary Map
Southeast Upper Salt Creek Watershed

# GOALS AND OBJECTIVES

Successful master planning for stormwater management involves identifying issues, establishing goals, and preparing a plan to meet those goals. Public involvement in each of these areas is key to developing support for the Stormwater Master Plan (SWMP). Four open houses were held to gather public comment on existing and projected stormwater issues and goals. The objectives of the meetings were to confirm the issues, refine the goals, develop SWMP concepts, and create the SWMP in a form ready for adoption into the Lincoln-Lancaster Comprehensive Plan (LLCCP).

**Public Involvement Process**

The open houses were held at Cavett Elementary School and at the Bess Dodson Walt Branch Library. City of Lincoln, NRD and consultant team staff were on hand to answer questions posed by attendees. Notices were sent to over 500 landowners. Concerns voiced were generally related to loss of floodplain storage, preservation of habitat along streams, and changes from agricultural to urban land uses. One landowner expressed an interest in upgrading an existing pond to meet possible detention needs. A meeting was also held with local and state governmental agency representatives to provide information on public involvement and technical processes, and to discuss preliminary issues and goals. Landowners most likely to be affected by proposed master plan components were invited to meet with City, NRD and consultant staff. Copies of the sign-in sheet and written comments are provided in Appendix A. The public involvement process has contributed to public and governmental objectives.

**Goal**

The goal of this planning project is to create a master plan for stormwater management policies, procedures, and facilities. The master plan serves to plan for, and anticipate the effects of, development in the watershed. The master plan also serves to proactively coordinate the efforts of the various entities that may be responsible for creating or maintaining infrastructure, buildings, or property in the watershed (i.e. State Department of Roads, City of Lincoln/Lancaster County Roads Department, private developers, landowners, business owners, etc.). The master plan is intended to be up-to-date, cost-conscious, effective, practical and meet the unique current and foreseeable community needs of Lincoln, while being responsive to applicable provisions of regulatory requirements.

**Objectives**

Objectives determined during the public involvement process address the issues listed below.

**Key Issues**

Following are the key issues to be addressed for the watershed in the Stormwater Basin Planning Project:

- Stream stability and management of increased volume and runoff due to urbanization and development in the watershed
- Increased flood hazard and risk due to development in the floodplain
- Evaluation of runoff quantity and quality on wetlands and other environmental resources
- Road crossings, existing development in the floodplain, and private property rights
- Funding and coordination with floodplain regulation review
- Evaluating and improving upland land use and water quality during and after development
- Management of runoff and drainage into Wilderness Park
- Lack of delineated floodplain in the watershed

## LAND USE

Land use changes that accompany urbanization have a significant impact on the hydrologic response of a watershed to rainfall events. Stormwater master plans evaluate existing and projected hydrologic conditions and, based on established goals, identify actions to mitigate undesirable conditions and preserve desirable conditions.

**Evaluation**

Information on existing and projected land use, soil type, and other hydrologic characteristics for the watershed are presented in the following text. Results from hydrologic and hydraulic models prepared and operated for existing and projected land use conditions are presented. Evaluation of the results indicate that the peak rates of runoff will increase from subbasins projected for urbanization. However, other factors may have a more significant impact on stormwater management. The master planning process has helped determine what actions should be taken to mitigate stormwater management issues for existing and projected conditions.

**Existing Land Use Conditions**

As urbanization occurs, runoff volume and runoff rates typically increase due to increased impervious areas and more efficient conveyance through paved streets and storm drain pipes. Unless anticipated during the design process, increased runoff volume and rates may cause new problems or exacerbate existing problems in the storm drain system such as increased flooding, more frequent flooding, stream degradation, or bridge replacement needs.

Table I-1 provides a summary of 2001 land uses based on information from aerial photography, watershed tours, current land use maps, the LLCCP, and built-out conditions based on typical City development patterns. Figure I-3 shows the spatial distribution of 2001 Land Use in the study area. The City is expected to grow in this watershed with full urban services in the next 25 years, which is identified in the Comprehensive Plan as a Priority A, Tier I growth area. These are areas designated for near-term development, are generally contiguous to existing development, and should be provided with basic infrastructure within 12 years of the adoption of the plan.

Existing development generally consists of mostly agricultural land use in the lower portion of the watershed west of the 48$^{th}$ Street alignment, and large lot residential in the upper portion of the watershed.

Future urbanization in this watershed is projected to occur almost exclusively to the west of the 48$^{th}$ Street alignment. Rural residential land use will continue to be the predominant category type in the eastern portion of the watershed. The Comprehensive Plan indicates industrial and commercial centers along Yankee Hill Road near 14$^{th}$, 27$^{th}$ and 40$^{th}$ Streets, near 40$^{th}$ Street and Rokeby Road and near Yankee Hill. The South Beltway is planned within the watershed, 1/2 -mile South of Saltillo Road. This part of UPZ S-5 is identified as a Tier I growth area in the LLCCP.

Urban residential lots average 8,000 to 10,000 sf. (1/6-acre to 1/4-acre). Typically, between 40% and 50% is impervious pavement or roof tops. Soil characteristics are a lesser factor than the impervious percentage on stormwater management issues. Runoff is typically collected in street gutters, flows through a storm drain system, and discharges into a tributary channel.

Rural residential lots average 3 acres, less than 12% of the area is typically impervious pavement or roof top, and runoff from impervious areas flow overland through swales before entering the storm drain system. Soil characteristics are a greater factor than the impervious percentage on stormwater management issues. The lot area not paved or built upon is covered with grass or other permanent vegetative cover. The runoff curve number value for a subbasin with rural residential land use is often less than the value for most cultivated agricultural land uses.

Commercial development is characterized by large expanses of impervious area that are directly connected to the storm drain system. More precipitation becomes runoff and, because the storm drain system efficiently transports water, it arrives at the channel sooner.

Agricultural land use has a very low impervious component, typically less than 2%. Residual cover, tillage practices, and soil type are equally important factors for stormwater management.

Natural and environmental land use, parks, and open spaces are characterized by large expanses of pervious areas that are not connected to a storm drain system. Issues due to runoff from adjacent property are typical stormwater management concerns.

The channels in the upper portions of the SEUSC Watershed exhibit little degradation. The channels show mild to moderate incision downstream of 40$^{th}$ Street. There was no water in the channel at the time of the site visit (September 2000), precluding biological sampling of the stream. The riparian area has been preserved in some areas, but in other areas agricultural activities take place right up to the edge of the drainageway channel. Development in the upper portion of the watershed is predominantly large-lot residential. The natural drainageways have been respected generally. Wright Water Engineers prepared a report titled "Constraints of Habitat and Channel Stability on the Development of Drainage Improvement Alternatives for the S-1 to S-3 and N-1 to N-5 Urban Planning Zones". The report is an evaluation of channel stability written by Edwin Herricks P.E., Professor of Environmental Biology, University of Illinois at Urbana-Champaign. The complete text of the report is available in Appendix B. The studies commissioned for this watershed and for the Lower Little Salt Creek Watershed were published in a single report to reduce costs.

**Table I-1**
**Summary of 2001Land Use in the UPZ S-1, S-2/S-3 & Portion of S-5 Watershed (in percent)**

| Condition | Urban Residential | Rural Residential | Commercial and Industrial | Agricultural | Natural / Environ-mental | Parks / Open Space | Total |
|---|---|---|---|---|---|---|---|
| Existing | 2.9 | 25.8 | 7.4 | 52.5 | 4.3 | 7.1 | 100.0 |
| LLCCP | 45.0 | 26.7 | 7.4 | 9.5 | 4.3 | 7.1 | 100.0 |
| Built-out | 44.5 | 31.8 | 9.7 | 2.6 | 4.3 | 7.1 | 100.0 |

**Projected Land Use Conditions - Lincoln-Lancaster Comprehensive Plan (LLCCP)**

Projections of land use through the year 2025 from the LLCCP were used to determine future hydrologic conditions in the watershed. Figure I-4 shows the spatial distribution of Projected Future Land Use in the SEUSC Watershed. The comprehensive plan projects land uses for the next 25-year plan period. Typical components identified in stormwater master plans such as dams and road crossings have a design life in

excess of 25 years and should be designed so as to not become prematurely obsolete. Component performance should be evaluated with built-out peak flow rate values for cost analysis. Built-out conditions are those expected to exist when all of the properties within the watershed have attained their "highest and best use." This is influenced by future revisions to the LLCCP, availability of sewer and water utilities, zoning restrictions, restrictive (protective) covenants, or by other legally-binding documents. In this watershed, many of the rural subdivisions have covenants restricting properties to single family housing. The high cost of extending public sewer and water utilities to the upper portions of the watershed that has not been urbanized will likely limit the density of development to that which can support private wells and septic systems.

Projected land use through the year 2025 from the LLCCP were used to determine future hydrologic conditions in the watershed for near-term planning. Built-out land use conditions beyond the 25-year planning period were determined using hypothetical build-out development base data by traffic zone provided by the Lincoln-Lancaster County Planning Department. While the relative land use percentages change slightly, the changes do not significantly affect the runoff curve number because it is a "lumped" parameter (i.e., an area weighted average of individual curve numbers within the subbasin, so effects of land use changes within a subbasin are most-appropriately addressed during review of the proposed subdivision). In general, the northwest portion of the watershed is developed or currently under construction, the area west of the 48$^{th}$ Street extended is projected to be typical urban residential development, and the remaining area is projected to develop in land uses consistent with the current rural residential land use (see Tables I-2b and Table I-2c).

**Redevelopment**

Many of the subdivisions have covenants prohibiting redevelopment of lots without a unanimous vote of the property owners; however, during the public process, the point was raised that covenants are periodically updated and potentially changed. It is reasonable to expect some level of redevelopment of the existing large lot rural residential development in the upper portion of the watershed, but wholesale redevelopment is unlikely due to the configuration of lots and roadways, utility access, and the large number of individual property owners. While a portion of a subbasin may be redeveloped to a higher density and percent impervious surface area, development is not likely to be concentrated; and thus, the weighted average runoff parameters are not likely to change (e.g., 1 house per 13 acres to 1 house per acre) enough to significantly increase peak flow rates and runoff volumes along the mainstem. Local impacts would need to be evaluated and addressed if they would increase flow rates or contribute to stream instability within the subbasin.

**On-Site Detention**

Most urban watersheds tend to develop first in the lower reach, then in the upper reach. So, it is important that runoff from subsequent upstream development does not overload downstream stormwater management facilities which have been previously designed and constructed. Limiting post-development stormwater discharge rates to pre-development values by utilizing on-site stormwater detention storage facilities is a widely applied practice for limiting increases in peak flow rates due to urbanization. Limiting flow is a requirement of the DCM unless stormwater master planning has shown that the detention requirement can be transferred to regional facilities. Stormwater detention facilities, when designed correctly and properly maintained, temporarily store runoff and release the stored volume at metered rates, effectively controlling the release rate by extending the duration of peak flow rates.

In contrast, the SEUSC Watershed developed first in the upper portion, with future development projected to occur in the lower portion. The type of development (large lot acreages) in this watershed also sets it apart from typical watershed in that the urbanized land use resulted in lower runoff rates and volumes than the pre-urbanization land use (row crops). Additionally, the runoff pattern of large lot acreage land use in this watershed delays arrival of the runoff peak from the upper watershed until after the peak from the lower watershed is conveyed through the lower reaches. Hydrologic and hydraulic evaluation, performed during the stormwater master planning process of this watershed, indicates the effect of future urbanization on stormwater runoff from this watershed will cause an increase in the 2-year flood event and decreases in the 10- and 100-year flood events if the entire 100-year floodplain is preserved. The City's DCM requires on-site detention facilities for the 2-, 10-, and 100-year events. In the SEUSC Watershed, detention for the 10-year and 100-year storm events may not be necessary if an individual development proposes to dedicate the 100-year floodplain as permanent open space. However, any such proposal must be reviewed on a case-by-case basis and must still provide detention for the 2-year storm. The addition of water quality BMPs is also strongly encouraged.

**Table I-2a**
**Development in the UPZ S-1 Watershed**

| Parameters | |
|---|---|
| Area, Square Miles | 1.36 |
| Percent Urbanized - Existing Conditions* | 100 |
| Percent Urbanized - Projected Comprehensive Plan Conditions (2025) | 100 |
| Percent Urbanized - Projected Ultimate Built-Out Conditions | 100 |

*includes developments proposed in the foreseeable future.

**Table I-2b**
**Development in the UPZ S-2/S-3 Watershed**

| Parameters | |
|---|---|
| Area, Square Miles | 7.31 |
| Percent Urbanized - Existing Conditions | 40 |
| Percent Urbanized - Projected Comprehensive Plan Conditions (2025) | 100 |
| Percent Urbanized - Projected Ultimate Built-Out Conditions | 100 |

**Table I-2c**
**Development in Portion of the UPZ S-5 Watershed**

| Parameters | |
|---|---|
| Area, Square Miles | 1.77 |
| Percent Urbanized - Existing Conditions | 18 |
| Percent Urbanized - Projected Comprehensive Conditions (2025) | 100 |
| Percent Urbanized - Projected Ultimate Built-Out Conditions | 100 |

Insert Figure I-3 Existing Land Use and Zoning Map
Southeast Upper Salt Creek Watershed

Insert Figure I-4 2025 Future Land Use Plan
Southeast Upper Salt Creek Watershed

## SOILS

Soil type can have a profound effect on the amount of precipitation that becomes runoff. The amount of precipitation that infiltrates into the soil does not immediately become runoff. The predominant soil associations found in the S-1, S-2/S-3, and a portion of S-5 watersheds are listed in Table I-3 in descending order of approximate area. Approximately half belongs to the Wymore series which erodes easily, consists of deep, gently sloping to strongly sloping, moderately well drained, silty soils that formed in loess and loamy soils that formed in glacial till. This upland soil association has a very slow infiltration rate (high runoff potential) when thoroughly wet, high shrink-swell potential and low percolation rate which requires special design and increased maintenance of septic systems. The Sharpsburg series consists of deep, nearly level and very gently sloping, moderately well drained to poorly drained, silty soils that formed in alluvium. This soil erodes easily, has a moderate to slow infiltration rate when thoroughly wet, is subject to flooding, and is found in floodplains. The Pawnee-Burchard association consists of deep, gently sloping to steep, moderately well drained and well drained, loamy and clayey soils that formed in glacial till. These soils erode easily, percolate slowly, have a slow infiltration rate (high runoff potential) when thoroughly wet, and are found on uplands. Outcrops of the Dakota Sandstone formation are shown along the Burlington Northern Santa Fe Railroad in the Salt Creek valley. Figure I-5 graphically displays the distribution of soil associations in the SEUSC Watershed.

**Table I-3**
**Comparison of Soil Associations Found in the Watershed (USDA, SCS Soil Survey of Lancaster County, NE)**

| Soil Property | | Soil Series | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Wymore** | **Sharpsburg** | **Pawnee** | **Kennebec** | **Judson** | **Nodaway** | **Zook** |
| **Parent Material** | | Formed in loess | Formed in loess | Formed in glacial till | Formed in noncalcareous colluvial silty sediment from the dark upland soils | Formed in noncalcareous colluvial silty sediment | Alluvium, occurs in narrow drainageways | Formed in alluvium along streams |
| **Drainage** | | Moderately well drained on uplands, slow permeability | Moderately well drained | Moderately drained on uplands, slow permeability | Deep, moderately well drained, moderate permeability | Deep, moderately well drained, moderate permeability | Moderately well drained, moderately permeable | Deep, poorly drained, slow permeability |
| **Surface Layer** | | Very dark brown silty clay loam, weak fine granular structure, hard | Very dark brown friable silty clay loam | Very dark brown clay loam, very dark grayish brown, weak fine granular structure, slightly hard | Very dark gray silt loam, weak fine granular structure, hard, friable | Very dark brown silt loam, very dark grayish brown, weak fine granular structure, slightly hard | Very dark grayish brown silt loam, weak fine granular structure, slightly hard | Very dark gray silty clay loam, weak fine granular structure, slightly hard |
| **Subsoil** | **Upper** | Dark brown silty clay, moderate fine and medium subgranular blocky structure, hard | Dark brown, firm silty clay | Very dark grayish brown clay, moderate fine and medium subangular blocky structure | Very dark gray silt loam, weak fine and medium granular structure, hard, friable | Black silt loam very dark gray weak fine granular structure, slightly hard | Very dark grayish brown silt loam, massive, slightly hard | Black silty clay loam, weak medium prismatic structure, hard |
| | **Middle** | Dark grayish brown silty clay, moderate medium prismatic structure, hard | Brown firm silty clay | Dark grayish, moderate medium prismatic structure, very hard | Black silty clay loam, moderate medium subangular blocky structure, slightly hard | Dark brown silty clay loam, weak medium granular structure, slightly hard | Very dark grayish brown silt loam, massive, slightly hard | Black silty clay, moderate medium prismatic structure, very hard |
| | **Lower** | Olive brown silty clay loam, weak medium prismatic structure, hard | Yellowish brown, firm or friable silty clay loam | Olive brown clay, moderate medium prismatic structure, very hard | Very dark gray silty clay loam, moderate coarse and medium subangular blocky structure, slightly hard | Dark brown silty clay loam, moderate medium prismatic structure, hard | Very dark grayish brown silt loam, massive, slightly hard | Black silty clay, moderate medium prismatic structure, very hard |
| **Underlying Material** | | Olive gray silty clay loam, slightly hard | Light yellowish brown silty clay loam | Olive clay loam, weak coarse prismatic structure, slightly hard | Very dark silty clay loam, moderate coarse and medium subangular blocky structure. | Brown silty clay loam, massive, slightly hard | Very dark grayish brown silt loam, massive, slightly hard | Very dark gray silty clay, moderate medium prismatic structure, hard |

Insert Figure I-5 Soil Associations Map
Southeast Upper Salt Creek Watershed

**HYDROLOGIC SOIL GROUPS**

NRCS soil scientists have classified soils into four hydrologic soil groups according to minimum infiltration rate when thoroughly wetted. The manual for TR-20, "Urban Hydrology for Small Watersheds", provides the following definitions:

"Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

Group B soils have moderate infiltration rates [and moderate runoff potential] when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C soils have low infiltration rates [and high runoff potential] when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission.

Group D soils have a high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission."

The Lancaster County Soil Survey indicates presence of Group A soils on the Wilderness Ridge Golf Course Development. Group B soils are found generally along the mainstem and tributary channels. A very small amount of Group C soils are located in the floodplain of Salt Creek between the UP Railroad and BNSF Railroad tracks. Group D soils are the predominant hydrologic soil group found mostly in the uplands. Table I-4 provides a soil legend and description of the soils found in this watershed. Figure I-6 displays the hydrologic soil groups found in the watershed. A soil is assigned two hydrologic groups if part of the acreage is artificially drained and part is not.

**Table I-4**
**Soil Legend and Hydrologic Soil Group (HSG)**

| Description | HSG |
|---|---|
| Burchard, clay loam, 2 to 30% slopes | B |
| Burchard clay loam, 6 to 11% slopes | B |
| Cold-Nodaway silty clay loams, 0 to 2% slopes | B/D |
| Crete silty clay loam, terrace, 1 to 3% slopes | D |
| Dickinson fine sandy loam, 6 to 11% slopes | A |
| Hedville sandy loam, 6 to 30% slopes | D |
| Judson silt loam, 2 to 6% slopes | B |
| Kennebec silt loam, 0 to 2% slopes | B |
| Mayberry silty clay loam, 2 to 11% slopes, eroded | D |
| Morrill clay loam, 6 to 11% slopes | B |
| Nodaway silt loam, 0 to 2% slopes and channeled | B |
| Pawnee clay and clay loam, 2 to 11% slopes, eroded and severely eroded | D |
| Sharpsburg silty clay loam, 5 to 9% slopes, eroded | B |
| Shelby clay loam, 6 to 11% slopes | B |
| Wymore silty clay loam, 0 to11% slopes | D |
| Zook silt loam and silty clay loam, 0 to 2% slopes | C/D |

Insert Figure I-6 Hydrologic Soil Groups
Southeast Upper Salt Creek Watershed

# HYDROLOGY

## DESCRIPTION OF MODEL

Delineation of the study area boundary was accomplished using topographic contour mapping derived from digital aerial photography and refined using supplemental data such as storm drain system plat maps and field verification. Subbasins were delineated in keeping with the points of interest with respect to master planning efforts, hydrologic characteristics, and areal variability requirements. The Corps of Engineers Hydraulic Engineering Center in Davis, California developed a computer model (HEC-1) to evaluate hydrologic conditions. HEC-1 can be used to analyze the impacts of projected watershed parameters on the hydrologic characteristics such as land use, soil type, and capacity of channels and ponds. The mitigating characteristics of proposed master plan components can be compared using HEC-1 analysis. The hydrologic characteristics of each subbasin are represented in the model by area in square miles, runoff curve number, and the lag time in hours.

Segmentation of the watershed into subbasins determines the number and type of stream network components. Subbasin areas range from 0.06 square miles to 0.37 square miles in size, with an average of 0.18 square miles. Reach lengths range from 220 feet to 5,510 feet. In S-1 the majority of the stream segments have modified cross-sections. In S-2/S-3 and a portion of S-5, reaches are nearly natural and undisturbed, except for the stream segments west of 38$^{th}$ Street. It appears landowners have constructed non-conforming levees to convey runoff from frequent runoff events to the railroad ditch without flooding the adjacent crop ground.

HEC-1 uses the model components described below to represent the precipitation-runoff process.

| | |
|---|---|
| Precipitation - | The amount of rainfall that occurs during a storm event. |
| Watershed - | The unit of land upon which water from direct precipitation, snow melt, and other storage collects in a channel and flows downhill to a common outlet. |
| Area - | An essential consideration in the initial evaluation of watershed hydrologic behavior. |
| Runoff Curve Number - | A measure of the watershed soil and cover conditions that affect runoff potential. |
| Time of Concentration, $T_c$ - | The time it takes for water to travel from some specified point on watershed to the basin outlet. |
| Lag - | The time between the center of mass of the rainfall excess and the peak of the unit hydrograph, a value equal to 60% of the time of concentration is used in HEC-1. |
| Antecedent Moisture Condition - | The amount of water stored in the soil, in small depressions, and on vegetation at the start of a hydrologic event. |
| Initial Abstraction - | The amount of precipitation that is absorbed or adsorbed by the soil and vegetation, respectively, before runoff occurs. |

**RUNOFF PARAMETERS**

The amount of rainfall on a watershed that becomes runoff is dependent on many factors including; the interval since the last rain, land use, the capacity of the soil and vegetation to absorb and hold water, the type of vegetation, the percent of the area covered by pavement and rooftops, the type and condition of drainage paths (swales, channels, pipe, etc.), the rainfall duration and intensity, land slope, and watershed shape. These characteristics can be approximated using the following parameters.

**Area -** The size of the contributing area is directly correlated to the amount of runoff that reaches a point. Drainage subbasins delineated for the watershed are shown on Figure I-7.

**Runoff Curve Number -** In simplistic terms, the runoff curve number is a measure of the amount of precipitation that becomes runoff. The major factors that determine runoff curve number (CN) are the hydrologic soil group, cover type (land use/ treatment), hydrologic condition, and antecedent runoff condition. Another factor considered is whether impervious areas outlet directly to the drainage system. Values of CN for average hydrologic runoff conditions for urban land uses, published in Table 2-8 and found on page 2-22, of the DCM, were used to determine runoff curve numbers for the existing land uses. Figure I-7 shows existing land use. Tables I-5a, I-5b, and I-5c display the runoff curve numbers used for existing land use conditions for the SEUSC Watershed.

**Time of Concentration -** Runoff curve numbers alone do not adequately reflect the effect of urbanization on stormwater systems. Runoff volume is the same for a field of small grain crops planted in straight rows in good condition as for the same field developed into 1/4-acre residential units for hydrologic soil groups B, C, and D. Urban land use provides a more efficient flow pattern, that is, the runoff arrives at the outlet quicker. Time of concentration ($T_c$) for each subbasin was estimated using the procedure provided in SCS TR-55. Time of concentration was converted to lag-time for use in HEC-1.

A compilation of the watershed parameters described above is given for existing and projected conditions for S-1, S-2/S-3, and a portion of S-5 in Tables I-5a, I-5b, and I-5c, respectively.

The runoff from each subbasin is represented by a unit hydrograph. “A unit hydrograph is the direct runoff from a unit depth of excess rainfall produced by a storm of uniform intensity and specified duration” (from Handbook of Hydrology, by David R. Maidment, pg 9.26). The unit hydrograph and excess rainfall are combined to form a runoff hydrograph, and the runoff hydrographs from each subbasin are routed through the reaches and combined to form a complex hydrograph at each point of interest. The complex hydrographs modeled for 2001 and projected future conditions can then be compared and used to evaluate the effectiveness of proposed stormwater management practices. A schematic outline of model components shows the sequence in which components are combined, see Figure I-8.

**QUALIFICATIONS AND LIMITATIONS**

Hydrologic and hydraulic procedures used for this Master Plan are consistent with procedures outlined in publications of the Water Environmental Federation and the American Society of Civil Engineers.

Municipal stormwater management practices are typically designed for a range of design storms with an average return period of 2-year through 500-years. The City of Lincoln requires analysis of the 5-year or 10-year for design of the minor storm drain system and the 100-year storm for design of the major storm drain system. Detention ponds are designed at a minimum to release runoff from the post development 2-, 10-, and 100-year storms at no greater than the predevelopment rate. Design storms with 1-, 2-, 5-, 10-, 25-, 50-, 100-, and 500-year average return periods were analyzed for this report. Summary tables generally include values for the 1-, 2- 10-, 50-, 100-, and 500-year storms. Comparison tables generally report flow values for the 2-, 10-, and 100-year storms. Water surface profiles and flood-prone areas are depicted only for the 2-, 10-, and 100-year runoff for clarity. This study does not address the effects of urbanization on ground water.

Insert Figure I-7 Hydrologic Parameters - Existing Conditions
Southeast Upper Salt Creek Watershed

**Table I-5a**
**Hydrologic Parameters for UPZ S-1 in Southeast Upper Salt Creek Watershed**

| Basin Designation | Basin Area (sm) | Existing Conditions | | LLCCP Conditions | | Ultimate Built-out Conditions | |
|---|---|---|---|---|---|---|---|
| | | CN | $T_c$ (hours) | CN | $T_c$ (hours) | CN | $T_c$ (hours) |
| S-1A4 | 0.06 | 80 | 0.37 | - - | - - | - - | - - |
| S-1A3 | 0.17 | 77 | 0.59 | - - | - - | - - | - - |
| S-1A1 | 0.29 | 68 | 0.25 | - - | - - | - - | - - |
| S-1B | 0.11 | 73 | 0.35 | - - | - - | - - | - - |
| S-1C | 0.19 | 85 | 0.63 | - - | - - | - - | - - |
| S-1D | 0.20 | 93 | 0.39 | - - | - - | - - | - - |
| S-1E | 0.17 | 89 | 0.45 | - - | - - | - - | - - |
| S-1F | 0.14 | 94 | 0.78 | - - | - - | - - | - - |
| S-1G | 0.19 | 87 | 0.61 | 90 | 0.32 | - - | - - |
| Total | 1.52 | | | | | | |

**Table I-5b**
**Hydrologic Parameters for UPZ S-2/S-3 in Southeast Upper Salt Creek Watershed**

| Basin Designation | Basin Area (sm) | Existing Conditions | | LLCCP Conditions | | Ultimate Built-out Conditions | |
|---|---|---|---|---|---|---|---|
| | | CN | $T_c$ (hours) | CN | $T_c$ (hours) | CN | $T_c$ (hours) |
| S-2A | 0.24 | 67 | 0.25 | - - | 0.25 | - - | - - |
| S-2B1 | 0.14 | 74 | 0.64 | 79 | 0.25 | - - | - - |
| S-2B2 | 0.07 | 75 | 0.51 | - - | 0.51 | - - | - - |
| S-2B3 | 0.07 | 79 | 0.57 | - - | 0.57 | - - | - - |
| S-2C | 0.35 | 81 | 0.47 | 86 | 0.19 | - - | - - |
| S-2E | 0.25 | 83 | 0.71 | 89 | 0.32 | - - | - - |
| S-2F1 | 0.15 | 79 | 0.52 | 85 | 0.20 | - - | - - |
| S-2F2 | 0.18 | 82 | 0.56 | 88 | 0.24 | - - | - - |
| S-2G | 0.09 | 83 | 0.55 | 89 | 0.25 | - - | - - |
| S-2H | 0.20 | 82 | 0.45 | 88 | 0.19 | - - | - - |
| S-2I1 | 0.11 | 83 | 0.46 | 88 | 0.20 | - - | - - |
| S-2I2 | 0.22 | 78 | 0.83 | 85 | 0.56 | - - | - - |
| S-2J | 0.23 | 88 | 0.85 | 91 | 0.53 | - - | - - |
| S-2K | 0.31 | 83 | 0.61 | 88 | 0.35 | - - | - - |
| S-2L | 0.17 | 81 | 0.37 | 90 | 0.18 | - - | - - |
| S-2M1 | 0.16 | 76 | 0.42 | - - | 0.42 | 86 | - - |
| S-2M2 | 0.23 | 75 | 0.65 | - - | 0.65 | - - | - - |
| S-2N | 0.16 | 76 | 0.70 | - - | 0.70 | - - | - - |
| S-2O | 0.27 | 79 | 0.64 | 84 | 0.42 | 80 | - - |
| S-2P | 0.19 | 74 | 0.60 | - - | 0.60 | - - | - - |
| Total | 3.79 | | | | | | |

- - Value is not projected to change

**Table I-5b (continued)**
**Hydrologic Parameters for UPZ S-2/S-3 in Southeast Upper Salt Creek Watershed**

| Basin Designation | Basin Area (sm) | Existing Conditions | | LLCCP Conditions | | Ultimate Built-out Conditions | |
|---|---|---|---|---|---|---|---|
| | | CN | $T_c$ (hours) | CN | $T_c$ (hours) | CN | $T_c$ (hours) |
| S-2Q | 0.14 | 79 | 0.43 | - - | 0.43 | - - | - - |
| S-2R | 0.21 | 77 | 0.39 | - - | 0.39 | 86 | - - |
| S-2S | 0.22 | 76 | 0.34 | - - | 0.34 | - - | - - |
| S-2T | 0.36 | 83 | 0.67 | 88 | 0.35 | - - | - - |
| S-2U | 0.12 | 78 | 0.48 | 85 | 0.36 | - - | - - |
| S-2V | 0.21 | 77 | 0.44 | 80 | 0.24 | 86 | - - |
| S-2W | 0.16 | 80 | 0.66 | - - | 0.66 | - - | - - |
| S-2X | 0.09 | 81 | 0.64 | - - | 0.64 | - - | - - |
| S-2Y | 0.27 | 82 | 0.66 | - - | 0.66 | - - | - - |
| S-2Z | 0.11 | 82 | 0.44 | - - | 0.41 | - - | - - |
| S-2AA | 0.20 | 75 | 0.71 | 76 | 0.63 | - - | - - |
| S-2AB | 0.20 | 79 | 0.54 | - - | 0.54 | - - | - - |
| S-2AC | 0.15 | 77 | 0.38 | 76 | 0.35 | - - | - - |
| S-2AD | 0.17 | 85 | 0.33 | 72 | 0.30 | - - | - - |
| S-2AE | 0.17 | 81 | 0.59 | 78 | 0.54 | - - | - - |
| S-2AF | 0.22 | 83 | 0.65 | 79 | 0.60 | 89 | - - |
| Total | 3.00 | | | | | | |

- - Value is not projected to change

**Table I-5c**
**Hydrologic Parameters for Portion of UPZ S-5 in Southeast Upper Salt Creek Watershed**

| Basin Designation | Basin Area (sm) | Existing Conditions | | LLCCP Conditions | | Ultimate Built-out Conditions | |
|---|---|---|---|---|---|---|---|
| | | CN | $T_c$ (hours) | CN | $T_c$ (hours) | CN | $T_c$ (hours) |
| S-5A | 0.22 | 81 | 0.58 | 84 | 0.48 | - - | - - |
| S-5B | 0.37 | 81 | 0.55 | 83 | 0.46 | - - | - - |
| S-5C | 0.23 | 80 | 0.58 | 86 | 0.33 | - - | - - |
| S-5D | 0.34 | 80 | 0.35 | 86 | 0.20 | - - | - - |
| S-5E | 0.18 | 80 | 0.47 | 86 | 0.26 | - - | - - |
| S-5F | 0.28 | 76 | 0.35 | 83 | 0.26 | - - | - - |
| S-5G | 0.15 | 77 | 0.23 | 84 | 0.16 | - - | - - |
| Total | 1.77 | | | | | | |

Insert Figure I-8 HEC-1 Model Schematic
Southeast Upper Salt Creek Watershed

## PONDS

There are seven existing reservoirs in the watershed model. Five of these are designed for stormwater management purposes. Several other ponds exist in the watershed but were not modeled. They do not have sufficient flood storage to significantly affect downstream peak flow rates. Characteristics of each modeled stormwater management pond are presented in Table I-6. For purposes of hydrologic modeling, the full flood storage volume was assumed to be available in each of the ponds at the beginning of the storm. Storage volume and spillway overflow elevation data were determined from topographic contour maps.

**Table I-6**
**Pond Characteristics**

| Pond Location | Master Plan Element Number | Storage Volume at Spillway (acre-feet) | Spillway/ Overflow Elevation (MSL) | Ownership and Uses |
|---|---|---|---|---|
| Wilderness Ridge Golf Course | PONDK | 11.4 | 1,194.6 | Private Detention/Golf Water Hazard |
| Wilderness Ridge Golf Course | PONDN | 3.5 | 1,211.6 | Private Detention/Golf Water Hazard |
| Wilderness Ridge Golf Course | Det-U | 1.8 | 1,203.5 | Private Detention/Golf Water Hazard |
| Wilderness Ridge Golf Course | PONDA | 1.3 | 1,220.1 | Private Detention/Golf Water Hazard |
| Pine Lake Heights So 3rd | 27THA | 33.3 | 1,248.0 | Private Detention |
| NE ¼ Section 31 T9N, R6E | S2EDAM | 7.0 | 1,224.0 | Private Grade Stabilization |
| Yankee Hill Golf Course | S2MDAM | 8.8 | 1,300.0 | Private Detention/Golf Water Hazard |
| NE ¼ Section 5 T9N, R7E | S-5B | 9.4 | 1,268.0 | Private Grade Stabilization |

## PRECIPITATION DATA

The use of design storms is a widely utilized and accepted methodology for stormwater management. Design storms provide a sound basis for comparison of stormwater management practices and assist in predicting the conditions under which flooding and other problems may occur. Two types of design storms are recognized, synthetic and historic. The first are derived by synthesis and generalization of a large number of actual storms. The second are events that occurred in the past and for which the impacts on the watershed may be well documented. There are no well documented storm events available for the SEUSC Watershed. Synthetic storms were used to develop hydrographs, peak flow rates, and runoff volumes to be used for comparison of stormwater management practices. The Soil Conservation Service (now called Natural Resources Conservation Service or NRCS) developed rainfall distributions for regions of the United States. Lincoln is in the region where a Type II distribution is appropriate. 24-hour precipitation values for the 2-, 5,- 10-, 25-, 50-, and 100-year storm were obtained from Table 2-7 in the Drainage Criteria Manual prepared by the City of Lincoln and the Lower Platte South NRD. The value for the 1-year storm was obtained from the National Weather Bureau, "Technical Paper No. 40, Rainfall Frequency Atlas of the United States" (TP-40). The precipitation value for the 500-year storm was determined using logarithmic extrapolation of data from TP-40.

Precipitation hyetographs are used to represent average precipitation over a computation interval. Synthetic design storm distributions were used to develop runoff hydrographs for existing and projected conditions using the precipitation values given in Table I-7.

**Table I-7**
**Total 24-hour Precipitation**

| | Average Frequency of Recurrence | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
| Total Precipitation | 2.48 | 3.00 | 3.93 | 4.69 | 5.37 | 6.00 | 6.68 | 8.20 |

## CALIBRATION

Precipitation data and high water marks were not available for use in calibrating the model of this watershed at the time of study. The adjacent Beal Slough Watershed has similar soil types and land use in the upper area. Several significant rainfall/flood events in the Beal Slough Watershed were used to calibrate and confirm the response of the hydrologic model with the response of that watershed. Flow rates were compared at locations with like drainage areas and similar land use conditions, and found to have a good correlation. Consistent procedures were used to determine existing and projected hydrologic conditions. While actual rainfall/flood events may generate flow rates different from the hydrologic model, the model can be used with confidence to evaluate the relative changes resulting from urbanization, to evaluate the effect of proposed master plan components, and for design of project components.

## FUTURE BASIN HYDROLOGY

Peak flow rate values in the mainstem for built-out conditions are within ± 3% of the values for LLCCP conditions. Since the change in peak flow rate values is not significant, projected land uses provided in the LLCCP for 2025 were used for the purposes of stormwater master planning in the study area. Local peak flow rates within individual subbasins are likely to change if proposed land use differs from land use projected in the built-out. Peak flow rate changes at that scale are addressed through compliance with the DCM and are beyond the scope of this master plan. Appendix C contains a complete runoff summary for the 1-, 2-, 5-, 10-, 25-, 50-, 100-, and 500-year storms for existing land use conditions, projected future built-out land use conditions and LLCCP land use conditions.

**Area -** Urbanization occasionally results in minor changes to the subbasin shape as a result of grading operations. Of course, the adjacent subbasin shape also changes; however, it is impossible to accurately forecast where future changes may occur. Therefore, it was assumed for the purposes of this report that the areas of subbasins did not change due to urbanization.

**Runoff Curve Number -** Changes in cover type (land use) can affect the runoff curve number. Values of CN for average hydrologic runoff conditions for urban land uses published in the DCM (Table 2-8, page 2-22) were used to determine runoff curve numbers for the projected land uses. Figure I-9 shows projected land use conditions. Tables I-5a, I-5b, and I-5c display the runoff curve numbers used for projected future land use conditions for the SEUSC Watershed.

**Time of Concentration -** The alignment of streets and storm drains greatly affects the time of concentration. Studies have shown that the reduction in travel time can be estimated using the future CN, the percent impervious area, and the percent of the hydraulic length that is modified by development. Impervious area percentages provided in the DCM were used for future urban residential and commercial development land uses. For future development, it was assumed that 100 percent of the hydraulic length would be modified within each subbasin, but stream channels with tributary areas greater than 150 acres would remain substantively unaltered, in accordance with the DCM. Refer to Tables I-5a, I-5b, and I-5c for the values of time of concentration for projected future conditions.

Insert Figure I-9 Hydrologic Parameters - Projected Conditions
Southeast Upper Salt Creek Watershed

# HYDRAULICS

Channel and valley hydraulic characteristics determine the water depth generated by a given flow rate. Characteristics such as slope, available flow area, cross-section shape, degree of meander, overbank conditions, and the presence of bridges, culverts, or other crossings all affect the flow depth in a channel or flood corridor. Experience has shown that channel modifications built with thentent of increasing flow capacity, such as channel straightening or construction of levees, often have unforeseen side-effects, such as channel degradation or accelerated bank sloughing. Increasing the duration, frequency, or peak rate of flow may result in similar undesirable changes to the channel. Natural streams in natural (i.e., unmodified) watersheds tend to reach an equilibrium condition determined by vegetation, runoff, and geology. Studies have shown that stream channels generally have a bankfull capacity between the 2-year to 5-year flood. Changes in the watershed or stream characteristics can cause a reaction upsetting equilibrium. For example, increased peak flow rates can result in greater depths of flow. The Corps of Engineers Hydraulic Engineering Center in Davis California developed a River Analysis System computer model (HEC-RAS) to evaluate water surface profiles. HEC-RAS can be used to analyze the impacts of projected watershed parameters on the hydraulic characteristics of the stream channel. The mitigating characteristics of proposed master plan components can be compared using HEC-RAS analyses.

### STREAM AND TRIBUTARY MODELING

HEC-RAS allows the analysis of one-dimensional steady flow hydraulics and calculates water surface profiles. To perform these calculations the program requires channel geometric and flow data. A stream system schematic can be helpful to organize the data into a useable form and define how a stream system is connected. The watershed basin schematic generated for the Visual HEC-1 model, Figure I-8, was used to establish connectivity for a HEC-RAS model of the watershed.

**Cross-Section Geometry -** Cross-section geometry and cross-section properties are located along the stream at sufficient intervals to reasonably represent the channel and overbank geometry. Cross-section data were extracted from the Triangular Irregular Network (TIN) generated by computer from aerial photography. Locations near bridges and culverts were selected to define the structure geometry. Other data for bridges and culverts was collected from digital topographic mapping, the City and county, previous studies, and through field visits. Stream cross-sections were located perpendicular to anticipated flow lines.

**Energy Loss Coefficients -** Energy loss coefficients are used to evaluate hydraulic energy losses. These include Manning's *n* values for channel and overbank flow, contraction and expansion coefficients for evaluation of transition losses at beginning and ending of "bottlenecks", and bridge and culvert loss coefficients to evaluate hydraulic energy losses related to bridge and culvert characteristics. The model also evaluates the hydraulic energy losses associated with stream tributary junctions.

**Coordination with Existing Models -** The FEMA Flood Insurance Study (FIS) of Lincoln indicates the area between Yankee Hill Road and approximately 2,000 ft north of Saltillo Road is an Unnumbered A Zone of Salt Creek. The area from there to Saltillo Road is a Zone AE, which indicates water surface elevations and a floodway have been established. A Letter of Map Revision (LOMR) reflecting the grading completed for Wilderness Ridge was approved in the S-1 watershed. The floodplain is now contained within the channel. The City of Lincoln and LPSNRD sponsored a study by the US Army Corps of Engineers of Salt Creek through Wilderness Park that includes the confluence from this study watershed. Information from that study was used to determine the starting water surface elevations in the HEC-RAS model of this watershed. The main channel was modeled starting at the confluence with Salt Creek in Wilderness Park near South 27th Street and Saltillo Road. Tributaries were modeled from their confluence with the mainstem to the bottom of the uppermost subbasin of the SEUSC Watershed. The main channel was modeled along the railroad ditch starting near Saltillo Road. Tributaries were modeled from their confluence with the mainstem to the bottom of the uppermost subbasin.

**Flow Data -** Values for the peak flow rates generated by Visual HEC-1 for each of the design storms were entered into the HEC-RAS model. The analysis was carried out with existing channel characteristics for the 1-, 2-, 5-, 10-, 25-, 50-, 100-, and 500-year average return frequency storms for existing and projected future land use conditions. Refer to Tables I-9, I-10, I-11, and I-12 for a comparison of existing and projected condition peak flow rates for selected return periods.

**Road Crossing Data -** Road crossing geometrics can have a considerable affect on the hydraulics of a stream. Culvert or bridge capacity determines how frequently the road will be overtopped. Roadway sag points determine the location of overtopping and are not always located above the bridge or culvert. The low chord elevation is measured at the inside top or roof of the structure. Clearance requirements between water surface and low chord elevations are frequently stipulated for bridges. Tables I-8a, I-8b, and I-8c provide a summary of the road crossing data in UPZ S-1, S-2/S-3, and a portion of S-5, respectively. Refer to Figures I-7 and I-8 for model element and section locations.

**Table I-8a**
**Existing Road Crossing Data Summary for UPZ S-1**

| | Model Element | | Road Crossing Elevations | | | |
|---|---|---|---|---|---|---|
| Location | HEC-1 | HEC-RAS | Top of Road | Low Chord | Sag Point | Size |
| Yankee Hill Road | D37 | 3,921 | 1,197.3 | 1,193.2 | 1,197.3 | Dbl CBC 10' x 5' x 32' |
| Executive Ridge Drive | NODE10 | 3,129 | 1,195.0 | 1,191.0 | 1,192.0 | Trpl CBC 12' x 6' x 40' |
| BNSF Railroad | NODE9 | 1,956 | 1,187.4 | 1,184.3 | 1,187.4 | Dbl CBC 8' x 6' x 56' |
| South 14th Street | 14TH | 1,023 | 1,182.0 | 1,180.5 | 1,182.0 | CCSB 80' x 35' |
| UP Railroad | 14TH | 815 | 1,184.0 | 1,181.0 | 1,181.0 | 5 Span Timber Bridge 63' x 10' |

Abbreviation Key:
CBC - Concrete Box Culvert
CCSB - Continuous Concrete Span Bridge
CSB - Concrete Slab Bridge
Trpl - Triple25
CMP - Corrugated Metal Pipe
IBB - I-Beam Bridge
Dbl - Double

**Table I-8b**
**Existing Road Crossing Data Summary for UPZ S-2/S-3**

| Location | Model Element | | Road Crossing Elevations | | | |
|---|---|---|---|---|---|---|
| | HEC-1 | HEC-RAS | Top of Road | Low Chord | Sag Point | Size |
| Mainstem | | | | | | |
| Rokeby Road | 202 | 25,159 | 1,325.0 | 1,323.3 | 1,324.5 | CBC 4' x 4' x 52' |
| South 66th Street | 66TH | 24,449 | 1,318.0 | 1,314.0 | 1,318.0 | CMP 72" x 53' |
| South 56th Street | 56THB | 20,036 | 1,272.0 | 1,270.6 | 1,272.0 | CSB 36' x 30' |
| Cromwell Road | NODE62 | 17,440 | 1,256.0 | 1,254.0 | 1,254.0 | Trpl CBC 8' x 6' x 40' |
| South 40th Street | 40THB | 12,655 | 1,227.6 | 1,224.7 | 1,226.0 | Trpl CBC 10' x 5' x 48' |
| Rokeby Road | ROKEBY | 6,395 | 1,206.0 | 1,204.2 | 1,206.0 | CBC 10' x 10' x 54' |
| South 27th Street | 27THB | 3,607 | 1,194.0 | 1,191.8 | 1,192.0 | IBB 23' x 30' |
| BNSF Railroad | BNSF | 2,600 | 1,194.0 | 1,189.5 | 1,194.0 | Timber Bridge 100' x 30' |
| Northeast Tributary | | | | | | |
| Rebel Drive | REBEL | 9,430 | 1,292.0 | 1,289.5 | 1,292.0 | Dbl CMP 48" x 48' |
| South 56th Street | 56THA | 8,265 | 1,284.0 | 1,277.8 | 1,284.0 | CBC 9' x 8' x 101' |
| South 53rd Street | S53RD | 7,195 | 1,272.0 | 1,268.0 | 1,272.0 | CMP Arch 14' x 6' x 50' |
| Private Drive | R22 | 6,120 | 1,258.0 | 1,257.0 | 1,258.0 | CMP 36" x 24' |
| Private Drive | R22 | 5,670 | 1,255.0 | 1,254.0 | 1,254.0 | CMP 36" x 32' |
| Southwest Tributary | | | | | | |
| South 40th Street | S2T | 500 | 1,232.1 | 1,228.3 | 1,229.6 | CBC 6' x 6' x 54' |
| Southcentral Tributary | | | | | | |
| New Castle Road | CLV310 | 310 | 1,266.0 | 1,264.3 | 1,266.0 | Dbl CMP 60" x 48' |
| Southeast Tributary | | | | | | |
| Rokeby Road | 201 | 464 | 1,294.0 | 1,290.7 | 1,294.0 | CBC 6' x 4' x 25' |
| Northwest Tributary | | | | | | |
| Yankee Hill Road | YANKB | 5,700 | 1,260.0 | 1,253.2 | 1,260.0 | CBC 10' x 6' x 98' |
| South 40th Street | 40THA | 3,875 | 1,242.0 | 1,239.3 | 1,242.0 | Dbl CBC 6' x 5' x 36' |

**Table I-8c**
**Existing Road Crossing Data Summary for Portion of UPZ S-5**

| Location | Model Element | | Road Crossing Elevations | | | |
|---|---|---|---|---|---|---|
| | HEC-1 | HEC-RAS | Top of Road | Low Chord | Sag Point | Size |
| So. 38th St. (north) | S38 | 7,280.686 | 1,218.5 | 1,217.7 | 1,218.0 | 8' x 8' x 40' CBC |
| Saltillo Road | Saltil | 1,466.451 | 1,200.0 | 1,198.3 | 1,198.0 | Twin 6' x 6' x 42' CBC |
| So. 38th St. (south) | | 3,706.069 | 1,221.5 | 1,220.5 | 1,221.5 | 5' x 4' x 35' CBC |

**HEC-RAS RESULTS**

The output from the HEC-RAS model includes the water surface elevation, width of flow, flow velocity, and scour energy at each cross-section. All computed flow velocities in channel reaches are sub-critical with the Froude number (NF) ranging from about 0.01 to 0.80, well within the acceptable boundaries. Supercritical velocities are indicated through several bridges/culverts, and immediately downstream in some instances. Scour likely occurs in the stream bed at the bridges during passage of runoff from larger storms.

The City and the NRD asked that HEC-RAS modeling be performed for existing, projected LLCCP and built-out land use conditions.

UPZ S-1 is nearing built-out conditions. All of the land is developed, under construction or has approved preliminary plats on file. Pending development was assumed to be in place for purposes of modeling existing conditions. As peak flow rates for projected 2025 and for built-out conditions are duplicates of those for existing condition, they are not shown for UPZ S-1. Peak flow rates at South 14th Street and at the UP Railroad decrease because floodplain storage is available to temporarily hold flood water until the downstream channel can accommodate the flow. If the floodplain storage is not preserved the flow rates would likely increase to approximately the flow rates at the BNSF Railroad bridge.

The LLCCP for 2025 indicates that land use conditions for UPZ S2/S-3 and a portion of S-5, west of South 48th Street extended, are currently classified as agricultural land use and are located in the Tier I growth area, indicating full urbanization by 2025.

**Table I-9a**
**Peak Flow Rate Values at Selected Locations on the Mainstem EXISTING CONDITIONS in UPZ S-1**

| Location | Model Element | | Average Return Period, years | | | | | |
|---|---|---|---|---|---|---|---|---|
| | HEC-1 | HEC-RAS | 1 | 2 | 10 | 50 | 100 | 500 |
| Yankee Hill Road | D37 | 3,921 | 312 | 415 | 760 | 957 | 1,058 | 1,359 |
| Executive Ridge Drive | NODE10 | 3,129 | 326 | 454 | 1,019 | 1,362 | 1,531 | 1,987 |
| BNSF Railroad | NODE9 | 1,956 | 358 | 501 | 1,130 | 1,524 | 1,689 | 2,145 |
| South 14th Street | 14TH | 1,023 | 248 | 330 | 648 | 899 | 1,063 | 1,444 |
| UP Railroad | 14TH | 815 | 248 | 330 | 648 | 899 | 1,063 | 1,444 |

**Table I-9b**
**Peak Flow Rate Values at Selected Locations on the Mainstem EXISTING CONDITIONS in UPZ S-2/S-3**

| Location | Model Element | | Average Return Period, years | | | | | |
|---|---|---|---|---|---|---|---|---|
| | HEC-1 | HEC-RAS | 1 | 2 | 10 | 50 | 100 | 500 |
| Mainstem | | | | | | | | |
| Rokeby Road | 202 | 25,159 | 129 | 177 | 341 | 470 | 537 | 687 |
| South 66th Street | 66TH | 24,449 | 122 | 169 | 344 | 461 | 535 | 699 |
| South 56th Street | 56THB | 20,036 | 356 | 545 | 1,200 | 1,752 | 2,004 | 2,631 |
| Cromwell Road | NODE62 | 17,440 | 484 | 734 | 1,557 | 2,277 | 2,668 | 3,545 |
| South 40th Street | 40THB | 12,655 | 577 | 908 | 2,216 | 3,344 | 3,933 | 5,266 |
| Tributary Confluence | NODE25 | 8,707 | 824 | 1,249 | 3,193 | 4,860 | 5,734 | 7,690 |
| Rokeby Road | ROKEBY | 6,395 | 898 | 1,383 | 3,387 | 5,189 | 6,141 | 8,330 |
| South 27th Street | 27THB | 3,607 | 936 | 1,430 | 3,519 | 5,422 | 6,468 | 8,874 |
| BNSF Railroad | BNSF | 2,600 | 936 | 1,427 | 3,500 | 5,373 | 6,441 | 8,856 |
| Salt Creek | R6A | 2,491 | 936 | 1,427 | 3,500 | 5,373 | 6,441 | 8,856 |
| Northeast Tributary | | | | | | | | |
| Rebel Drive | REBEL | 9,430 | 164 | 257 | 612 | 914 | 1,075 | 1,441 |
| South 56th Street | 56THA | 8,265 | 132 | 179 | 609 | 878 | 1,042 | 1,376 |
| South 53rd Street | S53RD | 7,195 | 132 | 178 | 533 | 747 | 830 | 1,013 |
| Private Drive | R22 | 6,120 | 171 | 275 | 700 | 996 | 1,136 | 1,430 |
| Private Drive | R22 | 5,670 | 171 | 275 | 700 | 996 | 1,136 | 1,430 |
| Southwest Tributary | | | | | | | | |
| South 40th Street | S2T | 500 | 165 | 233 | 471 | 662 | 762 | 986 |
| Southcentral Tributary | | | | | | | | |
| New Castle Road | CLV310 | 310 | 115 | 164 | 328 | 439 | 488 | 609 |
| Southeast Tributary | | | | | | | | |
| Rokeby Road | 201 | 464 | 169 | 243 | 506 | 717 | 827 | 1,076 |
| Northwest Tributary | | | | | | | | |
| Yankee Hill Road | YANKB | 5,700 | 113 | 167 | 371 | 546 | 639 | 852 |
| South 40th Street | 40THA | 3,875 | 175 | 253 | 507 | 708 | 814 | 1,034 |

**Table I-9c**
**Peak Flow Rate Values at Selected Locations on the Mainstem PROJECTED CONDITIONS in UPZ S-2/S-3**

| Location | Model Element | | Average Return Period, years | | | | | |
|---|---|---|---|---|---|---|---|---|
| | HEC-1 | HEC-RAS | 1 | 2 | 10 | 50 | 100 | 500 |
| Mainstem | | | | | | | | |
| Rokeby Road | 202 | 25,159 | 111 | 157 | 319 | 449 | 517 | 669 |
| South 66th Street | 66TH | 24,449 | 111 | 150 | 325 | 443 | 516 | 684 |
| South 56th Street | 56THB | 20,036 | 313 | 489 | 1,164 | 1,714 | 1,992 | 2,607 |
| Cromwell Road | NODE62 | 17,440 | 444 | 687 | 1,525 | 2,234 | 2,639 | 3,505 |
| South 40th Street | 40THB | 12,655 | 602 | 934 | 2,286 | 3,457 | 4,031 | 5,350 |
| Tributary Confluence | NODE25 | 8,707 | 1,262 | 1,748 | 3,634 | 5,297 | 6,217 | 8,231 |
| Rokeby Road | ROKEBY | 6,395 | 1,423 | 1,984 | 4,039 | 5,895 | 6,934 | 9,224 |
| South 27th Street | 27THB | 3,607 | 1,491 | 2,080 | 4,309 | 6,394 | 7,564 | 10,111 |
| BNSF Railroad | BNSF | 2,600 | 1,484 | 2,073 | 4,311 | 6,378 | 7,495 | 10,105 |
| Salt Creek | R6A | 2,491 | 1,469 | 2,057 | 4,325 | 6,408 | 7,574 | 10,105 |
| Northeast Tributary | | | | | | | | |
| Rebel Drive | REBEL | 9,430 | 164 | 257 | 612 | 914 | 1,075 | 1,441 |
| South 56th Street | 56THA | 8,265 | 132 | 179 | 609 | 878 | 1,042 | 1,376 |
| South 53rd Street | S53RD | 7,195 | 132 | 178 | 533 | 747 | 830 | 1,013 |
| Private Drive | R22 | 6,120 | 171 | 275 | 700 | 996 | 1,136 | 1,430 |
| Private Drive | R22 | 5,670 | 171 | 275 | 700 | 996 | 1,136 | 1,430 |
| Southwest Tributary | | | | | | | | |
| South 40th Street | S2T | 500 | 315 | 419 | 766 | 1,036 | 1,175 | 1,486 |
| Southcentral Tributary | | | | | | | | |
| New Castle Road | CLV310 | 310 | 115 | 164 | 328 | 439 | 488 | 609 |
| Southeast Tributary | | | | | | | | |
| Rokeby Road | 201 | 464 | 136 | 206 | 461 | 679 | 796 | 1,058 |
| Northwest Tributary | | | | | | | | |
| Yankee Hill Road | YANKB | 5,700 | 113 | 167 | 371 | 546 | 639 | 852 |
| South 40th Street | 40THA | 3,875 | 249 | 332 | 612 | 824 | 929 | 1,166 |

**Table I-9d**
**Peak Flow Rate Values at Selected Locations on the Mainstem EXISTING CONDITIONS in Portion of UPZ S-5**

| | Model Element | | Average Return Period, years | | | | | |
|---|---|---|---|---|---|---|---|---|
| Location | HEC-1 | HEC-RAS | 1 | 2 | 10 | 50 | 100 | 500 |
| Saltillo Road | Saltil | 1,466.451 | 418 | 637 | 1,445 | 2,104 | 2,454 | 3,242 |
| UPRR Ditch | RRjctn | 3,802.426 | 235 | 369 | 873 | 1,281 | 1,501 | 1,993 |
| So. 38th St. (north) | S38th | 7,280.686 | 220 | 322 | 660 | 940 | 1,140 | 1,642 |
| | | | | | | | | |
| So. 38th St. (south) | S5E | 3,706.069 | 82 | 120 | 257 | 369 | 428 | 560 |

**Table I-9e**
**Peak Flow Rate Values at Selected Locations on the Mainstem PROJECTED CONDITIONS in Portion of UPZ S-5**

| | Model Element | | Average Return Period, years | | | | | |
|---|---|---|---|---|---|---|---|---|
| Location | HEC-1 | HEC-RAS | 1 | 2 | 10 | 50 | 100 | 500 |
| Saltillo Road | Saltil | 1,466.451 | 755 | 1,062 | 2,151 | 3,024 | 3,485 | 4,522 |
| UPRR Ditch | RRjctn | 3,802.426 | 427 | 617 | 1,310 | 1,872 | 2,172 | 2,921 |
| So. 38th St. (north) | S38th | 7,280.686 | 300 | 428 | 855 | 1,266 | 1,481 | 2,010 |
| | | | | | | | | |
| So. 38th St. (south) | S5E | 3,706.069 | 150 | 203 | 390 | 537 | 613 | 783 |

**Table I-10**
**2-year Peak Flow Rate Values at Selected Locations in UPZ S-2/S-3**

| Location | Model Element | | Existing | Projected | |
|---|---|---|---|---|---|
| | HEC-1 | HEC-RAS | Q | Q | % change |
| Mainstem | | | | | |
| Rokeby Road | 202 | 25,159 | 177 | 157 | -11% |
| South 66th Street | 66TH | 24,449 | 169 | 150 | -11% |
| South 56th Street | 56THB | 20,036 | 545 | 489 | -10% |
| Cromwell Road | NODE62 | 17,440 | 734 | 687 | -6% |
| South 40th Street | 40THB | 12,655 | 908 | 934 | 3% |
| Tributary Confluence | NODE25 | 8,707 | 1,249 | 1,748 | 40% |
| Rokeby Road | ROKEBY | 6,395 | 1,383 | 1,984 | 43% |
| South 27th Street | 27THB | 3,607 | 1,430 | 2,080 | 45% |
| BNSF Railroad | BNSF | 2,600 | 1,427 | 2,073 | 45% |
| Salt Creek | R6A | 2,491 | 1,427 | 2,057 | 44% |
| Northeast Tributary | | | | | |
| Rebel Drive | REBEL | 9,430 | 257 | 257 | 0% |
| South 56th Street | 56THA | 8,265 | 179 | 179 | 0% |
| South 53rd Street | S53RD | 7,195 | 178 | 178 | 0% |
| Private Drive | R22 | 6,120 | 275 | 275 | 0% |
| Private Drive | R22 | 5,670 | 275 | 275 | 0% |
| Southwest Tributary | | | | | |
| South 40th Street | S2T | 500 | 233 | 419 | 80% |
| Southcentral Tributary | | | | | |
| New Castle Road | CLV310 | 310 | 164 | 164 | 0% |
| Southeast Tributary | | | | | |
| Rokeby Road | 201 | 464 | 243 | 206 | -15% |
| Northwest Tributary | | | | | |
| Yankee Hill Road | YANKB | 5,700 | 167 | 167 | 0% |
| South 40th Street | 40THA | 3,875 | 253 | 332 | 31% |

**Table I-11**
**10-year Peak Flow Rate Values at Selected Locations in UPZ S-2/S-3**

| Location | Model Element | | Existing | Projected | |
|---|---|---|---|---|---|
| | HEC-1 | HEC-RAS | Q | Q | % change |
| Mainstem | | | | | |
| Rokeby Road | 202 | 25,159 | 341 | 319 | -6% |
| South 66th Street | 66TH | 24,449 | 344 | 325 | -6% |
| South 56th Street | 56THB | 20,036 | 1,200 | 1,164 | -3% |
| Cromwell Road | NODE62 | 17,440 | 1,557 | 1,525 | -2% |
| South 40th Street | 40THB | 12,655 | 2,216 | 2,286 | 3% |
| Tributary Confluence | NODE25 | 8,707 | 3,193 | 3,634 | 14% |
| Rokeby Road | ROKEBY | 6,395 | 3,387 | 4,039 | 19% |
| South 27th Street | 27THB | 3,607 | 3,519 | 4,309 | 22% |
| BNSF Railroad | BNSF | 2,600 | 3,500 | 4,311 | 23% |
| Salt Creek | R6A | 2,491 | 3,500 | 4,325 | 24% |
| Northeast Tributary | | | | | |
| Rebel Drive | REBEL | 9,430 | 612 | 612 | 0% |
| South 56th Street | 56THA | 8,265 | 609 | 609 | 0% |
| South 53rd Street | S53RD | 7,195 | 533 | 533 | 0% |
| Private Drive | R22 | 6,120 | 700 | 700 | 0% |
| Private Drive | R22 | 5,670 | 700 | 700 | 0% |
| Southwest Tributary | | | | | |
| South 40th Street | S2T | 500 | 471 | 766 | 63% |
| Southcentral Tributary | | | | | |
| New Castle Road | CLV310 | 310 | 328 | 328 | 0% |
| Southeast Tributary | | | | | |
| Rokeby Road | 201 | 464 | 506 | 461 | -9% |
| Northwest Tributary | | | | | |
| Yankee Hill Road | YANKB | 5,700 | 371 | 371 | 0% |
| South 40th Street | 40THA | 3,875 | 507 | 612 | 21% |

**Table I-12**
**100-year Peak Flow Rate Values at Selected Locations in UPZ S-2/S-3**

| Location | Model Element | | Existing | Projected | |
|---|---|---|---|---|---|
| | HEC-1 | HEC-RAS | Q | Q | % Change |
| Mainstem | | | | | |
| Rokeby Road | 202 | 25,159 | 537 | 517 | -4% |
| South 66th Street | 66TH | 24,449 | 535 | 516 | -4% |
| South 56th Street | 56THB | 20,036 | 2,004 | 1,992 | -1% |
| Cromwell Road | NODE62 | 17,440 | 2,668 | 2,639 | -1% |
| South 40th Street | 40THB | 12,655 | 3,933 | 4,031 | 2% |
| Tributary Confluence | NODE25 | 8,707 | 5,734 | 6,217 | 8% |
| Rokeby Road | ROKEBY | 6,395 | 6,141 | 6,934 | 13% |
| South 27th Street | 27THB | 3,607 | 6,468 | 7,564 | 17% |
| BNSF Railroad | BNSF | 2,600 | 6,441 | 7,495 | 16% |
| Salt Creek | R6A | 2,491 | 6,441 | 7,574 | 18% |
| Northeast Tributary | | | | | |
| Rebel Drive | REBEL | 9,430 | 1,075 | 1,075 | 0% |
| South 56th Street | 56THA | 8,265 | 1,042 | 1,042 | 0% |
| South 53rd Street | S53RD | 7,195 | 830 | 830 | 0% |
| Private Drive | R22 | 6,120 | 1,136 | 1,136 | 0% |
| Private Drive | R22 | 5,670 | 1,136 | 1,136 | 0% |
| Southwest Tributary | | | | | |
| South 40th Street | S2T | 500 | 762 | 1,175 | 54% |
| Southcentral Tributary | | | | | |
| New Castle Road | CLV310 | 310 | 488 | 488 | 0% |
| Southeast Tributary | | | | | |
| Rokeby Road | 201 | 464 | 827 | 796 | -4% |
| Northwest Tributary | | | | | |
| Yankee Hill Road | YANKB | 5,700 | 639 | 639 | 0% |
| South 40th Street | 40THA | 3,875 | 814 | 929 | 14% |

**Table I-13a**
**2-year Peak Flow Rate Values at Selected Locations in Portion of UPZ S-5**

| Location | Model Element | | Existing | Projected | |
|---|---|---|---|---|---|
| | HEC-1 | HEC-RAS | Q | Q | % Change |
| S-5A | S5A | 11,568.87 | 25 | 35 | 40% |
| S-5up | S5up | 9,309.881 | 254 | 308 | 21% |
| So. 38th St. (north) | S38th | 7,280.686 | 322 | 428 | 33% |
| BNSF RR Ditch | RRjctn | 3,802.426 | 369 | 617 | 67% |
| Saltillo Road | Saltil | 1,466.451 | 637 | 1,062 | 67% |
| So. 38th St. (south) | S5E | 3,706.069 | 120 | 203 | 69% |

**Table I-13b**
**10-year Peak Flow Rate Values at Selected Locations in Portion of UPZ S-5**

| Location | Model Element | | Existing | Projected | |
|---|---|---|---|---|---|
| | HEC-1 | HEC-RAS | Q | Q | % change |
| S-5A | S5A | 11,568.87 | 129 | 158 | 22% |
| S-5up | S5up | 9,309.881 | 530 | 610 | 15% |
| So. 38th St. (north) | S38th | 7,280.686 | 660 | 855 | 30% |
| BNSF RR Ditch | RRjctn | 3,802.426 | 873 | 1,310 | 50% |
| Saltillo Road | Saltil | 1,466.451 | 1,445 | 2,151 | 49% |
| So. 38th St. (south) | S5E | 3,706.069 | 257 | 390 | 52% |

**Table I-13c**
**100-year Peak Flow Rate Values at Selected Locations in Portion of UPZ S-5**

| Location | Model Element | | Existing | Projected | |
|---|---|---|---|---|---|
| | HEC-1 | HEC-RAS | Q | Q | % change |
| S-5A | S5A | 11,568.87 | 434 | 529 | 22% |
| S-5up | S5up | 9,309.881 | 886 | 1,053 | 19% |
| So. 38th St. (north) | S38th | 7,280.686 | 1,140 | 1,481 | 30% |
| BNSF RR Ditch | RRjctn | 3,802.426 | 1,501 | 2,172 | 45% |
| Saltillo Road | Saltil | 1,466.451 | 2,454 | 3,485 | 42% |
| So. 38th St. (south) | S5E | 3,706.069 | 428 | 613 | 43% |

There is a slight decrease in peak flow rates for built-out conditions at the top of UPZ S-2/S-3 due to projected land use change from agricultural to rural residential. The proposed land use generates less runoff than the existing land use. There is virtually no change in peak flow rates at Cromwell and South 40th Street Road crossings, because there is no projected change in land use conditions in upstream portion of the watershed. Peak flow rates increase significantly due to projected land use changes and anticipated method of development in the lower portion of the watershed.

The existing peak flow rates for UPZ S-1, as stated in Table I-9a, are not projected to change. The Yankee Hill Road and Executive Drive culverts were built within the last two years and designed to meet minimum DCM requirements, which include passing the 50-year flood with 1-ft of freeboard below the roadway shoulder and 1-ft of freeboard below low-opening of upstream or adjacent buildings for the 100-year storm. Projected conditions were used for hydrologic and hydraulic analysis of the new bridges.

**Table I-14a**
**Comparison of Road Crossing Capacity Mainstem Channel for UPZ S-1**

| Location | Size and Type | 100-Year Flow | | Capacity cfs | Avg Return Period [2] |
|---|---|---|---|---|---|
| | | Existing | Projected | | Existing |
| Yankee Hill Rd. | Dbl CBC 10' x 5' x 32' | 1,058 | 1,058 | 1,220 | 100 |
| Executive Ridge Dr | Trpl CBC 12' x 6' x 40' | 1,531 | 1,531 | 1,730 | 500 |
| BNSF Railroad | Dbl CBC 8' x 6' x 56' | 1,689 | 1,689 | 1,820 | 500 |
| South 14th Street | CCSB 80' x 35' | 1,063 | 1,063 | 910 | 100 |
| UP Railroad | 5SpBridge 63' x 10' | 1,063 | 1,063 | 1,410 | 500 |

**Table I-14b**
**Comparison of Road Crossing Capacity Mainstem Channel for UPZ S-2/S-3**

| Location | Size and Type | 100-Year Flow | | Capacity cfs | Avg Return Period | |
|---|---|---|---|---|---|---|
| | | Existing | Projected | | Existing | Projected [3] |
| Rokeby Road | CBC 4' x 4' x 52' | 537 | 517 | 160 | 2 | 2 |
| South 66th Street | CMP 72" x 53' | 535 | 516 | 330 | 10 | 10 |
| South 56th Street | CSB 36' x 30' | 2,004 | 1,992 | 1,950 | 100 | 100 |
| Cromwell Drive | Trpl CBC 8' x 6' x 40' | 2,639 | 2,639 | 820 | 2 | 2 |
| South 40th Street | Trpl CBC 10' x 5' x 48' | 3,933 | 4,031 | 1,240 | 3 | 3 |
| Rokeby Road | CBC 10' x 10' x 54' | 6,141 | 6,217 | 1,100 | 1 | 1 |
| South 27th Street | IBB 23' x 30' | 6,468 | 6,934 | 1,100 | 1 | 1 |
| BNSF Railroad | Timber Bridge 100' x 30' | 6,441 | 7,564 | 5,090 | 25 | 25 |

Areas above 48th Street extended to 63rd Street are in projected land use conditions in the S-2/S-3 watershed. The area upstream of 63rd Street is within the subbasins and beyond the scope of this master plan. The watershed is not fully developed in the area downstream of 48th Street. Encroachment to minimum corridor limits. according to DCM requirements, was applied to the floodplain downstream from 40th Street. The projected average return frequencies in Tables 1-14b and 1-14c are the same as existing average return frequencies because the crossings downstream from 40th Street are overtopped by events which fit within the encroached stream corridor.

**Table I-14c**
**Comparison of Road Crossing Capacity Tributary Channels for UPZ S-2/S-3**

| Location | Size and Type | 100-Year | | Capacity cfs | Avg Return Period | |
|---|---|---|---|---|---|---|
| | | Existing | Projected | | Existing | Projected |
| Yankee Hill Rd. | CBC 10' x 6' x 98' | 639 | 639 | 1,020 | 500 | 500 |
| South 40th Street | Dbl CBC 6' x 5' x 36' | 814 | 929 | 630 | 25 | 10 |
| South 40th Street | CBC 6' x 6' x 54' | 762 | 1,175 | 290 | 2 | 2 |
| Rebel Drive | Dbl CMP 48" x 48' | 1,075 | 1,075 | 240 | 2 | 2 |
| South 56th Street | CBC 9' x 8' x 101' | 1,042 | 1,042 | 1,130 | 100 | 100 |
| South 53rd Street | CMP Arch 14' x 6' x 50' | 830 | 830 | 830 | 100 | 100 |
| Private Drive | CMP 36" x 24' | 1,136 | 1,136 | 160 | 1 | 1 |
| Private Drive | CMP 36" x 32' | 1,136 | 1,136 | 120 | 1 | 1 |
| New Castle Road | Dbl CMP 60" x 48' | 488 | 488 | 340 | 10 | 10 |
| Rokeby Road | CBC 6' x 4' x 25' | 827 | 796 | 320 | 2 | 5 |
| So. 38th St. (north) | 8' x 8' CBC | 1,140 | 1,481 | 775 | 25 | 10 |
| Saltillo Road | Twin 6' x 6' CBC | 2,454 | 3,485 | 645 | 2 | 2 |
| So. 38th St. (south) | 5' x 4' CBC | 428 | 613 | 98 | 2 | 1 |

1. Capacity for stormwater master planning is defined as the flow rate that occurs prior to roadway overtopping.
2. Number of years (on average) that can be expected between overtopping events. For example, a bridge has a capacity before overtopping the road of 600 cfs, the 10% return frequency storm (10-year) flow rate is listed as 660 cfs and the 20% return frequency storm (5-year) flow rate is 540 cfs. By interpolation on probability paper, the bridge capacity would be less than the 10% return frequency storm or on average the bridge can be expected to be overtopped more frequently than every 10 years based on flow rates.
3. Value for existing structure with flow rates for projected conditions.

## FLOOD PRONE AREAS

HEC-RAS provides a graphical interface that displays the extent of the reach subject to flooding. The information for the 100-year event was transferred to the digital topographic mapping. Straight-line interpolation was used to determine the water surface elevations for the areas between cross-sections. To determine the extent of flood prone areas the water surface profile was projected to the valley land surface represented in the digital topographic map. The limits of the area prone to the 100-year flood, as modeled based on existing conditions, is shown in Figure I-10. The flooding limits for the 2-, 10-, and 100-year storms, as modeled based on existing conditions, are shown on Figures I-11A through I-11J. Profile sheets showing 2-, 10-, and 100-year floods, as modeled based on existing conditions, are shown on Figures I-12A through I-12i. The extent of flood prone areas can be used for planning purposes to assist in evaluation of the effect that projected land use changes would have on the watershed and that of proposed master plan components.

### Effects of Urbanization

To understand the effects of urbanization on the watershed, incremental changes were made to flow models. As a first step, future condition land uses for the watershed were applied to the HEC-1 model while not changing existing floodplain geometry. This modeling run shows that flow rates would likely not increase in the mainstem of the basin (see Table 1-15 and compare to Table 1-9b on page 26). One reason for this is that urbanization reduces the amount of time it takes for flow from the northwest tributary to meet the mainstem. The urbanized peak tributary flow would arrive in the mainstem before mainstem peak flows arrive. Another reason is that available floodplain storage would help to attenuate (buffer) increased flow rates.

As a second step, another scenario was modeled to represent the effects of preserving only a minimum flood corridor and the elimination of floodplain storage outside this corridor. For areas below 40th Street in S-2/S-3 and a portion of S-5, a minimum flood corridor with 30' buffers, 3:1 side slopes, and original bottom width was modeled. Encroachment to this minimum corridor does not effect the 1-, 2-, or 5-year water surface elevations, but does increase water surface elevations for larger storms. For the 100-year storm, water surface elevations would increase as much as 3 to 4 ft in S-2/S-3 and as much as 1 ft in S-5. The effect of encroachment on flows is illustrated by comparing Tables 1-9b and 1-9c on p. 26 and Tables 1-9d and 1-9e on p. 27. This analysis shows that floodplain storage in the existing floodplains plays a critical role in determining peak flow rates and water surface elevations.

**Table I-15**
**Future Conditions Peak Flow Rate Values at Selected Locations with Existing Conditions Geometry in UPZ S-2/S-3 & Portion of UPZ S-5**
**(Prior to Application of Minimum Corridor Stream Channels)**

| Location | | Model Element | | Average Return Period, years | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | HEC-1 | HEC-RAS | 1 | 2 | 10 | 50 | 100 | 500 |
| Rokeby Road | S-2/S-3 | 202 | 25,159 | 129 | 177 | 341 | 470 | 537 | 687 |
| South 66th Street | S-2/S-3 | 66TH | 24,449 | 122 | 169 | 344 | 461 | 535 | 699 |
| South 56th Street | S-2/S-3 | 56THB | 20,036 | 356 | 545 | 1,200 | 1,752 | 2,004 | 2,631 |
| Cromwell Road | S-2/S-3 | NODE62 | 17,440 | 484 | 734 | 1,557 | 2,277 | 2,668 | 3,545 |
| South 40th Street | S-2/S-3 | 40THB | 12,655 | 575 | 899 | 2,171 | 3,264 | 3,836 | 5,105 |
| Tributary Confluence | S-2/S-3 | NODE25 | 8,707 | 1,006 | 1,423 | 2,954 | 4,435 | 5,207 | 6,944 |
| Rokeby Road | S-2/S-3 | ROKEBY | 6,395 | 1,097 | 1,606 | 3,240 | 4,770 | 5,637 | 7,640 |
| South 27th Street | S-2/S-3 | 27THB | 3,607 | 1,108 | 1,607 | 3,419 | 5,028 | 5,935 | 8,071 |
| BNSF Railroad | S-2/S-3 | BNSF | 2,600 | 1,099 | 1,587 | 3,408 | 5,016 | 5,934 | 8,094 |
| Salt Creek | S-2/S-3 | R6A | 2,491 | 1,080 | 1,451 | 3,043 | 4,061 | 4,318 | 6,522 |
| Saltillo Road | S-5 | Saltil | 1,466 | 773 | 1,075 | 2,109 | 2,918 | 3,339 | 4,276 |
| UPRR Ditch | S-5 | RRjctn | 3,802 | 445 | 630 | 1,267 | 1,766 | 2,028 | 2,604 |
| So. 38th St. (north) | S-5 | S38th | 7,280 | 293 | 408 | 786 | 1,070 | 1,250 | 1,744 |
| So. 38th St. (south) | S-5 | S5E | 3,706 | 150 | 203 | 390 | 537 | 612 | 783 |

Insert Figure I-10 Flood Prone Area Map - Existing Conditions
Southeast Upper Salt Creek Watershed

## STREAM SEGMENT EVALUATION

Stormwater management involves evaluation of the channels and crossing structures in the watershed. If not anticipated, modifications to the hydrologic and hydraulic conditions may adversely affect the performance of the channels and structures. Figures I-11A through I-11o display the plan view of the 2-year, 10-year, and 100-year floodplain limits for existing condition on Stream Segments 1 through 15. Figures I-12A through I-12o display the existing conditions water surface profiles on Stream Segments 1 through 15. Figure I-13 displays the flood hazard for existing conditions to bridges and houses in the watershed.

**Channel Stability**

Channel stability is important not only as a safety issue but also from a water quality standpoint. A degrading channel causes bank sloughing, which can reduce tillable land in agricultural areas or threaten adjacent infrastructures in urban areas. Bank failure is also a significant source of sediment in many urban streams. The 2-5 year storm events are considered to provide channel forming flows. They occur frequently and have sufficient energy to determine the shape and slope of the channel. When channel forming flows increase, stream forces attempt to maintain a stable bed slope by either lengthening the flow path or reducing the elevation difference. Meanders migrate outward and head cuts reduce channel slope.

A reach stability analysis was performed utilizing a process outlined in the NRCS "Stream Corridor Restoration Manual", which uses the following factors; bend radius; flow width and depth, soil classification, plasticity index, and void ratios. The evaluation supports the field observations of the project team. Observations of channel stability were made from or adjacent to public right-of way or public property.

**Flood Hazard**

The hazard due to flooding is determined by stream and valley shape (a.k.a. "the lay of the land"), channel restrictions, channel crossings, proximity of buildings, and flow rates.

**Threats to Infrastructure**

Infrastructure includes road and railroad bridges or culverts, and buried or overhead utilities. Road crossings cannot only influence flooding but can be threatened by flooding. Refer to Table I-13e for roadway overtopping frequency values. In addition to flooding, localized scour and head cutting can undermine the stability of bridges or culverts. Utilities are often installed parallel to, or across stream channels. Channel meandering can threaten adjacent buried conduits or support towers for overhead utilities. Head cutting can expose buried utilities in stream beds. Utility crossings often share or are near road right-of-ways (ROW). Road crossings can either protect the utility (i.e., a box culvert providing a local hardpoint) or accelerate erosion (i.e., increased stream velocities causing local scour).

**Land use and ownership**

Existing or projected land use, and ownership of property adjacent to streams is an important consideration in stormwater management. For example, channel improvements or maintenance activities may be facilitated by a channel easement along a stream or public park adjacent to the stream.

**Multi-Purpose Use Potential**

An important benefit of master planning is the opportunity to coordinate the efforts of several interests, such as private developers, City, county, NRD, and other agencies (i.e., coordinating existing and potential future public open space along stream channels). Stream corridor can serve alternately as both connectors and as separators. They provide connective habitat for movement of wildlife and provide recreation trail opportunities. Riparian areas serve as boundaries and edges and riparian forests shade streams. Flood waters can be temporally stored along channels until down stream capacity can drain the runoff volume. Riparian buffers can filter surface runoff and provide opportunities for nutrient uptake.

**Water Quality**

Land use has been shown to affect stormwater runoff water quality. Accessing adjacent land use or projected land use can provide an indicator of potential water quality concerns.

**EVALUATION**

Stream characteristics were determined for segments of the mainstem channel in Urban Planning Zone S-1, and of the mainstem channel and tributaries in S-2/S-3 and a portion of S-5. Reach stability, flood hazard, potential threats to bridges and utilities, land use and ownership, multi-purpose use potential, and water quality issues were used to evaluate each stream segment. Photographs of channel characteristics are provided to help illustrate the evaluation of each segment on the following pages. (Additional photographs may be exposed after consulting landowners.)

**THREAT MATRIX**

The following ranking protocol was used to determine the relative threat to the stream segments in the watershed for existing conditions.

Reach Stability

| | |
|---|---|
| High | - Active bed or bank erosion |
| Medium | - Few indicators of active bed or bank erosion |
| Low | - No indicators of active bed or bank erosion |

Flood Hazard

| | |
|---|---|
| High | - Flooded houses, outbuildings, or arterial roadways |
| Medium | - Minor roadways flooded, building surrounded but not flooded |
| Low | - Flooding confined to agricultural land or private drives |

Infrastructure

| | |
|---|---|
| High | - Exposed or eminently threatened utilities or roadbed |
| Medium | - Utilities or roadbed present but not eminently threatened |
| Low | - No utilities or roadbed present |

Water Quality

| | |
|---|---|
| High | - Potential point source pollutant within the floodplain limits |
| Medium | - Potential non-point source activities without riparian buffer zone |
| Low | - Potential non-point source activities with 30-ft minimum width riparian buffer zone |

Insert Figure I-11A - Plan View of Stream Segment 1
Southeast Upper Salt Creek Watershed

Photo 1. Mainstem channel looking downstream near UP Railroad.

Photo 2. Mainstem channel looking upstream from 14th Street.

## Stream Segment 1 in UPZ S-1
## Evaluation

Steam Segment 1 begins at the confluence with Salt Creek in Wilderness Park and extends through Yankee Hill Road. UP Railroad, South 14th Street, BNSF Railroad, Executive Drive and Yankee Hill Road cross the channel.

- **Reach Stability** — The channel near the mouth has not been modified although some evidence of head cutting is apparent downstream of the 14th Street bridge. The channel between 14th Street and Yankee Hill Road appears to be stable, it was likely straightened prior to the 1940's. A terrace has formed in the lower half of the cross-section. The channel between BNSF Railroad and Yankee Hill Road is contained within a minimum flood corridor. There are no signs of active stream bed or bank erosion.

- **Flood Hazard Potential** — The Salt Creek floodplain, as delineated in the Salt Creek at Wilderness Park Hydrologic Study, controls the water surface elevations west of BNSF Railroad. The crossings at UP Railroad, South 14th Street, and BNSF Railroad will be inundated by the 100-year event (see the hydraulics section for more information). Bridges at Executive Drive and Yankee Hill Road were designed based on the DCM. Site grading for adjacent development was designed based on the water surface profiles for built-out conditions in the watershed. A minimum flood corridor has been preserved along the reach between BNSF Railroad and Yankee Hill Road. Several buildings are located to the north of the channel between BNSF Railroad and 14th Street. From two-ft city contour maps, it appears that these buildings are located at, or just above, the 100-year floodplain of Salt Creek. Building low opening elevations would need to be confirmed to accurately determine flood hazard exposure on these properties.

- **Threats to Infrastructure** — UP Railroad and BNSF Railroad ROWs contain buried fiber optic cable. Head cutting, if allowed to continue, could expose the cable in the UP Railroad ROW. The overhead utilities along 14th Street do not appear to be immediately threatened. The BNSF Railroad box culvert provides a hardpoint in the channel. A sanitary trunk sewer serving Wilderness Ridge, and ultimately UPZ S-2, crosses the stream channel upstream of the BNSF Railroad box culvert. The box culvert should serve to protect from stream bed degradation. The outlet and inlet of the Yankee Hill Road box culvert are protected with rock riprap. Interior cart path crossings on the golf course will be frequently inundated.

- **Land Use and Ownership** — The mouth of this reach is in Wilderness Park and the property upstream from UP Railroad is privately held. The reach between UP Railroad and BNSF Railroad is currently in crops on the south side of the channel. The north side of the channel is part of the Wilderness Ridge Golf Course maintenance facility. The portion east of the BNSF Railroad has either been developed or is currently undergoing development. A golf course intertwined with commercial buildings is being developed on either side of the channel.

- **Multi-Purpose Use Potential** — Multi-use potential outside of Wilderness Park is limited. The minimum flood corridor provides open space and a buffer zone along the channel.

- **Water Quality** — Parking lot and roof top runoff from the adjacent crop land, the golf course, and commercial land use are the dominant characteristics affecting surface water quality. Riparian vegetation is associated with the entire length of this segment. In the short-term, ongoing construction, upstream of this reach will be a source of sediment and other contaminants if the BMPs are not properly installed and maintained.

## Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12A - Flood Profile Stream Segment 1
Southeast Upper Salt Creek Watershed

Insert Figure I-11B - Plan View of Stream Segment 2
Southeast Upper Salt Creek Watershed

Photo 3. Looking east upstream of the Yankee Hill Road culvert.

Photo 4. Looking southwest from the upper stream segment.

## Stream Segment 2 in UPZ S-1
## Evaluation

Stream segment 2 begins upstream of Yankee Hill Road and extends to South 27th Street and it includes a tributary that extends to the north side of the intersection of South 27th Street and Yankee Hill Road.

- **Reach Stability** — The channel along Yankee Hill Road is generally confined to the road ROW. It is relatively narrow, but there is no apparent head cutting. Yankee Hill Road was widened next to this portion of the reach. Additional widening of Yankee Hill Road will be completed upon development of the adjoining land. The effects of urbanization on stream stability will be evaluated as part of the design process, as required by the Lincoln Subdivision Ordinance and DCM. There are no signs of active stream bed or bank erosion.
- **Flood Hazard Potential** — The area is currently undeveloped and flooding is confined to crop land. Proposed development in the area will need to meet Lincoln DCM requirements. Low openings in buildings adjacent to the channel will be at or above the 100-year water surface profile for projected flows. A minimum flood corridor has been designated on the plat for the proposed development.
- **Threats to Infrastructure** — A sanitary sewer crosses the mainstem near Yankee Hill Road and runs parallel to the minor tributary along the north side. The sewer and other buried utilities should not be threatened as long as the stream remains stable.
- **Land Use and Ownership** — The land is privately held on both sides of the channel. The adjoining land is currently agricultural, but is planned to be developed as residential and commercial property. The approved preliminary plat for the proposed development shows the minimum corridor along the stream plotted as an "out lot." In this area, Yankee Hill Road is programed to become a four-lane urban section roadway.
- **Multi-Purpose Use Potential** — The minimum flood corridor provides open space and a buffer zone along the channel. The corridor will serve as a boundary in the proposed development and along Yankee Hill Road. The golf course and the railroad effectively cut off recreational connection to Wilderness Park, but wildlife will likely move along the corridor.
- **Water Quality** — 30-foot buffer zones, included in the minimum corridor, will provide opportunities for filtering runoff from adjacent property and nutrient uptake. Parking lot and roof top runoff from the proposed adjacent and existing upstream residential and commercial land use will be the dominant characteristic affecting surface water quality. In the short-term, ongoing construction, adjacent to and upstream of this reach, will be a source of sediment and other contaminants if the BMPs are not properly installed and maintained.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12B - Flood Profile Stream Segment 2
Southeast Upper Salt Creek Watershed

Insert Figure I-11C - Plan View of Stream Segment 3
Southeast Upper Salt Creek Watershed

Photo 5. Looking west southwest along mainstem from 27th Street.

Photo 6. Looking east along mainstem from 27th Street.

## Stream Segment 3 in UPZ S-2/S-3
## Evaluation

Stream segment 3 begins at the confluence with Salt Creek in Wilderness Park near Saltillo Road, and extends through Rokeby Road. BNSF Railroad, South 27th Street and Rokeby Road cross the channel. The area is currently in agricultural land use with scattered acreages and farmstead dwellings. This area is in the Tier I growth vision identified in the draft Comprehensive Plan.

- Reach Stability — The channel near the mouth has not been modified. Some evidence of head cutting is apparent downstream of the BNSF Railroad bridge. Minor channel incision has occurred upstream of 27th Street, but the channel appears to have stabilized at its current profile. The channel between BNSF Railroad and Rokeby Road, that is visible from the road, appears to be stable. There are no signs of active stream bed or bank erosion visible from the road, but this stream segment may be susceptible to bank erosion under projected conditions.

- Flood Hazard Potential — The Salt Creek floodplain controls the water surface elevations west of BNSF Railroad as delineated in the Salt Creek at Wilderness Park Hydrologic Study conducted by the US Army Corps of Engineers. The stream and valley characteristics west of BNSF Railroad control the water surface profiles upstream of BNSF Railroad. The crossings at BNSF Railroad, South 27th Street and Rokeby Road do not meet current city stormwater criteria, see the hydraulics section for more information on overtopping frequency. The residence located approximately 400 feet to the west of the Rokeby Road crossing is located at an elevation close to the 100-year flood elevation. Building low opening elevations would need to be confirmed to accurately determine flood hazard exposure on these properties.

- Threats to Infrastructure — The BNSF Railroad ROW contains buried fiber optic cable. Head cutting, if allowed to occur, could expose the cable in the BNSF Railroad ROW and threaten bridge abutments. The overhead utilities along 27th Street do not appear to be threatened. The Rokeby Road box culvert provides a hardpoint in the channel.

- Land Use and Ownership — The mouth of this reach is in Wilderness Park, and the property upstream from BNSF Railroad and Wilderness Park is privately held. The reach between BNSF Railroad and Rokeby Road is currently in crops on both sides of the channel.

- Multi-Purpose Use Potential — The stream corridor could potentially provide a linear connection between Wilderness Park and neighborhood parks. A direct connection with Wilderness Park enhances the viability has a wildlife and habitat corridor. Preservation of the existing floodplain storage volume would help mitigate the impact of projected development in the watershed.

- Water Quality — Runoff from adjacent and upstream crop land is the dominant characteristic affecting surface water quality. Riparian vegetation is associated with the entire length of this segment. Tillage has encroached to the top of bank along the reach between South 27th Street and Rokeby Road. As the area develops, construction upstream of this reach will be a source of sediment and other contaminants if BMPs are not properly installed and maintained.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |

Water Quality

Insert Figure I-12C - Flood Profile Stream Segment 3
Southeast Upper Salt Creek Watershed

Insert Figure I-11D - Plan View of Stream Segment 4
Southeast Upper Salt Creek Watershed

Photo 7. Looking southwest from 40th Street.

Photo 8. Looking northeast from Rokeby Road.

## Stream Segment 4 in UPZ S-2/S-3
## Evaluation

Stream Segment 4 begins at Rokeby Road and extends to South 40th Street. South 40th Street crosses the stream channel. The reach is currently in agricultural land use. The agricultural ground is identified in the draft Comprehensive Plan as a Tier I growth area, projected to be urban residential land use.

- **Reach Stability** — Most of the channel in this reach has natural riparian vegetation or planted buffer zones. The lower 2000 feet of the reach was straightened some time after 1978, shortening the stream length by approximately 50%. The project team has not made a close-up visual evaluation of the reach, since the channel is on private property. No evidence of stream instability is visible from the road. According to Wright Water Engineers (Appendix B), mild to moderate channel incision has occurred in this reach. Bank erosion in this stream segment is likely under projected conditions.
- **Flood Hazard Potential** — The area is currently undeveloped, and flooding is confined to crop land. The South 40th Street crossing on the mainstem, and on the tributary crossing, do not meet current city stormwater criteria (see the hydraulics section for more information). Proposed development in the area will need to meet Lincoln Drainage Criteria Manual requirements. Low openings in buildings adjacent to the channel will need to be one-ft above the 100-year water surface profile for projected flows. The roadways are expected to be widened to meet increased traffic demands as the area develops.
- **Threats to Infrastructure** — Roadways subject to frequent overtopping require more frequent maintenance. There is no immediate threat apparent to overhead or buried utilities in the road ROW.
- **Land Use and Ownership** — The land in this stream segment is privately held. The adjoining land is currently agricultural, but is projected to be developed as residential and commercial property.
- **Multi-Purpose Use Potential** — Preserving the minimum corridor in accordance with DCM requirements would provide open space in the development along the channel. The stream corridor could provide a potential linear connection between Wilderness Park and neighborhood parks. A direct connection with Wilderness Park enhances the viability of this segment as a wildlife and habitat corridor. Preservation of the existing floodplain storage volume would help mitigate the impact of projected development in the watershed.
- **Water Quality** — Runoff from adjacent crop land is currently the dominant characteristic affecting surface water quality. Riparian vegetation is associated with the entire length of this segment. As the area develops, construction adjacent to this reach will be a source of sediment and other contaminants if BMPs are not properly installed and maintained. The DCM requirement for 30-ft buffer zones included in the minimum corridor will provide opportunities for filtering runoff from adjacent property and nutrient uptake.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12D - Flood Profile Stream Segment 4
Southeast Upper Salt Creek Watershed

Insert Figure I-11E - Plan View of Stream Segment 5
Southeast Upper Salt Creek Watershed

Photo 9. Looking northeast from 40th Street.

Photo 10. Looking southeast from 40th Street.

## Stream Segment 5 in UPZ S-2/S-3
## Evaluation

Stream Segment 5 begins at South 40th Street and ends at South 48th Street extended. The reach is agricultural land use. The agricultural ground is identified in the draft Comprehensive Plan as a Tier I growth area, projected to be urban residential land use.

- **Reach Stability** — Most of the channel in this reach has natural riparian vegetation or at least planted buffer zones. The channel is on private property. The project team has not made a visual evaluation. No evidence of stream instability is visible from the road, but analysis suggests the stream segment may be susceptible to bank erosion. There is no significant development projected for the watershed that would increase peak flow rates.
- **Flood Hazard Potential** — The area adjacent to the reach is currently undeveloped, and flooding is confined to crop land. Proposed development in the area will need to meet Lincoln DCM requirements. Low openings in buildings adjacent to the channel will need to be one-ft above the 100-year water surface profile for projected flows.
- **Threats to Infrastructure** — The reach has no known buried or overhead utilities or roadway crossings.
- **Land Use and Ownership** — The land in this stream segment is privately held. The land use is agricultural and is projected to become residential.
- **Multi-Purpose Use Potential** — Preserving the minimum corridor will provide open space in the development along the channel. The stream corridor could provide a potential linear connection between Wilderness Park and neighborhood parks. A direct connection with Wilderness Park enhances the viability of this segment as a wildlife and habitat corridor. Preservation of the existing floodplain storage volume would help mitigate the impact of projected development in the watershed.
- **Water Quality** — Runoff from adjacent crop land is currently the dominant characteristic affecting surface water quality. Riparian vegetation is associated with the entire length of this segment. As the area develops, construction adjacent to this reach will be a source of sediment and other contaminants if BMPs are not properly installed and maintained. The upstream watershed is fully developed into large lot acreages. Failed, or poorly maintained, individual sanitary sewer systems could adversely impact surface water quality.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12E - Flood Profile Stream Segment 5
Southeast Upper Salt Creek Watershed

Insert Figure I-11F - Plan View of Stream Segment 6
Southeast Upper Salt Creek Watershed

Photo 11. Looking east from Cromwell Street.

Photo 12. Looking west from 56th Street.

## Stream Segment 6 in UPZ S-2/S-3
## Evaluation

Stream Segment 6 begins at South 48th Street extended and ends at South 56th Street. Cromwell Drive and South 56th Street cross the stream channel. The reach is encompassed by large lot acreages.

- **Reach Stability** — Most of the channel in this reach has natural riparian vegetation or at least planted buffer zones. The channel is on private property. The project team has not made a visual evaluation. No evidence of stream instability is visible from the road.
- **Flood Hazard Potential** — In the Silver Springs Subdivision between South 48th Street extended and South 56th Street, it appears a residence may be surrounded by a 100-year flood event and possibly inundated. Building low opening elevations would need to be confirmed to accurately determine flood hazard exposure on these properties. On the mainstem, Cromwell Drive has less than a 50-year capacity before overtopping. South 56th Street passes the 100-year storm without overtopping, see the hydraulics section for more information.
- **Threats to Infrastructure** — Roadways subject to frequent overtopping require more frequent maintenance. There is no immediate threat apparent to overhead or buried utilities in the road ROW.
- **Land Use and Ownership** — The land in this stream segment is privately held. The land use is large lot, single family, residential land use. The riparian habitat has been preserved with only scattered removal of beneficial understory vegetation.
- **Multi-Purpose Use Potential** — Open space exists along the reach but has not been preserved by easement or in an out lot. The stream corridor provides a potential linear connection between Wilderness Park and the preserved riparian area. A direct connection with Wilderness Park enhances the viability of this segment as a wildlife and habitat corridor. Preservation of the existing floodplain storage volume helps to mitigate the impact of existing development in the watershed.
- **Water Quality** — Riparian vegetation is associated with the entire length of this segment. The area is fully developed into large lot acreages. Failed, or poorly maintained, individual sanitary sewer systems could adversely impact surface water quality.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12F and I-12Fa - Flood Profiles Stream Segment 6
Southeast Upper Salt Creek Watershed

Insert Figure I-11G - Plan View of Stream Segment 7
Southeast Upper Salt Creek Watershed

Photo 13. Looking northeast from 56th Street.

Photo 14. Looking east from private drive.

## Stream Segment 7 in UPZ S-2/S-3
## Evaluation

Stream segment 7 begins at South 56th Street and extends eastward along Rokeby Road to a crossing approximately 1,000 ft west of South 70th Street. The mainstem is crossed by many private drives and South 66th Street.

- Reach Stability: Stream bank erosion is evident at a private driveway crossing approximately 300 feet east of 56th Street. The remainder of the segment is stable with no apparent indications of stream bed or bank erosion visible from the roadway or private drive crossings. Bank erosion in the mainstem is not likely to occur, but bank erosion is likely on the tributary entering the mainstem from the south near 63rd Street extended.
- Flood Hazard Potential: Two homes in the northeast corner of 56th and Rokeby Road are possibly below the 100-year flood elevation and most certainly will be surrounded by flood waters. A house on the southeast quadrant on this intersection appears to be above the 100-year floodplain but is approached by the 100-year flood waters. Building low opening elevations would need to be confirmed to accurately determine flood hazard exposure on these properties.
- Threats to Infrastructure: Roadways subject to frequent overtopping require more frequent maintenance. There is no immediate threat apparent to overhead or buried utilities in the road ROW. Private driveways appear to have undersized culverts and are prone to scour failures in addition to frequent overtopping. South 66th Street passes the 100-year storm without overtopping (see the hydraulics section for more information). Overtopping frequency for private drives was determined only for selected locations in the watershed.
- Land Use and Ownership: The land in this stream segment is privately held. The current land use is large lot, residential development. Projected land use is expected to be unchanged.
- Multi-Purpose Use Potential: Open space exists along the reach but has not been preserved by easement or in an out lot. The stream corridor provides a potential linear connection between Wilderness Park and the existing adjacent riparian area. A direct connection with Wilderness Park would enhance the viability of this segment as a wildlife and habitat corridor. Although some houses encroach into the floodplain, preservation of the remaining floodplain storage volume helps to mitigate the impact of upstream development in the watershed.
- Water Quality: Runoff from adjacent large lot acreage land is the dominant characteristic affecting surface water quality. Riparian vegetation is associated with the entire length of this segment. As the area south of Rokeby Road develops, construction will be a source of sediment and other contaminants if BMPs are not properly installed and maintained. Failed, or poorly maintained, individual sanitary sewer systems could adversely impact surface water quality.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12G - Flood Profile Stream Segment 7
Southeast Upper Salt Creek Watershed

Insert Figure I-11H - Plan View of Stream Segment 8
Southeast Upper Salt Creek Watershed

Photo 15. Looking southwest from 40th Street.

Photo 16. Looking northeast at lower reach from Rokeby Road.

## Stream Segment 8 in UPZ S-2/S-3
## Evaluation

Stream segment 8 begins at the confluence with the mainstem 2,000 ft upstream of Rokeby Road and extends northeasterly through South 40th Street. The area is agricultural land use with no stream crossings until South 40th Street. The agricultural ground is identified as a Tier I growth area, projected to be urban residential land use in the Comprehensive Plan.

- Reach Stability — Most of the channel in this reach has natural riparian vegetation or at least planted buffer zones. The stream channel is stable with no evidence of stream bed or bank erosion visible from the road; although this segment is vulnerable to stream bank erosion and is likely to become more so as development occurs.
- Flood Hazard Potential — The area is currently undeveloped, and flooding is confined to crop land. The South 40th Street box culvert does not meet minimum DCM requirements for roadway overtopping. Proposed development in the area will need to meet Lincoln DCM requirements. Low openings in buildings adjacent to the channel will be one-ft. above the 100-year water surface profile for projected flows.
- Threats to Infrastructure — There is no threat apparent to overhead or known buried utilities in the road ROW. The South 40th Street box culvert provides a hardpoint in the stream bed.
- Land Use and Ownership — The land in this stream segment is privately held. Projected land use is expected to be residential.
- Multi-Purpose Use Potential — The stream corridor could potentially provide a linear connection between Wilderness Park and neighborhood parks. The stream corridor provides a potential linear connection between Wilderness Park and the preserved riparian area. A direct connection with Wilderness Park enhances the viability of this segment as a wildlife and habitat corridor. Preservation of the existing floodplain storage volume would help to mitigate the impact of projected development in the watershed.
- Water Quality — Runoff from adjacent and upstream crop land is the dominant characteristic affecting surface water quality. Riparian vegetation is associated with the entire length of this segment. As the area develops, construction adjacent to this reach will be a source of sediment and other contaminants if BMPs are not properly installed and maintained.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12H - Flood Profile Stream Segment 8
Southeast Upper Salt Creek Watershed

Insert Figure I-11i - Plan View of Stream Segment 9
Southeast Upper Salt Creek Watershed

Photo 17. Looking northeast from 40th Street.

Photo 18. Looking northeast from Yankee Hill Road.

## Stream Segment 9 in UPZ S-2/S-3
## Evaluation

Stream Segment 9 begins at South 40th Street and extends through the Yankee Hill Golf Course to a water feature. The stream is crossed by Yankee Hill Road and two cart paths. South of Yankee Hill Road, the land use is agricultural. North of Yankee Hill Road, it is developed as a golf course. The agricultural ground is identified as a Tier I growth area, projected to be urban residential land use in the Comprehensive Plan.

- Reach Stability — Most of the channel in this reach has natural riparian vegetation or at least planted buffer zones. The reach below Yankee Hill Road is particularly susceptible to stream bank erosion. The remainder of the segment is likely susceptible to bank erosion, but there is currently no visible evidence of stream bed or bank erosion.

- Flood Hazard Potential — Flood hazard in this area is reduced by the water feature in the golf course and an upstream detention facility. The area is currently undeveloped south of Yankee Hill Road. Flooding is confined to crop land. Proposed development in the area will need to meet Lincoln DCM requirements. Low openings in buildings adjacent to the channel will be one-ft above the 100-year water surface profile for projected flows. It appears flooding would be confined to open space or fairways in the golf course. Yankee Hill Road passes the 500-year storm without overtopping.

- Threats to Infrastructure — There is no immediate threat apparent to overhead or buried utilities in the road ROW or along the channel. Normal operation and maintenance practices in the golf course are expected to continue providing stable bank and bed conditions.

- Land Use and Ownership — The land in this stream segment is privately held. Projected land use south of Yankee Hill Road is expected to be residential.

- Multi-Purpose Use Potential — The stream corridor could potentially provide a linear connection between Wilderness Park and neighborhood parks. Preserving the minimum corridor will provide open space in the development along the channel. Preservation of the existing floodplain storage volume would help to mitigate the impact of projected development in the adjacent subbasin.

- Water Quality — Runoff from adjacent and upstream crop land is the dominant characteristic affecting surface water quality below Yankee Hill Road. Riparian vegetation is associated with the entire length of this segment. As the area develops, construction adjacent to this reach will be a source of sediment and other contaminants if BMPs are not properly installed and maintained. Above Yankee Hill Road, in the golf course, lawn care chemicals could affect surface water quality, if not properly applied. BMPs, such as the buffer zones along the channel, mitigate that threat. The area upstream of the golf course is fully developed into large lot acreages. Failed, or poorly maintained, individual sanitary sewer systems could adversely impact surface water quality.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12i - Flood Profile Stream Segment 9
Southeast Upper Salt Creek Watershed

Insert Figure I-11J - Plan View of Stream Segment 10
Southeast Upper Salt Creek Watershed

Photo 19. Looking northwest from 40th Street.

Photo 20. Looking southwest from Johnson Road.

## Stream Segment 10 in UPZ S-2/S-3
## Evaluation

Stream segment 10 begins at the mainstem confluence just upstream of South 40th Street and extends through agricultural land to South 48th Street extended. The stream meanders severely through this reach. The agricultural ground is identified as a Tier I growth area, projected to be urban residential land use in the Comprehensive Plan.

- Reach Stability — Most of the channel in this reach has natural riparian vegetation, or at least planted buffer zones. The stream channel is stable with no evidence of active stream bed or bank erosion visible from the road. This segment may be susceptible to bank erosion if flow rates or stream geometry are altered.
- Flood Hazard Potential — The area is currently undeveloped and flooding is confined to crop land. Proposed development in the area will need to meet Lincoln DCM requirements. Low openings in buildings adjacent to the channel will be one-ft above the 100-year water surface profile for projected flows.
- Threats to Infrastructure — There are no apparent buried or above ground utilities evident along the stream.
- Land Use and Ownership — Current land use is agricultural. This area is in Tier I with projected land use to be urban residential. The land in this stream segment is privately held.
- Multi-Purpose Use Potential — The stream corridor could potentially provide a linear connection between Wilderness Park and neighborhood parks. Preserving the minimum corridor will provide open space in the development along the channel.
- Water Quality — Runoff from adjacent and upstream crop land is the dominant characteristic affecting surface water quality west of 48th Street extended. Riparian vegetation is associated with the entire length of this segment. As the area develops, construction adjacent to this reach could be a source of sediment if BMPs are not properly installed and maintained. BMPs such as the buffer zones along the channel mitigate that threat. The area upstream is fully developed into large lot acreages. Failed, or poorly maintained, individual sanitary sewer systems could adversely impact surface water quality.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12J - Flood Profile Stream Segment 10
Southeast Upper Salt Creek Watershed

Insert Figure I-11K - Plan View of Stream Segment 11
Southeast Upper Salt Creek Watershed

Photo 21. Looking east from Johnson Drive.

Photo 22. Looking east from South 53rd Street.

## Stream Segment 11 in UPZ S-2/S-3
## Evaluation

Stream segment 11 begins at 48th Street extended and ends at Rebel Drive. Several private drives, South 53rd Street and South 56th Street cross the stream.

- Reach Stability — The stream channel is stable with no evidence of stream bed or bank erosion visible from the road. Most of the channel in this reach has natural riparian vegetation or at least planted buffer zones. There is some evidence of minor stream straightening near the beginning of the reach.
- Flood Hazard Potential — In the Kensington Subdivision, west of South 53rd Street, it appears the 100-year flood may approach a house. Building low opening elevations would need to be confirmed to accurately determine flood hazard exposure on this property. Two private drives are temporarily inundated by flood waters during the annual flood.
- Threats to Infrastructure — There are no apparent threats to buried or above ground utilities along the stream.
- Land Use and Ownership — The land in this stream segment is privately held. The current land use is large lot residential development. Projected land use is expected to be unchanged.
- Multi-Purpose Use Potential — The properties along either side of the channel are developed large lot acreages. Existing private development in the upper portion likely limits multi-use potential to existing uses.
- Water Quality — Runoff from adjacent large lot acreage land is the dominant characteristic affecting surface water quality. Riparian vegetation is associated with the entire length of this segment. The area is fully developed into large lot acreages. Failed, or poorly maintained, individual sanitary sewer systems could adversely impact surface water quality.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12K - Flood Profile Stream Segment 11
Southeast Upper Salt Creek Watershed

Insert Figure I-11L - Plan View of Stream Segment 12
Southeast Upper Salt Creek Watershed

Photo 23. Looking Downstream from Saltillo Road.

Photo 24. Looking Upstream from Saltillo Road.

## Stream Segment 12 in UPZ S-5
## Evaluation

Stream Segment 12 begins at the confluence with the S-2/S-3 mainstem upstream of the BNSF Railroad bridge, and follows the railroad, ending 1/4 mile south of Saltillo Road.

- Reach Stability — The channel is the railroad ditch and is periodically maintained by BNSF Railroad.
- Flood Hazard Potential — The entire stream segment is the Salt Creek floodplain. The railroad track is elevated above the 100-year profile. The area is currently undeveloped and flooding is confined to crop land. No building appears to be within the limits of the floodplain.
- Threats to Infrastructure — The railroad fill physically separates the stream reach from Salt Creek, but the fill does not meet FEMA construction requirements that would justify treating the fill as a levee. The road crossing at Saltillo Road does not meet minimum DCM requirements for overtopping because of the Salt Creek flood profiles.
- Land Use and Ownership — The low flow channel is on railroad ROW. The remainder of the land is privately held. The adjoining land in currently agricultural, but is planned to be developed.
- Multi-Purpose Use Potential — Multi-use potential outside of Wilderness Park is limited. A minimum flood corridor would provide open space and a buffer zone along the channel.
- Water Quality — No riparian vegetation is associated with the entire length of this segment.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12L - Flood Profile Stream Segment 12
Southeast Upper Salt Creek Watershed

Insert Figure I-11M - Plan View of Stream Segment 13
Southeast Upper Salt Creek Watershed

Photo 25. Looking downstream from South 38th Street.

Photo 26. Looking upstream from South 38th Street.

## Stream Segment 13 in UPZ S-5
## Evaluation

Steam Segment 13 begins at the confluence with the railroad ditch and proceeds east to South 38th Street. South 38th Street crosses the channel. The primary channel conveys the upstream runoff past the field. Flows up to the annual storm are contained within the spoil berm.

- Reach Stability — There are few signs of active stream bank erosion. The stream banks have been artificially raised to bypass frequent flows from the upstream watersheds. Infrequent storm events result in velocities greater than 5 fps, which is likely to be erosive.
- Flood Hazard Potential — Most of this stream segment is within the Salt Creek floodplain. South 38th Street does not meet minimum DCM requirements for overtopping. Commodity crops along the channel are subject to flood hazard. The channel has about a 1-year capacity.
- Threats to Infrastructure — There are no apparent overhead or buried utilities in this segment, nor roadway crossings.
- Land Use and Ownership — The land around this stream segment is privately held. The land use is agricultural and the stream corridor is projected for urban residential land use by the LLCCP.
- Multi-Purpose Use Potential — Preservation as an agricultural stream corridor will provide opportunities for connecting wildlife and habitat corridors.
- Water Quality — Runoff from adjacent and upstream crop land is the dominant characteristic affecting surface water quality. The amount of natural riparian vegetation has been reduced through stream modification and agricultural tillage to the edge of the stream bank.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12M - Flood Profile Stream Segment 13
Southeast Upper Salt Creek Watershed

Insert Figure I-11N - Plan View of Stream Segment 14
Southeast Upper Salt Creek Watershed

Photo 27. Mainstem channel looking upstream at S 38th Street.

## Stream Segment 14 in UPZ S-5
## Evaluation

Steam Segment 14 begins upstream of South 38th Street and extends northeasterly towards Saltillo Road.

- Reach Stability — This reach shows very few signs of active stream bank and bank erosion. The culvert at South 38th Street serves as a hard point in the channel.
- Flood Hazard Potential — Commodity crops along the channel are subject to flood hazard. The channel has less than a 2-year capacity. No buildings appear to be within the limits of the 100-year floodplain.
- Threats to Infrastructure — There is no immediate threat to apparent overhead or buried utilities in the road ROW.
- Land Use and Ownership — The land around this stream segment is privately held. The land use is agricultural and the stream corridor is projected for urban residential land use by the LLCCP.
- Multi-Purpose Use Potential — Preservation as an agricultural stream corridor will provide opportunities for connecting wildlife and habitat corridors.
- Water Quality — Runoff from adjacent crop land is currently the dominant characteristic affecting surface water quality. Riparian vegetation is associated with the entire length of this segment. As the area develops, construction adjacent to this reach will be a source of sediment and of other contaminants if BMPs are not properly installed and maintained. The upstream watershed is partially developed into large lot acreages. Failed, or poorly maintained, individual sanitary sewer systems could adversely impact surface water quality.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12N - Flood Profile Stream Segment 14
Southeast Upper Salt Creek Watershed

Insert Figure I-11o - Plan View of Stream Segment 15
Southeast Upper Salt Creek Watershed

## Stream Segment 15 in UPZ S-5
## Evaluation

Steam Segment 15 begins at the confluence with the railroad ditch and extends through South 38th Street (south location).

- Reach Stability — There are signs of head cutting and stream bank erosion. The stream banks are artificially raised to bypass frequent flows from the upstream watershed.
- Flood Hazard Potential — Most of this stream segment is within the Salt Creek floodplain. Commodity crops are subject to flood hazard. South 38th Street does not meet minimum DCM requirements for overtopping. The channel has about a 2-year capacity.
- Threats to Infrastructure — There is no immediate threat to apparent overhead or buried utilities in the road ROW. The road crossing at South 38th Street does not meet minimum DCM requirements for roadway overtopping.
- Land Use and Ownership — The land around this stream segment is privately held. The land use is agricultural and the stream corridor is projected for urban residential land use by the LLCCP.
- Multi-purpose Use Potential — Preservation as an urban stream corridor will provide opportunity for connecting wildlife and habitat corridors.
- Water Quality — Runoff from adjacent and upstream crop land is the dominant characteristic affecting surface water quality. The amount of natural riparian vegetation has been reduced through stream modification and agricultural tillage to the edge of the stream bank.

### Threat Matrix

| Issue | Degree of Threat | | |
|---|---|---|---|
| | Low | Medium | High |
| Reach Stability | | | |
| Flood Hazard Potential | | | |
| Infrastructure | | | |
| Water Quality | | | |

Insert Figure I-12o - Flood Profile Stream Segment 15
Southeast Upper Salt Creek Watershed

Insert Figure I-13 Flood Hazard - Existing Conditions
Southeast Upper Salt Creek Watershed