Executive Summary

Introduction

The City, Nebraska Department of Natural Resources (NRD), and United States Army Corp of Engineers (USACE) have been working together for the past several decades to provide flood protection for residents that live near the Salt Creek channel. The first major flood control effort began with the USACE Salt Valley Flood Control Project (1960s), which included 10 flood control dams and a levee system in Lincoln. Following the completion of these improvements, numerous planning efforts have been completed, including the USACE 205 and 216 studies, to identify additional feasible flood control improvements to increase the level of flood protection for area residents.

The USACE 205 study identified two technically feasible locations for constructing flood storage areas that would provide measurable flood control benefits, including an area along Oak Creek (Location 1) adjacent to the Lincoln airport, and the other location along Middle Creek (Location 2) between SW 27th and SW 40th Streets. In addition, the USACE 216 study results showed that Wilderness Park provides valuable flood control benefits and should be preserved (Location 3). These locations, shown in Figure ES-1, were examined in more detail for this report to determine their flood benefit along Salt Creek through Lincoln, NE.

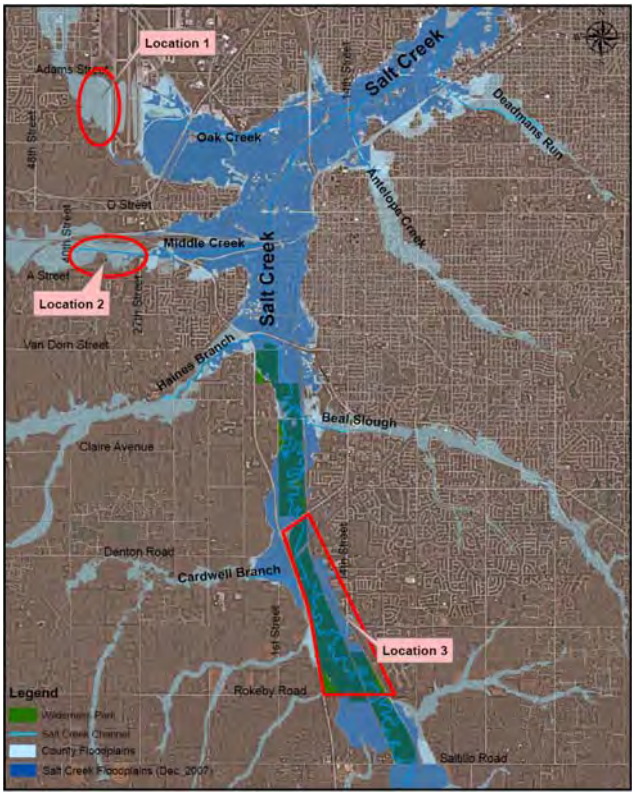

Figure ES-1 Locations for Flood Control Storage Areas

With the recent completion of the Salt Creek DFIRM Update project, a state-of-the-practice hydrologic and hydraulic computer model is now available to further evaluate the feasibility of constructing additional flood control projects. The updated FEMA DFIRM identified over 5,600 habitable buildings within the Salt Creek floodplain between Saltillo Road and 98th Street. Therefore, the purpose of this project is to simulate the two storage area facilities as previously identified by USACE, and locations near Wilderness Park, using the latest computer model to better quantify the flood control benefits of these potential facilities. In addition, the functionality of each storage facility will be further evaluated based on the existing site characteristics, multi-use features, construction constraints, and input received during the public participation process.

Wilderness Park

Wilderness Park is characterized by dense wooded area with few large opens spaces. It is owned by Lancaster County, and encompasses all of Salt Creek from Saltillo Road to Van Dorn Street, where the Creek enters City boundaries.

Existing Overbank Flood Storage

Wilderness Park along Salt Creek has preserved approximately 1,400 acres of undeveloped space that serves as overbank flood storage. During large rainfall events when Salt Creek exceed its banks this open space is temporarily flooded. Figure ES-2 is a photograph taken near S 14th Street and Yankee Hill Road which shows overbank flow in Wilderness Park. This was the result of a flood event on June 5, 2008.

Figure ES-2 Wilderness Park Overbank Flood Storage

This existing overbank flood storage within Wilderness Park has a flood benefit downstream. Using the available unsteady HEC-RAS model of Salt Creek the project team simulated two hypothetical conditions within Wilderness Park (Figure ES-3):

1) Loss of overbank flood storage up to the mapped FEMA floodway; and

2) Loss of overbank flood storage to width no greater than 300-feet.

This second more extreme encroachment case was an approximate representation of the typical encroached of Salt Creek downstream from Wilderness Park.

Figure ES-3 Wilderness Park Evaluation Scenarios

The analysis clearly showed that the existing overbank storage within Wilderness Park provides a reduction in flow and water surface elevations in the Park and downstream to the confluence with Haines Branch, with a diminished reduction downstream. As shown in Tables ES-1 and ES-2, peak flow attenuation is also seen immediately downstream of Beal Slough to the confluence with Middle Creek. Overall, this analysis shows that flood attenuation provided by Wilderness Park

reduces flooding in heavily urban areas of Lincoln, NE, along Salt Creek, especially downstream of the Park and upstream of Middle Creek (South Bottoms vicinity).

Table ES-1 Wilderness Park Analysis –Maximum Water Surface Comparison

	Salt Creek Storage Area Analysis				
Location Description	Salt Creek DFIRM Maximum Water Surface Elevation (ft)	Scenario 1 Maximum Water Surface Elevation (ft)	Elevation Difference between Scenario 1 & DFIRM (ft)	Scenario 2 Maximum Water Surface Elevation (ft)	Elevation Difference between Scenario 2 & DFIRM (ft)
US of Saltillo Rd	1,199	1,199	0.2	1,205	5.8
DS of 14th St	1,184	1,184	0.6	1,190	6.8
DS of Cardwell Branch	1,175	1,175	0.0	1,178	3.2
US of Old Cheney	1,166	1,166	0.5	1,172	5.5
DS of Beal Slough	1,159	1,159	0.2	1,161	1.9
DS of Haines Branch	1,156	1,156	0.0	1,156	0.2
DS of Middle Creek	1,153	1,153	0.0	1,153	0.3
US of Railroad Bridge	1,152	1,152	0.0	1,152	0.3
DS of Oak Creek	1,139	1,139	0.0	1,139	0.2

Shaded locations are within Wilderness Park

Table ES-2 Wilderness Park Analysis –Peak Flow Comparison

	Salt Creek Storage Area Analysis				
Location Description	Salt Creek DFIRM Peak Flow (cfs)	Scenario 1 Peak Flow (cfs)	Difference between Scenario 1 & DFIRM	Scenario 2 Peak Flow (cfs)	Difference between Scenario 2 & DFIRM
US of Saltillo Rd	14,401	14,321	-0.6%	14,394	-0.1%
DS of 14th St	14,486	14,350	-0.9%	14,555	0.5%
DS of Cardwell Branch	14,723	14,637	-0.6%	14,645	-0.5%
US of Old Cheney	14,697	14,623	-0.5%	14,689	-0.1%
DS of Beal Slough	14,880	15,571	4.6%	17,491	17.5%
DS of Haines Branch	21,031	21,025	0.0%	23,576	12.1%
DS of Middle Creek	28,005	28,028	0.1%	27,767	-0.8%
US of Railroad Bridge	24,658	24,760	0.4%	25,034	1.5%
DS of Oak Creek	40,410	40,514	0.3%	40,951	1.3%

Shaded locations are within Wilderness Park

Additional Offline Detention

Within the Wilderness Park Area several options were considered for locations of additional offline storage. However, there were limited opportunities for additional flood storage without significantly impacting the mature riparian vegetation. In addition, existing linear transportation infrastructure that bound the area on the west and east limit the area for additional offline flood detention. One area of existing open space located to the west of Yankee Hill Road and South 14th Street, shown in Figure ES-4, was determined to be the best available option for additional offline detention. An evaluation of this offline detention location resulted in no additional flood benefit downstream. The primary reason for the lack of flood benefit at this location is the large drainage area to this point and the double runoff peak of Salt Creek. As shown in Figure ES-5, Salt Creek

has a double peak runoff response which significantly limits the flood benefit of offline detention because the offline detention is filled by the first peak leaving no flood storage for the larger second peak. Therefore no further evaluation of additional offline detention was completed for this study.

Figure ES-4 Wilderness Park Offline Storage Site

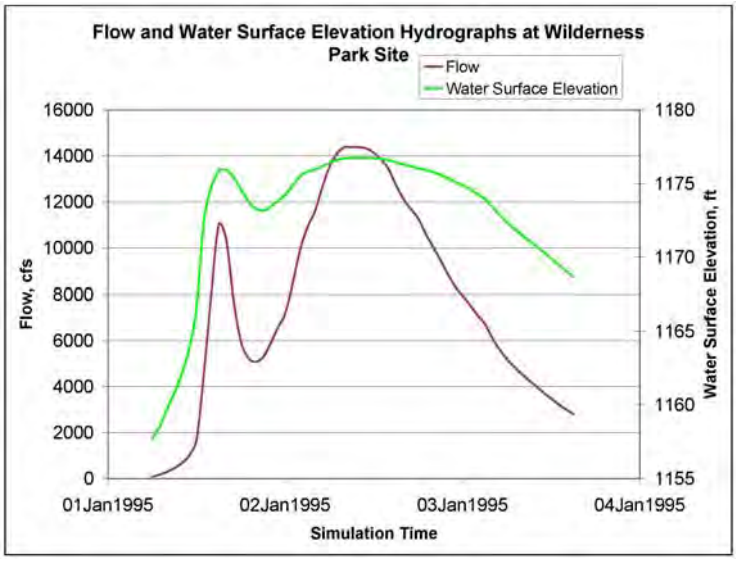

Figure ES-5 100-Year Runoff Flow and WSE

Storage Area Evaluation

Offline storage sites were evaluated in detail at only two of the three proposed locations because the Wilderness Park site was eliminated during the preliminary evaluation. As shown in Figure ES-6, three offline detention sites were evaluated for the two remaining locations. The three offline storage sites that were evaluated in detail for this study were:

- Middle Creek Site - South of A Street, between SW 27th and SW 40th Streets
- Oak Creek Upstream Site - Near the airport located west of the airport runway and south of Lincoln Air Park West; and
- Oak Creek Downstream Site - Located south of the Air National Guard base and north of Oak Creek.

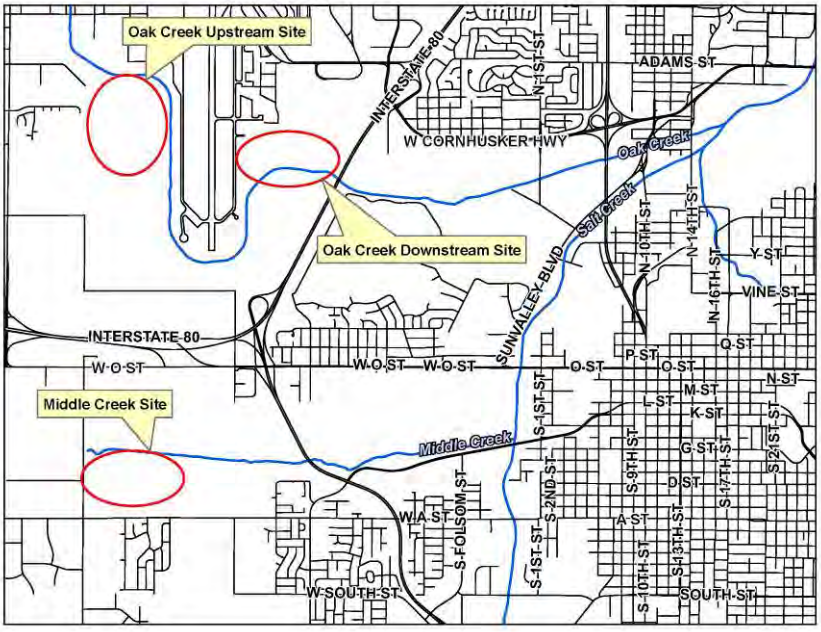

Figure ES-6 Offline Storage Sites Evaluated

Middle Creek Site

The Middle Creek site generally bounded by Southwest 40th Street to the west, Southwest 27th Street to the east, West "A" Street to the south, and Middle Creek to the north, is characterized by open space which is currently agricultural fields . As shown in Figure ES-7, the conceptual offline storage area design is two large storage basins that are hydraulically connected which provided maximum flood storage at this site. This design allowed for expanded storage along Middle Creek with an East Middle Creek and West Middle Creek storage basin. Several options for conveying flow into, out, and between the basins were considered. The resulting design uses concrete culverts with flap gates to control flow into and out of the basins and concrete culverts to connect the various cells. An unsteady HEC-RAS model was used to simulate this

Middle Creek offline storage design which simulated the filling and dewatering of the basins.

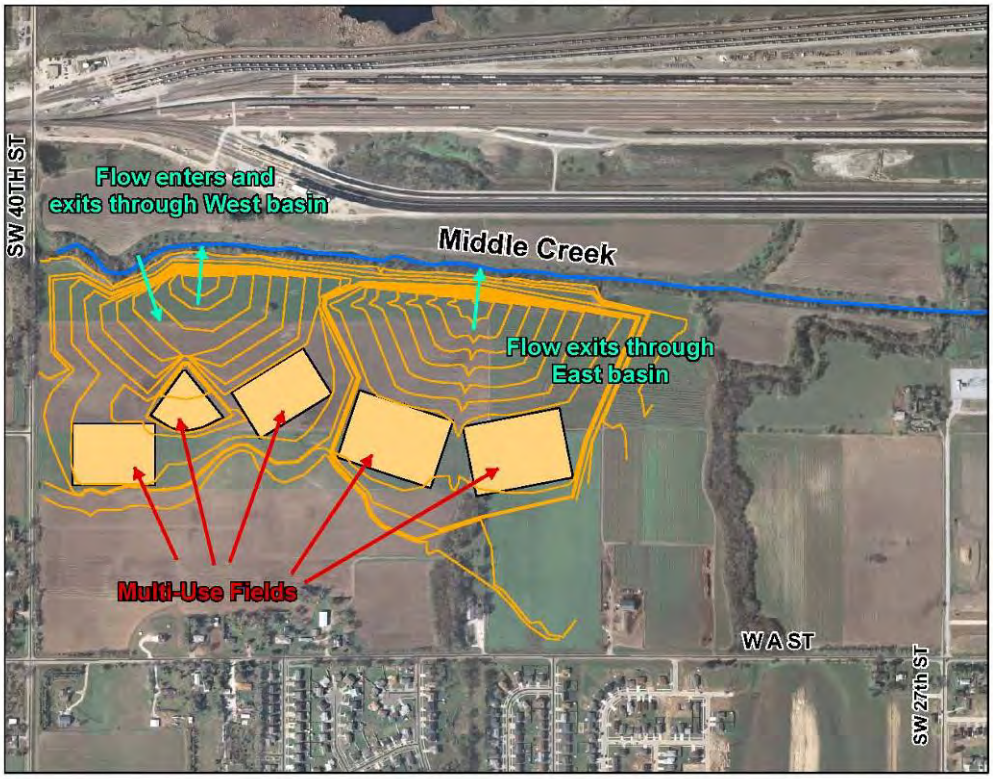

Figure ES-7 Middle Creek Offline Storage

The westernmost basin has a maximum storage of 222.9 acre-feet at water surface elevation of 1,164 feet, and the eastern most basin has a maximum storage of 334.1 acre-feet at a water surface elevation of 1,164 feet. The conceptual design allows for the possibility of the inclusion of five multi-use fields to utilize the site area during dry conditions.

Excavation will be extensive with an estimated **680,000 cubic yards** of excess material. As proposed, the excess material will be disposed on the adjoining site to the south and southeast. Disposing the excess fill material on site was the most cost effective alternative. The estimated cost of these storage basins along Middle Creek was **$15.4 million**.

Oak Creek Upstream Site

The Oak Creek upstream site is generally bounded by Oak Creek to the north, Lincoln Airport to the east, and Northwest 41st Street to the west. It is characterized by open space which is currently used as agriculture, as shown in Figure ES-8.

The Oak Creek upstream storage basin conceptual design followed a similar process to that of Middle Creek to increase the volume of storage; two hydraulically connected basins were designed as well as a third, separate basin. This allowed

storage to expand along Oak Creek, producing a Northwest (NW) upstream Oak Creek storage basin, a Northeast (NE) upstream Oak Creek storage basin, and a South (S) upstream Oak Creek storage basin (Figure ES-8). Several options for conveying flow between the basins were considered, and concrete culverts were found to be the most cost-effective solution. An unsteady HEC-RAS model was used to simulate this offline storage design which simulated the filling and dewatering of the basins.

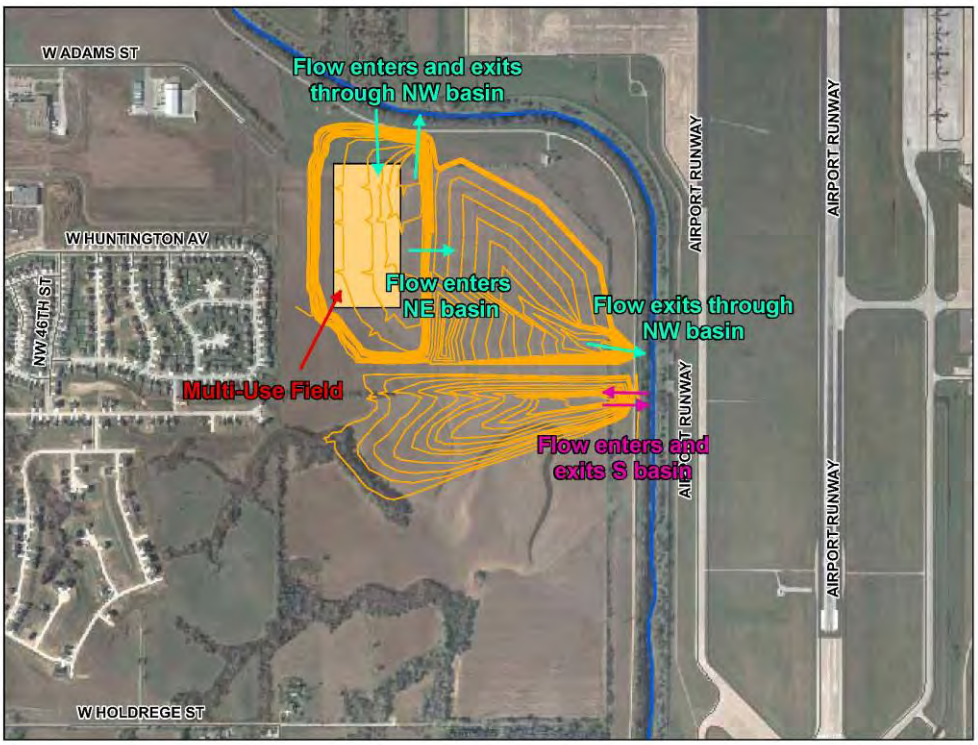

Figure ES-8. Oak Creek Upstream Offline Storage

The conceptual-level design included two northernmost basins (NW and NE basins) which are hydraulically connected as well as an independent southern basin. The NW basin has a maximum storage of 545.0 acre-feet at a water surface elevation of 1,164 feet, the NE basin has a maximum storage of 343.3 acre-feet at water surface elevation of 1,164 feet, and the S basin has a maximum storage of 288.8 acre-ft at a water surface elevation of 1,164 feet. The conceptual design provides a total of **1,177.1 acre-feet** of offline flood storage. In addition, the design allows for the possibility of the inclusion of a multi-use field to utilize the site under normal, dry conditions. Flow enters and exits the basins through concrete culverts with tensioned flap gates, which are used to control the timing and amount of flow allowed into and out of the basins.

As with the Middle Creek sites the excavation will be extensive with an estimated **950,000 cubic yards** of excess material. As proposed, the excess material will be disposed on open areas owned by the Lincoln Airport within 1-mile of the site. The estimated cost of these storage basins at the upstream Oak Creek site was **$ 18.2 million**.

Oak Creek Downstream Site

The Oak Creek downstream site was identified during the site evaluation process, and is generally bounded by Oak Creek to the south, Air National Base to the north and Lincoln Airport to the west. It is characterized as an open grassed area as shown in Figure ES-9.

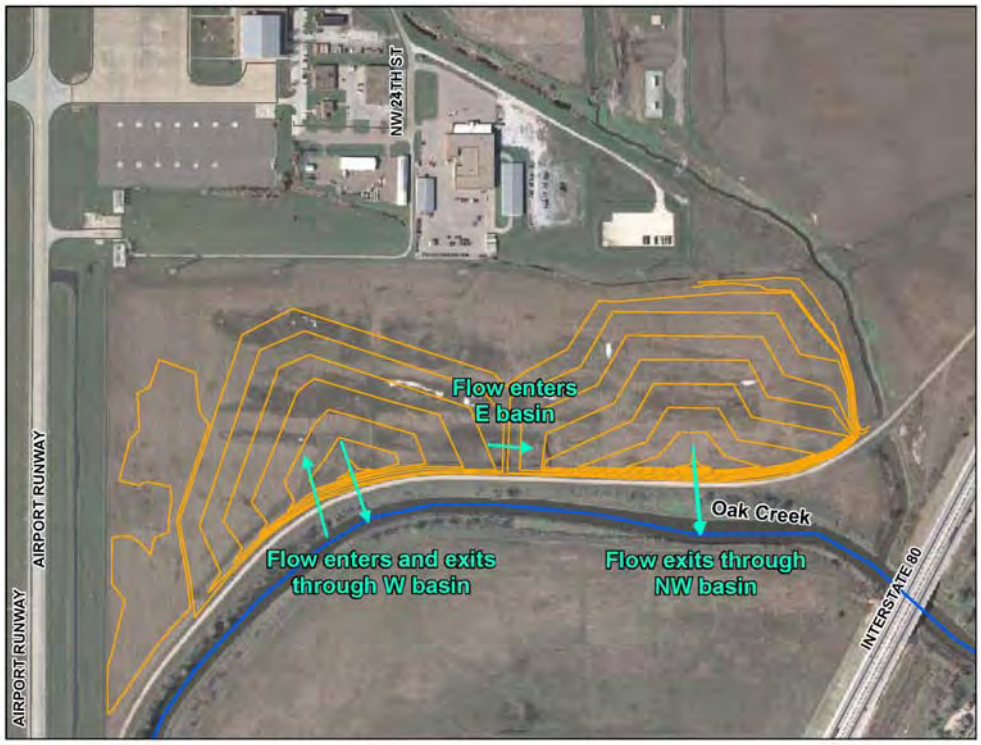

Figure ES-9 Oak Creek Downstream Offline Storage

This storage area was also divided into two cells, east and west. These offline storage sites are relatively small compared to the upstream site. The design included two basins (W and E basins) which are hydraulically connected. The W basin has a maximum storage of 95.4 acre-feet at a water surface elevation of 1,154 feet; the E basin has a maximum storage of 127.7 acre-feet at a water surface elevation of 1,154 feet. The conceptual design provides a total of **223.1 acre-feet** of offline flood storage. Flow enters and exits the basins through concrete culverts with tensioned flap gates, which are used to control the timing and amount of flow allowed into and out of the basins.

The estimated excavation is **240,000 cubic yards** of excess material. As proposed, the excess material will be disposed on open areas owned by the Lincoln Airport within 1-mile of the site. The estimated cost of these storage basins at the downstream Oak Creek site was **$5.0 million**.

Summary of Cost

These seven storage basins at three sites were the preferred storage alternative that provided the most flood benefit downstream along Salt Creek. Table ES-3 provides a summary of the seven basins including the estimated cost.

Table ES-3 Summary of Seven Basins by Location

Site Location (No. of Basins)	Surface Area	Estimated Excavation	Maximum Flood Storage	Cost
Middle Creek (2)	83 ac	680,000 CY	557 ac-ft	$15,400,000
Oak Creek – Upstream (3)	124 ac	950,000 CY	1,177 ac-ft	$18,200,000
Oak Creek – Downstream (2)	41ac	240,000 CY	223 ac-ft	$5,000,000
Total (7)	**248 ac**	**1,870,000 CY**	**1,957 ac-ft**	**$38,600,000**

Summary of Flood Benefit

The combination of all seven basins at the Oak Creek Upstream, Oak Creek Downstream, and Middle Creek sites represents the most beneficial offline storage design, taking into account the combined effect of the basins, site specific issues, constructability, cost, and maintenance. The average and maximum flood benefit downstream along Salt Creek through Lincoln for the 100-year event is shown in Table ES-4. Figure ES-10 provides a map of the flood benefits along Salt Creek.

Table ES-4 Preferred Alternative Flood Depth Reduction

Salt Creek Reach	Average Flood Depth Reduction ft	Maximum Flood Depth Reduction, ft	Approximate Limits
MC110	-0.02	0	Saltillo Road to Confluence with Cardwell Branch
MC80	0.01	0.05	Confluence with Cardwell Branch to Confluence with Haines Branch
MC60	0.09	0.12	Confluence with Haines Branch to Confluence with Middle Creek
MC50	0.12	0.14	Confluence with Middle Creek to Confluence with Oak Creek
MC50	0.06	0.11	Confluence with Oak Creek to Confluence with Little Salt Creek
MC10	0.00	0.03	Confluence with Little Salt Creek to North 98th Street
MC05	0.02	0.02	Confluence with Little Salt Creek to North 112th Street

The preferred alternative would take approximately 31 structures out of the 100-year floodplain, and typically reduces the 100-year flooding depths by 0.1 feet at structures. For the 50-year event, the preferred alternative takes approximately 51 structures out of the floodplain and typically reduces flooding depths by 0.3 feet, and for the 10-year event, it takes approximately 64 structures out of the floodplain and typically reduces flooding depths by 0.4 feet.

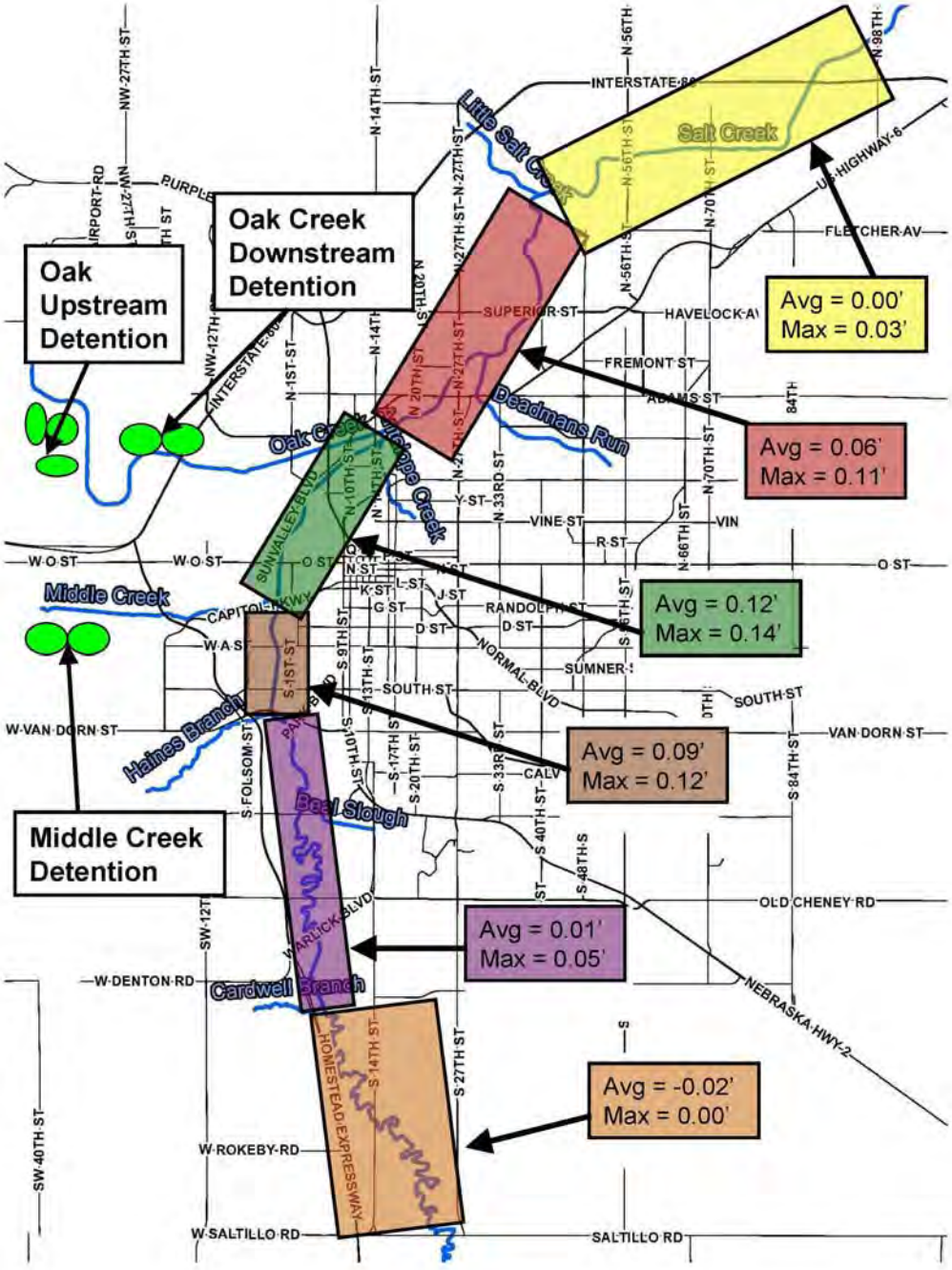

Figure ES-10 Preferred Alternative 100-Year Flood Depth Reduction through Lincoln, Nebraska

Benefit-Cost Analysis

Due to the magnitude of the preferred storage alternative, which encompasses all seven (7) basins, a benefit-cost analysis (BCA) was conducted to evaluate the economic feasibility of implementation. The economic evaluation was conducted using a benefit-cost ratio (BCR) approach based on FEMA procedures.

The FEMA BCR procedure consists of determining whether the cost of the mitigation project today will result in sufficient flood damage reduction in the future to justify the capital investment of the project. If the benefit is determined to be greater than the estimated project cost, then the project is considered justified. However, if the benefit is less than the project cost, then the project is not considered cost-effective. Thus, the BCR, which is calculated by dividing the benefits by the costs, should have a value of 1.0 or greater.

Estimated Benefits

The estimated flood damages before the projects (existing conditions) and after the projects are summarized in Tables ES-5 and ES-6, respectively. The total damages from the 100-year event include damages to the airport estimated in the Oak Creek Levee Study, completed by HWS Consulting Group, Inc.

Table ES-5 Total Physical Damages *Before* Preferred Alternative

Flood Frequency Events (Years)	Buildings	Contents	Streets	Total Damages and Losses
10	$19,000,000	$7,000,000	$400,000	$26,400,000
50	$94,000,000	$39,000,000	$4,000,000	$140,000,000
100	$166,000,000	$64,000,000	$7,000,000	$240,600,000*
Total Annualized Damages				$7,180,000

*The 100-year total damages includes damages to the airport estimated in the Oak Creek Levee Study, completed by HWS Consulting Group, Inc

Table ES-6 Total Physical Damages *After* Preferred Alternative

Flood Frequency Events (Years)	Buildings	Contents	Streets	Total Damages and Losses
10	$16,000,000	$5,000,000	$300,000	$21,300,000
50	$88,000,000	$33,000,000	$3,000,000	$124,000,000
100	$149,000,000	$60,000,000	$7,000,000	$216,000,000
Total Annualized Damages				$6,250,000

The benefit is defined as the avoided physical damages after project compared to that of existing conditions. Subtracting the total annualized damages of existing conditions from the total annualized damages after implementing the preferred alternative, the total annual benefit equals approximately $0.93 million. Before calculating BCR, the expected annual benefit must be converted to present value dollars. Using the current Water Resources Institute discount rate of 4 7/8 percent and a project life of 50 years, the present value of $0.93 million equals **$17.3 million**.

The estimated cost for the preferred storage basin alternatives was approximately $38.6 million plus $0.56 million operation and maintenance for a total project cost of **$39.2 million**. In summary, a BCR value of 1.0 or above is desirable to justify the economic feasibility of constructing large-scale improvement projects. For this Study a

preliminary BCR value of **0.44** was estimated based solely on physical damages. Typically, if the BCR ratio is above 0.75 when only assuming physical damages, then the BCR will exceed 1.0 when the other three categories (loss of function, emergency management, and casualties) are factored into the calculations. Therefore, at this conceptual stage of the project formulation process, **the preferred alternative does not appear to be economically viable**.

However, the proposed storage basins along Oak Creek may be a viable project when considering the local flood benefits along Oak Creek and the desire by the airport to update the existing levees to FEMA standards. A more detailed analysis of this combined benefit would need to be evaluated which was beyond the scope of this study.