

Nephi Watershed Protection & Storm Drainage Master Plan

Prepared for:



**Nephi City
21 East 100 North
Nephi, Utah 84648**

Prepared by:



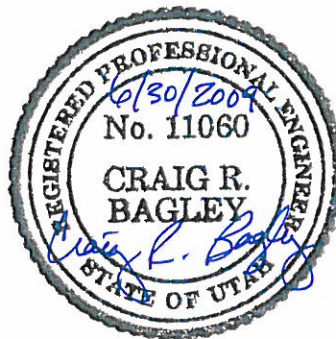
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Richfield
Utah 84701**

June 2009

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SECTION 1 INTRODUCTION

BACKGROUND

Nephi City (City) is located on an alluvial fan. Rocky and clayey soils and steep slopes in the mountain watersheds east of the City make the Nephi area susceptible to flash flooding. Historically, the City has experienced significant localized flooding from cloudburst events that typically occur in the summer and fall. Because the radial contours of the alluvial fan in the City convey runoff water away from Salt Creek and Big Hollow, there are no major natural drainage corridors to collect and convey storm water runoff generated in most areas of the City. Historical newspaper articles contain multiple records of cloudburst events in the area that have produced flooding and debris flows across major highways and damage to businesses, livestock, and agriculture. Damaging flash floods that occurred in 1935, 1943, 1952, 1955, and 1956 prompted City officials and the Natural Resources Conservation Service (NRCS) to construct detention basins in Miller and Bigelow Canyons in 1961. In 1983 and 1984 some minor flooding occurred along the reach of Big Hollow located in the City in response to the melting of large snowpack in the Salt Creek watershed.

When I-15 was constructed by the Utah Department of Transportation (UDOT), culverts were installed where natural drainage paths existed to convey runoff across the right-of-way. Since then, development has occurred adjacent to the I-15 right-of-way, creating potential flooding problems where buildings are located near the outlets of the cross drainage culverts.

Prior to the recent development of a pressurized irrigation system in the area, runoff generated in the City was collected in a network of irrigation ditches that existed throughout the City. Those ditches conveyed both irrigation water and runoff to agricultural fields west of the railroad. Since the pressurized irrigation system was constructed, most of the irrigation ditches have been filled in or abandoned, leaving no means of conveying storm water runoff west of the railroad. This has resulted in increased flooding on agricultural fields, residential property, and business developments. The problems created by the abandonment of the historic irrigation/drainage system and the installation of pavement and other impervious surfaces associated with recent development have created drainage problems that did not previously exist.

The City has also allowed storm drain sumps that allow water to percolate into the ground to be installed in some of the recent developments in an effort to manage storm water runoff. Storm drain sumps have been successfully utilized in other communities in Northern Utah to manage and dispose of storm water. However, City personnel have since found that collapsible soils exist in many of those areas. As storm water runoff has been discharged into some of the new sumps, the underlying soils have consolidated, creating sink holes that have caused damage to the sumps, roads, and curb and gutter.

Salt Creek conveys runoff from a 95 square mile mountain watershed to the mouth of Salt Creek Canyon located just east of the City. A structure has been constructed at the mouth

of that canyon to divert water from Salt Creek into the Salt Creek Irrigation Channel. The main channel between that diversion and West Creek is referred to as Big Hollow. The reach of Big Hollow located in Nephi City is susceptible to flooding from both snowmelt and cloudburst events.

Recent development and growth in the City have exacerbated some drainage deficiencies and created significant concerns to City officials. Because of these drainage problems and the drainage problems that will occur as the City continues to develop, the City has seen the need to develop a plan to identify means to solve existing and projected future drainage problems. The City retained a team of consulting engineers consisting of Jones and DeMille Engineering and Bowen, Collins & Associates (BC&A) to develop a Watershed Protection and Storm Drainage Master Plan that identifies storm drain system improvements that are needed to protect life and property during periods of significant storm water runoff. This is the first Storm Drainage Master Plan to be developed for the City.

PURPOSE OF STUDY

The City's primary objectives of this study are to:

- Resolve flooding problems associated with I-15 culverts
- Identify improvements to resolve existing and future urban drainage problems
- Identify needed drainage corridors west of the City
- Develop a drainage system capital improvements plan that can be used to develop an appropriate funding source
- Develop a flood control plan for Salt Creek
- Involve stakeholders and other interested parties in identifying problems and recommended solutions.

The purpose of this report is to describe the methods used to accomplish these objectives, as well as to summarize the results and recommendations associated with the hydrologic and hydraulic analyses. This study seeks to address the following issues and challenges with regards to effective storm water management:

- **Growth.** Larger amounts of storm water runoff are generated from paved surfaces and curb and gutter as historically agricultural areas are developed and urbanized.
- **Lack of Major Drainage Corridors west of Main Street.** Existing cross drain culverts on Main Street drain onto farm land, residential lawns, or business parking. There are no functioning drainage corridors to West Creek. There are also multiple culverts on Main Street, I-15, and other locations in the City that

are damaged or have sediment or debris built up in them. Many of these culverts will not function properly during runoff events.

- **Lack of Drainage Facilities to convey storm water from the east of I-15.** There are no open channel conveyance facilities west of I-15 to convey runoff from many of the culverts that cross I-15.
- **Collapsible Soils.** Much of the urban area has collapsible soils making it difficult for sumps to operate and drain properly.
- **City Liability for Flood-Related Damage.** Increased storm water runoff from development combined with the inadequate capacity of existing storm water collection and conveyance facilities can potentially lead to flood-related damage claims.
- **Lack of Adequate Funding for Storm Drainage Improvements.** The arid climate and general infrequency of flood events in the western region of the United States means that many cities tend to assign a low priority to storm drainage improvements. This tendency generally results in significant under-funding of programs that address flood control problems.

SCOPE OF WORK COMPLETED

Tasks that were performed in completing this study are identified below.

- Collected and Reviewed Existing Information
- Field Survey Work Completed
- Developed Aerial Topographic Mapping
- Inventoried Existing Storm Drain Facilities
- Drainage System Evaluated and Planning Criteria Created
- Defined Boundaries of Drainage Basins and Subbasins
- Performed Hydrologic Analysis of Salt Creek and Big Hollow
- Developed Hydrologic Computer Model of Existing Land Use Conditions
- Developed Hydrologic Computer Model of Projected Full Build-Out Conditions
- Developed Hydraulic Models of Salt Creek and Big Hollow
- Evaluated Alternative Improvements to Storm Drainage System
- Developed Recommended Flood Control Plan for Salt Creek
- Developed Construction Cost Estimates for Recommended Improvements
- Prioritized Recommended Improvements
- Prepared Report
- Held Three Public Meetings
- Explored Funding Assistance Options.

SECTION 2

DESCRIPTION OF STUDY AREA

LOCATION

The Nephi Storm Drainage Master Plan study limits extend beyond the Nephi City boundaries on all sides of the City. The study area, shown in Figure 2-1, is generally bounded by the mountains on the east, 500 West on the west, just south of I-15 and gravel pit on the south, and just south of Exit 228 on I-15 and Highway 41 to the north.

In general, the storm drain facilities evaluated as part of this study are located within the Nephi City limits. In order to thoroughly evaluate the Nephi City storm water conveyance and detention facilities, it was necessary to take into account all contributing drainage areas, including mountain watersheds that drain through the City from east of the City.

ELEVATION

Elevations in the watershed area that drain to Nephi range from approximately 5,066 feet above M.S.L. at 500 West to approximately 10,400 feet above M.S.L. in the Salt Creek watershed east of I-15. The average elevation within the corporate limits of Nephi City is approximately 5,200 feet. The ground surface generally slopes from the mountains on the east toward West Creek, located about 3 miles west of the City limits.

NATIVE SOILS

Figure 2-2 identifies the hydrologic soil group classifications that exist in the study area. These hydrologic soil classifications, based on infiltration potential, were established by the United States Department of Agriculture, Natural Resource Conservation Service (NRCS). The information in Figure 2-2 is based on the NRCS Soil Survey for the Nephi Area (2000). Type A soils are well-drained sands, gravels, and sandy-loams, with high infiltration rates that generally result in low storm water runoff potential. At the other end of the scale, Type D soils have high clay content with low infiltration rates, generally resulting in relatively high storm water runoff during intense storm events.

Native soils in the study area are primarily composed of soil Types B, C, and D with moderate to high relative potential for storm water runoff. The predominance of Type C and D soils means that the mountains and undeveloped areas in the east portion of the study area are capable of generating significant runoff during high intensity cloudburst events. As shown on Figure 2-2, the area west of I-15 consists of primarily of Type B soils. Development with impervious surfaces in areas with Type B soils will significantly increase storm water runoff and often creates the need for new or larger storm water management facilities to manage runoff from the developed areas.

EXISTING DEVELOPMENT CONDITIONS

Nephi City is the largest city and the fastest growing community in Juab County. The population 2000 Census population was 4,733. The current population is estimated to be 5,370. Population growth, accompanied by the progression of urban development on the north and south sides of the City, has resulted in increased storm water runoff as historical agricultural lands with relatively low runoff potential have been converted to residential, industrial, and commercial developments with a lot of impervious paved areas and roof tops. As recent development has occurred, the City has enforced a requirement that curb and gutter be installed on streets that front new construction. The City currently has curb and gutter on about one-third of its streets. The typical paved widths of streets are 30 feet in the older and largest portion of the City, 66 feet in the older portion of the City where new homes are being constructed, and 48 feet in newer subdivisions. Installing curb and gutter and widening the width of the paved street section as part of new developments will increase the storm water runoff as the City continues to grow.

EXISTING MAJOR DRAINAGE CHARACTERISTICS

There are 16 drainage basins that produce runoff that impacts the City, 9 of which are mountain drainage basins that have potential to produce flash flooding due to the rocky and clayey soils in the area and the steep terrain. The major drainage basins are shown in Figure 2-3 along with their runoff discharge locations. During cloudburst events in the mountain watersheds, storm water is conveyed through canyons, washes, and ravines to culverts that cross I-15. These culverts concentrate storm water runoff in many areas that historically experienced shallow sheet flow. In most developed areas of the City, runoff flows off the asphalt streets onto gravel- and grass-lined shoulders where significant ponding and infiltration occurs.

All of the mountain watersheds east of the City, with the exception of Salt Creek, convey little or no runoff for long periods during the year due to the desert climate of the area. Salt Creek conveys streamflow year round. The majority of the streamflow in Salt Creek is diverted at the mouth of Salt Creek Canyon into the Salt Creek irrigation channel between mid-April and mid-October when irrigation water is utilized for agricultural purposes. Big Hollow is the major flood control channel through the City and conveys flood flows from Salt Creek to West Creek.

REFERENCES

U.S. Department of Agriculture, Soil Conservation Service, 2000, Soil Survey of Juab Area, Utah.

U.S. Census Bureau, Census 2000.

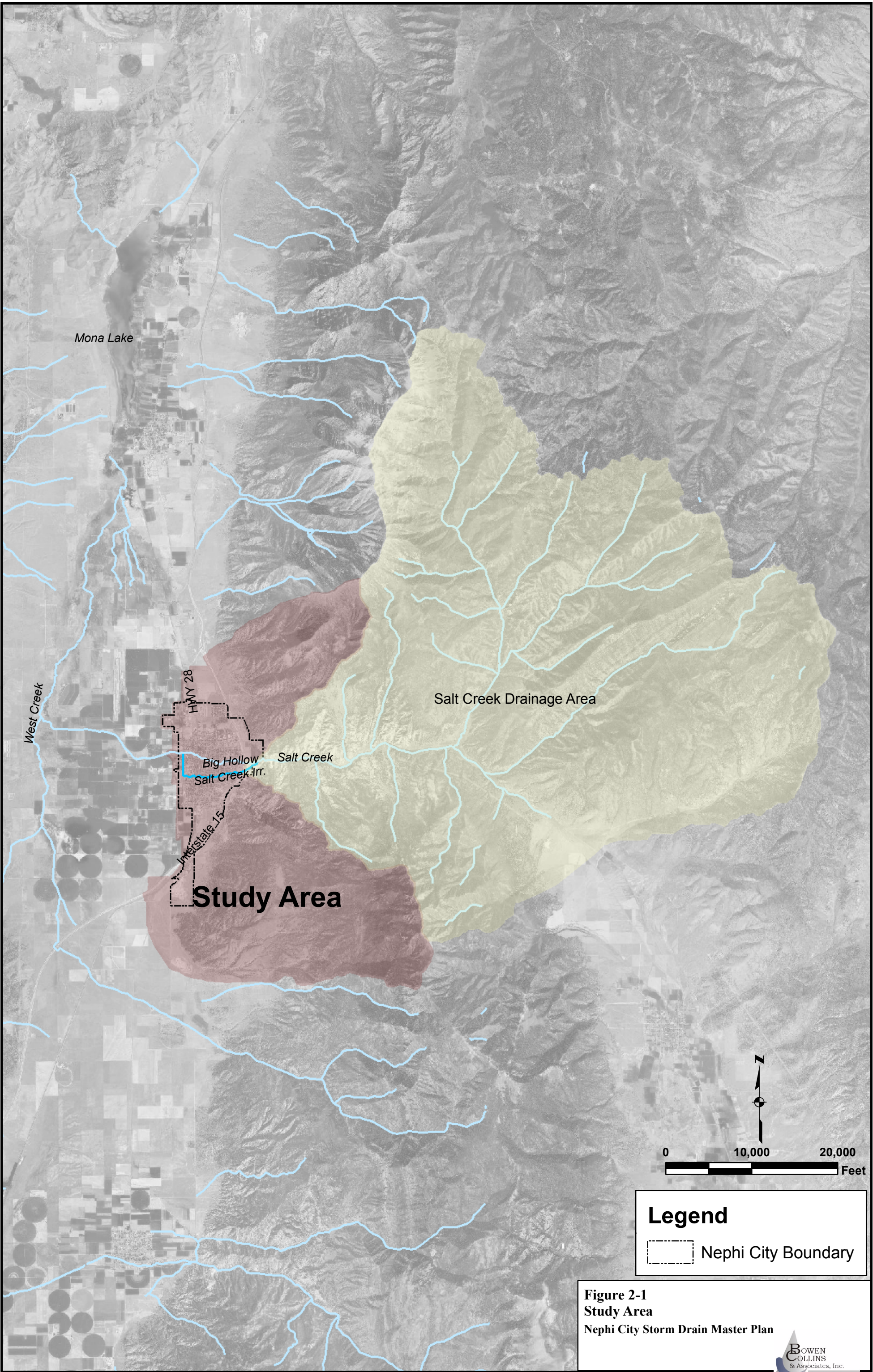
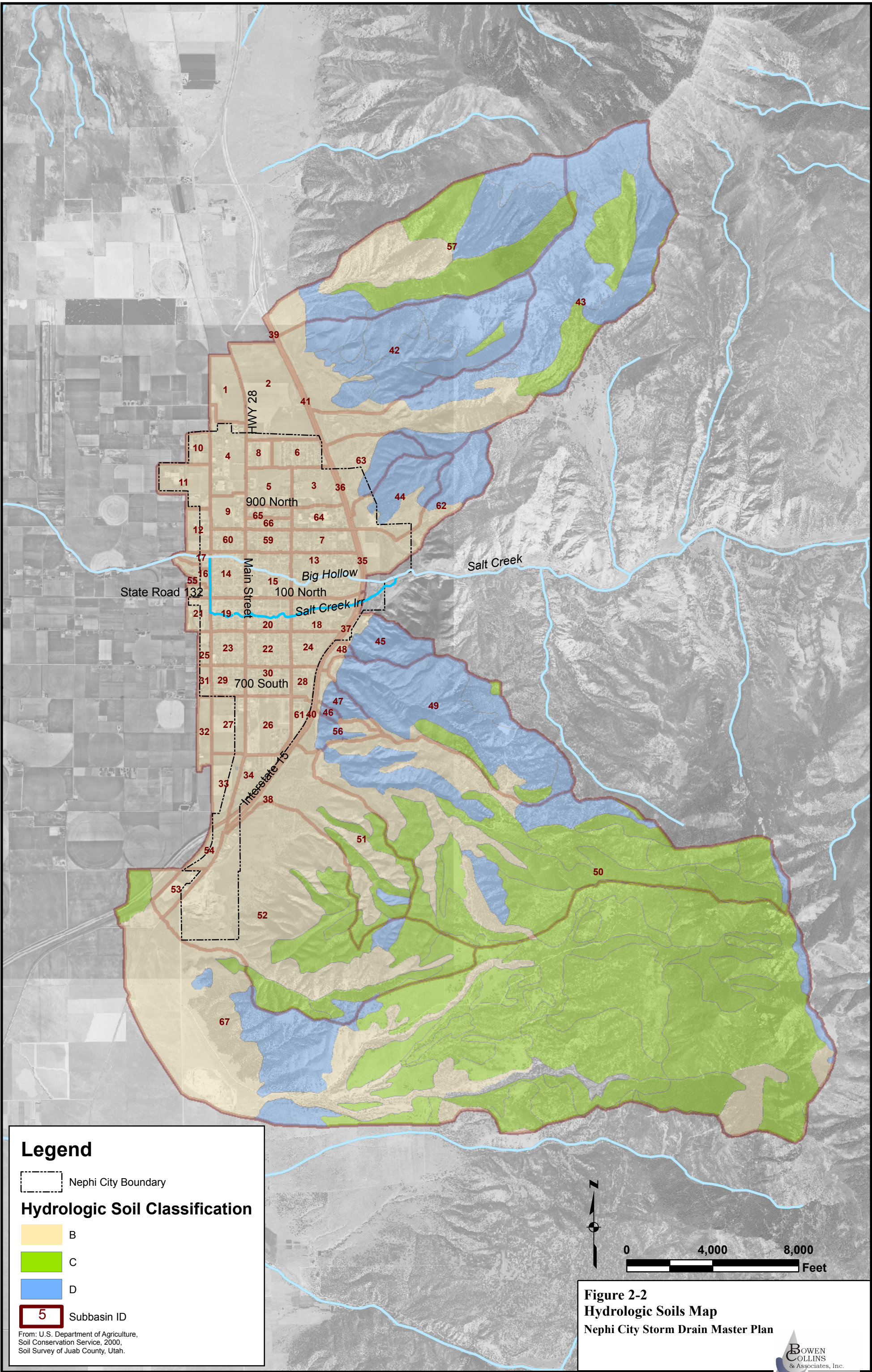
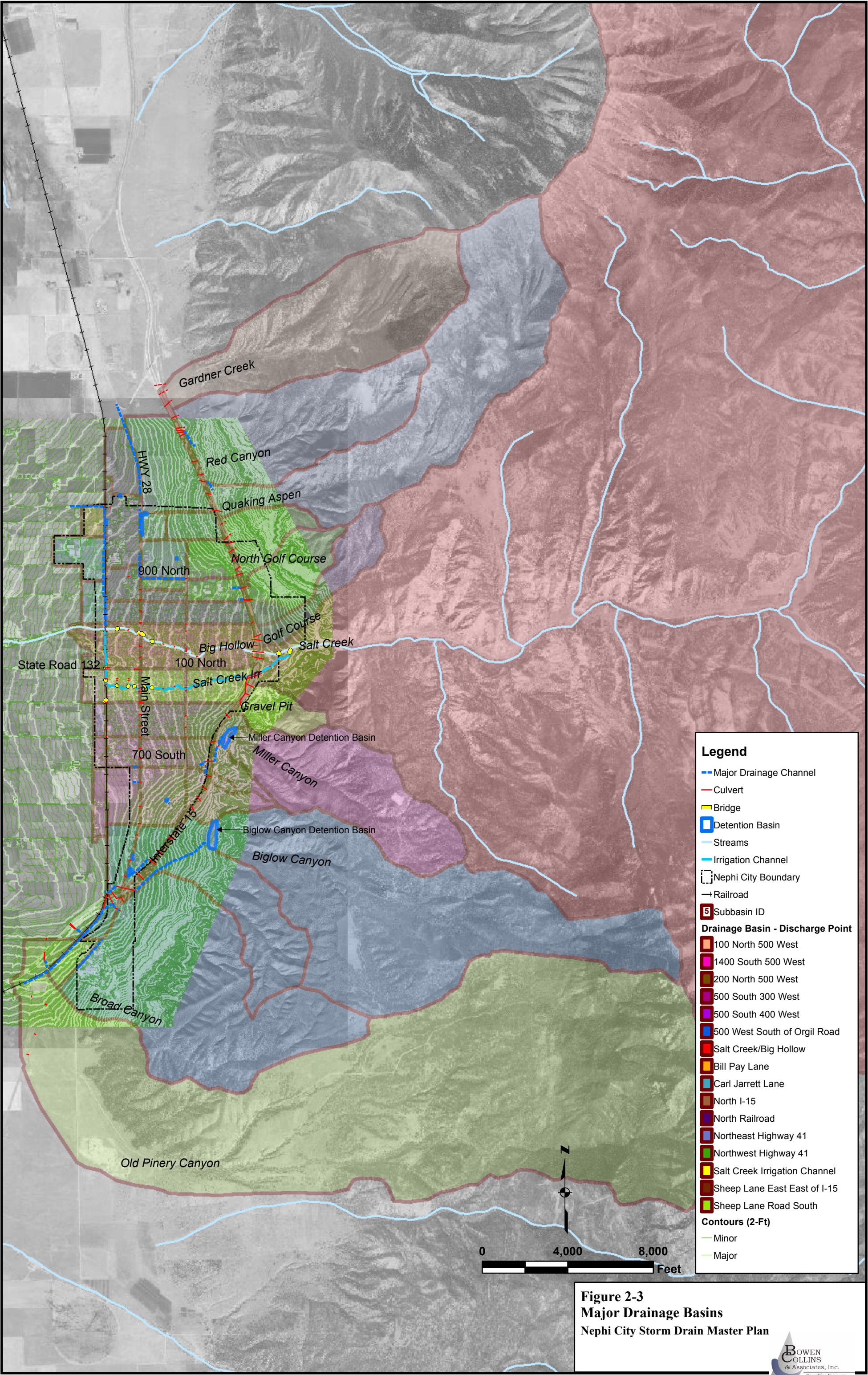


Figure 2-1
Study Area
Nephi City Storm Drain Master Plan





SECTION 3

STORM DRAINAGE FACILITY INVENTORY

One of the major tasks of this study was to develop an inventory of existing storm drainage facilities within the City limits. Field work to complete the inventory was performed by Jones and DeMille, BC&A, and City personnel. Inventory information collected in the field was compiled into a GIS database of storm drainage facilities and is presented in Figure 3-1. Information from this inventory was used to estimate hydraulic capacities of major storm drainage facilities within the City.

Storm drain facilities inventoried as part of this study can be placed into two categories:

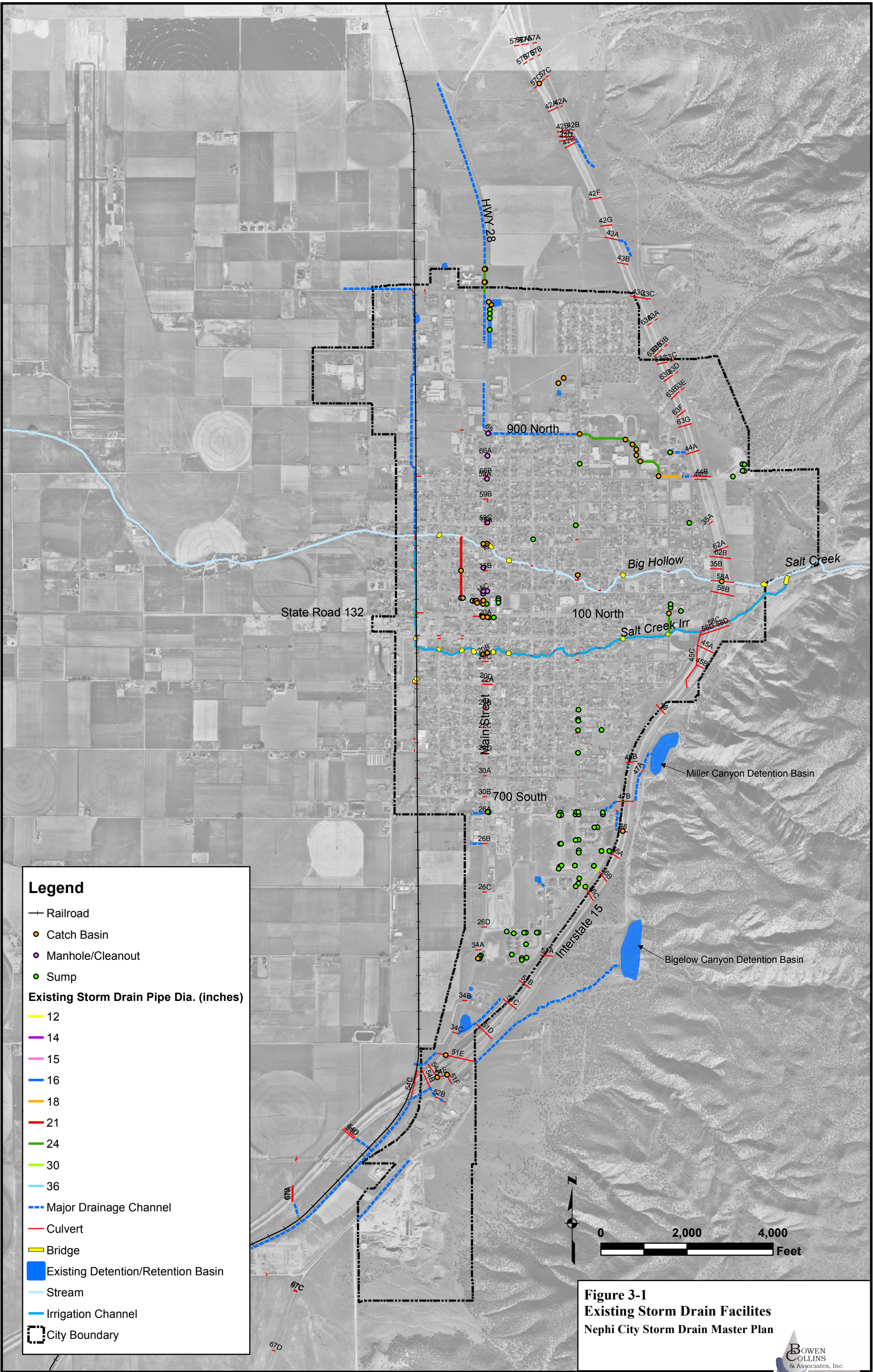
1. Storm water catch basins, manholes, sumps, culverts, open channels, and storm drain pipes.
2. Storm water detention and retention facilities.

NEPHI CITY STORM DRAIN FACILITY INVENTORY

Figure 3-1 shows the locations of storm drain facilities that were inventoried as part of this project. Table 3-1 also summarizes the size of storm drains and major drainage ditches, and provides estimates of the capacity of the inventoried storm drains. The storm drain inventory includes major open channels, storm drains, catch basins and manholes, sumps, and detention and retention facilities.

Table 3-1
Estimated Peak Storm Water Discharges and Capacities for Major Open Channels and Pipelines
Nephi City Storm Drainage Master Plan

	Existing Development		Future Development		Bottom Width or Pipe Diameter (feet)	Estimated Channel or Pipe Capacity (cfs) ⁽¹⁾
	10-Year Peak Storm Water Flow (cfs)	100-Year Peak Storm Water Flow (cfs)	10-Year Peak Storm Water Flow (cfs)	100-Year Peak Storm Water Flow (cfs)		
Major Channels						
<i>Within City Boundaries</i>						
900 North	20	-	50	-	.5	10.5
west side of Highway 91	44	-	82	-	1	10.5
300 West, Big Hollow to 1500 N	22-28	-	50-115	-	1	18
<i>Outside City Boundaries</i>						
below Miller Canyon Detention Basin	-	30	-	30	4	80
Below Bigelow Detention Basin	-	50	-	50	5	120
Storm Drain Pipelines						
<i>Within City Boundaries</i>						
150 North to 100 West to Big Hollow	11	-	11	-	1 to 3	2.7
700 North	3	101	17	-	1.5	14.5
700 North to 900 North	20-30	101	17-35	-	2.5	43



SECTION 4 HYDROLOGIC ANALYSIS

INTRODUCTION

A hydrologic model of the study area shown in Figure 2-1 was developed for the purpose of estimating storm water runoff volumes and peak discharges generated by a design cloudburst event. The model development process is outlined in the following general steps, with detailed information on each step provided later in this section:

1. Delineate drainage basin and subbasin boundaries based on topography, parcel maps, aerial photography, and existing storm drainage facility information
2. Estimate hydrologic modeling parameters for each subbasin based on soil type, land use, slope, and other storm water conveyance characteristics.
3. Combine subbasin, channel routing, and storage elements in an integrated hydrologic model
4. Develop a design precipitation event (or events) using local rainfall data.

DRAINAGE BASIN DELINEATION

Aerial photography and topographic mapping was obtained for all of the detailed study area and the area between the Nephi City limits and West Creek as part of this study. Because Juab County personnel were interested in the area west of the City limits, Juab County provided funds to help purchase the aerial mapping. The aerial photography and topographic mapping were used in conjunction with the existing storm drainage facility inventory to delineate drainage basins and subbasins. The drainage basins and subbasin boundaries are shown in Figure 4-1 along with their drainage areas.

The major drainage basins were divided into subbasins with areas generally between 12 and 129 acres for hydrologic modeling purposes, with some larger subbasin delineations used in the undeveloped mountain region of the study area. The Salt Creek Drainage Area was not hydrologically modeled because statistical analyses performed by the USGS were available for use in estimating the 100-year discharge at the canyon mouth.

DESIGN STORM

After multiple discussions with Nephi City personnel, a 3-hour design storm with a 10-year return period was selected for the basis of the hydrologic analyses in urban areas and a 24-hour design storm with a 100-year return period was selected as the basis for the hydrologic analyses in mountain drainage basins was for this study. The 3-hour design storm utilizes a modified Farmer-Fletcher precipitation distribution. The 24-hour design storm utilizes the SCS Type 2 precipitation distribution. Other cities and counties in Utah along the Wasatch Front

utilize similar design storms in planning and designing storm drain facilities. The precipitation distributions for the 10-year, 3-hour and the 100-year, 24-hour design storms are shown graphically in Figures 4-2a and 4-2b. More detailed information on the 10- and 100-year design storms is included in the Technical Appendix.

Precipitation depth-duration-frequency data from NOAA Atlas 14 (2007) were used in developing the design storm depths. The design storm precipitation depths used in the study are presented in Table 4-1.

Table 4-1
Design Storm Depth, Duration, Frequency Data
Nephi City Storm Drainage Master Plan
(from NOAA Atlas 14)

Precipitation Frequency Estimates (inches)		
ARI* (Years)	3 Hour	24 Hour
10	1.02**	1.81
25	1.27**	2.1
100	1.75	2.54**

* **ARI** is the Average Recurrence Interval.

** Values used in hydrologic analysis

MODELING METHODS AND ASSUMPTIONS

The hydrologic analysis of the study area was performed using the HEC-HMS software package developed by the U.S. Army Corps of Engineers (USACE). HEC-HMS uses the HEC-1 Flood Hydrograph Package algorithms in a Windows environment, with additional pre- and post-processing capabilities. A complete description of HEC-HMS modeling methods and capabilities is presented in the USACE HEC-HMS User's Manual. The model input parameters were assembled using multiple data sources, including drainage basin delineations, soil surveys, land use maps, recent aerial photography, and model input data used in similar hydrologic studies within or in the vicinity of the study area.

The following standard assumptions were made in completing the hydrologic analyses of the study area:

1. Rainfall return frequency is equal to associated runoff return frequency.
2. Design storm rainfall has a uniform spatial distribution over the watershed with a modified Farmer-Fletcher temporal distribution.
3. Normal (SCS Type 2) antecedent soil moisture conditions exist at the beginning of the design storm.

4. The hydrologic computer model adequately simulates watershed response to precipitation.
5. All storm water runoff generated by the model is conveyed through downstream model elements (the hydrologic model does not account for storm drain inlet or conveyance deficiencies).

Modeling Parameters for Mountain Drainage Basins

The subbasins for undeveloped drainages in the study area were hydrologically modeled using the SCS Curve Number Method. The assigned curve number defines the amount of precipitation that will be lost to infiltration and abstraction. Table 4-2 shows the curve numbers applied to sub-basins within the undeveloped drainages. Groundcover in the mountains and foothills of the study area generally consists of cedars, sagebrush, junipers, and scrub oak; the predominant ground cover for each sub-basin was chosen based on aerial photographs. Typical soils in the study area consist primarily of hydrologic soil Types B and C, as shown in Figure 2-2. These soils generally consist of sandy to clayey loams, and exhibit fair to poor infiltration characteristics. An average (fair to poor) watershed vegetation condition was assumed for this study rather than a poorly vegetated or burned watershed.

Table 4-2
SCS Curve Numbers for Undeveloped Drainage Areas⁽¹⁾
Nephi City Storm Drainage Master Plan

Cover Description		Curve Numbers for Hydrologic Soil Group			
Cover Type	Hydrologic Condition	A	B	C	D
Pinyon-juniper—pinyon, juniper, or both; grass understory	Poor	NA	75	85	89
	Fair	NA	58	73	80
	Good	NA	41	61	71
Sagebrush with grass understory	Poor	NA	67	80	85
	Fair	NA	51	63	70
	Good	NA	35	47	55
Vegetated Urban Areas					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80

(1) From SCS TR-55 (1986), Table 2-2a and Table 2-2d, Runoff Curve Numbers for Arid and Semiarid Rangelands.

Drainage basin lag times were estimated based on approximate collection channel lengths and slopes using the USACE version of Snyder's equation for lag time (USBR, 1989).

$$\text{Lag Time} = 1.8 \left(\frac{LL_{ca}}{S^{0.5}} \right)^{0.33}$$

where:

L = the longest water course in a given basin from the drainage boundary to the point of concentration (in miles)

L_{ca} = the length along L from a point perpendicular to the basin centroid to the point of concentration (in miles)

S = the overall slope of L (in feet per mile).

Typical subbasin lag times for undeveloped drainages ranged from about 25 to 90 minutes, depending on basin slope and geometry.

Modeling Parameters for Urban Drainages

The subbasins for urban drainages in the study area were hydrologically modeled using the SCS Curve Number Method. Table 4-2 shows the curve numbers applied to subbasins within the urban drainages. In areas of urban development, the top layer of native soil is typically paved over or replaced with topsoil which supports the growth of lawns and other urban vegetation. The percentages of impervious area for each subbasin were assigned based on the City's land use map shown in Figure 4-3, recent aerial photographs, and the information shown in Table 4-3.

Table 4-3
Average Percent Impervious Area
by Land Use Category(1)
Nephi City Storm Drainage Master Plan

Land Use Category	Average Impervious Area (%)
Highway Commercial	60
Commercial/Industrial Mix	50
Commercial/Residential Mix	40
Central Business District	40
Light Industrial Residential Mix	35
High Density Residential	30
Low Density Residential	20

Drainage basin lag times were calculated based on approximate collection channel lengths and slopes using the following equation for lag time (Humphrey, 1993).

$$\text{Lag Time} = T_o + T_g + T_p + T_c$$

where:

T_o = Overland flow time
 T_g = Gutter flow travel time
 T_p = Pipe flow travel time
 T_c = Channel flow travel time

$$T_o = (0.66 * L^{0.50} * n^{0.52}) / (S^{0.31} * i^{0.38})$$

where:

T_o = overland flow time of concentration, in min
 L = overland flow length, in feet
 n = roughness coefficient of overland flow
 S = average of precipitation, in inches per hour
 i = intensity of precipitation, in inches per hour

$$V_g = (1.12/n) * S_x^{0.67} * S^{0.50} * T^{-0.67}$$

where:

V_g = velocity of flow in the gutter
 S_x = street cross slope
 S = street longitudinal slope, in feet per foot
 T = spread of flow in gutter
 d = depth of flow in gutter
 n = Manning's n for pavement

$$V_p = (1.49/n) * R^{0.67} * S^{0.50}$$

where:

V_p = velocity in pipe, in feet per second
 R = hydraulic radius, D/4 for full pipe flow, in feet
 D = diameter of pipe, in feet
 S = slope, in ft/ft
 N = Manning's n

$$V_c = 37.0 * w^{0.667} * S^{0.5}$$

where:

V_c = velocity, in feet per second
 b = bottom width, in feet
 n = $0.16 * (V * R)^{-0.58}$

Typical subbasin lag times for the urban drainages ranged from 10 minutes to 45 minutes, depending on subbasin size, slope and geometry.

Channel and Storage Routing

The Muskingum-Cunge channel routing method was used for routing runoff from subbasins to and through the primary storm drain conveyances. Detailed information on channel geometry, slope, and roughness collected during surveys of the canals and creeks was used where appropriate. Storm drain inventory information was combined with topographic information, where necessary, to estimate routing parameters for storm drain pipelines. In areas where this information was not collected, typical routing parameters were assigned based on field observations. Manning's channel roughness values of 0.035 to 0.045 were used for natural and irrigation channels, while a value of 0.015 was used for concrete-lined channel sections and storm drain culverts.

Storage routing elements were included in the model to simulate major detention basins. In general, only detention basins with volumes greater than one acre-feet were included in the model (local onsite detention was not included in the model, except as noted in the projected future land use conditions modeling explanation provided later in this section). Where available, volume-discharge relationships for these detention facilities were obtained from the City. For many of the cases where this information was not available, capacity was estimated based on maps of existing topography and outfall capacities were estimated based on existing storm drain inventory information. It is estimated that the capacities of the Miller Canyon, Bigelow Canyon, and 1450 North detention basins are approximately 75, 106, and 1.5 acre-feet respectively.

MODEL CALIBRATION

In general, calibration of a hydrologic model of an urban area refers to the process of adjusting parameters to achieve results consistent with available reference information in nearby areas, rather than adjusting for actual stream flow observations from the study area. Based on information from drainage studies from nearby areas, the natural (undeveloped) subbasins in the study area were calibrated to generate peak runoff ranging from 100 to 700 cfs per square mile for a 100-year 24-hour design storm, with an average of 280 cfs per square mile. Urban subbasins were calibrated to generate peak runoff ranging from 0.1 to 0.35 cfs per acre for a 10-year 3-hour design storm for existing development conditions, with an average of 0.15 cfs per acre based on data from nearby small urban drainages.

PROJECTED FUTURE LAND USE CONDITIONS

For the purposes of this study, it was assumed that the current trends of growth and development in the City would continue. The hydrologic model for existing land use conditions was modified to represent projected future land use conditions based on zoning and projected land use maps provided by the City. The Projected Land Use Map is shown in Figure 4-3. The hydrologic model for future land use also reflects the City's direction to place curb and gutter on all of its streets.

Mountain drainages east of the City limits and south of SR-132 were assumed to remain undeveloped in the future. Planned development east of the City limits and north of SR-132 shown in Figure 4-3 was incorporated into the hydrologic model. If development occurs east of

the areas planned for development shown in Figure 4-3 and the associated storm water runoff is conveyed into the City, storm water runoff will need to be detained or retained to reduce the post-development peak discharges to a level no greater than the estimated peak discharges from pre-developed conditions. Effects of development in these areas on City storm drain facilities should be carefully modeled, since existing downstream detention facilities may not be capable of accommodating significant increases in runoff volume, even if peak flows are detained to pre-development rates.

HYDROLOGIC MODELING RESULTS

Rainfall-runoff simulations were completed using the 10-year 3-hour, 25-year 3-hour, and 100-year 24-hour design storms for both existing and projected full build-out conditions. Average estimated peak discharges generated in the older part of town for existing development conditions generate approximately 0.15 cfs/acre for a 10-year design storm. Future development conditions (with curb and gutter and wider streets in the same area) would generate between 0.30 and 0.45 cfs/acre from the same storm. Detailed results, as well as HEC-HMS model schematics, are included in the Technical Appendix.

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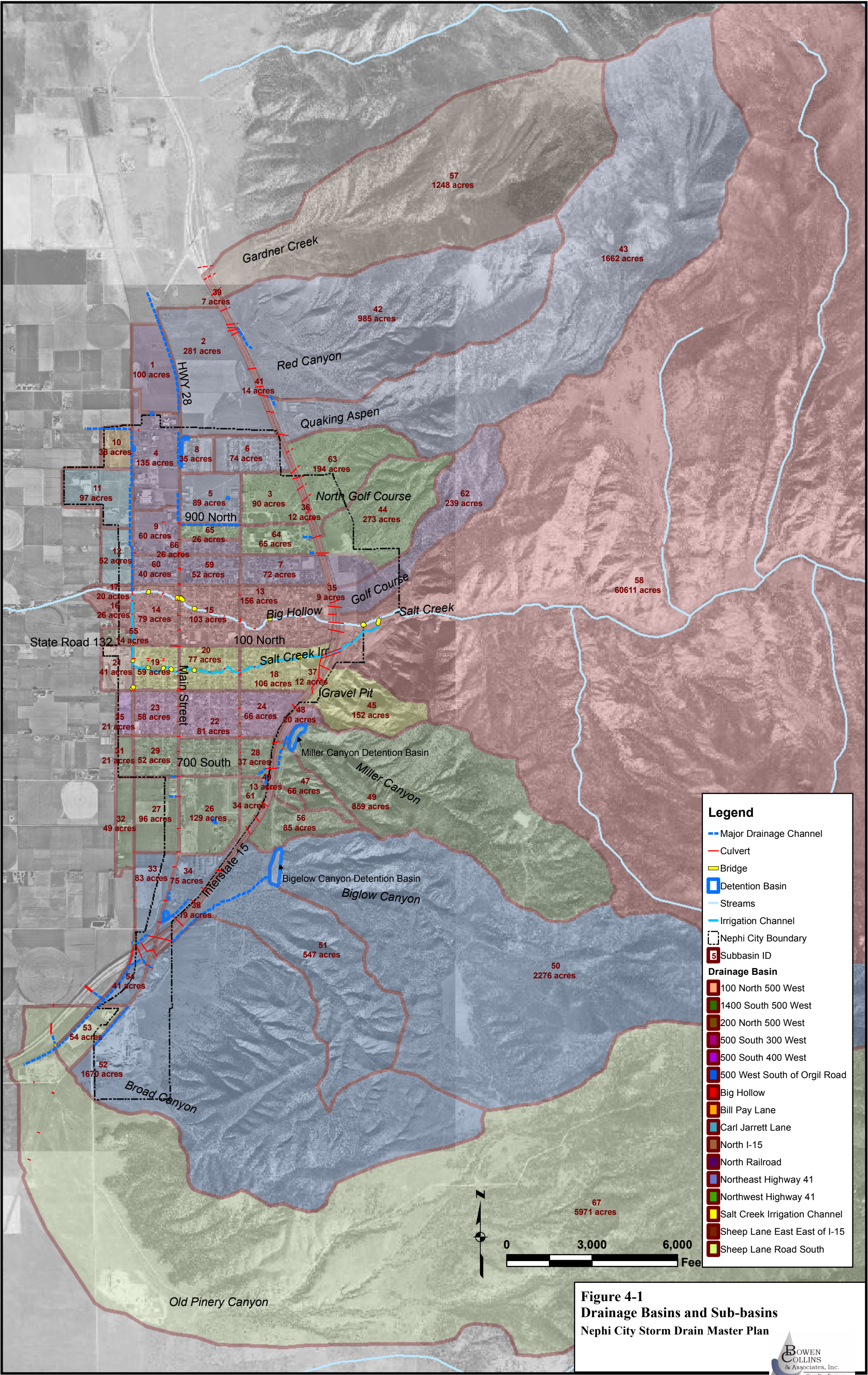


Figure 4-1
Drainage Basins and Sub-basins
Nephi City Storm Drain Master Plan



Figure 4-2a
10-Year 3-Hour Design Storm Precipitation Distribution
Nephi City 2008 Master Drainage Plan Update

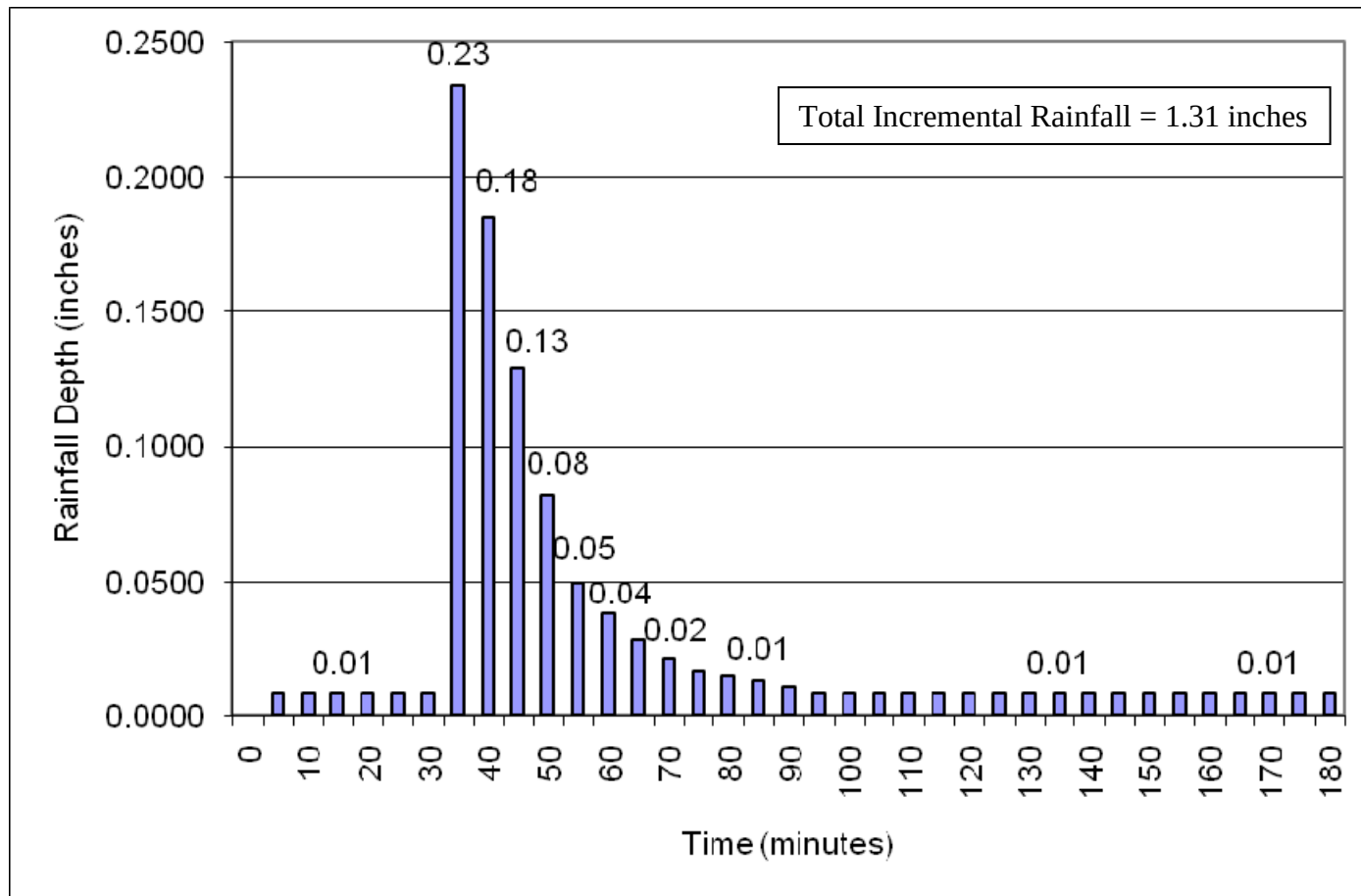
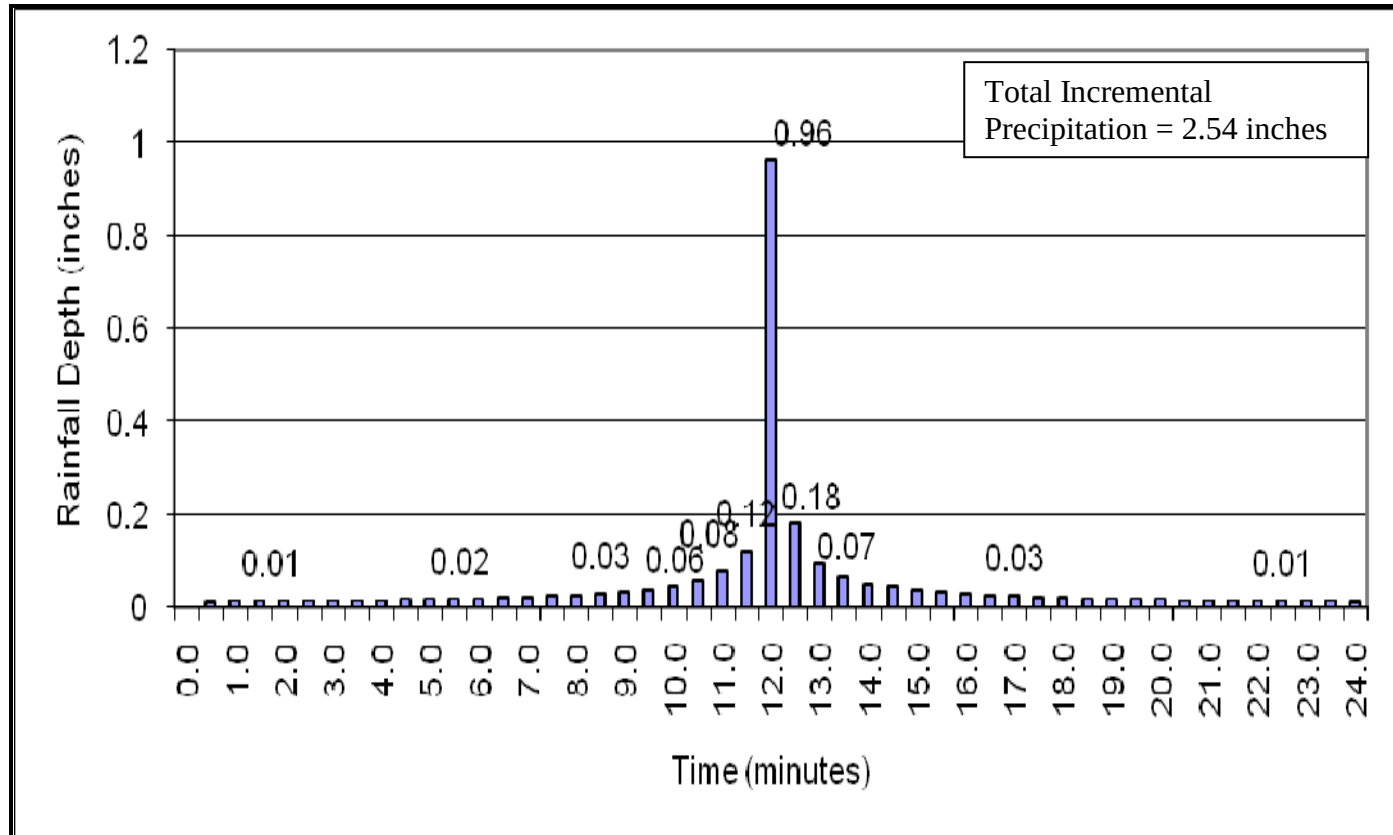
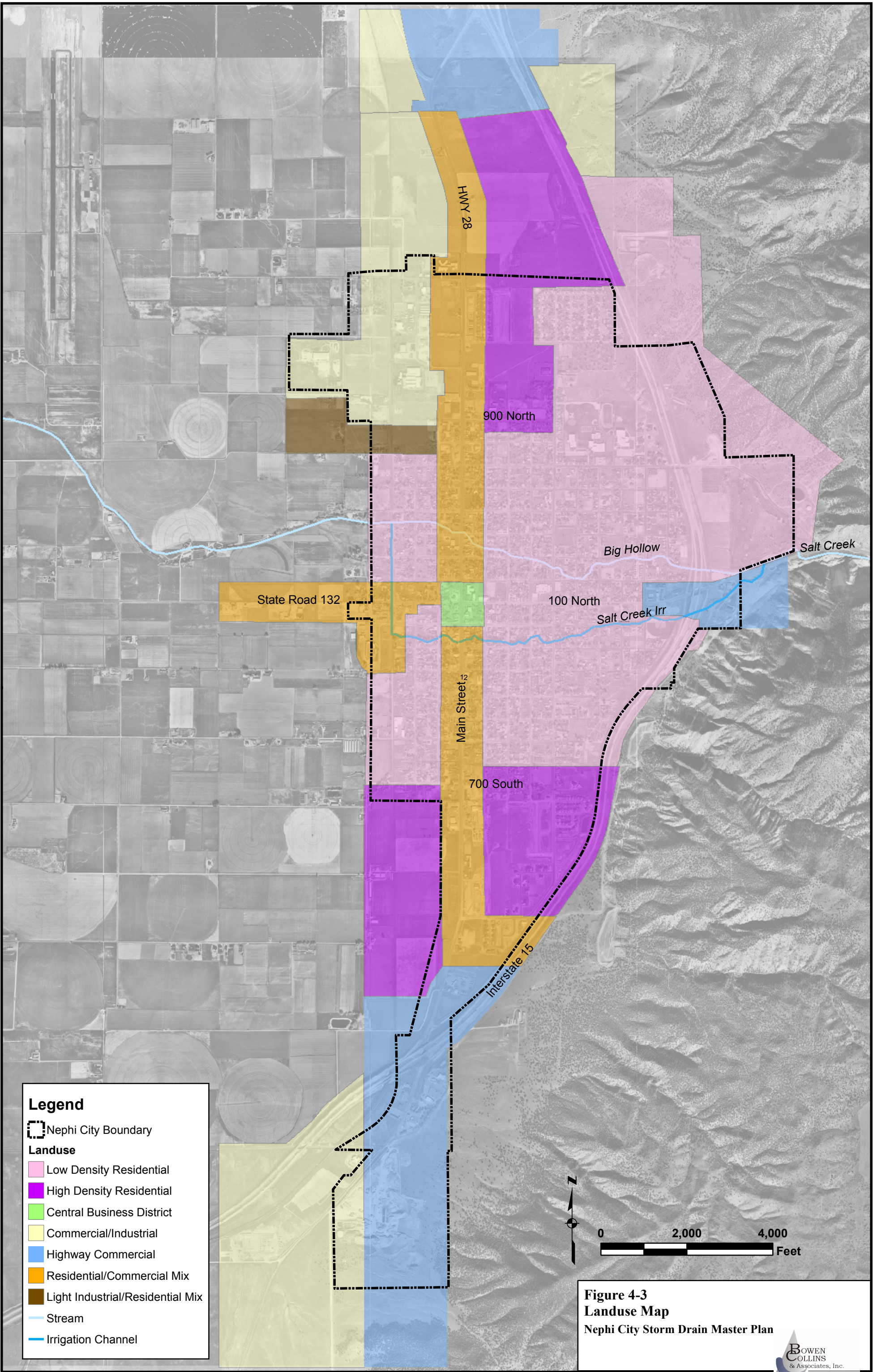


Figure 4-2b
100-Year 24-Hour Precipitation Design Storm Distribution
Nephi City 2008 Master Drainage Plan Update





SECTION 5 HYDRAULIC ANALYSIS

INTRODUCTION

Hydraulic analyses of 5 types of flood control facilities were performed as part of this study. These facilities include:

1. Open channels
2. Existing storm drain pipelines
3. Existing culverts
4. Salt Creek/Big Hollow
5. Storm water detention facilities.

The results from hydraulic analyses of major storm water detention facilities are presented along with detention basin capacity estimations based on survey information and hydrologic analysis results in Section 4 of this report. Descriptions of the hydraulic analyses which were completed for the remaining 4 types of flood control facilities are presented in this section, along with the resulting hydraulic capacity estimates. Recommended improvements for deficient facilities are identified in Section 7 of this report.

OPEN CHANNELS

Within the City limits there are several open channels that were used for irrigation before the pressurized system was installed. These channels are located on 900 North, on the west side of Highway 91, and along 300 West from Big Hollow to 1500 North. These open channels are now used as storm water conveyance facilities. Topographic maps and culvert elevations were used to estimate channel slopes. Roughness coefficients for the channels were based on a visual assessment of the condition of the channel and engineering judgment. Dimensions were measured during field investigations. The estimated bank full capacities were estimated using Manning's equation. Channel capacities were compared with the estimated 10-year peak discharge results from the hydrologic analysis for both existing and future development conditions. Channel capacities that were estimated are summarized in Table 3-1. The open channels are identified in Figure 3-1. Many sections of these open channels have been backfilled or are plugged with debris, such as the 900 North open channel. Estimated channel capacities listed in Table 3-1 were made without consideration for channel blockages or debris. Therefore, the estimated existing channel capacities are quite conservative.

STORM DRAIN PIPELINES

There are currently only 3 existing storm drain pipelines in the City as shown in Figure 3-1. One storm drain at 700 North; one that is constructed from 700 North to 900 North and located on the Juab High School property; and one at approximately 150 North that traverses from Main Street to 100 West, then along 100 West to Big Hollow. Pipe material and invert elevations were used to estimate pipe slope and

roughness for each of the pipe segments. The estimated maximum pipe conveyance capacities were estimated using Manning's equation. Pipeline capacities were compared with the estimated 10-year peak discharge results from the hydrologic analysis for both existing and future development conditions. Pipelines with the capacity to convey at least 85 percent of the estimated peak design discharges were considered to be adequate assuming that limited surcharging would allow for safe conveyance of the peak design flow. Table 3-1 summarizes the results of the hydraulic analysis for the storm drain lines evaluated.

CULVERTS

Pipe size, material, and invert elevation data were used to estimate the capacity of culverts. The estimated maximum conveyance capacities of the culverts were estimated using Manning's equation. Culvert capacities were compared with the estimated 10-year and 100-year peak discharge results from the hydrologic analysis for both existing and future development conditions. Table 5-1 summarizes the results of the hydraulic analyses for the existing culverts. The culverts inventoried are identified in Figure 3-1.

BIG HOLLOW AND SALT CREEK IRRIGATION CHANNEL

Modeling Methods and Assumptions

The hydraulic computer models of Big Hollow and the Salt Creek irrigation channel consist of a mathematical representation of the geometry and flow characteristics of the drainage creek channels and existing bridge and culvert crossings. The software used in this study was HEC-RAS, a hydraulic computer model developed by the USACE. This program was developed to calculate water surface profiles in channels with irregularly shaped cross sections. A complete discussion of the methodology used by HEC-RAS can be found in the USACE HEC-RAS User's Manual.

Cross section data for the model were developed using survey information and topographic aerial mapping. Cross sections were taken along the channel at intervals of approximately 500 feet from the Salt Creek diversion at the mouth of Salt Creek Canyon to just west of the railroad at 300 West on both Big Hollow and the Salt Creek irrigation channel. Survey information was collected at all major hydraulic structures, including bridges and culverts. Survey data at these structures included culvert dimensions, channel invert, and road or canal bank elevations.

Roughness coefficients for the channel were based on a visual assessment of the condition of the channel and engineering judgment. Big Hollow and Salt Creek cross sections were generally assigned a Manning's roughness coefficient between 0.035 and 0.045. Higher roughness coefficients, ranging from 0.50 to 0.60, were used for vegetated overbank areas adjacent to the main channel.

The USGS has estimated the 100-year peak discharge for Salt Creek (Big Hollow) to be 906 cfs (2008). This value was used in calibrating the computer model.

Table 5-1
Inventory for Culverts on I-15 and Main Street
Nephi City Storm Drainage Master Plan
(Existing deficient and proposed new facilities are highlighted in yellow)

Drainage Area ID	Facility ID	Existing Development		Future Development		Drainage Area (mi ²)	Location	Estimated Hydraulic Capacity (cfs)	Existing Drainage Facility	Notes and Recommended Improvements
		Estimated 100-year Peak Discharge (cfs)	Estimated 100-year Peak Discharge (cfs)	Estimated 100-year Peak Discharge (cfs)	Estimated 100-year Peak Discharge (cfs)					
I-15/Highway 28										
57	57A	415	415	415	1.951	I-15/Gardiner Canyon	35	30" CMP	Construct Detention Basin 57	
57	57B	415	415	415	1.951	I-15/Gardiner Canyon	80	42" CMP	Construct Detention Basin 57	
57	57C	415	415	415	1.951	I-15/Gardiner Canyon	20	24" CMP	Construct Detention Basin 57	
42	42A	378	378	378	1.540	I-15/Red Canyon	20	24" CMP		
42	42B	378	378	378	1.540	I-15/Red Canyon	200	60" CMP		
42	42C	378	378	378	1.540	I-15/Red Canyon	80	42" CMP		
42	42D	378	378	378	1.540	I-15/Red Canyon	80	42" CMP		
42	42E	378	378	378	1.540	I-15/Red Canyon	80	42" CMP		
42	42F	378	378	378	1.540	I-15/Red Canyon	25	24" CMP		
42	42G	378	378	378	1.540	I-15/Red Canyon	50	42" CMP		
43	43A	327	327	336	0.303	I-15/Quaking Aspen	300	84" CMP		
43	43B	327	327	336	0.303	I-15/Quaking Aspen	25	24" CMP		
43	43C	327	327	336	0.303	I-15/Quaking Aspen	29	24" CMP		
63	63A	32	32	32	0.303	I-15 South of Quaking Aspen	15	24" CMP		
63	63B	32	32	32	0.303	I-15 South of Quaking Aspen	16	24" CMP		
63	63C	32	32	32	0.303	I-15 South of Quaking Aspen	16	24" CMP		
63	63D	32	32	32	0.303	I-15 South of Quaking Aspen	21	24" CMP		
63	63E	32	32	32	0.303	I-15 South of Quaking Aspen	22	24" CMP		
63	63F	32	32	32	0.303	I-15 South of Quaking Aspen	25	24" CMP		
63	63G	32	32	32	0.303	I-15 South of Quaking Aspen	86	36" CMP		
44	44A	120	120	120	0.371	I-15/Golf Course	67	42" CMP	Construct Detention Basin 44	
44	44B	120	120	120	0.371	I-15/Golf Course	25	30" CMP	Construct Detention Basin 44	
44	44C	73	73	73	0.429	I-15/Golf Course	15	24" CMP	Construct Detention Basin 44	
35	35A	5	5	5	0.014	I-15 Below Golf Course	17	24" RCP		
35	35B	5	5	5	0.014	I-15 Below Golf Course	17	24" RCP		
62	62A	73	73	73	0.429	I-15/Golf Course	9	12" CMP	Construct Open Channel	

Table 5-1
Inventory for Culverts on I-15 and Main Street
Nephi City Storm Drainage Master Plan
(Existing deficient and proposed new facilities are highlighted in yellow)

Drainage Area ID	Facility ID	Existing Development		Future Development		Drainage Area (mi ²)	Location	Estimated Hydraulic Capacity (cfs)	Existing Drainage Facility	Notes and Recommended Improvements
		Estimated 100-year Peak Discharge (cfs)	Estimated 100-year Peak Discharge (cfs)	Estimated 100-year Peak Discharge (cfs)	Estimated 100-year Peak Discharge (cfs)					
62	62B	73	73	73	73	0.429	I-15/Golf Course	17	24" CMP	Construct Open Channel
58	58A	906	906	906	906	94.750	Nephi Canyon/Big Hollow	3,300	20' x 8' Box Culvert	
58	58B	906	906	906	906	94.750	Nephi Canyon	47	36" CMP	
58	58C	906	906	906	906	94.750	Nephi Canyon/Salt Creek	1,300	10' x 6' Box Culvert	
58	58D	906	906	906	906	94.750	Nephi Canyon	47	36" CMP	
45	45A	138	138	138	138	0.237	I-15/Gravel Pit	31	36" CMP	
45	45B	138	138	138	138	0.237	I-15/Gravel Pit	31	36" CMP	
45	45C	138	138	138	138	0.237	I-15/Gravel Pit	55	36" CMP	
48	48	4	4	4	4	0.032	I-15 South of Gravel Pit	55	36" CMP	
48	48B	41	41	41	41	0.104	I-15 South of Miller Canyon	20	24" CMP	
49	49A	321	321	321	321	1.343	I-15/Miller Canyon	130	48" CMP	
47	47A	41	41	41	41	0.104	I-15 South of Miller Canyon	55	42" CMP	
47	47B	41	41	41	41	0.104	I-15 South of Miller Canyon	130	48" CMP	
46	46	10	10	10	10	0.020	I-15 South of Miller Canyon	35	30" CMP	
56	56A	27	27	27	27	0.134	I-15 South of Miller Canyon	35	30" CMP	
56	56B	27	27	27	27	0.134	I-15 South of Miller Canyon	45	30" CMP	
56	56C	27	27	27	27	0.134	I-15 South of Miller Canyon	45	30" CMP	
51	51A	57	57	57	57	0.855	I-15/South Biglow Canyon	17	24" CMP	
51	51B	57	57	57	57	0.855	I-15/South Biglow Canyon	17	24" CMP	
51	51C	57	57	57	57	0.855	I-15/South Biglow Canyon	51	36" CMP	
51	51D	57	57	57	57	0.855	I-15/South Biglow Canyon	17	24" CMP	
51	51E	57	57	57	57	0.855	I-15/South Biglow Canyon	240	64" CMP	
52	52A	257	257	257	257	2.610	I-15/South of South Biglow Canyon	10	20" CMP	Construct Open Channel
52	52B	257	257	257	257	2.610	I-15/South of South Biglow Canyon	78	38" CMP	Construct Open Channel
52	52C	257	257	257	257	2.610	Highway 28	55	44" CMP	Construct Open Channel
54	54A	43	43	43	43	2.610	I-15 South Interchange	56	36" CMP	

Table 5-1
Inventory for Culverts on I-15 and Main Street
Nephi City Storm Drainage Master Plan
(Existing deficient and proposed new facilities are highlighted in yellow)

Drainage Area ID	Facility ID	Existing Development		Future Development		Drainage Area (mi ²)	Location	Estimated Hydraulic Capacity (cfs)	Existing Drainage Facility	Notes and Recommended Improvements
		Estimated 100-year Peak Discharge (cfs)	Estimated 100-year Peak Discharge (cfs)	Estimated 100-year Peak Discharge (cfs)	Estimated 100-year Peak Discharge (cfs)					
54	54B	43	43	43	43	2.610	I-15 South Interchange	225	60" CMP	
54	54C	43	43	43	43	2.610	I-15 South Interchange	10	24" CMP	
52, 53, 54	54D	340	340	340	340	2.800	I-15 South Interchange	700	2-66" CMP	
67	67A	428	428	530	530	9.300	I-15 South of South Gravel Pit	225	66" CMP	
67	67B	428	428	530	530	9.300	I-15 South of South Gravel Pit	324	72" CMP	
67	67C	428	428	530	530	9.300	Highway 28	70	2-36" CMP	Construct Open Channel
67	67D	428	428	530	530	9.300	Highway 28	9	21" CMP	Construct Open Channel
67	67E	428	428	530	530	9.300	Highway 28	35	36" RCP	Construct Open Channel
Main Street		Estimated 10-year Peak Discharge (cfs)	Estimated 10-year Peak Discharge (cfs)	Estimated 10-year Peak Discharge (cfs)	Estimated 10-year Peak Discharge (cfs)					
65	65	44	44	82	82	0.041	Main Street/900 North	6	18" CMP	Construct Storm Drain Pipe
66	66A	4	4	8	8	0.041	Main Street/800 North	4.75	18" CMP	
66	66B	4	4	8	8	0.041	Main Street/700 North	4.75	18" CMP	
54	54E	43	43	43	43	2.610	Highway 28	10	21" CMP	
59	59A	14	14	28	28	0.081	Main Street/700 North	6	18" CMP	
59	59B	14	14	28	28	0.081	Main Street/600 North	6	18" CMP	
59	59C	14	14	28	28	0.081	Main Street/500 North	4	18" CMP	
15	15A	4	4	15	15	0.161	Main Street/500 North	4	18" CMP	
15	15B	4	4	15	15	0.161	Main Street/300 North	2.5	15" CMP	
15	15C	4	4	15	15	0.161	Main Street/200 North	2.5	15" CMP	
20	20A	6	6	8	8	0.121	Main Street/100 North	5	18" CMP	Construct Storm Drain Pipe
20	20B	17	17	19	19	0.121	Main Street/70 South	see Hyd Profile	Salt Creek-Big Hollow	
20	20C	6	6	8	8	0.121	Main Street/100 South	1.7	12" CMP	Construct Storm Drain Pipe
20	20D	6	6	8	8	0.121	Main Street/200 South	1.7	12" CMP	Construct Storm Drain Pipe
22	22A	20	20	50	50	0.126	Main Street/200 South	2	12" CMP	Construct Storm Drain Pipe
22	22B	20	20	50	50	0.126	Main Street/300 South	2.5	12" CMP	Construct Storm Drain Pipe
22	22C	20	20	50	50	0.126	Main Street/400 South	3	18" CMP	Construct Storm Drain Pipe

Table 5-1
Inventory for Culverts on I-15 and Main Street
Nephi City Storm Drainage Master Plan
(Existing deficient and proposed new facilities are highlighted in yellow)

Drainage Area ID	Facility ID	Existing Development		Future Development		Drainage Area (mi ²)	Location	Estimated Hydraulic Capacity (cfs)	Existing Drainage Facility	Notes and Recommended Improvements
		Estimated 100-year Peak Discharge (cfs)	Estimated 100-year Peak Discharge (cfs)	Estimated 100-year Peak Discharge (cfs)	Estimated 100-year Peak Discharge (cfs)					
22	22D	20	50	50	50	0.126	Main Street/500 South	3	18" CMP	Construct Storm Drain Pipe
30	30A	10	38	38	38	0.104	Main Street/600 South	11.8	24" CMP	
30	30B	10	38	38	38	0.104	Main Street/700 South	11.8	24" CMP	
26	26A	11	84	84	84	0.202	Main Street/800 South	12.8	24" CMP	
26	26B	11	84	84	84	0.202	Main Street/900 South	4	16" CMP	
26	26C	11	84	84	84	0.202	Main Street/1100 South	13	24" CMP	
26	26D	11	84	84	84	0.202	Main Street/130000 South	4.5	18" CMP	
34	34A	7	41	41	41	0.118	Main Street/1375 South	6	18" CMP	
34	34B	7	41	41	41	0.118	Main Street/Orgill Road	70	48" CMP	
34	34C	7	41	41	41	0.118	Main Street/I-15 SB On Ramp	35	36" CMP	

(1) - Hydraulic capacity estimated using HEC-RAS model for Big Hollow and Salt Creek. All other culvert and pipe capacities estimated as the less of outlet control and inlet control estimated capacities.

(2) - Culverts and pipes with estimated capacities less than 85 percent of 100-year peak discharge (future development) were considered deficient. Facilities with greater than 85 percent but less than 100 percent of 100-year peak discharge were assumed to have minor local flooding during a 100-year event.

(3) - Assumed slope for recommended improvements was 1.5 percent. Culvert sizes should be adjusted in design according to design slope.

Big Hollow

Big Hollow serves as the major east-to-west storm water conveyance facility in Nephi. For the purposes of this study, it originates at the mouth of Salt Creek Canyon and runs west through Nephi City, discharging to West Creek 3 miles west of town. The results of the hydraulic analysis of Big Hollow demonstrated that the creek channel has inadequate capacity to convey the peak 100-year discharge in several locations. A complete summary of the estimated capacity of Big Hollow by reach is summarized in Table 5-2 and shown in a figure in the Technical Appendix.

Table 5-2
Estimated Capacity Information for Big Hollow
Nephi City Storm Drainage Master Plan

Crossing or Reach	Capacity (cfs)
Salt Creek Diversion to Golf Course Bridge	906+ cfs
Golf Course Bridge	906+ cfs
Golf Course Bridge to I-15	906+ cfs
I-15 Culvert	906+ cfs
I-15 to 800 East	906+ cfs
800 East Culvert	700 cfs
800 East to 600 East	906+ cfs
600 East Bridge	906+ cfs
600 East to 500 East	650 cfs
500 East Culvert	800 cfs
500 East to 400 East	650 cfs
400 East Culvert	906+ cfs
400 East to 300 East	906+ cfs
300 East Culvert	906+ cfs
300 East to 200 East	400 cfs
200 East Culvert	650 cfs
200 East to 100 East	400 cfs
100 East Culvert	906+ cfs
100 East to 400 North	500 cfs
400 North Culvert	906+ cfs
400 North to Main Street	906+ cfs
Main Street Culvert	906+ cfs
Main Street to 100 West	600 cfs
100 West Culvert	906+ cfs
100 West to 200 West	600 cfs
200 West Bridge	906+ cfs
200 West to 300 West	600 cfs
300 West Culvert	906+ cfs
300 West to City Boundary	906+ cfs

+ represents greater capacity than value listed

Salt Creek Irrigation Channel

The hydraulic modeling results for Salt Creek demonstrated that the channel, in general, has capacity to convey a peak flow of between 150 and 200 cfs between I-15 and 100 West. Between 100 West and the diversion structure at 250 West, the capacity decreases to about 80 cfs. The tailwater ditch downstream of the diversion can only convey an estimated 5 to 10 cfs. A summary of the capacity of the Salt Creek irrigation by reach is presented in Table 5-3 and shown in a figure in the Technical Appendix.

Table 5-3
Estimated Capacity Information for Salt Creek Irrigation Channel
Nephi City Storm Drainage Master Plan

Crossing or Reach	Capacity (cfs)
Salt Creek Diversion to SR-132	120 cfs
SR-132 Bridge	200+ cfs
SR-132 to Sheep Lane	200 cfs
Sheep Lane Culvert	200+ cfs
Sheep Lane to I-15	200 cfs
I-15 Culvert	200+ cfs
I-15 to 800 East	200+ cfs
800 East Bridge	200 cfs
800 East to 600 East	200+ cfs
600 East Bridge	200+ cfs
600 East to 500 East	200 cfs
500 East Culvert	200+ cfs
500 East to 400 East	150 cfs
400 East Culvert	200+ cfs
400 East to 300 East	200+ cfs
300 East Culvert	200+ cfs
300 East to 200 East	150 cfs
200 East Culvert	200+ cfs
200 East to 100 East	120 cfs
100 East Bridge	200+ cfs
100 East to 400 North	150 cfs
Main Street Bridge	200 cfs
Main Street to 100 West	200+ cfs
100 West Bridge	200+ cfs
100 West to 200 West	80 cfs
200 West Bridge	80 cfs
200 West Bridge to Irrigation Diversion	80 cfs
Irrigation Diversion to 300 West (Railroad)	40 cfs

Table 5-3
Estimated Capacity Information for Salt Creek Irrigation Channel
Nephi City Storm Drainage Master Plan
(continued)

Crossing or Reach	Capacity
	(cfs)
300 West Culvert (Railroad)	40 cfs
300 West to Center Street	40 cfs
Center Street Bridge	40 cfs
Center Street to 100 North	10 cfs
100 North Bridge	40 cfs
100 North to 300 North	15 cfs
300 North Culvert	15 cfs
300 North Culvert to Big Hollow	5 cfs

+ represents greater capacity than value listed

BIG HOLLOW AND SALT CREEK IRRIGATION CHANNEL SUMMARY OF HYDRAULIC ANALYSIS

In a 100-year runoff event, there will be minor flooding at various locations due to insufficient channel capacity and culvert/bridge capacity on Big Hollow and the Salt Creek irrigation channel. Figure 5-1 shows the approximate floodplain for Big Hollow with a discharge of 800 cfs and the Salt Creek irrigation channel with a discharge of 120 cfs. These discharge values were used to evaluate the capacity of both channels assuming they are both used to convey the 100-year peak discharge of 906 cfs estimated by USGS. The Salt Creek irrigation channel limit of study is just west of the railroad tracks. It should be noted that flooding will likely occur at the fairgrounds and various private properties west of the railroad tracks if flows greater than 40 cfs were released in the tailwater ditch after the irrigation diversion. HEC-RAS profiles for Big Hollow and the Salt Creek irrigation channel are found in the Technical Appendix.

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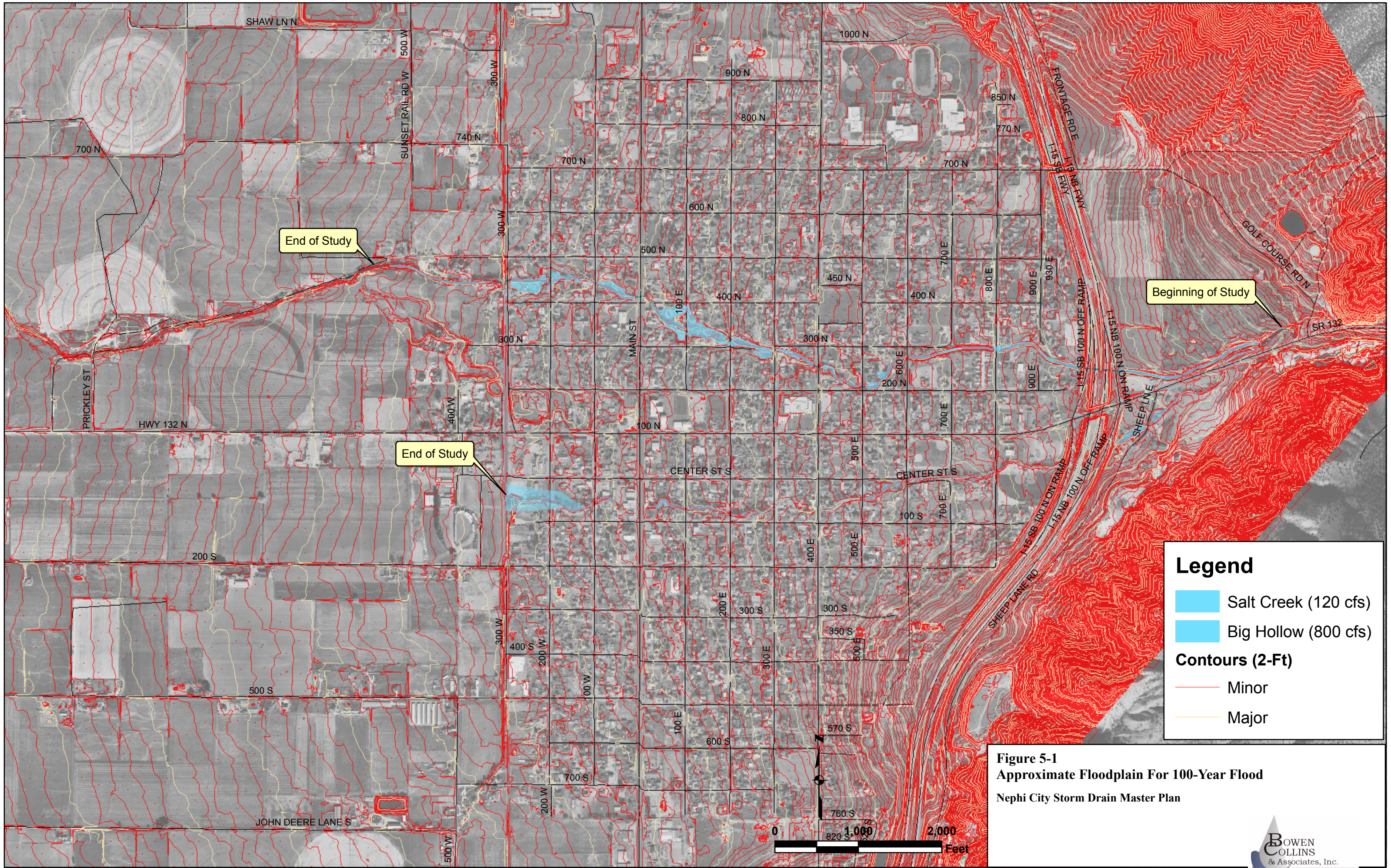


Figure 5-1
Approximate Floodplain For 100-Year Flood
Nephi City Storm Drain Master Plan

SECTION 6

DRAINAGE SYSTEM DEFICIENCIES

GENERAL APPROACH

The following major tasks were completed to identify drainage system deficiencies:

- Peak discharge rates and runoff volumes produced by design storms were estimated for the drainage basins and sub-basins within the study area.
- Hydraulic capacities for storm drains, minor irrigation channels, and culverts in the City were estimated based on storm drain inventory information collected as part of this study.
- Hydraulic capacities for Big Hollow and the Salt Creek irrigation channel were estimated using HEC-RAS computer models.
- The results of the hydrologic and hydraulic analyses were used to identify deficiencies in storm drain lines, storm water detention basins, culverts, irrigation channels, Big Hollow, and the Salt Creek irrigation channel.
- Improvements were recommended to resolve storm drain system deficiencies under existing and projected future development conditions.

The following criteria were used as the basis of identifying drainage system deficiencies as well as the design of recommended improvements:

- Storm drain pipelines serving urban areas should have capacity to collect and convey storm water runoff generated from a 10-year, 3-hour design storm.
- Storm water detention facilities east of I-15 should have capacity to manage runoff generated from a 100-year, 24-hour design storm. These facilities should also have emergency spillways to convey runoff from larger storm events. Large facilities will likely need to meet State Dam Safety regulations.
- Open channels that collect storm water runoff only from urban areas should have capacity to convey runoff generated from a 10-year, 3-hour design storm.
- Big Hollow, the Salt Creek irrigation channel, and all other natural drainage channels that convey runoff from mountain watersheds should have capacity to convey runoff generated from a 100-year, 24-hour design storm.

The evaluation of drainage system facilities was performed using runoff estimates for both existing and projected full build-out development conditions. Existing drainage deficiencies are identified in Figure 6-1 and summarized below.

EXISTING DRAINAGE SYSTEM DEFICIENCIES

The major existing drainage system deficiencies are presented below. Many of these problems will become more serious if additional development is allowed to occur without taking steps to mitigate the existing problems.

Lack of Conveyance Facilities West of I-15

Developed areas on the west side of the I-15 corridor are susceptible to shallow flooding during large storm events due to the lack of existing storm water conveyance facilities. Nuisance flooding caused by rainstorms and significant snowmelt events is frequently experienced near the cross culvert outlets. The culverts that cross under I-15 were sized to convey runoff from large runoff events. However, runoff from the impervious area of I-15 likely increased runoff from the conditions that existing before the freeway was constructed. Now that development is occurring adjacent to the freeway, managing storm water discharged through the culvert crossings is becoming a bigger issue. City personnel have reported that the area that currently is the biggest flood concern is a corridor at about 760 South, between I-15 and Main Street. Runoff generated from a portion of I-15 and drainage areas east of I-15 is conveyed through two culverts that discharge into an open drainage channel located behind homes that have been constructed near the freeway right-of-way. That drainage channel, which currently has inadequate capacity, ends between two homes located at about 500 East 760 South. This situation creates a shallow flooding hazard for homes in that area as well as flooding issues with the street and areas west of 400 East. Ultimately, City personnel plan to make improvements to that open channel so that it will convey runoff discharged through those culverts into the 760 South Street right-of-way. However, there are currently no storm water conveyance facilities between 760 South 500 East and Main Street. Therefore, a corridor at about 760 South, primarily between 400 East and Main Street, is subject to shallow flooding, erosion, and sediment deposition during large storm events.

On the north end of the study area, significant flood hazards exist on properties downstream of the large culvert crossings that convey runoff from several small canyons east of the City. There are no flood conveyance facilities to convey runoff discharged from the large culverts.

Lack of Adequate Drainage Facilities on Main Street and 100 North

Main Street and 100 North, both state roads, do not have adequate drainage facilities to manage storm water runoff. The drainage deficiencies on these roads are significant and result in shallow flooding, driving safety hazards, and the potential to damage a business (credit union) on the west side of Main Street. The following items are drainage-related problems that occur on Main Street and 100 North.

- **150 North Main** – Inadequate inlet and pipe capacity for the storm drain that collects and conveys runoff from the north half of 100 North (SR 132) causes flooding on Main Street and developed properties located west of the sag in the roadway profile. The area that drains to the catch basins at this location is significantly deficient in inlet capacity.

- **SR-132 (100 North)** – Over 4,000 feet of SR-132 drains to 2 inlets at the Main Street intersection. The curb and gutter along 100 North, between 400 East and Main Street, does not appear to have capacity to convey runoff from the 10-year storm. In addition, there are not enough inlets to collect the runoff or adequate pipe facilities to convey the runoff from SR-132 to Big Hollow. These deficiencies result in shallow street flooding, ponding at the Main Street intersection with 100 North, and flooding at the sag at 150 North Main. This street flooding can be a safety hazard to drivers during a runoff event.
- **Main Street Drainage** – With the exception of a short segment between 100 North and 200 North, most of the runoff from Main Street is discharged into areas with no drainage facilities. In some areas, Main Street runoff is conveyed onto farm land, causing shallow flooding and crop damage. In many areas, ponding in the gutters occur because there are no receiving channels on the west side of the street.
- **Main Street Culvert Crossing** – Multiple culverts are smashed or have sediment or debris plugging the ends. These culverts will not function properly during runoff events.
- **800 North Main (S. East Corner of Intersection)** – Ponding frequently occurs due to inadequate culvert capacity.

Storm Runoff Discharged into Irrigation Facilities

Irrigation ditches are typically designed to have larger capacities at the upstream end of the ditch and smaller capacities at the downstream end of the ditch. Storm drain conveyance facilities are designed opposite of irrigation ditches. Storm drains are designed to have larger capacities and the downstream end and smaller capacities at the upstream end. Because the existing ditches in the City were designed to be irrigation facilities, they generally cannot be used to properly manage storm water runoff.

Historic Irrigation/Drainage Ditches are being Abandoned and Backfilled

Since the pressurized irrigation system has been constructed, most of the historic irrigation/drainage ditches have been abandoned and backfilled leaving nowhere for storm water to go. This has created shallow flooding and ponding problems in multiple areas of the City.

Storm Drain Sumps in Areas with Collapsible Soils

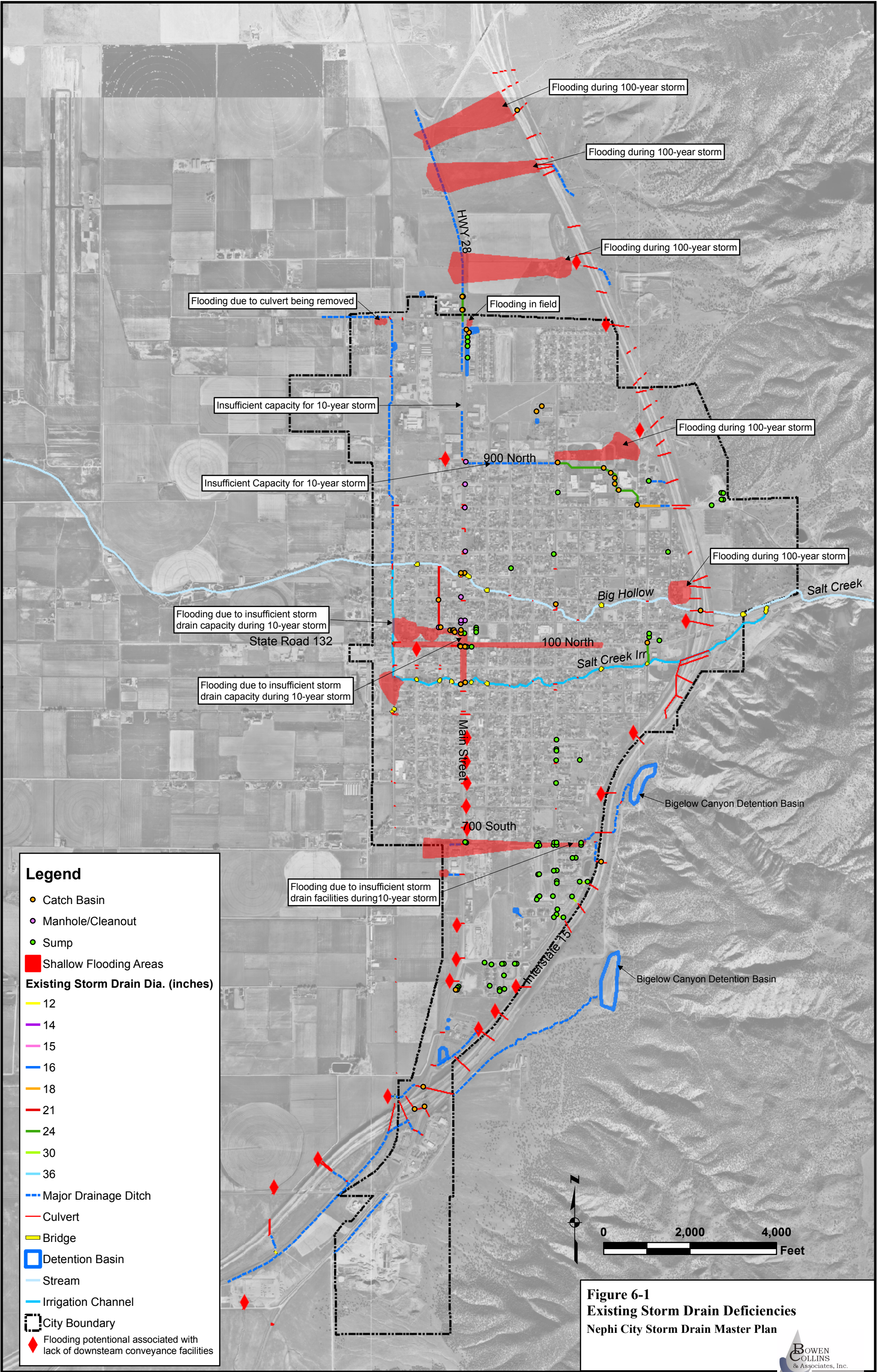
Some storm drain sumps have been installed with newer developments between Main Street and I-15 to allow runoff to percolate into the ground. Unfortunately, many of those sumps were installed in areas with collapsible soils, and ground settlement has occurred around the sumps after storm events. This has caused damage to roads and curb and gutter and could possibly damage underground utilities.

Street Runoff Discharged onto Private Property

Because of the nature of the street drainage and lack of drainage swales on the street shoulder in some areas of the City, the rainfall runs off the street onto private property, causing shallow flooding. Runoff from City streets should be contained within the street rights-of-way.

Lack of Conveyance Facilities West of the Railroad

Big Hollow is the only existing drainage channel that can convey runoff between the railroad and West Creek. There are several large culverts under I-15 near the south interchange that discharge onto agricultural fields that contain no storm water conveyance facilities. In other areas, runoff that was previously conveyed onto agricultural lands via the open ditch irrigation system now causes flooding on private property because the open ditch system has been abandoned.



SECTION 7 RECOMMENDED DRAINAGE SYSTEM IMPROVEMENTS

There are multiple challenges associated with solving the existing drainage deficiencies in the City that have been discussed throughout this report. These challenges include, but are not limited to the following:

1. Topography – the natural drainage pattern for most of the City area does not convey runoff to existing natural drainage channels. Only runoff from a narrow corridor can be discharged in to the Big Hollow channel.
2. Few culverts under the railroad – Runoff from Nephi City drains to the west and must be conveyed under the railroad, which is slightly elevated above the native ground surface. There are only a few places where water can flow under the railroad tracks.
3. Limited drainage conveyance facilities west of the railroad – historic irrigation ditches that were also utilized as drainage facilities have been abandoned and filled in as a pressurized irrigation system has been developed. In addition, there are culverts and bridges that have been designed to convey significant discharges under I-15 or the railroad that just discharge onto a field. With the exception of Big Hollow, there are no significant drainage facilities to convey runoff west of the railroad to West Creek.
4. Distance to West Creek – the only receiving stream for runoff from the study area is West Creek, which is located about 3 miles west of Nephi.
5. Collapsible soils – unless proper mitigation measures are taken, storm water should not be introduced into collapsible soils in areas where structural development is allowed to occur. Collapsible soils are located in several areas of Nephi City. Those areas are not suitable for installing storm drain sumps that discharge runoff into the ground.
6. Lack of existing drainage facilities – there are only a few storm drain pipes in Nephi that can be used to collect and convey runoff during a storm event. Therefore, as a general rule, there are no existing facilities available to receive runoff from new development.

The recommended improvements identified in this section have been made to address these drainage challenges. In accordance with instructions from City officials, the recommended improvements identified herein have been sized to accommodate runoff generated from projected full build-out conditions that include curb and gutter installed on every street throughout the City. The identified improvements focus primarily on larger conveyance facilities and regional detention/retention facilities. More detailed collection facilities and local detention/retention facilities must be designed as development occurs and as curb and gutter is installed on existing roads.

STORM WATER MANAGEMENT APPROACH

Two general approaches of managing storm water runoff in the City were explored as part of this project: conventional methods and low impact methods. Conventional storm water management methods generally include the following features:

- Collecting and conveying generated runoff using curb and gutter, inlets, and pipes in urban areas
- Retaining runoff – store runoff in a facility with no outlet
- Detaining runoff – temporarily store runoff in a facility to reduce the magnitude of the peak discharge to reduce the required size of downstream conveyance facilities
- Utilizing sumps to discharge runoff water into the ground after pretreatment wherever possible.

Low impact storm water management methods implement features that minimize urban runoff, thus minimizing the amount and sizes of storm drain infrastructure needed to collect and convey runoff from developed areas. Development that implements low impact drainage features have the following goals: reduce peak discharges; reduce runoff volume; improve water quality; and provide water conservation opportunities. Examples of storm drain features that could be implemented to accomplish those objectives include:

- Reducing pavement widths on streets
- Utilizing vegetated drainage swales in developments with lower densities
- Utilizing bio-retention cells
- Utilizing rain gardens
- Utilizing curbless parking lot islands
- Preserving natural hydrologic site characteristics.

Samples of low impact development are included in the Appendix. In a public meeting held in Nephi on February 4, 2009, the advantages and disadvantages of both conventional and low impact drainage concepts were discussed. City officials requested that the master plan facilities be developed around the concept that utilizes only conventional storm water management facilities.

EFFECTS OF NEW DEVELOPMENT USING CONVENTIONAL STORM WATER FACILITIES

Runoff from a 10-year design storm over undeveloped land in Nephi, west of I-15, is negligible. By implementing conventional storm water facilities, peak discharge from a 10-year design storm over developed land is estimated to be between 0.3 to 0.7 cfs/acre. Table 7-1 shows the effects of various widths of paved street on a road segment that is 500 feet long. This information should be considered as plans are made to install curb and gutter on existing streets in older areas of the City.

Table 7-1
Sample Effects of Paved Street
Width on the Generation of Storm Water Runoff
(Based on an Assumed 500 Feet Long Road Segment)
Nephi City Storm Drainage Master Plan

Width of Impervious Section(ft)	Peak Discharge (cfs)	Runoff Volume from 10 Minute Cloudburst (gal)	Maximum Inlet Spacing (ft)
66	1.72	7800	250
48	1.32	5700	500
32	0.83	3800	500+
24	0.63	3000	500+

+ represents greater capacity than value listed

GENERAL RECOMMENDATIONS

The following general recommendations should be implemented for storm water management in Nephi City.

1. All new development in areas where development was anticipated as part of this study should construct onsite retention facilities to retain storm water runoff produced from a 25-year, 1-hour storm (1 inch in 1 hour) until the major storm drain conveyance facilities and the regional detention/retention facilities identified in this report are constructed. Those local retention facilities could possibly be abandoned after the required downstream trunk lines, channels, and detention/retention facilities are constructed.
2. If development occurs in areas where development was not anticipated as part of this study, requirements should be enforced to either: a) retain all storm water runoff from new development on site or to construct onsite detention facilities that will attenuate the peak runoff rates to values that can be safely discharged into existing downstream storm drain conveyance facilities, or b) construct new or upgrade existing downstream storm drainage conveyance facilities to provide capacity to safely manage runoff from the development and existing upstream drainage areas.
3. All storm drain improvement projects constructed in City should be designed and constructed to manage runoff for projected full build-out conditions. The design storms and evaluation criteria used in this study should serve as the basis of design for the new facilities.
4. City storm drain maintenance and operations personnel should work closely with irrigation company operators to ensure that the Salt Creek irrigation channel can be utilized to collect limited storm water runoff generated in areas adjacent to the channel. This channel should also be used, to the

maximum extent possible, to alleviate flooding along Big Hollow during large runoff events.

5. The City should create a storm water utility to provide a steady source of funding for needed storm drain improvement projects as well as ongoing storm drain system maintenance. The City should also implement appropriate storm drain impact fees that can be assessed to new development to help pay for new storm drain facilities needed to manage runoff from new development.
6. The City should choose reasonable paved street widths to limit the amount of runoff as the City's street system continues to develop. As shown in Table 7-1, runoff produced from a 66-ft wide street is twice the runoff produced from a 32-ft wide street.
7. Development should not be allowed to occur north of the current City boundary unless the flood hazards from the canyons east of I-15 are first properly mitigated (detention, channels etc.).
8. Preserve and acquire permanent drainage corridors west of the railroad for facilities that can convey runoff to West Creek. Locations of recommended corridors are shown in Figure 7-2.
9. City officials and developers should use information in this master plan report to plan for and size needed drainage system facilities.
10. Ensure that garage floor elevations are constructed higher than streets, and grade lots to drain away from homes.
11. Before development is allowed to occur in the Broad Canyon and Old Pinery Canyon drainage basins, detailed evaluations should be performed to ensure that runoff from the canyons can be safely routed through the areas proposed for development. Until an adequate downstream receiving stream is constructed west of I-15, development in these areas should also include local retention facilities to mitigate the effects of development on the drainage system.
12. Extensive geotechnical investigations should be required in areas where local retention facilities and storm drain sumps are proposed to determine if collapsible soils are present. Those studies should address mitigating undesirable soil conditions and, where appropriate, recommend a minimum horizontal separation from the proposed storm water facility to the nearest structural improvement. Those studies should also evaluate the potential for water to migrate horizontally and create negative impacts to nearby structures.

During several of the public and stake holder meetings that were held as part of this project several citizens of the City expressed interest in constructing a large reservoir or detention

facility in Salt Creek Canyon. An evaluation of such a facility is outside the scope of this project. This project focuses primarily on the urban drainage facilities in Nephi. Constructing such a detention facility in the canyon would not correct any of the existing drainage deficiencies identified in Figure 6-1. If the City or irrigation companies wish to further explore the possibilities of constructing a large regulating/storage facility in the canyon, such work would have to be performed as part of a separate study.

RECOMMENDED DESIGN CRITERIA FOR STORM DRAIN FACILITIES

The following general recommendations are given for storm drain catch basins, collection pipes, and main pipelines:

Storm Drain Inlets and Pipes

1. Storm drain catch basins should be sufficient in number and size to collect runoff from a 10-year, 3-hour storm event, based on projected full build-out conditions. The maximum interval between storm drain inlets on new storm drain pipe construction should be 400 feet.
2. Storm drain pipes and trunklines in urban areas should be designed to convey runoff from a 10-year, 3-hour design storm, using the Farmer-Fletcher precipitation distribution, unless that pipeline serves as the primary conveyance for a natural creek or drainage. All pipes that convey runoff from large, natural drainage basins should be sized to convey runoff from a 100-year, 24-hour design storm that utilizes the SCS Type 2 storm distribution.
3. Storm drain pipes should be designed with slopes that will provide flow velocities greater than or equal to 2 feet per second at the design discharge. The minimum diameter of new storm drain pipes should be 18 inches.

Detention and Retention Facilities

1. All new regional storm water detention/retention basins should be designed to manage runoff from a 100-year, 24-hour design storm based on ultimate projected development conditions.
2. Local retention facilities in areas constructed to mitigate impacts of development should be designed to retain a minimum of the runoff produced from a 25-year, 1-hour storm using the Farmer-Fletcher storm distribution.
3. All new storm water detention/retention basins should be designed to include an emergency spillway.
4. Where possible, design detention facilities as dual-use facilities that can serve as parks or open space when not being utilized as storm water management facilities.

Open Channel Facilities

1. With the exception of the Salt Creek irrigation channel and the 900 North ditch, storm water should not be discharged into existing irrigation ditches.
2. Open channels should be designed to convey the appropriate design discharge while providing at least six inches of freeboard.
3. Maintenance easements should be acquired or maintained along all open channels.
4. City and County officials should begin preserving and acquiring needed drainage corridors for future drainage facilities, particularly the drainage corridors needed to convey runoff between the railroad and West Creek.

Storm Drain Sumps

1. Do not allow storm water sumps or injection wells to be installed within the 250-day well protection zones for culinary water facilities or future culinary water facilities. Figure 7-1 shows the 250-day protection zones for the existing wells in Nephi City. Allowing storm water to discharge into protection zones can contaminate culinary water.

Big Hollow and the Salt Creek Irrigation Channel Improvements

1. The sizes, invert elevations, and low chord elevations for bridges and culverts on Big Hollow should be determined using the Big Hollow hydraulic model developed as part of this study. Electronic copies of the models are included in the Technical Appendix.
2. The Salt Creek irrigation channel should be preserved to serve as a storm water drainage facility. The sizes, invert elevations, and low chord elevations for bridges and culverts on the Salt Creek irrigation channel crossings should be designed using the Salt Creek hydraulic model that was developed as part of this study.
3. New or replacement bridges and culverts on Big Hollow should be designed to convey a flow greater than or equal to the 100-year peak discharge of 920 cfs.
4. New or replacement bridges and culverts on the Salt Creek irrigation channel should be designed to convey a minimum discharge of 200 cfs.
5. No levees should be constructed on Big Hollow unless they are owned and operated by a governmental agency and can meet FEMA levee certification criteria.

RECOMMENDED STORM DRAIN IMPROVEMENT PROJECTS

Information obtained through consulting with City officials, field reconnaissance, and through performing hydrologic and hydraulic analyses of existing and projected full buildout conditions were used to identify drainage system improvements that are needed to safely collect and convey runoff from designated design storms in the vicinity of Nephi City. A list of prioritized recommended drainage system improvements has been developed for use in budgeting and planning for the needed improvements. The prioritized recommended improvements are shown in Figure 7-2 and summarized with conceptual costs estimates in Table 7-2. Higher priority projects should be constructed before lower priority projects. Unit costs used in developing the conceptual construction costs are presented in Table 7-3. The unit costs for construction were developed in 2009 dollars using information from a variety of sources including recent bids for similar projects, local contractors, and construction estimating guides.

FUNDING RECOMMENDED IMPROVEMENTS

The City should develop fair and reasonable means to fund the drainage system improvements identified in the report. It will not be possible for these improvements to be constructed in a reasonable time frame using money from the City's general fund. It is recommended that City officials take the following steps to develop funding for the needed improvements:

- Meet with UDOT representatives to discuss the State's participation in funding the recommended improvements associated with the projects on Main Street, 100 North, and the associated detention and outfall facilities. Runoff creating the drainage deficiencies in these areas is generated primarily on UDOT roads.
- Develop fair and reasonable impact fees that can be imposed on new developments to help fund needed development-related improvements.
- Establish a storm drain utility with a monthly user fee to generate revenue needed to maintain existing drainage facilities and construct new facilities to correct existing deficiencies.
- Pursue grants and loans from State and Federal sources that could be used in funding the recommended drainage improvements.

DESIGN INFORMATION

This report presents information that is intended to be used to plan for the funding and design of needed storm drain facilities. The design discharges associated with the recommended structural improvements are associated with projected full buildout conditions. More detailed analyses and studies should be completed during the design phase of the recommended storm drain projects. Some of the needed projects could be phased to match available funding streams. For example, a detention or retention facility could initially be constructed with a volume smaller than what is recommended if a significant portion of the storm drain collection system in developed parts of the City will not be constructed for some time. In addition, the actual locations of some of the drainage corridors, pipelines, and regional detention/retention facilities may be changed to better fit conditions not known when this plan was developed.

Table 7-2
Summary of Recommended Improvements
Nephi Watershed Protection and Storm Drainage Master Plan

					Percentage of Cost Attributable to: ⁽¹⁾		Cost Attributable to:	
Recommended Improvements Ranking	Project Name	Location	Design Flow ^{(2), (3)} (cfs)	Total Estimated Cost	Existing Development	Future Development	Existing Development	Future Development
HIGH PRIORITY IMPROVEMENTS								
1A	1100 South Detention Basin	1100 South 400 West	15	\$623,025	66%	34%	\$411,196.50	\$211,828.50
1B	800 South Storm Drain	800 South from 600 East to 300 West	134	\$1,485,000	56%	44%	\$831,600.00	\$653,400.00
1C	800 South Open Channel	from DB South to West Creek (See Figure 7-2)	55	\$1,778,463	58%	42%	\$1,031,508.54	\$746,954.46
2A	400 East Storm Drain	400 East, 480 East, 930 South	27	\$436,373	29%	71%	\$126,548.07	\$309,824.58
2B	South Main Street Storm Drain	Main Street from 900 South to 1200 South	32	\$371,250	23%	77%	\$85,387.50	\$285,862.50
2C	125 East Storm Drain	125 East from 800 South to 1200 South	25	\$386,100	12%	88%	\$46,332.00	\$339,768.00
2D	325 East Storm Drain	325 East from 800 South to 1000 South	9	\$187,782	22%	78%	\$41,312.11	\$146,470.19
2E	1300 South Storm Drain	1300 South, 150 East & 200 East	8	\$317,621	22%	78%	\$69,876.68	\$247,744.58
2F	930 South Open Channel	930 South from 300 West to 75 West	30	\$80,687	13%	87%	\$10,489.28	\$70,197.52
3A	Main Street and 150 North Storm Drain	Main Street from 100 North to 150 North	5	\$61,930	100%	0%	\$61,929.90	\$0.00
3B	100 North Storm Drain	200 East from 100 North to Big Hollow	6	\$180,885	50%	50%	\$90,442.58	\$90,442.58
3C	100 North Storm Drain	400 East from 100 North to Big Hollow	6	\$130,298	66%	34%	\$85,996.65	\$44,301.30
3D	100 North Storm Drain	600 East from 100 North to Big Hollow	6	\$145,625	66%	34%	\$96,112.17	\$49,512.33
3E	300 East and 100 North Storm Drain	300 East and 100 North	2	\$15,329	100%	0%	\$15,329.25	\$0.00
3F	200 North and Main Street Storm Drain	200 North from Main Street to 100 West	4	\$109,604	73%	27%	\$80,010.77	\$29,593.03
3G	300 North and Main Steet Storm Drain	300 North from Main Steet to 100 West	4	\$87,075	73%	27%	\$63,564.75	\$23,510.25
3H	100 West and 100 North Storm Drain	100 West from 100 North to approximately 175 North	1.5	\$67,295	100%	0%	\$67,294.80	\$0.00
4A	Salt Creek Irrigation Tailwater Open Channel	Salt Creek Irrigation Channel from the Irrigation Diversion to Big Hollow	120	\$337,500	63%	37%	\$212,625.00	\$124,875.00
4B	700 North Open Channel	700 North from 500 West to West Creek	57	\$242,964	38%	62%	\$92,326.15	\$150,637.40
4C	Bill Pay Lane Open Channel	Bill Pay Lane from 400 West to West Creek	15	\$933,597	14%	86%	\$130,703.52	\$802,893.03
4D	North Open Channel	From Highway 91 to West Creek (See Figure 7-2)	132	\$763,706	0%	100%	\$0.00	\$763,705.80
High Priority Improvements Total:				\$8,742,107			\$3,650,586	\$5,091,521
MEDIUM PRIORITY IMPROVEMENTS								
5A	Main Steet Storm Drain	600 South from 100 East to Main Street, then south on Main Street to 800	41	\$290,412	11%	89%	\$31,945.32	\$258,466.68
5B	Main Steet Storm Drain	500 South from 100 East to Main Street, then south to 600 South	34	\$208,233	9%	91%	\$18,741.01	\$189,492.44
5C	Main Steet Storm Drain	400 South from 100 East to Main Street, then south to 500 South	25	\$196,826	15%	85%	\$29,523.89	\$167,302.06
5D	Main Steet Storm Drain	300 South from 100 East to Main Street, then south to 400 South	16	\$191,765	15%	85%	\$28,764.72	\$163,000.08
5E	Main Steet Storm Drain	200 South from 100 East to Main Street, then south to 300 South	7	\$158,872	15%	85%	\$23,830.81	\$135,041.24
6A	Detention Basin 44	North Golf Course	15	\$914,085	67%	33%	\$612,436.95	\$301,648.05
6A	700 North Storm Drain	Open channel north and south of DB 44 (See Figure 2)	32/20	\$194,342	67%	33%	\$130,209.11	\$64,132.84
6B	700 North Storm Drain	700 North from 200 West to 500 West	57	\$318,176	38%	62%	\$120,906.92	\$197,269.18
6C	700 North Storm Drain	700 North from 200 East to 300 West	42	\$579,837	31%	69%	\$179,749.52	\$400,087.63
6D	700 North Storm Drain	200 West from 600 North to 700 North	4	\$346,873	50%	50%	\$173,436.53	\$173,436.53
6E	700 North Storm Drain	Main Street from 600 North to 700 North, then along 700 North to 200 East	30	\$384,606	17%	83%	\$65,382.94	\$319,222.61
6F	700 North Storm Drain	600 East from 500 North to 700 North, then along 700 North to 400 East	25	\$365,017	21%	79%	\$76,653.58	\$288,363.47
6G	700 North Storm Drain	500 North from 900 East to 800 East, then 800 East to 700 North, then along	5	\$621,682	58%	42%	\$360,575.42	\$261,106.34
7A	1500 North Detention Basin	1500 North 300 West	15	\$808,650	50%	50%	\$404,325.00	\$404,325.00
7B	900 North Storm Drain	1500 North from 100 West to the North DB	193	\$509,914	50%	50%	\$254,956.95	\$254,956.95
7C	900 North Storm Drain	Main Street from 1100 North to 1500 North, then along 1500 North to 100	107	\$952,804	61%	39%	\$581,210.65	\$371,593.70
7D	900 North Storm Drain	Main Street from 900 North to 1100 North	71	\$390,930	70%	30%	\$273,651.21	\$117,279.09
7E	900 North Storm Drain	900 North from 300 East to Main Street, and Main Street from 900 North to	64/6	\$369,999	67%	33%	\$247,899.03	\$122,099.52
7F	900 North Storm Drain	900 North from 400 East to 300 East	55	\$117,509	78%	22%	\$91,657.33	\$25,852.07
7G	900 North Storm Drain	200 West from 1100 North to 1500 North	27/24/21	\$348,489	17%	83%	\$59,243.13	\$289,245.87
7H	900 North Storm Drain	1250 North from 200 East to Main Street	10	\$328,413	19%	81%	\$62,398.50	\$266,014.65
7I	900 North Storm Drain	1250 North from 600 East to 200 East	26	\$347,390	58%	42%	\$201,486.26	\$145,903.84
7J	900 North Storm Drain	200 East from 1000 North to 900 North and 200 East from 800 North to 900	10	\$191,615	17%	83%	\$32,574.54	\$159,040.41
7K	900 North Storm Drain	400 East from 1100 North to 900 North and 400 East from 750 North to 900	10	\$286,504	30%	70%	\$85,951.13	\$200,552.63
8A	Open Channels South End of Nephi City	Between Elevator Road and I-15 (See Figure 7-2)	760	\$135,945	3%	97%	\$4,078.35	\$131,866.65
8B	Open Channels South End of Nephi City	Between Orgill Road and Morgan Lane (See Figure 7-2)	900	\$607,500	3%	97%	\$18,225.00	\$589,275.00
8C	Open Channels South End of Nephi City	West of I-15 to Orgill Road (See Figure 7-2)	760	\$290,250	3%	97%	\$8,707.50	\$281,542.50
8D	Open Channels South End of Nephi City	Between I-15 and Orgill Road (See Figure 7-2)	100	\$159,975	3%	97%	\$4,799.25	\$155,175.75
8E	Open Channels South End of Nephi City	East and West of Highway 28 (See Figure 7-2)	175	\$281,489	3%	97%	\$8,444.66	\$273,043.85
9A	Storm Drains to Salt Creek Irrigation Channel	200 West from Center Street to Salt Creek irrigation channel and from 100	2	\$94,275	65%	35%	\$61,278.46	\$32,996.09
9B	Storm Drains to Salt Creek Irrigation Channel	Main Street from Center Street to Salt Creek irrigation channel and from 100	2	\$91,800	57%	43%	\$52,326.00	\$39,474.00
9C	Storm Drains to Salt Creek Irrigation Channel	200 East from Center Street to Salt Creek irrigation channel and from 100	2	\$91,125	57%	43%	\$51,941.25	\$39,183.75
9D	Storm Drains to Salt Creek Irrigation Channel	400 East from Center Street to Salt Creek irrigation channel and from 100	2	\$89,676	57%	43%	\$51,115.58	\$38,560.87
9E	Storm Drains to Salt Creek Irrigation Channel	600 East from 200 South to Salt Creek irrigation channel	7	\$160,956	39%	61%	\$62,773.02	\$98,183.43
9F	Storm Drains to Salt Creek Irrigation Channel	700 East to Irrigation Channel	1	\$19,162	39%	61%	\$7,473.14	\$11,688.76
9G	Storm Drains to Salt Creek Irrigation Channel	800 East to Irrigation Channel	1	\$7,664	39%	61%	\$2,988.94	\$4,675.01
10A	Big Hollow Storm Drain	500 North from Main Street to 100 West, then along 100 West to Big Hollow	7	\$128,766	50%	50%	\$64,382.85	\$64,382.85
10B	Big Hollow Storm Drain	300 West from 500 North to Big Hollow	2	\$42,155	45%	55%	\$18,969.80	\$23,185.31
10C	Big Hollow Storm Drain	200 East from 400 North to Big Hollow	4	\$68,981	65%	35%	\$44,837.62	\$24,143.33
10D	Big Hollow Storm Drain	400 East from 400 North to Big Hollow	2.5	\$118,035	75%	25%	\$88,525.91	\$29,508.64
10E	Big Hollow Storm Drain	600 East from 400 North to Big Hollow	2	\$101,173	75%	25%	\$75,879.79	\$25,293.26
10F	Big Hollow Storm Drain	800 East from 400 North to Big Hollow	2	\$168,622	75%	25%	\$126,466.31	\$42,155.44
Medium Priority Improvements Total:				\$12,080,491			\$4,900,724	\$7,179,767

Table 7-2
Summary of Recommended Improvements
Nephi Watershed Protection and Storm Drainage Master Plan

					Percentage of Cost Attributable to: ⁽¹⁾		Cost Attributable to:		
Recommended Improvements Ranking	Project Name	Location	Design Flow ^{(2), (3)} (cfs)	Total Estimated Cost	Existing Development	Future Development	Existing Development	Future Development	
LOW PRIORITY IMPROVEMENTS									
11A	300 East Storm Drain	500 South from 400 East to 300 East then 300 East from 500 South to 800	30	\$386,284	13%	87%	\$50,216.87	\$336,066.73	
11B	300 East Storm Drain	400 South from 400 East to 300 East, then along 300 East to 500 South	21	\$196,826	13%	87%	\$25,587.37	\$171,238.58	
11C	300 East Storm Drain	300 South from 400 East to 300 East, then along 300 East to 400 South	15	\$191,765	19%	81%	\$36,435.31	\$155,329.49	
11D	300 East Storm Drain	200 South from 400 East to 300 East, then along 300 East to 300 South	9	\$158,872	33%	67%	\$52,427.78	\$106,444.27	
12A	200 West Storm Drain	200 West from 200 South to 800 South	16/26	\$473,369	30%	70%	\$142,010.82	\$331,358.58	
13A	Highway 28 Storm Drain	Highway 41 Storm Drain (See Figure 7-2)	65	\$273,803	0%	100%	\$0.00	\$273,802.95	
13B	Highway 28 Storm Drain	Highway 41 Storm Drain (See Figure 7-2)	56	\$524,880	0%	100%	\$0.00	\$524,880.00	
13C	Highway 28 Storm Drain	Open Channel between I-15 and and Highway 28	40	\$159,300	0%	100%	\$0.00	\$159,300.00	
13D	Highway 28 Storm Drain	Highway 41 Storm Drain (See Figure 7-2)	28	\$186,836	0%	100%	\$0.00	\$186,835.95	
13E	Detention Basin 43	Quaking Aspen	30	\$3,269,646	0%	100%	\$0.00	\$3,269,646.00	
13E	Highway 28 Storm Drain	Open Channel between DB 43 and I-15	30	\$81,000	0%	100%	\$0.00	\$81,000.00	
13F	900 North Storm Drain	North of 1500 North to Highway 28	10	\$157,738	0%	100%	\$0.00	\$157,738.05	
14A	North Nephi Open Channels	Open Channel between I-15 and Highway 28	30	\$92,502	0%	100%	\$0.00	\$92,502.00	
14B	Detention Basin 42	Red Canyon	30	\$1,955,475	0%	100%	\$0.00	\$1,955,475.00	
14B	North Nephi Open Channels	Open Channel between DB 42 and I-15	30	\$9,781	0%	100%	\$0.00	\$9,780.75	
14C	North Nephi Open Channels	Open Channel east of I-15 and south and west of DB 42	40	\$88,560	0%	100%	\$0.00	\$88,560.00	
15A	North Nephi Open Channels	Open Channel between I-15 and Highway 28 below DB 57	30	\$65,976	0%	100%	\$0.00	\$65,975.85	
15B	Detention Basin 57	Gardner Creek	30	\$2,316,600	0%	100%	\$0.00	\$2,316,600.00	
15B	North Nephi Open Channels	Open Channel east and west of I-15 below DB 57	30	\$85,761	0%	100%	\$0.00	\$85,761.45	
16A	900 North Open Channel	900 North from 100 West to 300 West	10	\$64,544	80%	20%	\$51,634.80	\$12,908.70	
16B	600 North 300 West Storm Drain	600 North to 300 West	1	\$17,169	50%	50%	\$8,584.65	\$8,584.65	
17A	300 West Open Channels	Open Channel from 100 South to 200 South	6	\$32,400	36%	64%	\$11,664.00	\$20,736.00	
17B	300 West Open Channels	Open Channel from 200 South to 930 South	6/12	\$163,890	50%	50%	\$81,945.00	\$81,945.00	
18A	East I-15 Open Channels	Open Channel along the west side of Hignway 28 from 1430 South to the	16/24	\$100,575	31%	69%	\$31,178.25	\$69,396.75	
18B	East I-15 Open Channels	Open Channel along the west side of I-15 from 1430 South to the existing open	25	\$52,353	3%	97%	\$1,570.59	\$50,782.41	
18C	East I-15 Open Channels	Open Channel along the west side of I-15 from culvert 48B to culvert 47B, and	2	\$45,536	3%	97%	\$1,366.07	\$44,169.44	
18D	East I-15 Open Channels	Open Channel from culvert 48 to the Salt Creek irrigation channel	5	\$72,752	5%	95%	\$3,637.58	\$69,113.93	
(1) - Percentage of estimated cost attributable to existing and future development based on a comparison of existing and future development needed design capacity (i.e. peak volumes for detention basins and peak flows for culverts, open channels, and storm				Low Priority Improvements Total:			\$11,224,192	\$498,259.08	\$10,725,932.52
RECOMMENDED DRAINAGE IMPROVEMENTS TOTAL:					\$32,046,790			\$9,049,569	\$22,997,221

(1) - Percentage of estimated cost attributable to existing and future development based on a comparison of existing and future development needed design capacity (i.e. peak volumes for detention basins and peak flows for culverts, open channels, and storm

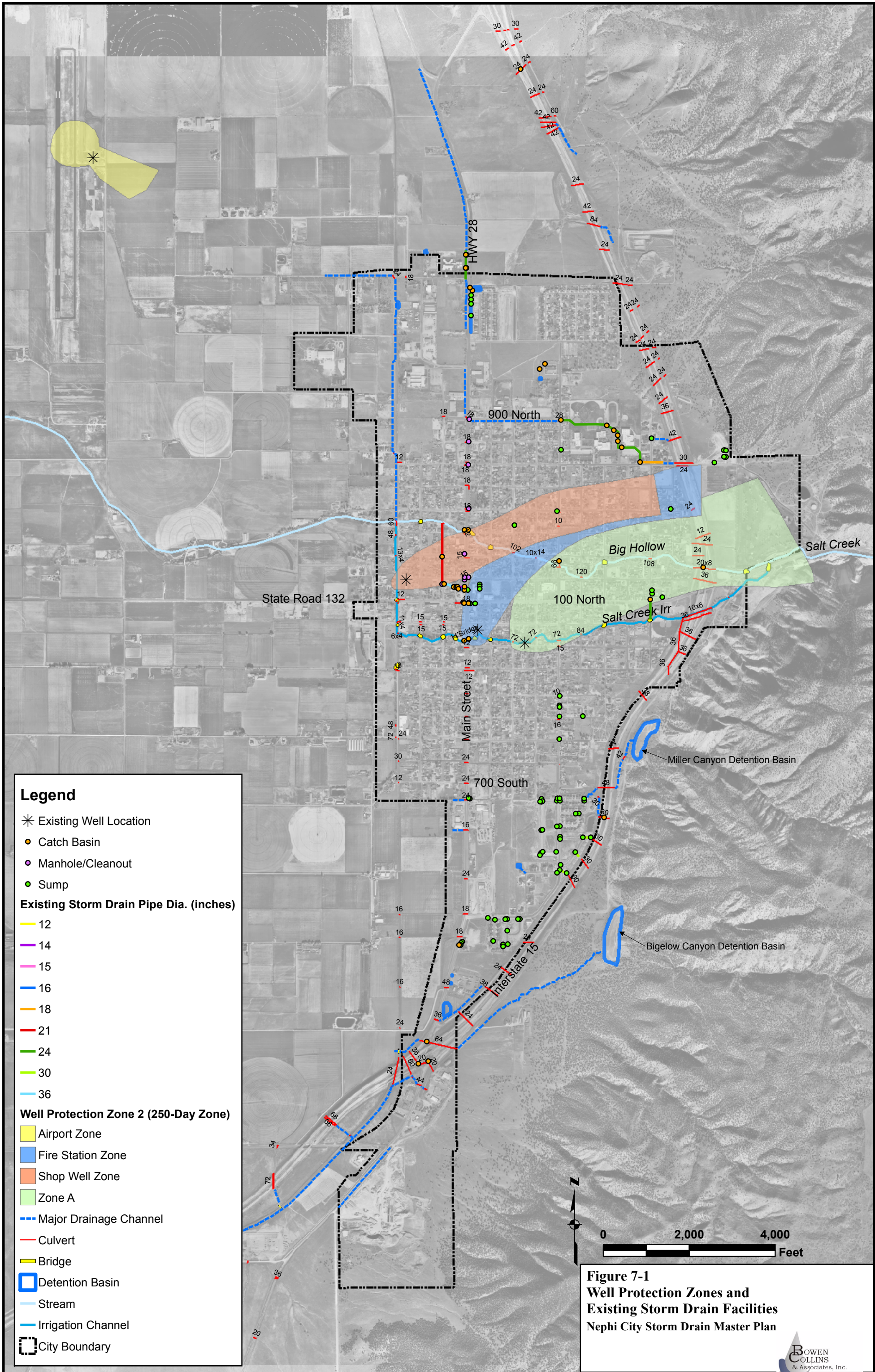
(2) - Estimated peak flow for full build-out development conditions.

(3) - For detention basins, design flow represents allowable discharge from detention basin outlet.

Table 7-3
Conceptual Cost Estimate Unit Cost Summary
Nephi City Storm Drainage Master Plan

Description	Unit	Unit Cost
Detention Basins		
Property Acquisition	Acre	\$50,000
Excavation and Hauling	Cubic Yard	\$13
Landscaping (Non-irrigated Native)	Square Foot	\$0.30
Landscaping (Irrigated Turfgrass)	Square Foot	\$2.60
Inlet Apron	Lump Sum	\$12,000
Outlet Structure	Lump Sum	\$16,000
Emergency Spillway	Lump Sum	\$5,000
Riprap	Lump Sum	\$20,000
Storm Drain Pipelines		
Permanent Easement Acquisition	Acre	\$10,000
18-inch RCP ⁽¹⁾	Linear Foot	\$75
24-inch RCP ⁽¹⁾	Linear Foot	\$100
30-inch RCP ⁽¹⁾	Linear Foot	\$120
36-inch RCP ⁽¹⁾	Linear Foot	\$145
42-inch RCP ⁽¹⁾	Linear Foot	\$180
48-inch RCP ⁽¹⁾	Linear Foot	\$210
54-inch RCP ⁽¹⁾	Linear Foot	\$240
60-inch RCP ⁽¹⁾	Linear Foot	\$290
66-inch RCP ⁽¹⁾	Linear Foot	\$330
72-inch RCP ⁽¹⁾	Linear Foot	\$360
Manhole ⁽¹⁾	Each	\$3,700
Catch Basin ⁽¹⁾	Each	\$2,700
Bore and Jack Steel Casing (for 18- to 42-inch RCP)	Linear Foot/ Inch Dia.	\$16.00
Bore and Jack Steel Casing (for 48- to 72-inch RCP)	Linear Foot/ Inch Dia.	\$17.00
Traffic Control	Linear Foot	\$16
Storm Drain Culvert Road Crossings for Creeks and Washes		
Pipe Culvert	See RCP Storm Drain Costs Above	
Reinforced Concrete Box	Varies - See Technical Appendix	
Headwalls	Lump Sum	\$4,800
Riprap	Lump Sum	\$64,000
Traffic Control	Lump Sum	\$5,300
Channel Construction		
Excavation and Hauling	Cubic Yard	\$13
Riprap	Cubic Yard	\$70
Landscaping (Non-irrigated Native)	Square Foot	\$0.30
Other		
Contingency	25 Percent of Construction Cost	
Engineering, Legal, and Administration	15 Percent of Construction Cost w/ Contingency	

(1) - Includes trenching, installation, backfill, and asphalt surface restoration.



SECTION 8

RECOMMENDED SALT CREEK FLOOD CONTROL PLAN

BACKGROUND INFORMATION

A diversion structure on Salt Creek, just upstream of I-15, diverts irrigation water into the Salt Creek irrigation channel after it passes through a trash rack and screen. Salt Creek becomes Big Hollow downstream of that diversion structure.

The estimated 100-year flood on Salt Creek, east of the diversion, is 906 cfs. In 1983 and 1984, the last time a large snowmelt flooding occurred on Salt Creek, runoff was routed through both the Big Hollow channel and the Salt Creek irrigation channel to minimize stream flooding in Nephi. The magnitude of those floods was not recorded by a streamflow gage. During the last 20 years, the open channel irrigation system that was supplied by the Salt Creek irrigation channel has been converted to a pressurized irrigation system.

The Salt Creek irrigation channel conveys water to an inlet of a pressurized irrigation system located at about 250 West. That facility has capacity to divert 80 cfs into the pressurized irrigation system. During the peak of a large flood event, it is likely that irrigators would not divert water into the pressurized system because of the sediment and debris in the water. The tailwater ditch between the pressure irrigation system inlet and the Big Hollow channel only has capacity to convey about 10 cfs. Therefore, in its current condition, the Salt Creek irrigation channel cannot be considered a reliable flood control facility during a large flood event. This means that nearly all of the runoff from a large flood event will need to be routed through the Big Hollow Channel until improvements are made to the tailwater ditch.

SUMMARY OF HYDRAULIC ANALYSES

Hydraulic models of the sections of the Big Hollow and Salt Creek irrigation channels that extend from the diversion structure upstream of I-15 to the railroad were developed as part of this study. Those models were used to estimate the flood conveyance capacities of both channels. In summary, the following deficiencies were identified as part of the hydraulic analyses.

Big Hollow

- The 800 East culvert crossing can safely pass about 600 cfs. With some minor flooding, it can pass 800 cfs.
- The 200 West, 100 East, 200 East, and 500 East bridges and culverts have capacity to safely convey approximately 700 cfs. With some surcharging and minor flooding, the bridges could pass about 800 cfs.
- Embankments or levees have been constructed along the channel between Main Street and 300 East to keep floodwater in the channel. From a flood insurance

standpoint, these levees cannot be considered as effective flood control structures unless they meet strict FEMA certification criteria. The floodplain shown in Figure 5-3 assumes that those levees do not exist.

Salt Creek Irrigation Channel

Between 200 West and 100 West, the channel can only safely convey about 80 cfs. Downstream of the irrigation diversion, the tailwater ditch has a capacity of between 5 and 10 cfs.

FLOOD MANAGEMENT RECOMMENDATIONS

In planning for the future, bridge and channel improvements should be made along Big Hollow to provide a minimum conveyance capacity of 906 cfs. To provide added flexibility, channel and bridge/culvert improvements should be made to the Salt Creek irrigation channel so it can safely convey between 120 and 200 cfs.

During large flood events from the Salt Creek watershed, most, if not all of the runoff should be routed through the Big Hollow channel. Only a small portion of the total flow, if any, should be routed through the Salt Creek irrigation channel.