COON/HARKERS CREEK STORM DRAINAGE MASTER PLAN

(HAL Project No.: 014.12.100)

FINAL REPORT

December 2008

HANSEN ALLEN & LUCE INC
ENGINEERS

SALT LAKE COUNTY

COON/HARKERS CREEK STORM DRAINAGE MASTER PLAN

(HAL Project No.: 014.12.100)

FINAL

Project Engineer

Recommended by: ______________________________
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HANSEN ALLEN & LUCE INC ENGINEERS

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ACKNOWLEDGMENTS

Successful completion of this study was made possible by the cooperation and assistance of many individuals, mostly the County Staff as shown below. We sincerely appreciate the cooperation and assistance provided by these individuals.

Salt Lake County

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CHAPTER I

INTRODUCTION

This master plan report addresses the storm drainage needs for Coon and Harkers Creeks and the storm drain system that carries their flows to the C-7 canal north of Magna. These canyon areas currently have no development but have received some attention as areas of possible residential, commercial and resort development. The Coon/Harkers Creek Storm Drainage Master Plan examines this important element of Salt Lake County's storm drainage system. Deficiencies were identified and the preferred solution alternatives were presented with cost estimates. A capital improvements plan has been developed for master plan projects.

BACKGROUND

Storm water runoff is a difficult resource to manage. In a dry climate such as Utah's, existing drainage ways are often dry and to the inexperienced may appear to be prime places to construct buildings. Unlike sanitary sewers and culinary water systems, there are no clearly defined minimum service requirements for storm water systems. Storm water flows are dependent on many complex time and spatially varied factors. Even a natural undeveloped drainage system is not static; streams can erode in one section while depositing in another; stream courses can also change alignment and cross section dramatically with just one storm runoff event. Urbanization compounds the problem and creates the need for a new drainage system with the basic goals of managing nuisance water, protecting development from damage, and protecting downstream waters from adverse quality and quantity impacts.

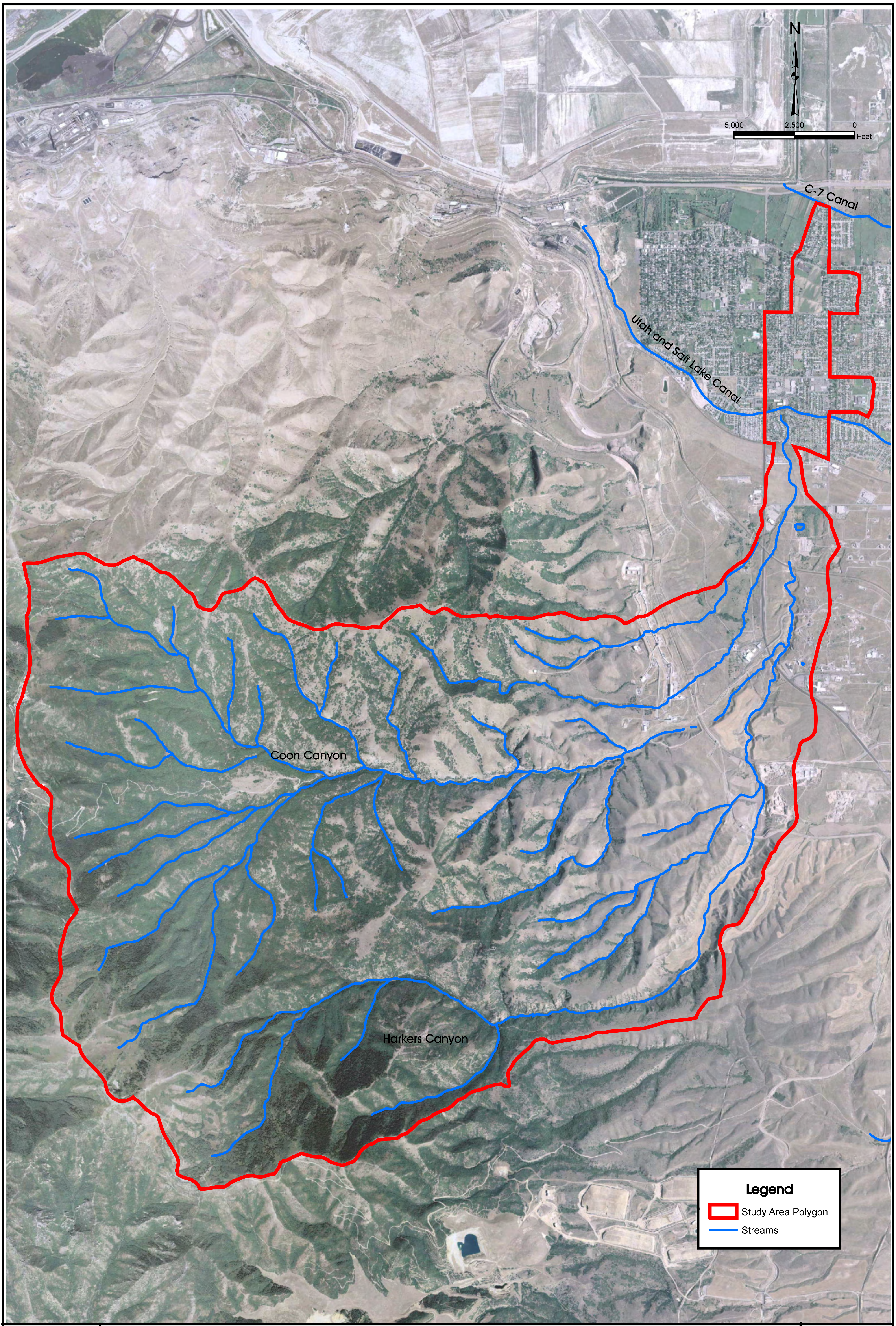
The West Bench Master Plan (Calthorpe Associates, December 2005) was prepared for property owned by Kennecott Land in the western part of the Salt Lake Valley. Potential future development of a ski resort and town center in the Coon/Harkers Creek drainage would alter the existing hydrology. Recognizing the need for a plan to guide Coon/Harkers Canyon Creek improvements, Salt Lake County initiated the preparation of a master plan for the creeks. This report presents the results of numerous hydrologic and hydraulic analyses which have culminated in the development of a master plan for Coon/Harkers Creek.

AUTHORIZATION

In November 2006, Salt Lake County requested that Hansen, Allen & Luce, Inc. (HAL) assist them in completing a master plan of the Coon and Harkers Creeks and the associated storm drainage system. Development of the Storm Drainage Master Plan was completed under the direction of, and in cooperation with County staff.

STUDY AREA

The master plan study area included the tributary canyon areas to Coon and Harkers Creeks as well as tributary urban areas that contribute storm drainage flow to the system prior to discharge into the C-7 canal. The study area is shown on Figure I-1.



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COON / HARKERS CREEK MASTER PLAN
STUDY AREA

Figure I-1

CHAPTER II

EXISTING STORM DRAINAGE SYSTEM

The storm flows originating in Coon and Harkers Canyons are conveyed through the natural creek systems until the flow enters the urban area of Magna where it is conveyed through storm drainage pipelines to the C-7 Canal. The existing storm drainage system is shown on Figure II-1.

CREEKS

The conveyance capacity and hydraulic characteristics of Coon and Harkers Creeks were not part of this study. All storm flows generated in Coon and Harkers Canyons were assumed to reach the ATK detention through the creeks. Channel losses were not included in the study

STORM DRAINS

Mapping from the county was relied on to determine the location and size of the existing conveyances. Meetings with County personnel were necessary to clarify sizes and locations indicated in the mapping.

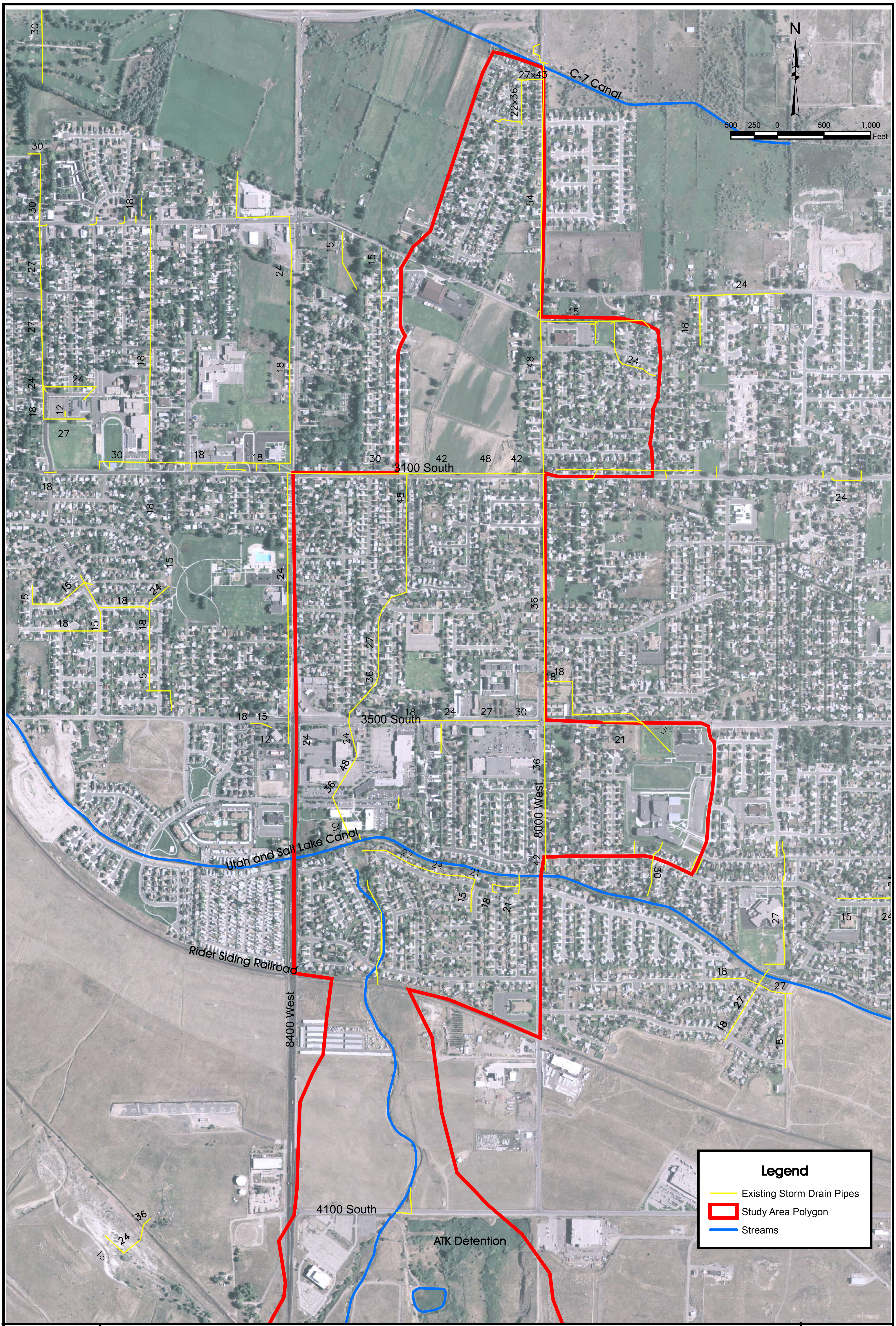
In addition to the creeks discussed above, the following storm drainage pipelines convey the storm flows from the Coon/Harkers Creek drainage to the C-7 canal (see Figure II-1).

- North along approximately 8300 West from the Utah and Salt Lake Canal to 3100 South
- East on 3100 South from 8200 West to 8000 West
- North on 8000 West from 3100 South to the C-7 Canal

Capacities of storm drainage pipes were estimated based upon size, slope, material type, and Manning's equation. Pipe slope was not available, therefore slope was assumed based on the County's 2-meter ground surface contours. Estimated pipe capacities are based on conceptual level engineering and do not consider limitations due to inlet capacities or downstream restrictions. Estimated capacities also do not consider allowable surcharging that might provide additional capacity. While the estimated capacities may not be precise, they are consistent with the precision of the runoff estimates and are sufficient for drainage planning efforts.

DETENTION

There are no existing detentions along Coon and Harkers Creeks upstream of their confluence. Downstream of the confluence, an approximately 90 acre-feet detention basin detains storm flows at the ATK site located between 8200 and 8000 West, on the south side of 4100 South. Discharge characteristics were defined by contour mapping of the detention, descriptions and drawings of the outlet works. The outlet has a 10 inch orifice located in a manhole at 4100



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COON / HARKERS CREEK MASTER PLAN
EXISTING STORM DRAINAGE SYSTEM

Figure II-1

South where the flow from the northwest corner of the detention basin is directed into Coon/Harkers Creek through an 18 inch outfall.

An additional detention storage area is located prior to where the Coon/Harkers Creek crosses the Utah and Salt Lake Canal. The capacity of this detention is unknown, although its main purpose is to detain flow from the neighborhood that surrounds it. This detention was not included in the model.

CHAPTER III

HYDROLOGY

The hydrology of the tributary area to Coon/Harkers Creek has both urban and mountain watershed characteristics. The following sections contain descriptions of the methodology used in the determination of design flows at several stations along Coon/Harkers Creek.

MODEL DESCRIPTION

The Coon/Harkers Creek Storm Drainage Model is a combination of an ArcGIS model and the Army Corps of Engineers (COE) Hydrologic Modeling System (HEC-HMS). HEC-HMS calculates peak flows and runoff hydrographs for all model elements including subbasins, reaches, junctions, and detention basins. ArcGIS 9.3 Geographic Information System (GIS) by Environmental Systems Research Institute (ESRI) was used as a spatial reference tool for development of the HEC-HMS model. Delineation of subbasins and determination of subbasin and reach characteristics was performed using the ArcGIS model. Subbasin boundaries and storm drain conveyance shapefiles were then imported as background images into HEC-HMS for creation of the storm drainage model. Urban subbasins were modeled using the SCS curve number method and the kinematic wave transform method. The Muskingham-Cunge method was used for routing hydrographs through channel reaches. The model, in conjunction with the GIS data, will help the County to continue to update and analyze for potential drainage deficiencies and facilitate the analysis of conceptual design of alternative mitigation measures.

DRAINAGE BASIN CHARACTERISTICS

A drainage basin is an area where all precipitation that falls within it will collect to a common point. Another name for a drainage basin is watershed or catchment. Subbasins are smaller than drainage basins located within a larger drainage basin. Drainage subbasin boundaries depend upon both the topography and the location of storm drainage facilities. Drainage subbasin boundaries used in the study are shown on Figure III-1.

Subbasin characteristics were developed based on field observations and the GIS mapping supplied by Salt Lake County. Important subbasin characteristics discussed in this report include:

- Subbasin Area
- Hydrologic Soil Type
- Percentage of Impervious Area
- SCS Curve Number

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COON / HARKERS CREEK MASTER PLAN
STORM DRAINAGE SUBBASIN BOUNDARIES

Figure III-1

Subbasin Area

Subbasins were delineated within ArcView GIS using USGS Topographic Quadrangle maps (mountain areas), the County's 2-meter contours (urban areas) and the locations of storm drainage facilities. Developed portions of the study area had smaller subbasins, usually less than 30 acres. Undeveloped areas and mountain watersheds were delineated as larger units. Mountain watersheds were divided into subbasins where distinct vegetation, soil type and precipitation characteristics were found.

Hydrologic Soil Type

Hydrologic soil type is a general indication of the soil's infiltration capacity. Soils are assigned a hydrologic type of A, B, C, or D by the Natural Resource Conservation Service (NRCS). Soils of hydrologic soil type A have the highest infiltration rate, and therefore produce the least amount of runoff. Soils of hydrologic soil type D have the lowest infiltration rate, and therefore produce the highest amount of runoff. Soil maps were obtained from the Utah Automated Geographic Reference Center (www.agrc.utah.gov). Soil characterization by the NRCS correlates general soil map units with hydrologic soil types. The hydrologic soil type was input into the GIS database for soil cover.

Percentage of Impervious Area

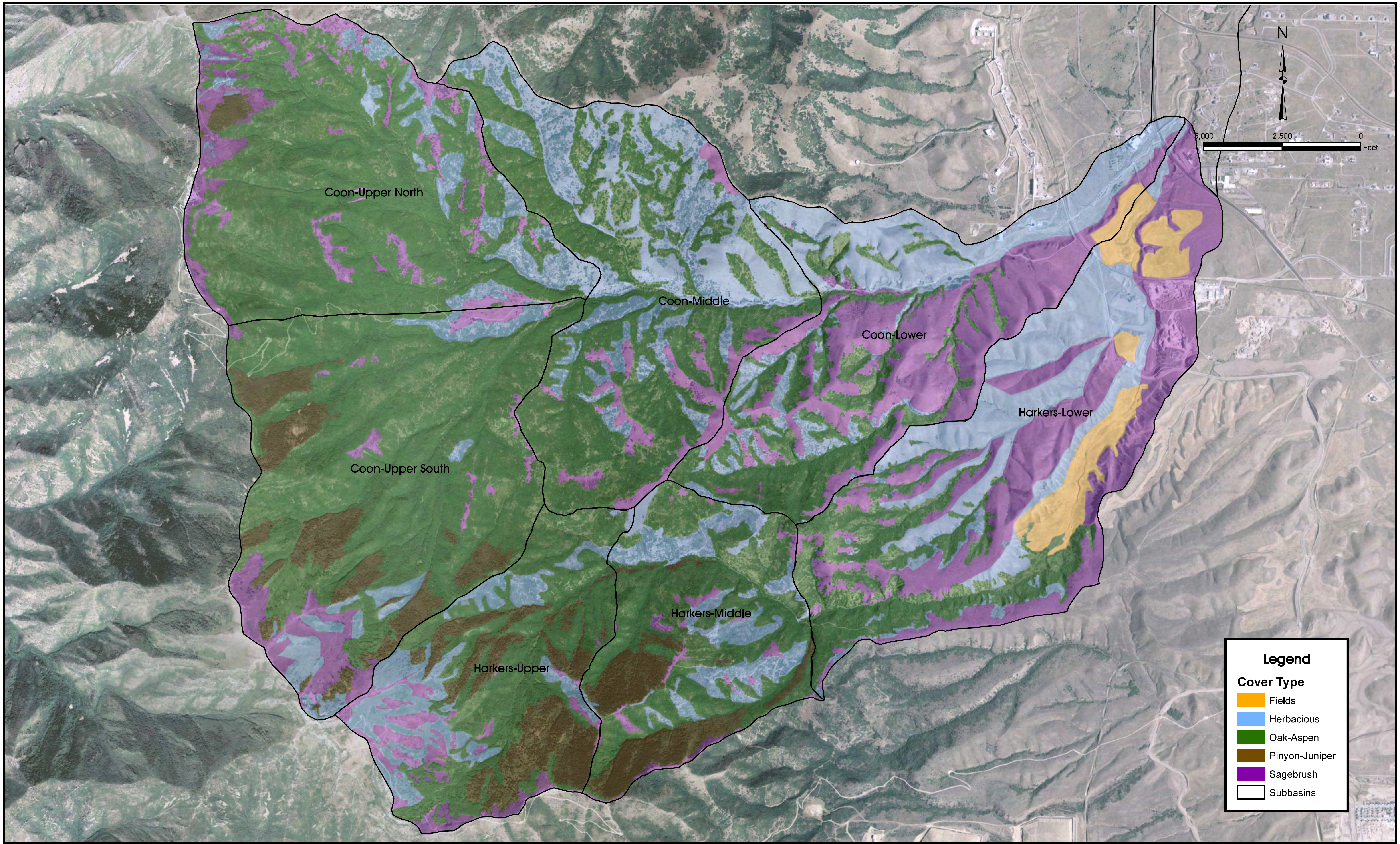
Impervious areas within each urban subbasin were estimated using the GIS model. The impervious area was divided into two components: directly connected impervious areas and unconnected impervious areas. Directly connected impervious areas provide a direct path for runoff from the impervious area to a conveyance such as a pipe, gutter, or channel. Directly connected impervious areas include roadways, parking lots, driveways, and sometimes the roofs of buildings. Runoff from unconnected impervious areas include sidewalks that are not adjacent to the curb, patios, sheds, and usually some portion of the roof of the house or structure. Unconnected impervious area is combined with the pervious area of a subbasin resulting in a weighted curve number for unconnected area.

SCS Curve Number

The SCS curve number methodology is described in the SCS publication TR-55. A curve number is determined based on several factors described in the manual. These factors include: soil and cover conditions, cover type, treatment and hydrologic condition. The soil cover conditions were discussed earlier in the hydrologic soil type section. The cover type is the kind of vegetation prominent in that area. Urban areas were assumed to have a normal mix of grasses and shrubs common in residential yards. Vegetation cover types for undeveloped areas were delineated using aerial photography and the NRCS soils map. Vegetation cover types were verified through site reconnaissance.

Mountain Areas

The mountain vegetation cover types are shown on Figure III-2 and described following.



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COON / HARKERS CREEK MASTER PLAN - MOUNTAIN AREA VEGETATION COVER TYPES

Figure III-2

Herbaceous. This complex includes a mixture of grass, weeds, and low-growing brush, with brush being the minor element. This cover was found on the ridges and more exposed areas.

Sagebrush. The sagebrush cover contains mostly sagebrush with a grass understory.

Pinyon-Juniper. This cover type includes pinyon, juniper or both with a grass understory.

Oak-Aspen. This vegatative cover consists of mountain brush mixture of oak brush, aspen, mountain mohogany, bitter brush, maple, and other brush. This is only found on the high north-facing slopes.

The vegetative types for the agricultural areas were observed in a site visit. The cover types in the agricultural zones were defined as the following:

Fields. This cover type includes grassy pastures or meadows and was located at the lower end of the Coon/Harkers drainages. The curve number used in the model for this land was either 58 or 78 for type B and D soils, respectively.

The drainage subbasin composite curve numbers were found by area weighting (see computations in the Appendix B).

The SCS lag time for mountain areas was calculated using the regression equation outlined in the article entitled "Lag Time Characteristics for Small Watersheds in the U.S." by M.J. Simas and R.H. Hawkins. The equation relies on basin area, slope, and curve number characteristics. The regression equation follows:

$$T_{lag} = .0051 \times width^{.594} \times slope^{-.15} \times S_{nat}^{.313}$$

where

width = Watershed Area / Watershed Length
slope = Maximum Elevation difference / Longest Flow Path
$S_{nat} = 1000/CN - 10$

Subbasin hydrologic characteristics for the mountain area conditions are summarized in Table III-1 for the model of existing conditions (referred hereinafter as Existing model).

TABLE III-1
Coon/Harkers Creek Subbasin Characteristics for Mountain Areas - Existing Conditions

Subbasin ID	Area (Acres)	Area Weighted CN	Lag Time (hr)
Coon-Lower	1,769	58.2	1.27
Coon-Middle	1,979	57.3	1.68
Coon-Upper North	2,093	45.5	1.82
Coon-Upper South	2,295	44.7	1.82
Harkers-Lower	2,243	67.2	1.30
Harkers-Middle	1,169	51.5	1.54
Harkers-Upper	1,288	45.2	1.60
Coon/Harkers ATK	383	63	0.48
TOTAL:	13,219		

Urban Areas

The Coon/Harkers drainage system becomes an urban system of curb and gutter with storm drain inlets downstream of the ATK Detention where the drainage crosses the Riter Siding railroad line. Delineation of urban subbasins was based on the location of existing storm drainage infrastructure as shown in mapping provided by the county (see Figure II-1). Contours were also utilized to determine flow direction. Urban hydrologic characteristics for use in modeling storm water runoff with the SCS Curve Number and kinematic wave technique include drainage area, composite curve number and percentage of directly connected impervious area. Each of these parameters are summarized for the existing model in Table III-2. The overland flow length, slope and roughness assumed for the model input are shown in Appendix B.

TABLE III-2
Urban Subbasin Characteristics - Existing Conditions

Subbasin ID	665	Composite Area CN	% Directly Connected Impervious
Urb1	30	78	24
Urb2	34	79	26
Urb3	26	79	38
Urb4	37	77	79
Urb5	42	79	31
Urb6	12	98	95

TABLE III-2 CONTINUED

Subbasin ID	665	Composite Area CN	% Directly Connected Impervious
Urb7	60	76	36
Urb8	63	80	31
Urb9	52	77	40
Urb10	50	79	28
Urb11	71	73	12
Urb12	47	86	34
Urb13	58	86	27
Coon/Harkers Lower	83	63	5
TOTAL:	665		

Channel Routing

Most mountain area runoff enters Coon/Harkers Creek via sheet flow, shallow concentrated flow and stream flow. In urban locations most of the channel routing is accomplished through storm drain pipes or road side drainage ditches until it reaches Coon/Harkers Creek.

DESIGN RAINSTORM

Precipitation depths were obtained from the Point Precipitation Frequency Estimates from NOAA Atlas 14 found on the website http://hdsc.nws.noaa.gov/hdsc/pfds. The precipitation values used were dependent upon the general elevation and location of the different sub-basins. The precipitation values were assigned to general zones which include: Upper Coon/Harkers, Middle Coon/Harkers, Lower Coon/Harkers and Urban Areas.

Meetings with the County to discuss criteria resulted in the selection of the 100-year event for the canyon areas and a 10-year event for the urban areas. It was felt that the urban system is designed to accommodate a 10-year event and that flows above that amount would not likely be conveyed to the main Coon/Harkers system. Table III-3 and III-4 present precipitation values for the mountain and urban areas, respectively.

TABLE III-3
Mountain Area Precipitation Zones for 100-year Storm Event

Zone	1hr (in)	3 hr (in)	6 hr (in)	12 hr (in)	24 hr (in)
Upper Coon/Harkers	1.79	2.11	2.38	2.99	3.79
Middle Coon/Harkers	1.79	2.08	2.31	2.87	3.52
Lower Coon/Harkers	1.71	1.96	2.13	2.57	3.04

TABLE III-4
Urban Area Precipitation Zones for 10-year Storm Event

Zone	1hr (in)	3 hr (in)	6 hr (in)	12 hr (in)	24 hr (in)
Existing Urban Areas	0.87	1.11	1.36	1.70	2.13

Storm Duration

Several different storm durations were reviewed for this study. Following a meeting to discuss these duration options, Salt Lake County chose the storm duration of 6 hours.

Storm Distribution

Salt Lake County chose the rainfall distribution for the design storms used in the master plan. The distribution that was chosen was the Farmer-Fletcher distribution for a 6-hour storm. During the 1960's and early 1970's, Dr. Eugene E. Farmer and Dr. Joel E. Fletcher completed a major study of the precipitation characteristics for storms in northern Utah. This effort has become the definitive source for rainfall distributions appropriate for the Wasatch Front area. In Davis County, Farmer and Fletcher (1971) examined rainfall gage records and classified storms based on whether the heaviest rainfall of the storm fell in the first, second, third, or fourth quarter of the storm period. Farmer and Fletcher found that "first and second quartile storms together comprise 76 percent of those storms containing a burst of 5-minute duration, with a 2-year recurrence interval of 92 percent of storms containing a burst of 10-minute duration, with a 10-year recurrence interval." Farmer and Fletcher developed model storms for first and second quartile storms.

Aerial Reduction

Aerial reduction factors were applied based on the Salt Lake City Hydrology Manual. These factors were developed to compensate for the aerial differences associated with different storm durations and drainage basin area. The total area for the combined sub-basins is 23.7 square miles which results in an aerial reduction factor of 0.91 or an equivalent precipitation depth reduction of 9%. This factor was applied to each of the precipitation depths obtained from the NOAA 14 Atlas.

MODEL RESULTS

Computation of Runoff Hydrographs

Hydrographs were computed for subbasins, conveyances, detention basin inlets and detention basin outlets modeled for the system. The maximum value from each hydrograph is the peak runoff flow rate. Hydrographs were calculated for the 6-hour storm duration with a 100-year condition applied to the mountain areas and a 10-year event applied to urban areas. The highest peak flow rate is used for design or evaluation of that element in the model. The peak flowrates were then compared to the capacities of the model elements to determine deficiencies. Peak runoff flowrates for each conveyance are provided in Appendix D.

Modeling Existing Conditions

The Existing model was prepared to identify existing deficiencies in the major storm drainage system. Major storm drainage facilities and features conveying storm drainage from the outlet of at least one subbasin have been represented in the model.

Future Conditions

Undeveloped areas within the model were evaluated based on information provided in the West Bench Master Plan developed by Kennecott Lands as shown in Figure III-3. Because of the conceptual nature of the future development plans, it was determined not to provide the projected future flows. The County chose to plan for future development by requiring detention of 100-year storm flows to the historic levels modeled in the Existing model.

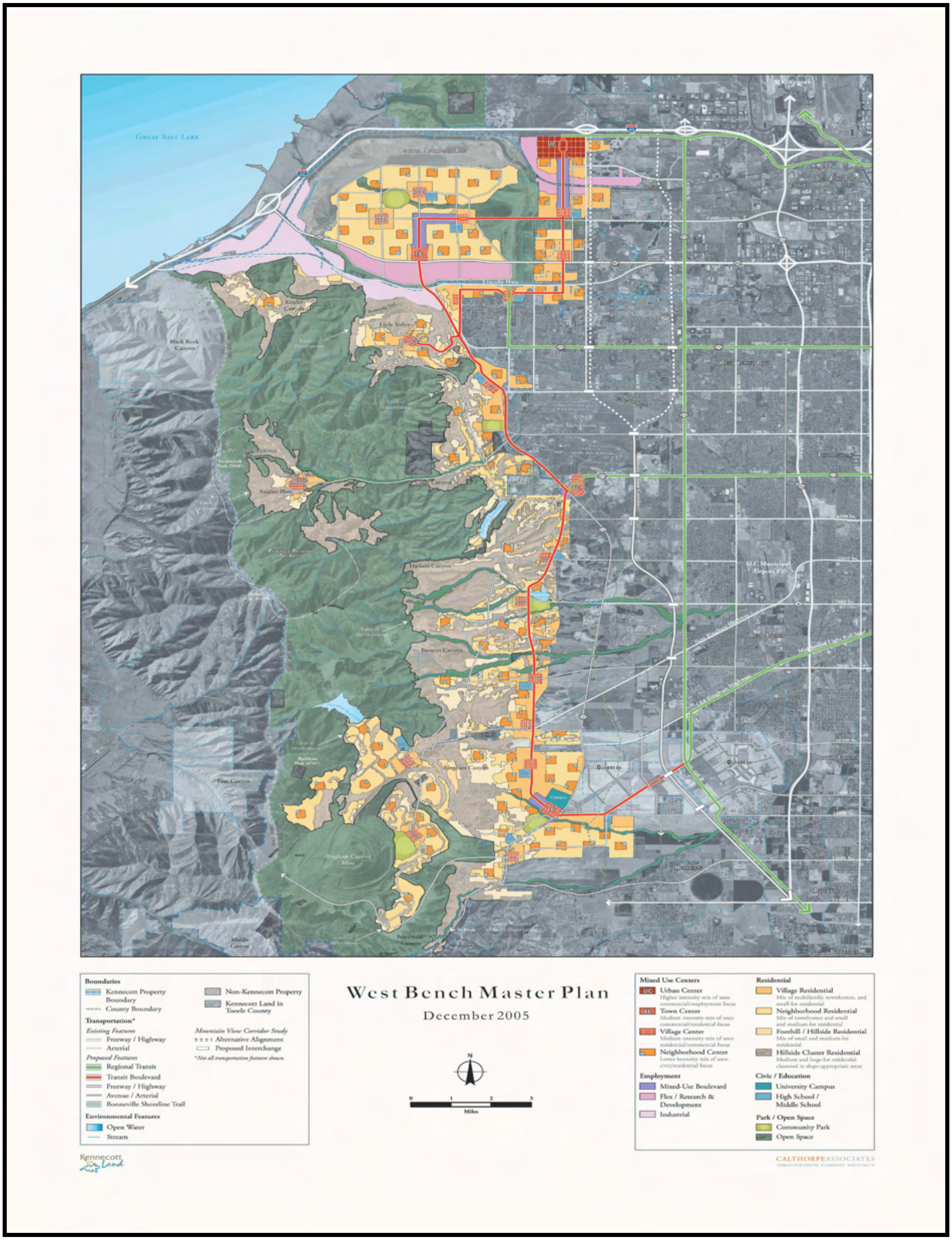
Design Flow Rates

The results from the HEC-HMS hydrologic model are summarized in Table III-5.

Table III-5
Existing Scenario Flow Rates

Location	Model Predicted Peak FLow (cfs)
Inflow to ATK Detention	191
Outlet to ATK Detention (Existing)	9
3100 South at 8200 West	43
C-7 Canal	136

FIGURE III-3
KENNECOTT LAND WEST BENCH MASTER PLAN



USGS REGRESSION COMPARISON

As a check of the computed flows from the HEC-HMS model coming to the ATK detention from Coon and Harkers Canyons, the USGS "Methods for Estimating Magnitude and Frequency of Peak Flows for Natural Streams in Utah" was used for comparison. The following regression equation is given for estimating peak runoff in the region of Coon and Harkers Canyons.

$$PK100 = 6.92\ DRNAREA^{0.613} 1.06^{PRECIP}$$

Where
DRNAREA = Drainage Area, in square miles
PRECIP = mean annual precipitation, in inches

This equation gives a 100-year peak flow of 152 cfs, using a total drainage are of 20.06 square miles and a mean annual average precipitation of 21.44 inches (Bingham Canyon, Utah (420699), Western Regional Climate Data Center, wrcc@dri.edu). The magnitude of the peak is in line with the 184 cfs that was calculated using the SCS curve number methodology and HEC-HMS.

SNOW MELT

Historical snowmelt peak flows are not available for Coon/Harkers Creek. Regression equations developed by Gingery and Associates ("Hydrology Report, Flood Insurance Studies, 20 Utah Communities, F.I.A. Contract H-4790", 1979) were used to estimate snowmelt runoff. The three equations are as follows:

$$Q_{10} = 14.13\ A^{0.94} \text{ where } R = 0.84$$

$$Q_{50} = 20.44\ A^{0.92} \text{ where } R = 0.84$$

$$Q_{100} = 22.57\ A^{0.91} \text{ where } R = 0.84$$

R= Correlation Coefficient
A = Drainage Area in Square Miles
Q = Discharge in Cubic Feet per Second

The area contributing to the snowmelt runoff was assumed to include only the upper subbasins of Coon/Harkers Canyon delineated for the study with an area of 8.9 square miles. The equations rely on the size of the basin area and the return period for the snowmelt event.

The predicted snowmelt flows are summarized on Table III-6. Coon/Harkers Creek does not currently have any stream gauging data available, making a determination about the accuracy of the snowmelt calculation difficult. The Gingery and Associates study focused on Wasatch Mountain canyons and slopes that are primarily west facing. Therefore, the applicability of this study to east facing Oquirh Mountain slopes is unknown.

Table III-6
Estimated Snowmelt Flow Rates

Location	Predicted Snowmelt Flow Rates (cfs)		
	10 year	50 year	100 year
Coon/Harkers Creek Confluence	110	152	164

CHAPTER IV

CAPITAL IMPROVEMENTS PLAN

DRAINAGE PLAN DEVELOPMENT

Meetings were held with Salt Lake County personnel to identify and evaluate alternatives for storm drainage improvements to solve the problems identified by the model and from County personnel. The process of selecting a preferred alternative included: reviewing the list of storm drainage inadequacies, brainstorming possible solutions to the problems, screening alternatives based on feasibility and public acceptance, and the development of alternatives. The preferred alternatives are the capital improvement projects discussed below.

The flows and pipe diameters provided in the capital improvement project descriptions are approximate and are for planning purposes only. A detailed hydrologic and hydraulic analysis should be performed during the design process for the improvement projects to identify final design pipe sizes.

SYSTEM DEFICIENCIES

Capacity deficiencies were identified based on peak flows calculated in the HEC-HMS model and pipe capacities from County mapping for pipe size and slopes. Additional deficiencies were identified by County personnel with regard to maintenance or performance.

TABLE IV-1
Existing Deficiencies

ID	LOCATION	PROBLEM
1	8300 West to 8200 West, 3500 South to 3100 South	County personnel indicated that this storm drainage line has poor access (located in landscaped backyards with fencing) and in most cases is 50 to 60 years old. The modeled peak flow through this line is 41 cfs. The estimated capacity based on the smallest pipe size and 2.5% slope estimated by surface contours gives a capacity of 36 cfs.
2	8300 West 3650 South	County personnel indicated that the detention area referred to as "Little Hoover" (south of the Utah & Salt Lake Canal) does create some basement flooding during high storm flow events.
3	8300 West 3500 South	According to County personnel, significant debris causes problems at the two inlets on 3500 South.
4	8200 West to 8300 West, 4100 South to 3650 South	Open channel currently experiences high erosion levels during flow events according to County personnel.

ALTERNATIVES ANALYSIS

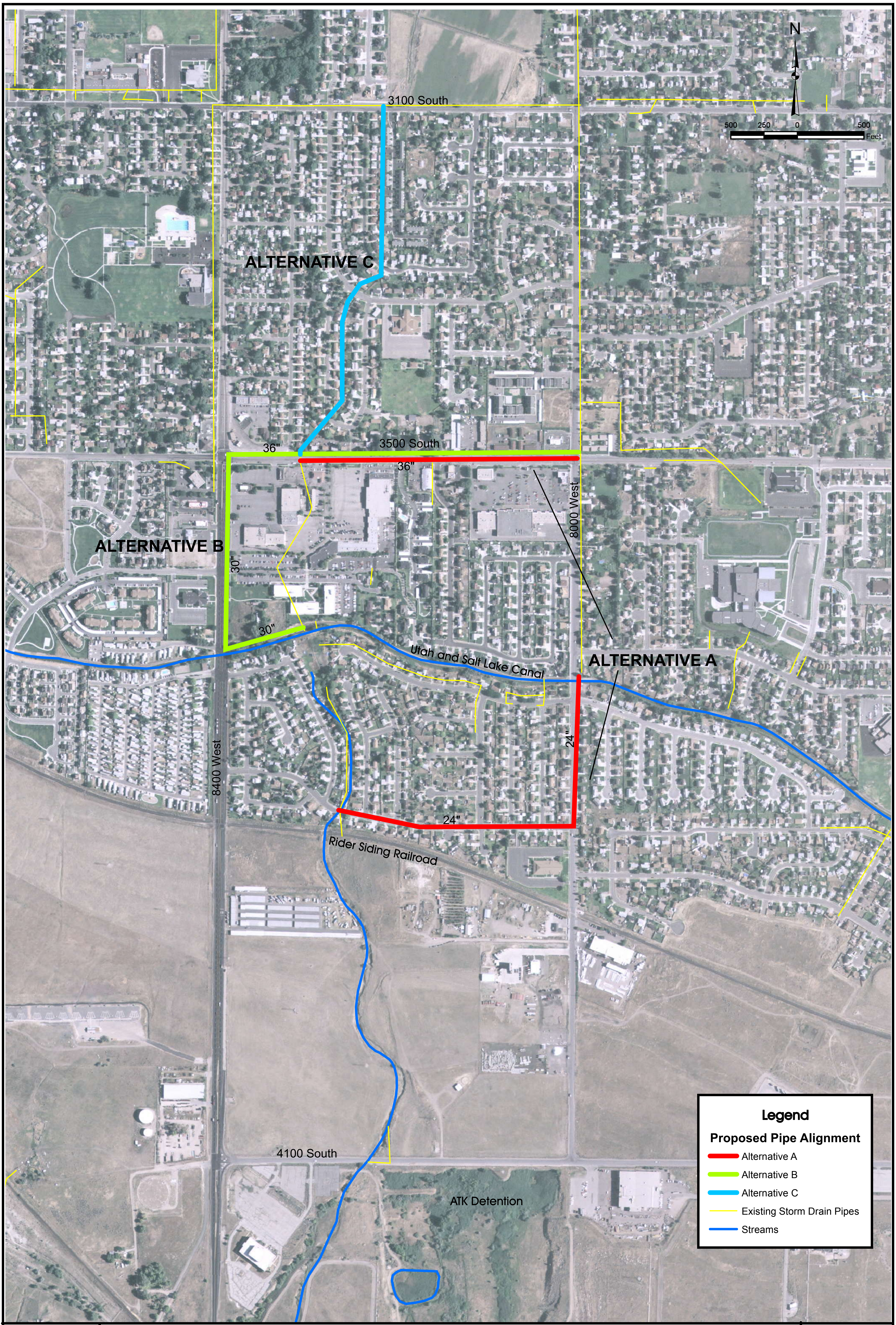
Three alternatives were presented and discussed with the County to mitigate the deficiencies presented previously. The major deficiency identified both in the storm drainage model and by County personnel is deficiency #1, from 8300 West to 8200 West, 3500 South to 3100 South. Mitigation of the deficiencies in this line may also solve other identified deficiencies. The following three alternatives were presented to the County for their review (see Figure IV-1).

TABLE IV-2
Alternatives

ALTERNATIVE ID	DEFICIENCY ID	SOLUTION
A	1,2,3,4	Reroute storm drainage from Coon/Harkers Creek and the ATK detention by rerouting flow at Danbury Drive (approximately 3790 South) east to 8000 West in a new 24 inch line. New 24" line continues north at Danbury Drive and 8000 West and will continue to the existing 8000 West storm drain at about 3660 South (north of the Utah and Salt Lake Canal). Reroute flows from Urb1, Urb2, Urb3 and Urb 4 at 8300 West 3500 South east along 3500 South in new 36" line to the existing storm drain at 8000 West.
B	1,3	Reroute storm drainage from Coon/Harkers Creek just north of the Utah and Salt Lake Canal at 8300 West. The existing outlet to the ATK detention will be unaltered. The flow will be routed through a new 30" line to 8400 West where the line will continue south to 3500 South and then east to the existing storm drainage line at 8200 West and 3500 South. The existing storm drain from 8200 West to 8000 West along 3500 South will be replaced with a new 36" line.
C	1	Replace existing storm drainage lines from 3500 South to 3100 South with 36 inch lines. Purchase the necessary permanent easements for access and maintenance through private property and back yards.

Alternative A would remove flows from the Coon/Harkers Canyon flows from the existing storm drainage line downstream (north) of 4100 South. The proposed line at 8300 West 3500 South would convey flows from Urb 1, Urb2, Urb3 and Urb4 to the existing storm drain in 8000 West. The existing system would remain in place and would convey local drainage from Urb8 only (10-year 6-hour peak flow of 14.5 cfs).

Alternative B would also remove Coon/Harkers Canyon drainage flows from the existing storm drainage line downstream (north) of 4100 South. The existing system would only convey local drainage from subbasin Urb8 (10-year 6-hour peak flow of 14.5 cfs) after the improvements are implemented. Flows from subbasins Urb4, Urb1, Urb2 and Urb3 would be diverted to the proposed new 36-inch line located at 8400 West.



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COON / HARKERS CREEK MASTER PLAN
IMPROVEMENT ALTERNATIVES

Figure IV-1

Alternative C was discussed during meetings with Salt Lake County and was dismissed because of the potential cost of easement procurement and disruption to residential properties for regular maintenance.

Both Alternative A and Alternative B were chosen by the County as viable alternatives to mitigating existing deficiencies. These alternatives are presented as alternatives in the Capital Improvement Plan with their respective costs.

PRECISION OF COST ESTIMATES

When considering cost estimates, there are several levels or degrees of precision, depending on the purpose of the estimate and the percentage of detailed design that has been completed. The following levels of precision are typical:

Type of Estimate	Precision
Master Planning	±50%
Preliminary Design	±30%
Final Design or Bid	±10%

For example, at the master planning level (or conceptual or feasibility design level), if a project is estimated to cost $1,000,000, then the precision or reliability of the cost estimate would typically be expected to range between approximately $500,000 and $1,500,000. While this may seem very imprecise, the purpose of master planning is to develop general sizing, location, cost, and scheduling information on a number of individual projects that may be designed and constructed over a period of many years. Master planning also typically includes the selection of common design criteria to help ensure uniformity and compatibility among future individual projects. Details such as the exact capacity of individual projects, the level of redundancy, the location of facilities, the alignment and depth of pipelines, the extent of utility conflicts, the cost of land and easements, the construction methodology, the types of equipment and material to be used, the time of construction, interest and inflation rates, permitting requirements, etc., are typically developed during the more detailed levels of design.

At the preliminary or 10% design level, some of the aforementioned information will have been developed. Major design decisions such as the size of facilities, selection of facility sites, pipeline alignments and depths, and the selection of the types of equipment and material to be used during construction will typically have been made. At this level of design the precision of the cost estimate for a $1,000,000 project would typically be expected to range between approximately $700,000 and $1,300,000.

After the project has been completely designed, and is ready to bid, all design plans and technical specifications will have been completed and nearly all of the significant details about the project should be known. At this level of design, the precision of the cost estimate for the same $1,000,000 project would typically be expected to range between approximately $900,000 and $1,100,000.

ESTIMATED CONSTRUCTION COSTS

Estimated construction costs for the storm drainage pipe lines include manholes, inlets, roadway repair, curb and gutter replacement, and utility relocation for larger storm drain diameters. It was assumed that one existing utility would need to be relocated for storm drain diameters larger than 30-inches, and two existing utilities would need to be relocated for storm drain diameters larger than 48-inches.

Unit costs for the construction cost estimates are based on conceptual level engineering. Unit construction costs were estimated based on construction cost indices, communication with material suppliers, and HAL experience with similar construction. All costs are presented in 2008 dollars. A detailed cost estimate of each alternative and a unit pipe cost table is provided in Appendix E.

CAPITAL IMPROVEMENTS PLAN

The master plan Capital Improvements Plan is presented with two alternatives. Alternative A and Alternative B presented above are shown with their accompanying costs in Table IV-3 and Table IV-4, respectively. Figure IV-1 shows the location of each alternative. Because the cost of Alternative A is the least and remedies more of the identified deficiencies, we recommend Alternative A as the preferred alternative.

SUMMARY OF RECOMMENDATIONS

General recommendations not included in the Capital Improvements Plan include:

- We recommend Alternative A as the preferred alternative. This alternative mitigates all of the identified deficiencies in the system and is the lowest cost alternative.
- We recommend a complete inventory of the storm drainage system (including pipe location, pipe invert elevations, pipe sizes, inlet locations and other drainage facilities) be completed.
- We recommend the consideration of the installation of stream gauging on Coon and Harkers Creek as well as strategically placed precipitation gauges. This data will help establish typical snowmelt flows and storm runoff peaks.
- Future development in Coon and Harkers Canyons should be required to detain flows from the 100-year storm to historic (presented in this report as Existing) levels.

TABLE IV-3
Alternative A Capital Improvement Costs

ID	LOCATION	PROJECT ASSUMPTIONS	COST
1	Danbury Drive from 8300 West to 8000 West	Install **1,850 feet** of new **24-inch** storm drain.	$313,000
2	8000 West from Danbury Drive to 3660 South	Install **1,100 feet** of new **24-inch** storm drain.	$186,000
3	3500 South from 8300 West to 8000 West	Install **2,000 feet** of new **36-inch** storm drain, replacing the existing 18, 24, 27 and 30 inch existing storm drain lines in 3500 South.	$542,000
		Engineering (15%) and Contingency (10%)	**$260,000**
		ALTERNATIVE A - TOTAL	**$1,301,000**

TABLE IV-4
Alternative B Capital Improvement Costs

ID	LOCATION	PROJECT ASSUMPTIONS	COST
1	Coon/Harkers Creek crossing at Utah and Salt Lake Canal to 8400 West	Install **700 feet** new **30-inch** storm drain. Acquire 20 foot easement adjacent to the Utah and Salt Lake Canal	$217,000
2	8400 West from 3800 South to 3500 South	Install **1,400 feet** of new **30-inch** storm drain.	$284,000
3	3500 South from 8400 West to 8000 West	Install **2,700 feet** of new **36-inch** storm drain., replacing the existing 18, 24, 27 and 30 inch existing storm drain lines in 3500 South.	$732,000
		Engineering (15%) and Contingency (10%)	**$308,000**
		ALTERNATIVE B - TOTAL	**$1,541,000**

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APPENDIX A

GLOSSARY AND ABBREVIATIONS

GLOSSARY

10-year storm - The storm event that has a 10% (1 in 10) chance of being equaled or exceeded in any given year.

100-year storm - The storm event that has a 1% (1 in 100) chance of being equaled or exceeded in any given year.

Cross drainage structures - Cross drainage structures convey storm drainage flows from one side of the street to the other and normally consist of storm drains or culverts.

Design Rainstorm - A rainfall event, defined by storm frequency and storm duration, that is used to design drainage structures or conveyance systems.

Detention Basin - An impoundment structure designed to reduce peak runoff flowrates by retaining a portion of the runoff during periods of peak flow and then releasing the runoff at lower flowrates.

HEC-HMS - A Hydrologic Modeling System developed by the U.S. Army Corps of Engineers.

Initial storm drainage system - The drainage system which provides for conveyance of the storm runoff from minor storm events. The initial drainage system usually consists of curb and gutter, storm drains, and local detention facilities. The initial drainage system should be designed to reduce street maintenance, control nuisance flooding, help create an orderly urban system, and provide convenience to urban residents.

Major storm drainage system - The drainage system that provides protection from flooding of homes during a major storm event. The major storm drainage system may include streets (including overtopping the curb onto the lawn area), large conduits, open channels, and regional detention facilities.

Major storm event - Generally accepted as the 100-year storm. Typically homes should be protected from flooding in storm events up to a 100-year event.

Minor storm event - Storm event which is less than or equal to a 10-year storm.

Probable Maximum Flood - A flood event with a very low probability, usually less than 0.2%, of being exceeded in any given year. This flood event is used as a design storm when failure of the structure could cause loss of life.

Retention Basin - An impoundment structure designed to contain all of the runoff from a design storm event. Retention basins usually contain the runoff until it evaporates or infiltrates into the ground.

Storm Duration - The length of time that defines the rainfall depth or intensity for a given frequency.

Storm Frequency - A measure of the relative risk that the precipitation depth for a particular design storm will be equaled or exceeded in any given year. This risk is usually expressed in years. For example, a storm with a 100-year frequency will have a 1% chance of being equaled or exceeded in a given year.

ABBREVIATIONS

ac-ft	acre-feet
cfs	cubic feet per second (ft^3/s)
cmp	corrugated metal pipe
DB	detention basin
Det	detention
E	East
ft	foot or feet
GIS	Geographic Information System
gw	groundwater
HAL	Hansen, Allen & Luce, Inc.
ID #	identification number
in	inches
IPP	Intermountain Power Project - IPA & Union Pacific facility at 400 N 1550 W
irr	irrigation
N	North
PE	polyethylene pipe
Q10	peak storm water flow in a 10-year event
Q100	peak storm water flow in a 100-year event
RR	railroad
S	South
tot	total
W	West
w/	with
w/o	without
Xing	crossing

APPENDIX B

SUBBASIN CHARACTERISTICS

Salt Lake County - Coon/Harkers Creek Study
Subbasin Composite Curve Numbers
Computed: GLJ
10/4/2007

Subbasin Name	Area (ft^2)	Area (mi^2)	CN
Coon-Lower	77,070,406	2.76	58.2
Coon-Middle	86,225,959	3.09	57.3
Coon-Upper North	91,159,748	3.27	45.5
Coon-Upper South	99,965,429	3.59	44.7
Harkers-Lower	97,685,230	3.50	67.2
Harkers-Middle	50,916,528	1.83	51.5
Harkers-Upper	56,106,289	2.01	45.2
TOTAL	559,129,588	20.06	53.2

Salt Lake County - Coon/Harkers Creek Study
Lag Time Calculations
Computed: GLJ
10/5/2007

Regression Equation **$Lag = 0.0051 \times width^{.594} \times slope^{-.15} \times S_{nat}^{.313}$** from Simas and Hawkins "Lag Time Characteristics for Small Watersheds in the U.S."

Where: **Width = Watershed Area / Watershed Length**
Slope = Maximum Elevation Difference / Longest Flow Path
S_{nat} = 1000/CN - 10

Subbasin Name	Area (ft^2)	Watershed Length (ft)	CN	S_{nat}	Width	Max Elev Difference (ft)	Slope	Lag Time (hours)
Coon-Lower	77,070,406	43,000	58.2	7.18	1792.34	2096	0.0487	1.27
Coon-Middle	86,225,959	28,500	57.3	7.44	3025.47	1841	0.0646	1.68
Coon-Upper North	91,159,748	29,500	45.5	11.99	3090.16	3310	0.1122	1.82
Coon-Upper South	99,965,429	33,500	44.7	12.38	2984.04	3597	0.1074	1.82
Harkers-Lower	97,685,230	47,000	67.2	4.88	2078.41	1586	0.0337	1.30
Harkers-Middle	50,916,528	18,500	51.5	9.43	2752.24	2466	0.1333	1.54
Harkers-Upper	56,106,289	22,000	45.2	12.11	2550.29	2763	0.1256	1.60

Subbasin Characteristics

			Directly Connected Impervious Area (DCIA)								Unconnected Impervious (UI) and Pervious Areas											
			Commercial	Road	Residential			Other	Total	%	Unconnected Impervious Area						Total	%		Pervious	Pervious	Composite
Basin ID	Area (ft2)	Area (mi2)	Imp. Area (ft2)	Area	# of Homes	DCIA/ Home	Area	Area	DCIA	DCIA	UI/Home	Home UI Area	Misc. UI Area	Other UI Area	Total UI Area	Pervious Area	UI & Perv Area	UI & Perv Area	Soil Group	Land Type	CN	CN
Urb1	1325582	0.0475	0	146048	104	1650	171600	0	317648	24	2160	224640	0	0	224640	783294	1007934	76	B	2-2a Lawn/Grass - Fair	72	78
Urb2	1501873	0.0539	0	168288	136	1650	224400	0	392688	26	2160	293760	0	0	293760	815425	1109185	74	B	2-2a Lawn/Grass - Fair	72	79
Urb3	1130356	0.0405	129649	173504	83	1650	136950	123166	433620	38	2160	179280	0	6482	185762	510973	696735	62	B	2-2a Lawn/Grass - Fair	72	79
Urb4	1625930	0.0583	1262182	81920	2	1650	3300	1199073	1284293	79	2160	4320	0	63109	67429	274208	341638	21	B	2-2a Lawn/Grass - Fair	72	77
Urb5	1816235	0.0651	61800	254774	154	1650	254100	58710	567584	31	2160	332640	0	3090	335730	912921	1248651	69	B	2-2a Lawn/Grass - Fair	72	79
Urb6	505211	0.0181	460211	45000	0	1650	0	437200	482200	95	2160	0	0	23011	23011	0	23011	5	B	2-2a Lawn/Grass - Fair	72	98
Urb7	2623404	0.0941	712018	126880	91	1650	150150	676417	953447	36	2160	196560	0	35601	232161	1437796	1669957	64	B	2-2a Lawn/Grass - Fair	72	76
Urb8	2742028	0.0984	84250	355104	252	1650	415800	80037	850941	31	2160	544320	0	4212	548532	1342555	1891087	69	B	2-2a Lawn/Grass - Fair	72	80
Urb9	2243553	0.0805	624792	149024	96	1650	158400	593553	900977	40	2160	207360	0	31240	238600	1103977	1342576	60	B	2-2a Lawn/Grass - Fair	72	77
Urb10	2170486	0.0779	0	289216	195	1650	321750	0	610966	28	2160	421200	0	0	421200	1138320	1559520	72	B	2-2a Lawn/Grass - Fair	72	79
Urb11	3112153	0.1116	258739	90064	28	1650	46200	245802	382066	12	2160	60480	0	12937	73417	2656671	2730088	88	B	2-2a Lawn/Grass - Fair	72	73
Urb12	2056383	0.0738	144982	282560	175	1650	288750	137733	709043	34	2160	378000	0	7249	385249	962091	1347340	66	C (B, C)	2-2a Lawn/Grass - Fair	81	86
Urb13	2527379	0.0907	0	256160	255	1650	420750	0	676910	27	2160	550800	0	0	550800	1299669	1850469	73	C (B,D)	2-2a Lawn/Grass - Fair	81	86

Average Road width of 32 ft was used in all road area calculations

APPENDIX C

DESIGN RAINSTORM

UPPER COON/HARKERS

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 40.648454 N 112.177853 W 6345 feet

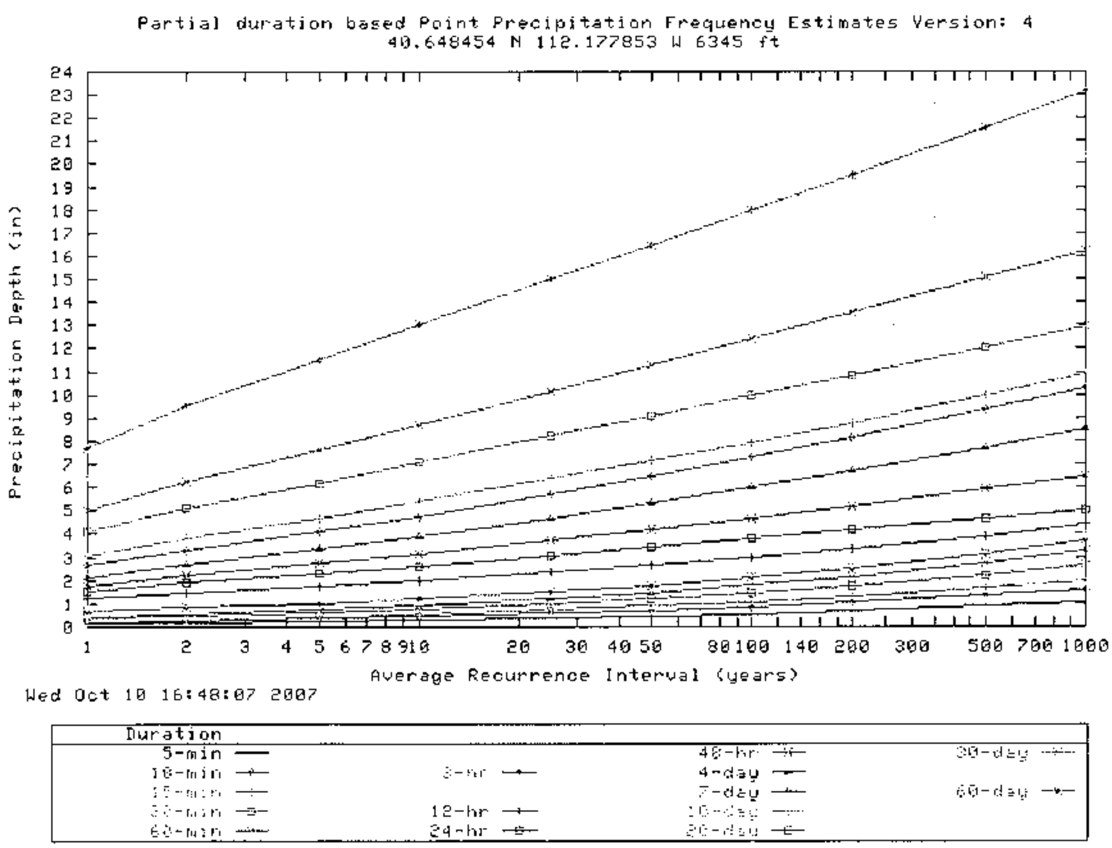
from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006
Extracted: Wed Oct 10 2007

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.14	0.21	0.26	0.35	0.43	0.56	0.66	0.90	1.18	1.53	1.79	2.16	2.63	3.04	4.11	5.06	6.40	7.69
2	0.17	0.26	0.33	0.44	0.54	0.69	0.81	1.10	1.44	1.90	2.21	2.69	3.28	3.79	5.11	6.28	7.93	9.55
5	0.24	0.36	0.45	0.60	0.74	0.90	1.02	1.33	1.73	2.29	2.71	3.34	4.08	4.66	6.21	7.63	9.56	11.51
10	0.29	0.45	0.55	0.75	0.92	1.09	1.21	1.53	1.99	2.63	3.13	3.90	4.76	5.38	7.07	8.71	10.87	13.02
25	0.39	0.59	0.73	0.98	1.21	1.41	1.51	1.83	2.36	3.08	3.72	4.68	5.71	6.36	8.20	10.15	12.63	14.99
50	0.47	0.72	0.89	1.20	1.48	1.69	1.78	2.09	2.66	3.43	4.18	5.32	6.47	7.14	9.07	11.26	13.98	16.48
100	0.57	0.87	1.08	1.45	1.79	2.03	2.11	2.38	2.99	3.79	4.68	5.99	7.29	7.96	9.95	12.39	15.39	17.98
200	0.69	1.05	1.30	1.75	2.16	2.42	2.51	2.73	3.35	4.16	5.20	6.70	8.14	8.79	10.83	13.53	16.82	19.50
500	0.88	1.33	1.65	2.23	2.76	3.06	3.15	3.38	3.92	4.65	5.91	7.71	9.34	9.95	12.01	15.07	18.80	21.54
1000	1.05	1.60	1.99	2.67	3.31	3.65	3.75	3.96	4.39	5.04	6.48	8.52	10.31	10.87	12.93	16.26	20.38	23.14

Text version of table

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.



MIDDLE COON/HARKERS

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 40.632652 N 112.151742 W 6732 feet

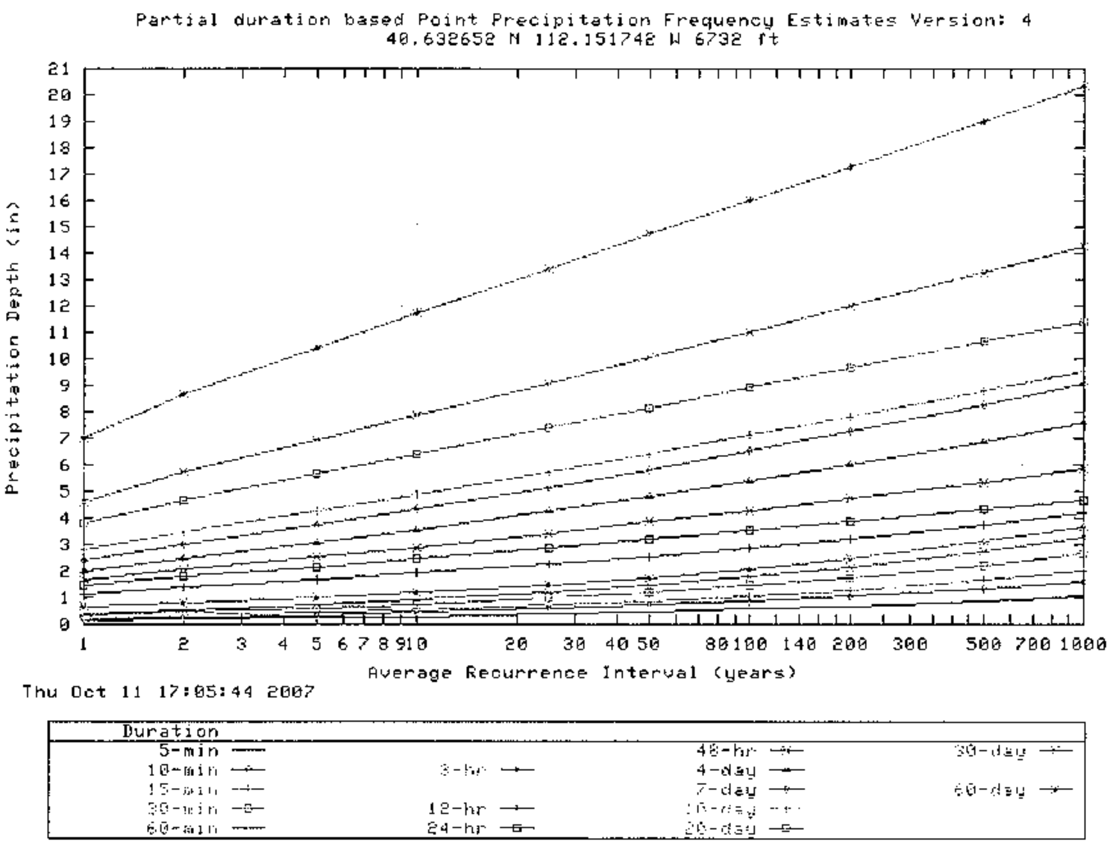
from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006
Extracted: Thu Oct 11 2007

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.14	0.21	0.26	0.34	0.43	0.55	0.65	0.87	1.13	1.44	1.67	2.00	2.43	2.80	3.77	4.62	5.83	7.00
2	0.17	0.26	0.32	0.44	0.54	0.68	0.80	1.07	1.38	1.78	2.07	2.48	3.02	3.47	4.67	5.72	7.21	8.67
5	0.23	0.36	0.44	0.60	0.74	0.89	1.00	1.29	1.66	2.15	2.52	3.07	3.73	4.24	5.64	6.90	8.64	10.38
10	0.29	0.44	0.55	0.74	0.92	1.08	1.19	1.49	1.91	2.45	2.90	3.56	4.32	4.88	6.40	7.84	9.78	11.70
25	0.38	0.58	0.72	0.97	1.21	1.39	1.48	1.78	2.26	2.86	3.42	4.25	5.15	5.73	7.39	9.10	11.31	13.42
50	0.47	0.71	0.88	1.19	1.47	1.67	1.75	2.02	2.55	3.19	3.83	4.81	5.81	6.41	8.14	10.04	12.47	14.70
100	0.57	0.86	1.07	1.44	1.79	2.00	2.08	2.31	2.87	3.52	4.27	5.40	6.51	7.10	8.90	11.01	13.66	15.99
200	0.69	1.04	1.29	1.74	2.15	2.39	2.46	2.65	3.21	3.85	4.72	6.02	7.24	7.82	9.65	11.98	14.87	17.28
500	0.87	1.33	1.65	2.22	2.75	3.03	3.10	3.29	3.76	4.30	5.35	6.89	8.26	8.79	10.65	13.26	16.50	18.98
1000	1.05	1.60	1.98	2.67	3.30	3.61	3.69	3.85	4.21	4.66	5.84	7.58	9.08	9.56	11.41	14.25	17.80	20.30

Text version of table

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.



LOWER
COON/HARKERS

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 40.641905 N 112.116803 W 5492 feet

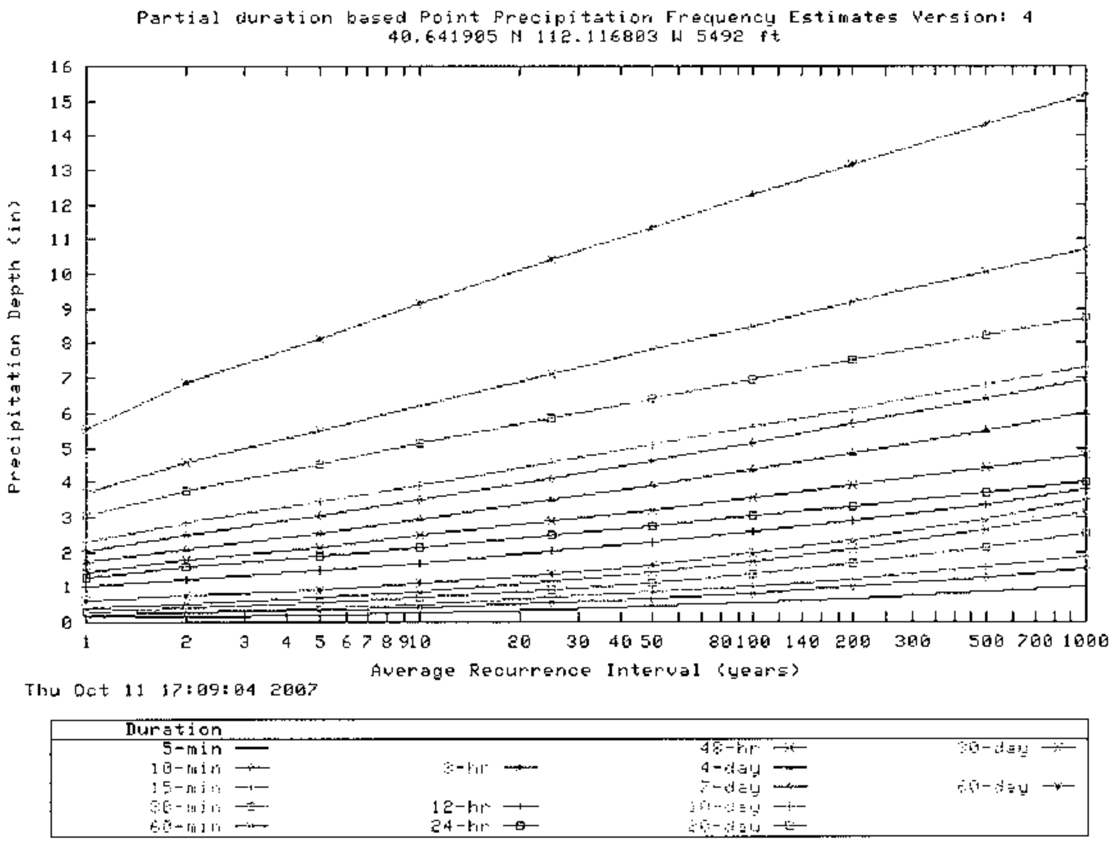
from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006
Extracted: Thu Oct 11 2007

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.13	0.19	0.24	0.32	0.40	0.51	0.60	0.79	1.01	1.26	1.45	1.70	2.02	2.30	3.06	3.71	4.65	5.55
2	0.16	0.24	0.30	0.41	0.51	0.64	0.74	0.97	1.23	1.55	1.78	2.10	2.50	2.85	3.78	4.58	5.73	6.85
5	0.22	0.34	0.42	0.56	0.69	0.83	0.93	1.18	1.48	1.87	2.15	2.56	3.04	3.44	4.53	5.48	6.82	8.14
10	0.28	0.42	0.52	0.70	0.87	1.01	1.11	1.36	1.70	2.13	2.47	2.95	3.50	3.93	5.11	6.19	7.67	9.14
25	0.36	0.55	0.69	0.92	1.14	1.31	1.39	1.64	2.02	2.48	2.89	3.49	4.13	4.58	5.86	7.12	8.79	10.41
50	0.45	0.68	0.84	1.13	1.40	1.58	1.65	1.87	2.29	2.76	3.22	3.92	4.63	5.08	6.42	7.81	9.63	11.35
100	0.54	0.83	1.02	1.38	1.71	1.90	1.96	2.13	2.57	3.04	3.57	4.38	5.14	5.60	6.98	8.51	10.47	12.27
200	0.66	1.00	1.24	1.67	2.06	2.28	2.33	2.45	2.88	3.32	3.92	4.85	5.67	6.11	7.52	9.19	11.29	13.17
500	0.84	1.28	1.59	2.14	2.64	2.89	2.94	3.06	3.38	3.71	4.40	5.50	6.40	6.80	8.22	10.07	12.37	14.32
1000	1.01	1.54	1.90	2.56	3.17	3.45	3.50	3.59	3.79	4.00	4.78	6.02	6.97	7.33	8.75	10.74	13.18	15.17

Text version of table

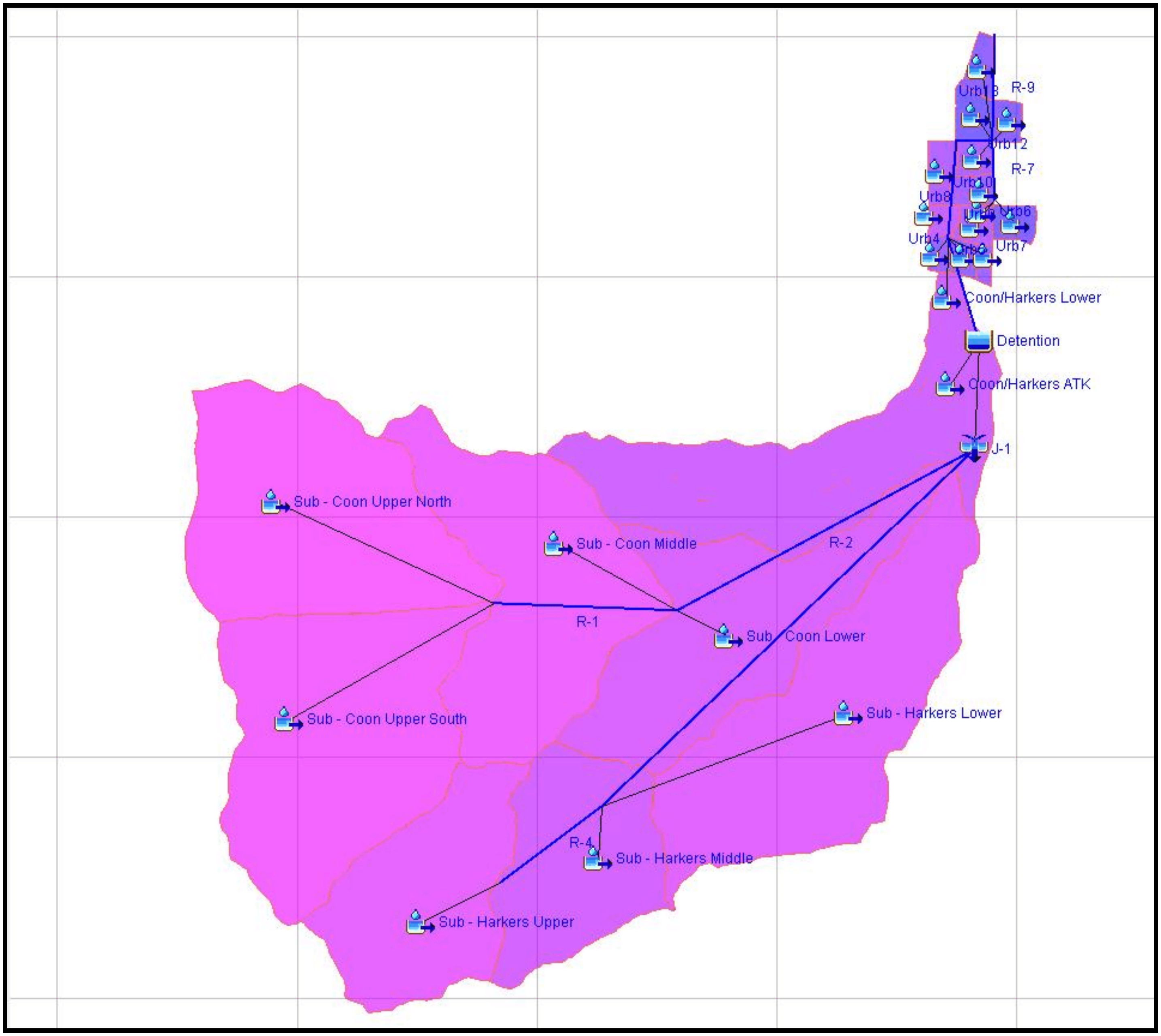
* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.



APPENDIX D

MODEL RESULTS

COON/HARKERS CREEK HEC-HMS MODEL



COON/HARKERS CREEK HEC-HMS MODEL OUTPUT
MOUNTAIN AREA 100-YR 6-HR - URBAN AREA 10-YR 6-HR

Hydrologic Element	Drainage Area (mi2)	Peak Discharge (cfs)	Time of Peak	Volume (Ac ft)
Coon/Harkers ATK	0.60	18.4	01Jan2000, 04:12	0.09
Coon/Harkers Lower	0.13	2.9	01Jan2000, 03:18	0.07
Detention	20.65	8.8	01Jan2000, 07:00	0
J-1	20.05	184.1	01Jan2000, 05:54	0.03
R-1	6.86	0	01Jan2000, 00:00	0
R-2	12.71	54.6	01Jan2000, 06:30	0.01
R-3	7.34	137.1	01Jan2000, 05:42	0.06
R-4	2.01	0	01Jan2000, 00:00	0
R-5	20.65	8.6	01Jan2000, 07:00	0
R-6	21.08	43.2	01Jan2000, 03:24	0.01
R-7	0.26	47.2	01Jan2000, 03:12	0.55
R-8	21.08	43.1	01Jan2000, 03:30	0.01
R-9	21.69	135.4	01Jan2000, 03:36	0.02
Sub - Coon Lower	2.76	23.7	01Jan2000, 05:42	0.03
Sub - Coon Middle	3.09	31.8	01Jan2000, 06:06	0.03
Sub - Coon Upper North	3.27	0	01Jan2000, 00:00	0
Sub - Coon Upper South	3.59	0	01Jan2000, 00:00	0
Sub - Harkers Lower	3.50	136.8	01Jan2000, 05:00	0.14
Sub - Harkers Middle	1.83	2.7	01Jan2000, 06:36	0
Sub - Harkers Upper	2.01	0	01Jan2000, 00:00	0
Urb1	0.05	7.7	01Jan2000, 03:12	0.4
Urb10	0.08	10.2	01Jan2000, 03:06	0.45
Urb11	0.11	6.1	01Jan2000, 03:00	0.21
Urb12	0.07	16.4	01Jan2000, 03:18	0.65
Urb13	0.09	19	01Jan2000, 03:18	0.59
Urb2	0.05	6.5	01Jan2000, 03:06	0.43
Urb3	0.04	7.1	01Jan2000, 03:00	0.55
Urb4	0.06	5.6	01Jan2000, 03:00	0.35
Urb5	0.07	9.4	01Jan2000, 03:00	0.48
Urb6	0.02	8.1	01Jan2000, 03:00	1.14
Urb7	0.0941	15.3	01Jan2000, 03:00	0.49
Urb8	0.0984	14.5	01Jan2000, 03:06	0.5
Urb9	0.0805	14.6	01Jan2000, 03:00	0.54

APPENDIX E
COST ESTIMATES

TABLE E-1
Alternative Capital Improvements Costs

		Size		Quantity		Unit	Construction	15% Engineering &	Total Cost	Notes
ID #	Description	Proposed	unit		unit	Cost	Cost	10% Contingency		
A	New storm drain pipeline from Danbury Drive to 8000 W	24	inch	1850	ft	$169	$312,650			
	New storm drain pipeline at 8000 W from Danbury Drive to 3660	24	inch	1100	ft	$169	$185,900			in street - native backfill - no dewatering
	New storm drain pipeline at 3500 S from 8300 W to 8000 W	36	inch	2000	ft	$271	$542,000			in street - native backfill - no dewatering
	Total						$1,040,550	$260,138	$1,300,688	
B	New storm drain pipeline from Coon/Harkers to 8400 W	30	inch	700	ft	$203	$142,100			out of street - native backfill - no dewatering
	New storm drain pipeline at 8400 W from 3800 S to 3500 S	30	inch	1400	ft	$203	$284,200			in street - native backfill - no dewatering
	New storm drain pipeline at 3500 S from 8400 W to 8000 W	36	inch	2700	ft	$271	$731,700			in street - native backfill - no dewatering
	Easment Acquisition along Utah and Salt Lake Canal	0.3	acre	0.3	acre	$250,000	$75,000			
	Total						$1,233,000	$308,250	$1,541,250	

AVERAGE STORM DRAIN PIPE COST PER FOOT

Diameter (in)	Diameter (ft)	Outside Diameter (ft)	Pipe Material & Installation (1)	Excavation	Imported Bedding Installed	Hauling Excess Native Mat'l	Trench Backfill Installed (3)	Trench Box per Day (2)	Average Daily Output	Trench Box Cost	Top Trench Width (ft)	Road Repair Width (ft)	Asphalt Cost	Manhole Cost	Inlet Cost	Curb & Gutter Cost	Utility Relocation	Trench Dewatering (4)	Total Cost per Foot of Pipe	Cost Out of Street (3)
15	1.3	1.46	31.50	4.21	18.61	4.82	1.89	202.65	190	1.07	4.86	8.86	32.53	10.25	11.25	12.41	0	0.00	129	86
18	1.5	1.75	36.50	4.74	21.05	5.64	2.01	202.65	130	1.56	5.15	9.15	33.44	10.25	11.25	12.41	0	0.00	139	96
21	1.8	2.04	42.00	5.30	23.56	6.53	2.13	202.65	115	1.76	5.44	9.44	34.35	10.25	11.25	12.41	0	0.00	150	105
24	2.0	2.33	56.50	5.89	26.12	7.47	2.25	202.65	100	2.03	5.73	9.73	35.27	10.25	11.25	12.41	0	0.00	169	125
27	2.3	2.63	77.50	6.52	28.74	8.48	2.37	202.65	94	2.16	6.03	10.03	36.18	10.25	11.25	12.41	0	0.00	196	150
30	2.5	2.92	79.50	7.18	31.42	9.55	2.49	202.65	88	2.30	6.32	10.32	37.10	10.25	11.25	12.41	0	0.00	203	157
33	2.8	3.21	89.75	7.86	34.16	10.69	2.61	202.65	88	2.30	6.61	10.61	38.01	10.25	11.25	12.41	33.84	0.00	253	172
36	3.0	3.50	100.00	8.59	36.96	11.88	2.74	202.65	72	2.81	6.90	10.90	38.93	11.63	11.25	12.41	33.84	0.00	271	189
42	3.5	4.08	127.00	10.12	42.74	14.46	2.98	202.65	72	2.81	7.48	11.48	40.75	11.63	11.25	12.41	33.84	0.00	310	227
48	4.0	4.67	166.00	11.79	48.75	17.28	3.22	202.65	64	3.17	8.07	12.07	42.58	17.75	11.25	12.41	33.84	0.00	368	283
54	4.5	5.25	218.00	13.58	54.99	20.36	3.46	202.65	56	3.62	8.65	12.65	44.41	17.75	11.25	12.41	101.52	0.00	501	347
60	5.0	5.83	270.00	15.49	61.48	23.68	3.70	202.65	48	4.22	9.23	13.23	46.24	25.00	11.25	12.41	101.52	0.00	575	419
66	5.5	6.42	290.00	17.54	68.19	27.25	3.95	202.65	44	4.61	9.82	13.82	48.07	25.00	11.25	12.41	101.52	0.00	610	453
72	6.0	7.00	310.00	19.71	75.15	31.07	4.19	202.65	40	5.07	10.40	14.40	49.90	25.00	11.25	12.41	101.52	0.00	645	487
78	6.5	7.58	402.50	22.01	82.34	35.14	4.43	202.65	36	5.63	10.98	14.98	51.72	25.00	11.25	12.41	101.52	0.00	754	594
84	7.0	8.17	495.00	24.44	89.76	39.46	4.67	202.65	32	6.33	11.57	15.57	53.55	25.00	11.25	12.41	101.52	0.00	863	702
6' x 3' box	3.0	6.00	340.00	11.02	36.35	14.81	3.77	202.65	32	6.33	9.40	13.40	46.76	25.00	11.25	12.41	101.52	0.00	609	453

Reference: 2008 RS Means Heavy Construction Cost Data

Assumptions:

- N **Total Import Trench Backfill? (Y/N)**
- N **Dewatering? (Y/N)**
- Y **Catch Basins & Inlets? (Y/N)**
- One side of street C&G is regraded (30' street).
- 10 v :1h trench side slope (use trench boxes)
- 3 ' average depth to top of pipe
- 0.33 ' thick asphalt road covering
- 0.75 ' thick untreated base course
- 200 ' Average distance between manholes
- 3 + Outside Diameter = Bottom trench width
- 1 ' bedding over pipe
- 0.5 ' bedding under pipe
- 1 Inlets per 100 ft of pipe
- 30% of curb & gutter is on radius

Costs:

- $ 12.18 /CY Native Trench backfill - pg 224: Fill by borrow w/o materials and convert from loose to compacted volume. $8.76/LCY * 1.39 LCY/ECY
- $ 43.62 /CY Imported Select Fill - pg 224-225: Sand, dead or bank w/ hauling (20 CY, 5 mi) and compaction. ($21.00/LCY + $7.10/LCY)*1.39 LCY/ECY + $4.56/ECY
- $ 5.05 /CY Excavation - pg 210 (Item 1375): 10-14 ft deep, 1 CY excavator, Trench Box.
- $ 28.21 /SY 4" Asphalt Pavement - pg 259-260,225: 9" Bank Run GravelBase Course ($9.15/SY), 2" Binder ($7.30/SY), 2" Wear ($8.20/SY [4"=$15.65/SY]) and Hauling ($7.10/LCY * 1.39LCY/ECY * 0.361CY/SY)
- $ 2.38 /LF 4" Asphalt cutting - pg 36: Saw cutting asphalt up to 3" deep ($1.60/LF), each additional inch of depth ($0.78/LF)
- $ 2,050.00 /EA 4' Manhole (for pipes =< 2.5' diameter) - pg 318: Precast 8' deep ($2,050/ea), each add'l foot of depth ($268/VLF)
- $ 2,325.00 /EA 5' Manhole (for pipes > 2.5' and <= 3.5') - pg 318: Precast 8' deep ($2,325/ea), each add'l foot of depth ($298/VLF)
- $ 3,550.00 /EA 6' Manhole (for pipes > 3.5' and <= 4.5') - pg 318: Precast 8' deep ($3,550/ea), each add'l foot of depth ($455/VLF)
- $ 5,000.00 /EA Manholes (for pipes > 4.5')
- $ 1,125.00 /EA Catch basins - pg 315: Curb inlet fram, grate, and curb box, Large 24" x 36" heavy duty
- $ 12.41 /LF Curb & Gutter - pg 266: Steel forms, 24" wide, straight ($10.85/LF) and radius ($16.05). Calculated based on percentage of C&G on radius.
- $ 9.87 /CY Hauling - pg 225: 20 CY dump truck, 5 mile round trip and conversion from loose to compacted volume. $7.10/LCY * 1.39 LCY/ECY
- $ 202.65 /day Trench Box (7' deep, 16' x 8', pg 245)
- $ 73.50 /CY Stabilization Gravel - pg 224-225: Bank Run Gravel ($42.50/LCY * 1.39 LCY/ECY) plus compaction ($4.56/ECY) and hauling ($7.10/LCY * 1.39 LCY/ECY)
- $ 880.00 /day Dewatering - pg 221: 4" diaphram pump, 8 hrs attended ($770/day). Second pump ($110/day)

NOTES:

(1) Assumes Class 3 RCP with no gaskets (pg. 313). 6' x 3' box cost from pg 312. 33", 54", 66", & 78" costs were estimated by linear interpolation between sizes - Costs for these sizes would likely be much higher because they are odd sizes.

(2) 7' deep trench box (16' x 8') - on page 245

(3) Backfill Material & Installation assumes in street. For out of street unit costs, the backfill material cost has been added in place of base course and asphalt.

(4) Dewatering assumes 1' stabilization gravel at the bottom of the trench plus dewatering pumps

(5) Conversion from loose to compacted volumes assumes 125 PCF for compacted density and 90 PCF for loose density. Or (125 PCF/ECY)/(90 PCF/LCY) = 1.39 LCY/ECY

(6) Conversion from cubic yards to square yards for hauling of asphalt paving assumed a total thickness of 13". 3 ft x 3 ft x (13 in)/(12 in/ft) = 0.361 CY/SY

Abbreviations:

VLF	vertical lineal foot
PCF	pounds per cubic foot
LCY	loose cubic yard
ECY	embankment cubic yard