SALT LAKE COUNTY

NEFFS CANYON CREEK MASTER PLAN

(HAL Project No.: 014.10.100)

FINAL REPORT

December 2007

HANSEN ALLEN & LUCE inc
ENGINEERS

SALT LAKE COUNTY

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CHAPTER I

INTRODUCTION

BACKGROUND AND PURPOSE

Neffs Creek is directly tributary to a residential development at the Canyon mouth. The 2002 Flood Insurance Study identified flooding associated with Neffs Creek affecting approximately 150 homes (see Flood Insurance Rate Map panels 49035C0316E and 49035C0317E). Currently normal Neffs Creek flows are conveyed to a storm drain system in Wasatch Boulevard.

The Neffs Canyon conveyance system was constructed prior to the inception of the Federal Flood Insurance Program. A key purpose of Salt Lake County Flood Control is to plan drainage improvements to better protect County residents from flooding and bring the system up to the requirements of the Federal Flood Insurance Program.

OBJECTIVES

Define the 100-year flood flows.

Evaluate debris flow hazard.

Identify means for flood and debris flow hazard mitigation.

SCOPE

The scope of the Neffs Canyon Creek Master Plan included the following:

Documentation and review of the existing Neffs Canyon Creek conveyance system,

Hydrologic analyses to define design stream flows.

Debris flow hazard evaluation.

Develop alternatives for mitigating flood hazards to residences.

Participate in public meetings to receive public input on flood hazard mitigation alternatives.

Prepare Master Plan Document.

AUTHORIZATION

The Neffs Canyon Creek Master Plan has been completed in accordance with a contract approved on April 7, 2005 between Salt Lake County and Hansen, Allen, & Luce, Inc.

CHAPTER II

HYDROLOGY

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 located within a larger drainage basin. Drainage subbasin boundaries depend upon both the topography and the location of storm drainage facilities. The delineated Neffs Creek drainage basin and subbasin boundaries are shown on Figure II-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 Group
- Percentage of Impervious Area
- SCS Curve Number
- Basin Lag Time
- Conveyance System Routing

Subbasin Area

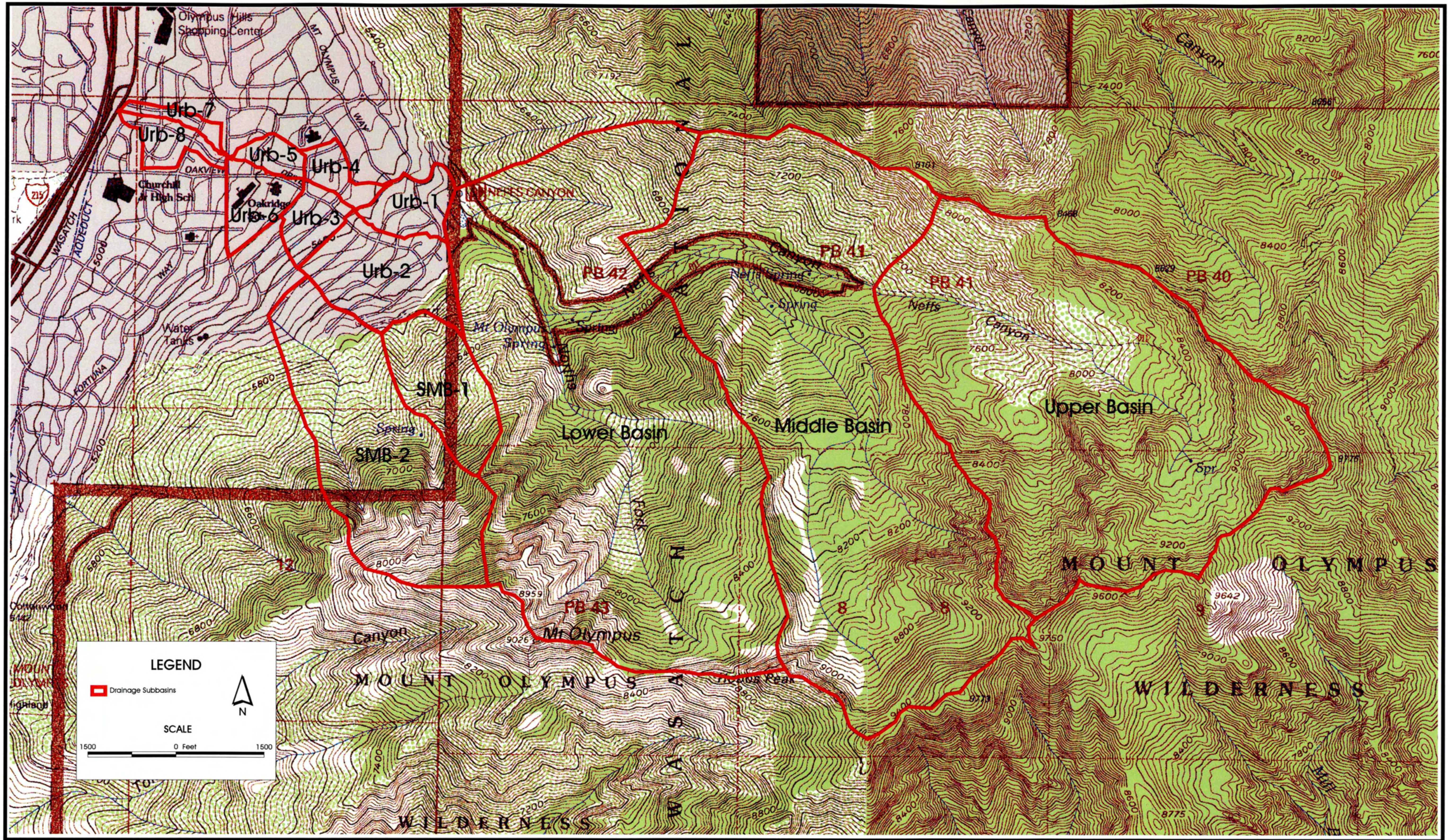
Subbasins were delineated within ArcView GIS using USGS Topographic Quadrangle maps and the locations of storm drainage facilities. Mountain watersheds were divided into subbasins where distinct vegetation, soil type and precipitation characteristics were found.

Hydrologic Soil Group

Hydrologic soil group is a indication of the soil's minimum infiltration rate. Soils are assigned a hydrologic group of A, B, C, or D by the Natural Resource Conservation Service (NRCS, formerly know as the Soil Conservation Service, SCS). Soils of hydrologic soil group A have the highest infiltration rate, and therefore produce the least amount of runoff. Soils of hydrologic soil group D have the lowest infiltration rate, and therefore produce the highest amount of runoff. Soil maps were obtained from the Natural Resources Conservation Service (NRCS) Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/app/).

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



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DRAINAGE SUBBASIN BOUNDARIES

FIGURE II-1

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 NRCS publication TR-55. A curve number is determined based on several factors described in the manual. These factors include: hydrologic soil group, cover type, treatment and hydrologic condition. The hydrologic soil groups were discussed earlier in the hydrologic soil group 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 were delineated using aerial photography and the NRCS soils map. Vegetation cover types were verified through site reconnaissance. The mountain vegetation cover types are described following.

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.

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 drainage subbasin composite curve numbers were calculated by an area weighting method.

Basin Lag Time

The basin 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:

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

where

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

Conveyance System Routing

Mountain area runoff enters Neffs Canyon Creek via sheet flow, shallow concentrated flow and stream flow. In urban locations runoff is routed to Neff's Creek through storm drain pipes or road side drainage ditches. The shape and roughness of these conveyance systems were estimated based on site visits and engineering judgment.

MOUNTAIN AREAS

Subbasin hydrologic characteristics for the mountain area conditions are summarized in Table II-1. Required hydrologic characteristics for use in modeling storm water runoff with the Soil Conservation Service Curve Number (CN) and Unit Hydrograph technique include drainage area, Curve Number, and Lag Time.

TABLE II-1
NEFFS CANYON SUBBASIN CHARACTERISTICS FOR MOUNTAIN AREAS

Subbasin ID	Area (Acres)	Area Weighted CN	Lag Time (hr)
Upper Basin	723	63	1.32
Middle Basin	822	67	1.18
Lower Basin	840	66	1.25
SMB1	73	65	0.12
SMB2	235	65	0.16
TOTAL:	2693		

URBAN AREAS

Hydrologic characteristics for urban areas in the model are presented in Table II-2. Urban hydrologic characteristics for use in modeling storm water runoff with the SCS Curve Number and Unit Hydrograph technique include drainage area, percent of the subbasin which is covered by impervious area, percent of the subbasin which is directly connected impervious area, composite curve number representing the portion of the subbasin which includes the pervious area plus the impervious areas which are unconnected (that is runoff off these areas flows across pervious surfaces prior to entering the conveyance system), and time of concentration.

TABLE II-2
NEFFS CANYON SUBBASIN CHARACTERISTICS FOR URBAN AREAS

Subbasin ID	Area (Acres)	% Impervious Area	% Directly Connected Impervious Area	CN Pervious + Unconnected Impervious	Time of Concentration (minutes)
Urb-1	31	32	14	65.6	42
Urb-2	81	35	17	66.0	43
Urb-3	24	38	19	66.6	18
Urb-4	18	38	19	66.5	17
Urb-5	13	32	16	64.8	18
Urb-6	30	45	29	66.0	28
Urb-7	10	42	25	66.3	15
Urb-8	21	53	36	68.0	16
TOTAL:	207				

DESIGN RAINSTORM

Precipitation depth-duration return period information provided in the"Rainfall Intensity Duration Analysis Salt Lake County, Utah" (TRC North American Weather Consultants, 1999) (hereinafter referred to as TRC 1999) and from National Oceanic and Atmospheric Administration Atlas 14 (NOAA 14) found on the website http://hdsc.nws.noaa.gov/hdsc/pfds were compared. The TRC 1999 depth-duration return period maps cover the urban portion of the study area. The following table provides a comparison between the predicted 100-year rainfall depths for the urban area taken from the two sources.

TABLE II-3
COMPARISON OF TRC 1999 AND NOAA 14 RAINFALL DEPTHS (INCHES)
OLYMPUS COVE URBAN AREA

RETURN PERIOD - DURATION	TRC 1999	NOAA 14
100-YEAR 30-MINUTE	1.24	1.49
100-YEAR 1-HOUR	1.62	1.84
100-YEAR 6-HOUR	2.38	2.33
100-YEAR 24-HOUR	3.46	3.53

Because the TRC 1999 depth-duration return period maps do not cover the mountain watersheds, it was decided to use the NOAA 14 data for consistency. 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 Neffs Canyon, Middle Neffs Canyon, Lower Neffs Canyon, and the Urban Area.

Storm Duration Sensitivity Analysis

The storm duration that will produce the highest peak runoff flow rate is dependent on rainfall-duration relationships, the characteristics of the basin, and upon the level of detention storage. Generally speaking, the longer runoff takes to flow through a drainage basin or detention basin, the longer the critical storm duration. A duration sensitivity analysis of the hydrologic study area was performed by successive model runs using 1-hour, 3-hour, 6-hour, 12-hour, and 24-hour storm durations. The 24-hour storm duration was found to produce the largest peak and was used as the basis for Neffs Canyon design flows.

Storm Distribution

Critical runoff events from urban areas along the Wasatch Front are caused by cloudburst type storms, characterized by short periods of high intensity rainfall. 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 based on data from two rainfall gage networks located in central and north-central Utah. These gage networks are referred to as the Great Basin Experimental Area (GBEA) and the Davis County Experimental Watershed (DCEW) respectively. This effort has become the definitive source for rainfall distributions appropriate for the Wasatch Front area. Because this study applied to short duration storms, it was not applied to durations exceeding the 6-hour event.

Thirteen separate gaging stations in the Great Basin Experimental Area (ranging in elevation from 5,500 feet to over 10,000 feet) were maintained for varying periods of time from 1919 to 1965. Fifteen gaging stations were maintained in the Davis County Experimental Watershed (ranging in elevation from 4,350 to 9,000 feet) for varying periods of time between 1939 and 1968. After completing their analyses of the data, Farmer and Fletcher found that "more than 50 percent of the storm rainfall depth occurs in 25 percent of the storm periods;" and that "usually more than half of the total depth of rain is delivered as burst rainfall." Farmer and Fletcher developed design storm distributions which have become accepted by governmental entities including Salt Lake County and Davis County as the characteristic distributions for storms in Utah of short duration (generally less than six hours).

The work of Farmer and Fletcher was expanded in 1985 to develop a 24-hour rainfall distribution from the GBEA data (VHA, 1985). For the derivation of the design 24-hour rainfall event, a storm was defined "as a period of continuous or intermittent precipitation delivering at least 0.1 inches of rainfall during which time dry periods without rainfall did not exceed four hours." Storms having durations ranging from 20 hours to 28 hours were accepted to be representative of a 24-hour storm duration. The 24-hour duration storms were then screened to include only storms which contained rainfall meeting the burst criteria of having over 50 percent of the precipitation occurring in less than 25 percent of the time. Storms meeting the burst criteria were further categorized in accordance with which quartile of the storm the burst had occured (i.e. the first, second, third or fourth quarter of the storm period). Identified storms were used to develop a 24-hour design storm distribution for use in Utah.

A sensitivity analysis for all storm distributions developed shows the 3rd quartile storm distribution to produce the higher runoff peaks. The SCS Type II distribution is an extreme distribution which includes a very intense burst of rainfall with over 35 percent of the 24-hour total rainfall occurring within a half hour. The GBEA 3rd Quartile storm distribution developed in 1985 includes a burst of rainfall with an approximate 10 percent of the 24-hour total rainfall falling within a half hour period. In a similar comparison, the SCS Type II distribution allows approximately 62 percent of the total precipitation to occur within the same period.

Because the distribution was developed based on local data, the GBEA distribution is believed to be the best available storm distribution for Utah for storms lasting between 6 and 24 hours. For the same reason, the Farmer-Fletcher distribution is the best available storm distribution for durations of less than 6 hours. Comparisons of the predicted runoff peaks from the GBEA storm distribution and from the Farmer Fletcher storm distribution reveal good agreement for a 6-hour duration storm.

Aerial Reduction

Aerial reduction factors were applied to the model 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 4.52 square miles which results in an aerial reduction factor of 0.96 or an equivalent precipitation depth reduction of 4% for the 24-hour event. The respective areal reduction amounts shown in Table II-4 were applied to each of the precipitation depths obtained from the NOAA 14 Atlas.

Table II-4
AREAL REDUCTION FACTORS

Storm Duration	Areal Reduction Factor
30-minute	0.82
1-hour	0.86
3-hour	0.91
6-hour	0.93
12-hour	0.95
24-hour	0.96

Rainfall Adjustment

Rainfall is assumed to produce the peak runoff for Neffs Canyon Creek. The NOAA Atlas 14 did not include an update to the May-October rainfall amounts included in NOAA Atlas 2. The precipitation values found in NOAA Atlas 14 are based on the complete data set (full year including snow). In order to predict the rainfall values based on the NOAA Atlas 14, a ratio was calculated using the NOAA Atlas 2 May-October rainfall versus the full year precipitation from NOAA Atlas 2. This ratio was applied to the NOAA Atlas 14 full year precipitation values to produce design storm rainfall amounts. The precipitation values from NOAA 14 with areal and rainfall adjustments are shown in Table II-5.

Table II-5
ADJUSTED PRECIPITATION VALUES FOR 100-YEAR DURATION

Zone	30-min	1-hour	3-hour	6-hour	12-hour	24-hour
Upper Neffs Canyon	1.20	1.58	1.98	2.32	3.10	3.97
Middle Neffs Canyon	1.20	1.56	1.95	2.26	3.01	3.77
Lower Neffs Canyon	1.16	1.51	1.86	2.12	2.74	3.32
Urban Area	1.14	1.49	1.80	2.04	2.60	3.12

TRANSMISSION LOSSES

Transmission losses result from infiltration along the drainage channel reaches and are calculated using methodology presented in the "National Engineering Handbook , Section 4 - Hydrology, Chapter 19 - Transmission Losses." These losses apply to ephemeral streams in semiarid regions typical of the Neffs Canyon area. The losses are calculated using regression equations based on the effective hydraulic conductivity.

A gaining stream is defined as a stream that receives groundwater discharge. The upper reaches of Neffs Canyon upstream of about 7,400 feet and tributary channels were assumed to be gaining, therefore, no losses were applied to those reaches.

DESIGN FLOWS

A storm rainfall runoff model was prepared for the Neffs Canyon watershed using the U.S. Army Corps of Engineers Hydrologic Modeling System (HEC-HMS) software. A summary of the design creek flow rates for a 10-Year and a 100-Year return period (a 100-year return period event has a 1% chance of being equaled or exceeded in any given year) are provided in Table VI-1. A duration sensitivity analysis was performed and the 24-hour storm was found to govern both the 10-year and 100-year events.

Table II-6
NEFFS CANYON CREEK – DESIGN FLOW RATES

Location	Predicted Rainstorm Runoff Flow Rates (cfs)	
	10-Year	100-Year
Canyon Mouth	70	300
Wasatch Blvd	90	350

SNOW MELT

Historical snowmelt peak flows are not available for Neffs Canyon. 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 equations rely on the size of the basin area and the return period for the snowmelt event. Table II-7 gives a summary of expected snowmelt flows at the canyon mouth.

Table II-7
ESTIMATED SNOW MELT FLOW RATES

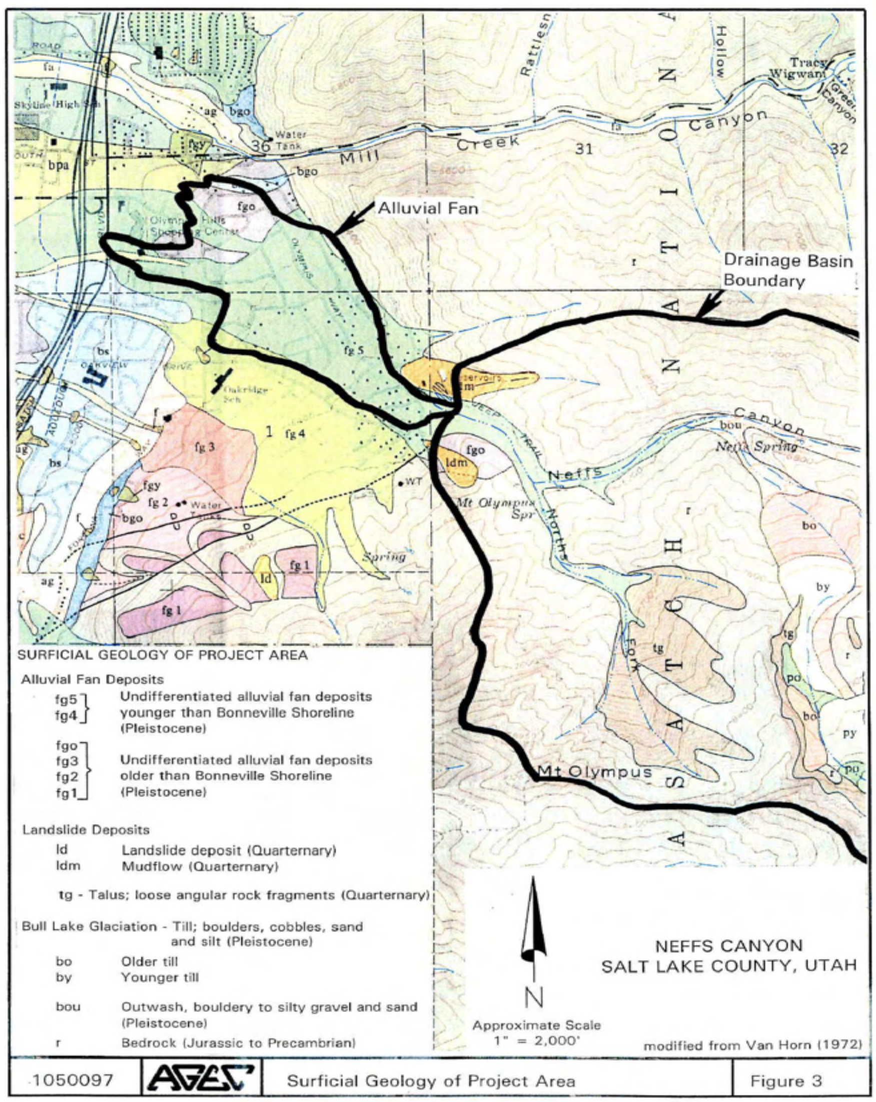
Location	Predicted Snowmelt Flow Rates (cfs)		
	10-Year	50-Year	100-Year
Mouth of Canyon	50	70	75

CHAPTER III

DEBRIS FLOW HAZARD STUDY

An evaluation of the debris flow hazard potential for Neffs Canyon was completed by Applied Geotehcinal Engineering Consultants (AGEC), P.C. (Project No. 1050097, August 10, 2005, see copy on CD in appendix). The debris flow hazard study included a review of geologic literature, an evaluation of aerial photographs, filed reconnaissance, and analysis. AGEC findings are summarized below.

- "The mouth of Neffs Canyon is situated approximately 400 feet above the Bonneville Shoreline. The Neffs Canyon Alluvial fan extends out onto and coalesces with Lake Bonneville deposits."
- "Study of the aerial photographs did not identify discrete debris flow lobes on the fan. However, the distal portion of the fan is irregular in extent, which may be interpreted as a series of discrete flows with variable run-out distances."
- "Personius and Scott (1992) map the area of the Neffs Canyon alluvial fan as af2, which is assigned the age of middle Holocene to uppermost Pleistocene (> 5000 years old)."



- "Landslides typically do not form in limestone and quartzite, which is the bedrock underlying Neffs Canyon, indicating that this debris flow triggering mechanism would be less likely than storm-induced erosion on denuded areas."

- "The southern reaches of the Neffs Canyon drainage basin contain abundant exposed bedrock, which promotes rapid surface-water runoff that could help generate a debris flow. However, these north-facing slopes also contain large areas of dense brush and trees that act to inhibit mobilization of slope colluviaum."

- "The potential for debris flow would be increased if a significant portion of the drainage is burned."

- "Possible geomorphic evidence of past debris flow activity was observed in the lower reach of Norths Fork tributary, where boulder trains and levees were observed between roughly parallel channels on either side of the drainage."

- "... although the lower drainage channel is relatively broad it contains an incised channel that would act to partially confine a debris flow."

- Two methods were used to calculate the potential debris flow volume for each channel segment. The total volume of debris flow calculated is 154,700 cubic yards and 148,200 cubic yards for the different methods.

- "The portion of the Neffs Canyon drainage below approximate elevation 6800 feet has a gradient suggesting deposition rather than erosion and would decrease the volume of sediment reaching the canyon mouth. The potential deposition in this reach is estimated at 13,000 cubic yards."

- "Overall, it is clear from the literature that debris flows have occurred in the past more commonly in Davis County than Salt Lake County. The drainages that produce these events are typically much smaller than Neffs Canyon."

- "The predicted debris flow volumes ... represent an event that occurs over the entire Neffs Canyon drainage basin. The potential for a smaller flow to occur within one of the tributary channels, or within tributary channels in a portion of the canyon, is greater than the potential for debris flows to occur simultaneously within the entire basin. Further, many of these smaller flows may be deposited before reaching the canyon mouth due to the low gradient of the main channel below approximate elevation 6800 feet."

It is difficult to assign a probability to the potential debris flow events. In discussion with the geologist and Salt Lake County, it was decided that taking the average of the predicted debris flow from the largest channel segment, upper Neffs Canyon, [(35,000 + 58,600)/2] = 46,800 cubic yards and subtracting the estimated deposition in the lower reach (13,000 cubic yards) provides an estimated debris flow volume (33,800 cubic yards) which may be an appropriate design volume for facilities with the objective of providing protection to developed ares below the canyon mouth. The design debris flow volume (33,800 cubic yards) is about 21 acre-feet.

CHAPTER IV

EXISTING CONVEYANCE SYSTEM DESCRIPTION AND CAPACITY

The existing Neffs Canyon Creek conveyance system consists of open channels and culverts. The existing channel alignment is shown on Figure IV-1. The conveyance system flows through the Olympus Cove subdivision. The Olympus Cove subdivision was constructed in about 1958. The Forest Service boundary defines the east border of the Olympus Cove subdivision. After development of the subdivision, the area was identified as an active alluvial fan, with significant flood and debris flow risk. This condition is exacerbated because the Neffs Creek low flows currently are delivered to the subdivision from a channel which is higher than the thalweg (lowest part) of the canyon. The higher channel appears to be the result of a past diversion (possibly for irrigation purposes). In places the water elevation in the current channel is significantly higher than the lower thalweg. The alignment of the current channel and the thalweg are shown on Figure IV-2.

The diversion to the current channel from the Neffs Canyon thalweg occurs about 1300 feet east of the homes. The diversion is somewhat fragile and storm runoff often spills into the lower thalweg.

The capacity of the existing conveyance system through the residential area was estimated by surveying the culverts (inlet flow line, outlet flow line, and available headwater elevation at the inlet) and surveying typical channel cross sections. A HEC-RAS model was prepared of the conveyance system and culvert capacities were estimated (see Appendix). Culvert capacities are provided in the following table.

TABLE IV-I
ESTIMATED CAPACITY OF EXISTING CULVERTS

LOCATION	DISTANCE UPSTREAM OF WASATCH Blvd. (feet)	LENGTH (feet)	DIAMETER (feet)	ESTIMATED CAPACITY (CFS)
Zarahemla Dr.	6375	175	2.5	50
Abinadi Rd	5476	59	3	100
Mathews Way	5192	60	4	130
Parkway Dr.	4597	29	3	50
Adonis Dr.	4232	70	3	55
Brockbank Dr.	3543	68	5	230

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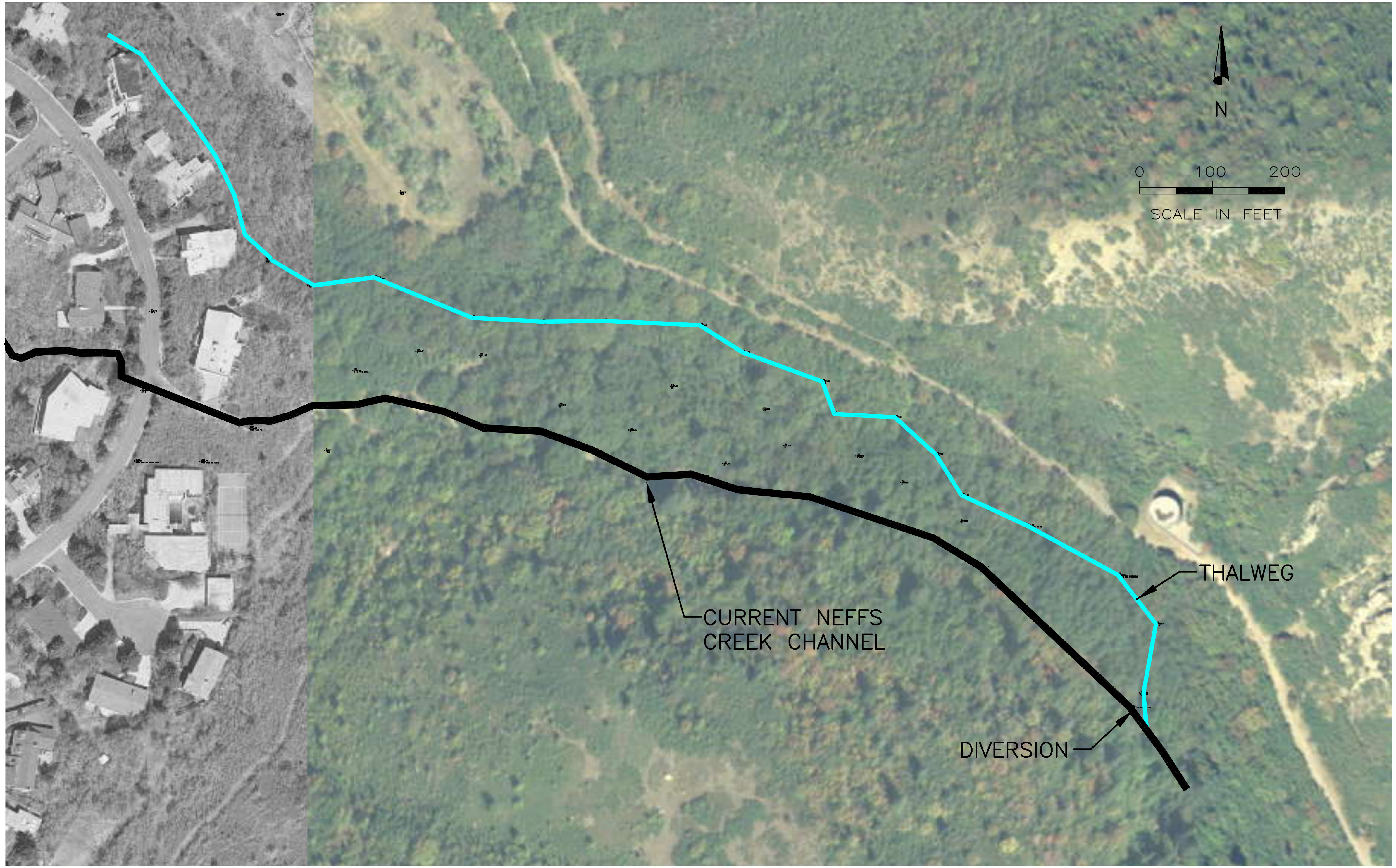
NEFFS CANYON CREEK

EXISTING NEFFS CREEK CHANNEL ALIGNMENT

FIGURE
IV-1



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NEFFS CANYON CREEK

CURRENT NEFFS CHANNEL AND CANYON THALWEG

FIGURE
IV–2

LOCATION	DISTANCE UPSTREAM OF WASATCH Blvd. (feet)	LENGTH (feet)	DIAMETER (feet)	ESTIMATED CAPACITY (CFS)
Neptune Dr.	2505	166	5	160
Jupiter Dr.	2099	93	5	138
Fortuna Way	1408	95	5	140
Achillies Dr.	715	45	5	150

Existing channel capacities vary significantly through the Olympus Cove subdivision. The existing channel between Abinadi Road and Zarahemla Drive has an estimated bank full channel capacity of less than 200 cfs (assuming no backwater effects from the culvert at Abinadi Road). The smallest existing channel capacity is located adjacent to Helaman Circle below Zarahemla Drive and has an estimated bank full capacity of about 120 cfs. The safe carrying capacity is much less than the bank full carrying capacity due to high erosion potential with higher flows on the steep channel slopes. The channel adjacent to Helaman Circle has a safe carrying capacity of less than 70 cfs (due to the risk to a berm).

The channel below Abinadi Road generally has sufficient capacity (in excess of the 100-year event assuming that the backwater effects are eliminated by replacing the culverts), but there is a high erosion potential and risk that the channel will move affecting existing buildings.

CHAPTER V

ALTERNATIVE EVALUATION

A key master plan study objective is to identify means for flood and debris flow hazard mitigation. The Federal Emergency Management Agency in "Guidelines for Determining Flood Hazards on Alluvial Fans" (FEMA, 2000) states: "Active alluvial fan flooding occurs only on alluvial fans and is characterized by flow path uncertainty so great that this uncertainty cannot be set aside in realistic assessments of flood risk or in the reliable mitigation of the hazard." Alternative mitigation methods have been investigated for debris flow and conveyance system flooding.

DEBRIS FLOW MITIGATION ALTERNATIVES

Mitigation measures for debris flows can be categorized into three types: debris basin, deflection, and watershed treatments.

Debris Basin. A debris basin positioned to intercept debris flows prior to reaching the residential area provides an embankment designed to stop the debris flow allowing the soilds portion of the debris flow to deposit in the debris basin and the liquid portion to flow through the basin outlet facilities. Debris basins have been used for years and have provided a reliable means of mitigating debris flow hazards.

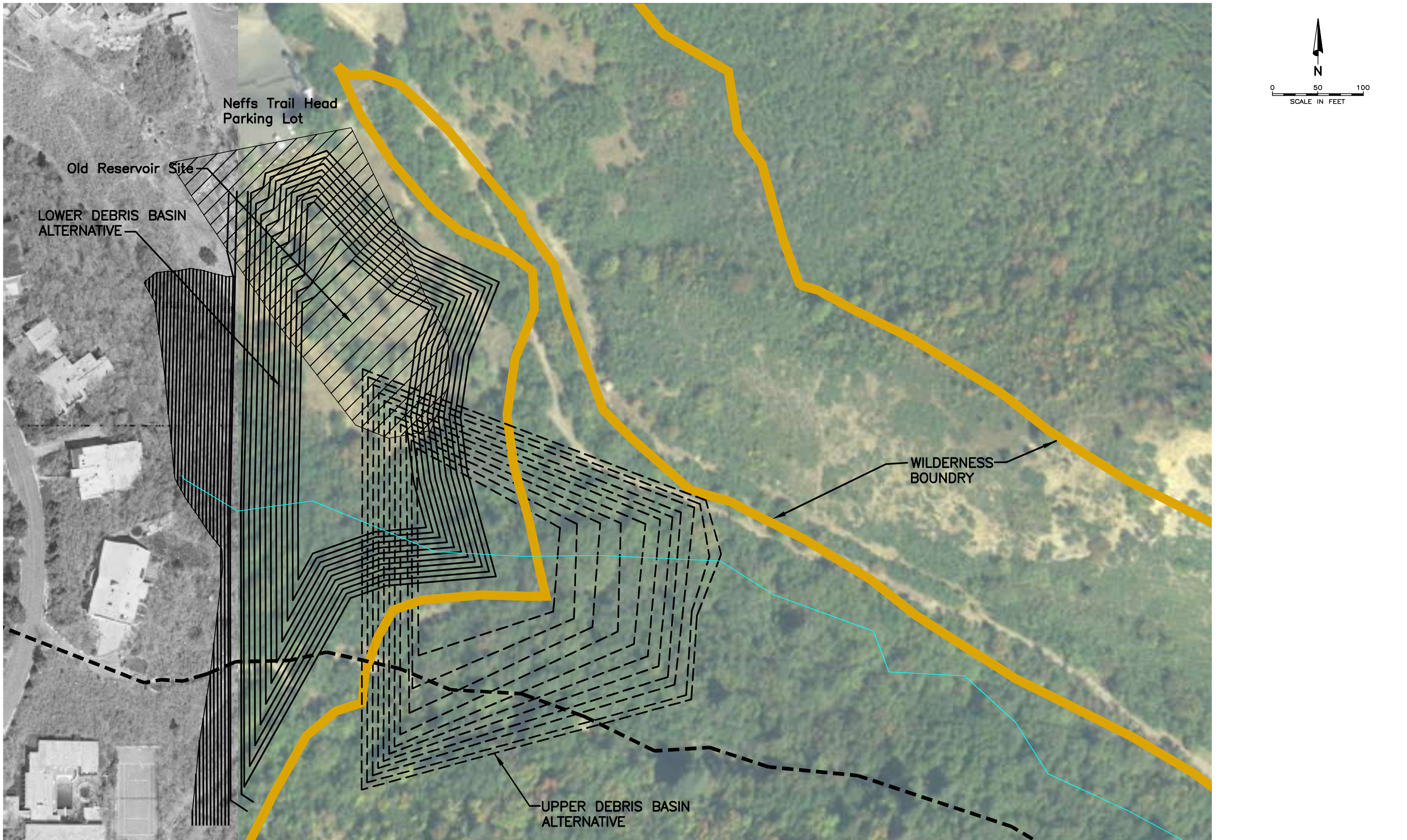
Deflection. Deflection utilizes an armored embankment to deflect debris flows away from homes. A suitable location to receive the deflected debris flows does not exist at the mouth of Neffs Canyon, therefore this alternative was eliminated.

Watershed Treatments. Watershed treatments include several different types of measures which are implemented in the watershed. These measures include construction of temporary measures such as silt fences, organic debris rakes, and matting. More permanent type measures include earth retaining structures to stabilize potential trigger areas. Because these measures would need to be implemented within the designated Wilderness Area, equipment for construction of these treatments would be limited to hand tools. Measures which could be constructed with hand tools would be temporary and not sufficiently durable to provide sufficient debris flow mitigation to remove the homes from the hazard. These measures could be effective in providing short term protection such as during the re-vegetation period after a fire.

Of the debris flow mitigation alternatives, only the debris basin was found to sufficiently reduce the debris flow hazard to the homes.

DEBRIS BASIN ALTERNATIVES

Two alternative debris basin locations have been identified: Upper Debris Basin (located partially in the Wilderness Area), and Lower Debris Basin (located below the Wilderness Area). The alternative debris basin locations are shown on Figure V-1.



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NEFFS CANYON CREEK

ALTERNATE DEBRIS BASIN LOCATIONS

FIGURE
V-1

Upper Debris Basin

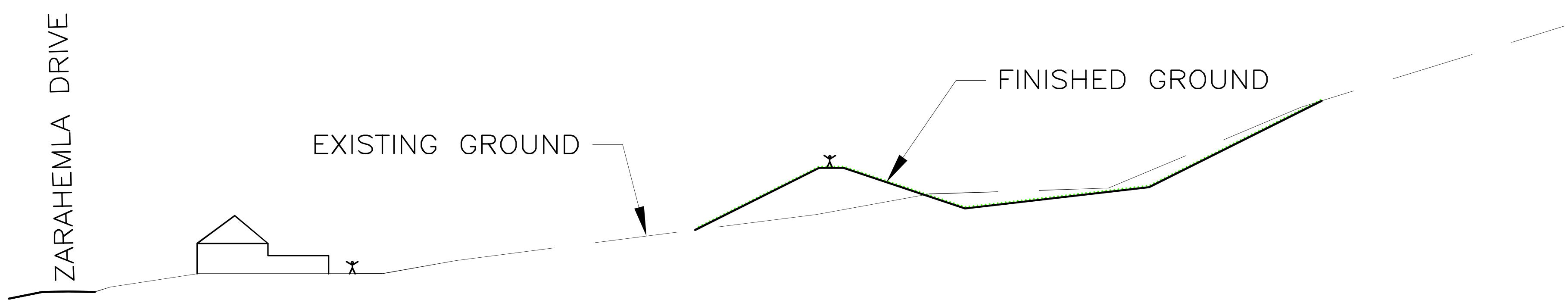
The Upper Debris Basin alternative is located partially within the wilderness area and would conceptually have a top of dam elevation of 5610 feet. For reference, the existing parking lot and the top of the old reservoir embankment are at about 5600 feet. This alternative would allow maintaining a portion of the existing trees between the homes and the embankment. A action of the U.S. Congress would be required to authorize construction and maintenance within the wilderness area. A typical cross section through the Upper Debris Basin is shown on Figure V-2.

Lower Debris Basin

The Lower Debris Basin alternative is located on U.S. Forest Service property between the wilderness area and the homes. The conceptual top of dam elevation is 5595 feet (about five feet lower than the top of the existing old reservoir embankment). A typical cross section through the Lower Debris Basin is shown on Figure V-3.

URBAN AREA FLOOD CONVEYANCE SYSTEM ALTERNATIVES

Conveyance system improvements without the debris basin discussed above are believed to be insufficient to remove the homes from the flood hazard designation. Four alternatives have been identified for improving the conveyance system through the residential area between Zarahemla Drive and Wasatch Blvd. Three of the alternatives (riprap channel, composite channel, and concrete low flow channel) assume that the existing under-capacity culverts (see Table IV-1) are replaced. The fourth alternative replaces the existing culverts and channels with a storm drain pipe. Conceptual cross sections of the alternatives are shown on Figure V-4. The alternatives are compared on Table V-1. An option for the composite channel alternative is included which does not include grade control structures.



UPPER DEBRIS BASIN ALTERNATIVE
CROSS SECTION TAKEN WEST TO EAST

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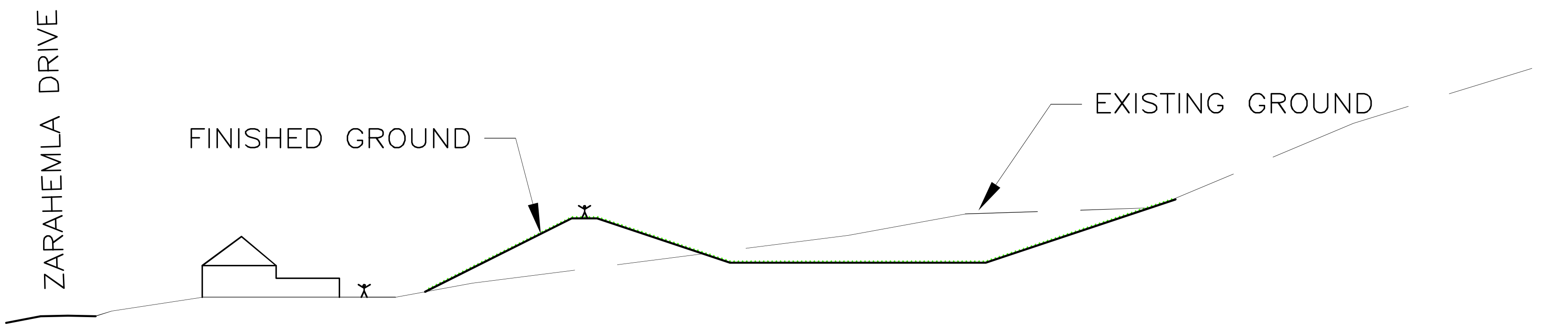
UPPER DEBRIS BASIN ALTERNATIVE

FIGURE V-2



LOWER DEBRIS BASIN ALTERNATIVE
CROSS SECTION TAKEN WEST TO EAST

FILE NAME: 014\10.100\CADFILES\FIGURES\FIG V-3.DWG FILE DATE: 12.17.2007 10:02:42 (JVH)

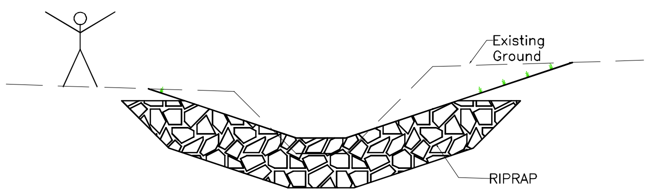
HANSEN ALLEN & LUCE INC ENGINEERS

SALT LAKE COUNTY
NEFFS CANYON CREEK

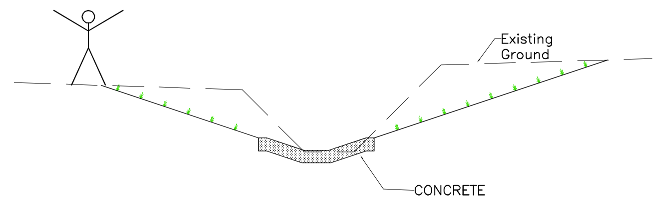
LOWER DEBRIS BASIN ALTERNATIVE

FIGURE V–3

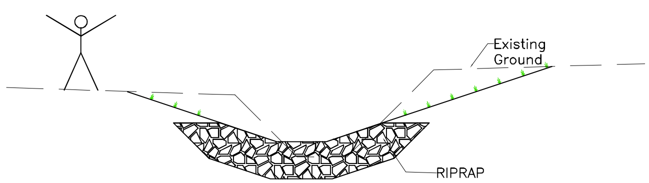
10/07



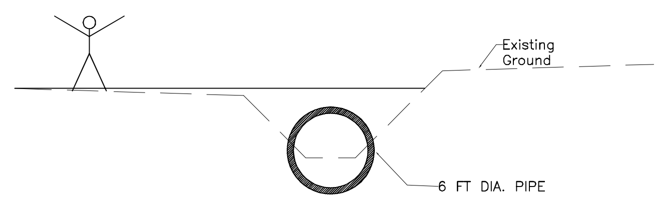
1. RIPRAP CHANNEL



3. CONCRETE LOWFLOW
& GRASS/MATT CHANNEL



2. COMPOSITE
RIPRAP & GRASS/MATT CHANNEL



4. PIPE ALTERNATIVE

FILE DATE:
FILE NAME:
3/04

SALT LAKE COUNTY
NEFFS CANYON CREEK

CONVEYANCE SYSTEM ALTERNATIVES

FIGURE
V—4

TABLE V-1
NEFFS CANYON CREEK
CONVEYANCE ALTERNATIVES COMPARATIVE MATRIX

CONVEYANCE ALTERNATIVE (Description/Location)	DESIGN FLOW & Criteria	COMMENT	COMPARE COST PER FOOT
1. RIPRAP CHANNEL	300 cfs SF=1 70 cfs SF=1.5	Likely the least maintenance costs.	$400
2A. COMPOSITE CHANNEL	50 cfs riprap lowflow 300 cfs w/ SF=1 on matt So = 7.0%, GSBD 5' height	The drops will affect the width of the improvements and will increase potential for conflict with existing structures.	$550
2B. COMPOSITE CHANNEL	50 cfs riprap lowflow Mat side slopes, but no drops	Potential for extensive erosion in higher flows.	$250
3. CONCRETE LOW FLOW CHANNEL with MAT PROTECTED GRASS CHANNEL	50 cfs low flow with concrete channel depth for sequent depth matt lined channel above to total 300 cfs sequent depth	Safety and aesthetics issues. Potential for extensive erosion in higher flows.	$240
4. PIPE ALTERNATIVE	300 cfs; min. depth to pipe flowline = sequent depth	Concerns over maintenance and integrity of pipeline without a debris basin.	$340

Note: The comparative cost per foot does not include costs for elements common to all alternatives. For example the road repair costs are not included and are considered equivalent for all alternatives and therefore not needed to compare conveyance alternatives.

CHAPTER VI

SUMMARY

A key purpose of Salt Lake County Flood Control is to plan drainage improvements to better protect County residents from flooding and bring the system up to the requirements of the federal Flood Insurance Program. An analysis of Neffs Canyon Creek flooding hazard mitigation has been completed for the subdivision located between the mouth of Neffs Canyon and Wasatch Blvd. The analysis and potential mitigation measures are summarized below.

DESIGN FLOWS

A storm rainfall runoff model was prepared for the Neffs Canyon watershed using the U.S. Army Corps of Engineers Hydrologic Modeling System (HEC-HMS) software (please see Chapter II above). A summary of the design creek flow rates for a 10-Year and a 100-Year return period (a 100-year return period event has a 1% chance of being equaled or exceeded in any given year) are provided in Table VI-1. The snow melt flood flows were estimated using regional regression equations (see estimated snow melt flow rates in Table VI-2).

Table VI-1
NEFFS CANYON CREEK – DESIGN FLOW RATES

Location	Predicted Rainstorm Runoff Flow Rates (cfs)	
	10-Year	100-Year
Canyon Mouth	70	300
Wasatch Blvd	90	350

Table VI-2
ESTIMATED SNOW MELT FLOW RATES

Location	Predicted Snowmelt Flow Rates (cfs)		
	10-Year	50-Year	100-Year
Mouth of Canyon	50	70	75

DEBRIS FLOW HAZARD

A debris flow flooding hazard associated with an alluvial fan has been identified for areas located downstream of the mouth of Neffs Canyon (see Chapter III). The design debris flow volume (33,800 cubic yards) is about 21 acre-feet.

EXISTING CONVEYANCE SYSTEM

Neffs Creek low flows currently are delivered to the Olympus Cove subdivision from a channel which is higher than the thalweg (lowest part) of the canyon. The alignment of the current channel and the thalweg are shown on Figure IV-2. The diversion to the current channel from the Neffs Canyon thalweg occurs about 1300 feet east of the homes. The diversion is somewhat fragile and storm runoff often spills into the lower thalweg.

The existing channel and culvert system which conveys Neffs Canyon flood flows through the subdivision to Wasatch Blvd. has capacity for about the 10-year snow melt event (about 50 cfs). There is risk of flooding of homes for events exceeding the 10-year snow melt event. In addition, the existing channel is steep and there is risk of rapid bank erosion during a major event.

DEBRIS FLOW AND FLOODING MITIGATION ALTERNATIVES

The recommended alternative for providing protection to developed areas below the canyon mouth is the construction of a debris basin for a design debris flow volume of 21 acre-feet. Alternative debris basin locations are shown on Figure V-1.

It is recommended that the conveyance system through the subdivision be improved to convey the 100-year flood event. It is recognized that without the debris basin recommended above, flooding risk to homes cannot be mitigated through conveyance system improvements alone.

Proposed Neffs Creek conveyance improvements are shown on Figure VI-1. Alternative channel cross section improvements are discussed in Chapter V (see Figure V-4) with a cost comparison (see Table V-1).

FILE DATE:

FILE NAME:

3/04

HANSEN ALLEN & LUCE inc ENGINEERS

SALT LAKE COUNTY
NEFFS CANYON CREEK

NEFFS CREEK CONVEYANCE IMPROVEMENTS

FIGURE
VI–1

REFERENCES

Farmer, E. E. and Joel E. Fletcher. 1972. *Distribution of Precipitation in Mountainous Areas*. Geilo Symposium, Norway.

National Oceanic and Atmospheric Administration (NOAA) website. 2006. http://hdsc.nws.noaa.gov/hdsc/pfds. Point Precipitation Frequency Estimates for Utah.

National Oceanic and Atmospheric Administration (NOAA). 1972. *NOAA Atlas 2 Precipitation-Frequency Atlas of the Western United States, Volume VI-Utah*.

Natural Resource Conservation Service (NRCS) Website. 2005. http://soildatamart.nrcs.usda.gov/. Soil Survey Geographic (SSURGO) Database for Salt Lake County, Utah.

RS Means. 2007. *Heavy Construction Cost Data*. RS Means Inc. Kingston, MA.

TRC North American Weather Consultants. 1999. "*Rainfall Intensity Duration Analysis Salt Lake County, Utah*"

U.S. Army Corps of Engineers (USACE). 2006. *User's Manual - HEC-HMS Version 3.0.1*. Davis, California.

U.S. Soil Conservation Service (SCS). 1972. *SCS National Engineering Handbook - Section 5 Hydrology*. United States Department of Agriculture, Washington, D.C.

U.S. Soil Conservation Service (SCS). 1986. *Urban Hydrology for Small Watersheds - Technical Release No. 55*. United States Department of Agriculture, Washington, D.C.

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.

thalweg (täl'veg) - The line defining the lowest points along the length of a river bed or valley. A subterranean stream. "The American Heritage® Dictionary of the English Language, Fourth Edition Copyright © 2005, 2000 by Houghton Mifflin Company. Updated 2005."

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.
in	inches
N	North
Q10	peak storm water flow in a 10-year event
Q100	peak storm water flow in a 100-year event
S	South
W	West
w/	with
w/o	without

APPENDIX B
HYDROLOGY

TABLE OF CONTENTS

Top of Neff's Canyon

1/4

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 40.66428 N 111.73556 W 9038 feet
from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 3
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2003
Extracted: Thu Jun 16 2005

Confidence Limits | Seasonality | Location Maps | Other Info. | Grids | Maps | Help | Docs

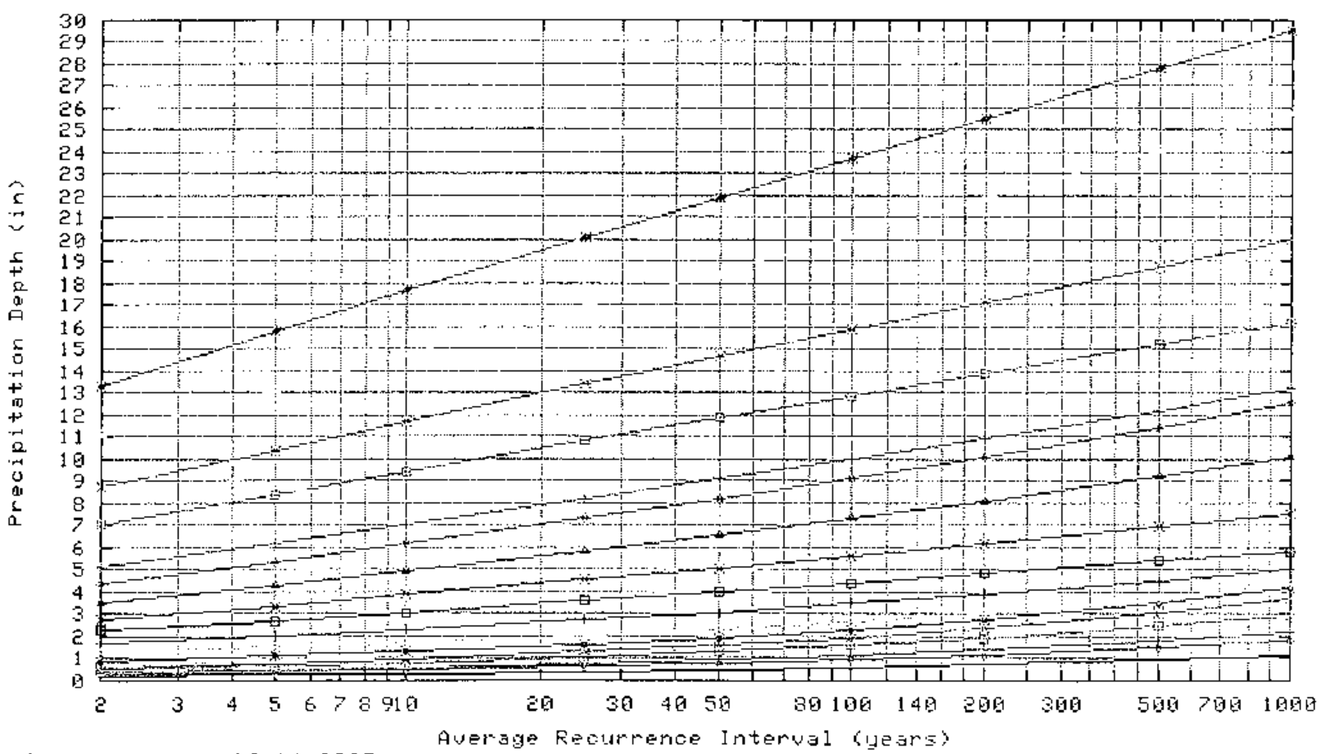
Precipitation Frequency Estimates (inches)

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
2	0.19	0.28	0.35	0.47	0.58	0.76	0.90	1.25	1.67	2.25	2.80	3.52	4.40	5.11	7.04	8.77	11.11	13.33
5	0.25	0.38	0.48	0.64	0.79	0.97	1.11	1.49	1.99	2.70	3.38	4.29	5.36	6.17	8.40	10.42	13.15	15.77
10	0.31	0.48	0.59	0.79	0.98	1.18	1.32	1.71	2.29	3.07	3.86	4.94	6.17	7.04	9.47	11.71	14.79	17.67
25	0.41	0.63	0.78	1.05	1.30	1.52	1.64	2.05	2.73	3.58	4.52	5.86	7.30	8.20	10.85	13.41	16.95	20.11
50	0.51	0.77	0.96	1.29	1.60	1.83	1.94	2.33	3.08	3.98	5.05	6.58	8.19	9.10	11.88	14.68	18.59	21.92
100	0.62	0.94	1.17	1.57	1.95	2.21	2.32	2.65	3.48	4.40	5.59	7.35	9.14	10.02	12.90	15.93	20.24	23.71
200	0.75	1.15	1.42	1.92	2.37	2.66	2.77	3.05	3.90	4.82	6.15	8.14	10.11	10.96	13.91	17.16	21.89	25.48
500	0.97	1.48	1.83	2.47	3.06	3.39	3.51	3.68	4.51	5.39	6.92	9.25	11.47	12.22	15.21	18.77	24.10	27.78
1000	1.18	1.79	2.23	3.00	3.71	4.05	4.19	4.34	5.00	5.84	7.52	10.13	12.56	13.21	16.21	19.98	25.82	29.54

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.

Partial duration based Point Precipitation Frequency Estimates Version: 3
40.66428 N 111.73556 W 9038 ft



Thu Jun 16 12:35:14 2005

Duration
5-min
10-min
15-min
30-min
60-min
3-hr
12-hr
24-hr
48-hr
4-day
7-day
10-day
20-day
30-day
60-day

Middle of Neff's Canyon

2/4

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 40.66848 N 111.753 W 7660 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 3
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2003
Extracted: Thu Jun 16 2005

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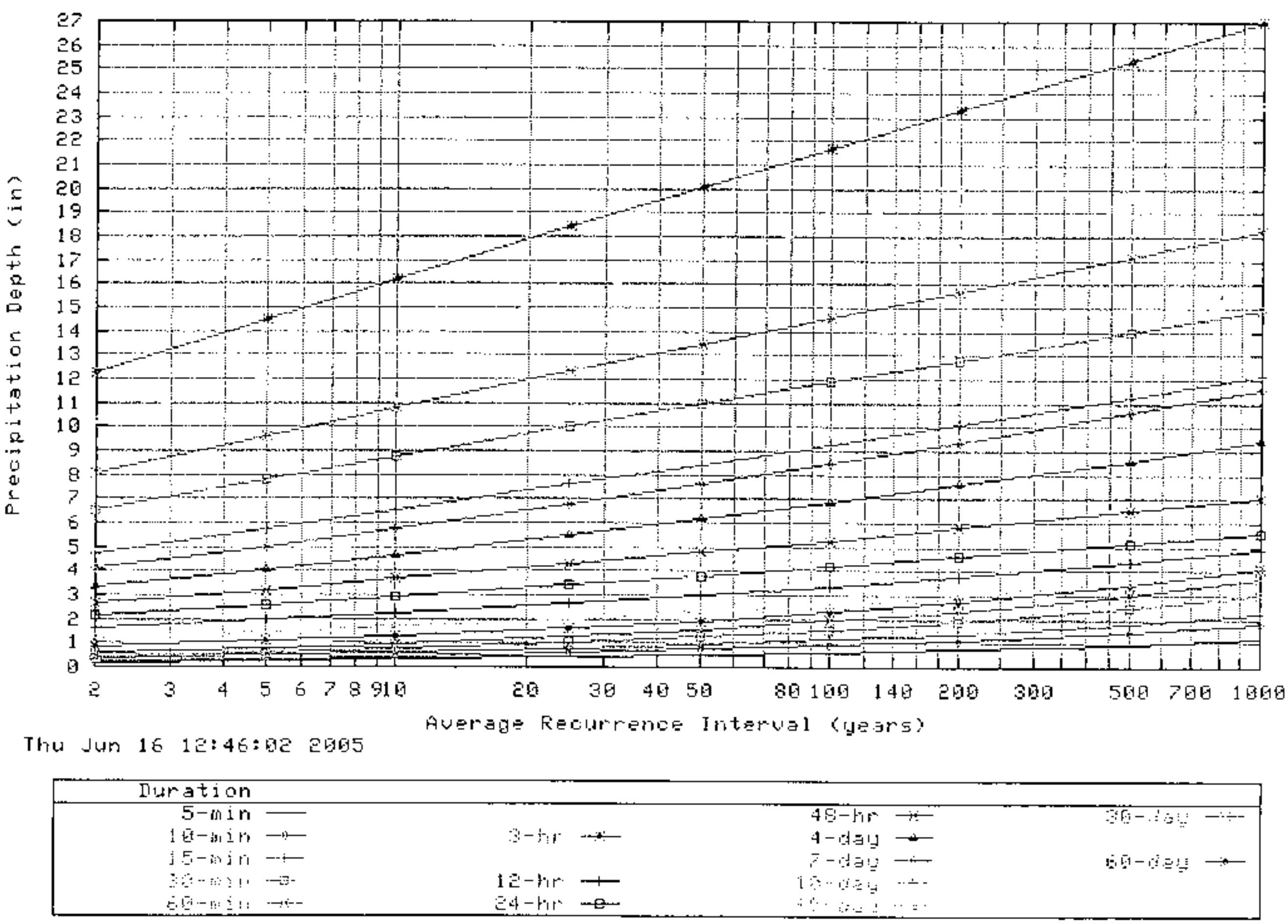
Precipitation Frequency Estimates (inches)

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
2	0.18	0.28	0.35	0.47	0.58	0.75	0.89	1.22	1.61	2.15	2.65	3.31	4.11	4.75	6.52	8.08	10.20	12.24
5	0.25	0.38	0.47	0.64	0.79	0.96	1.09	1.45	1.93	2.57	3.19	4.03	4.99	5.73	7.77	9.59	12.07	14.47
10	0.31	0.47	0.58	0.79	0.97	1.17	1.29	1.68	2.22	2.93	3.65	4.63	5.74	6.53	8.74	10.76	13.57	16.21
25	0.41	0.63	0.78	1.04	1.29	1.50	1.61	2.00	2.64	3.41	4.27	5.48	6.78	7.60	10.01	12.30	15.53	18.44
50	0.50	0.77	0.95	1.28	1.58	1.81	1.90	2.28	2.99	3.79	4.76	6.15	7.60	8.42	10.95	13.46	17.01	20.09
100	0.61	0.94	1.16	1.56	1.93	2.19	2.28	2.59	3.38	4.18	5.26	6.86	8.47	9.27	11.88	14.59	18.51	21.71
200	0.75	1.14	1.41	1.90	2.36	2.63	2.72	2.97	3.79	4.59	5.79	7.59	9.37	10.12	12.80	15.70	20.00	23.31
500	0.97	1.47	1.82	2.46	3.04	3.35	3.45	3.58	4.38	5.13	6.50	8.61	10.61	11.27	13.99	17.15	21.99	25.39
1000	1.17	1.78	2.21	2.98	3.69	4.02	4.12	4.23	4.86	5.55	7.06	9.42	11.59	12.16	14.89	18.23	23.52	26.97

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.

Partial duration based Point Precipitation Frequency Estimates Version: 3
40.66848 N 111.753 W 7660 ft



Bottom of Neff's Canyon

3/4

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 40.67666 N 111.77477 W 5593 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 3
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2003
Extracted: Thu Jun 16 2005

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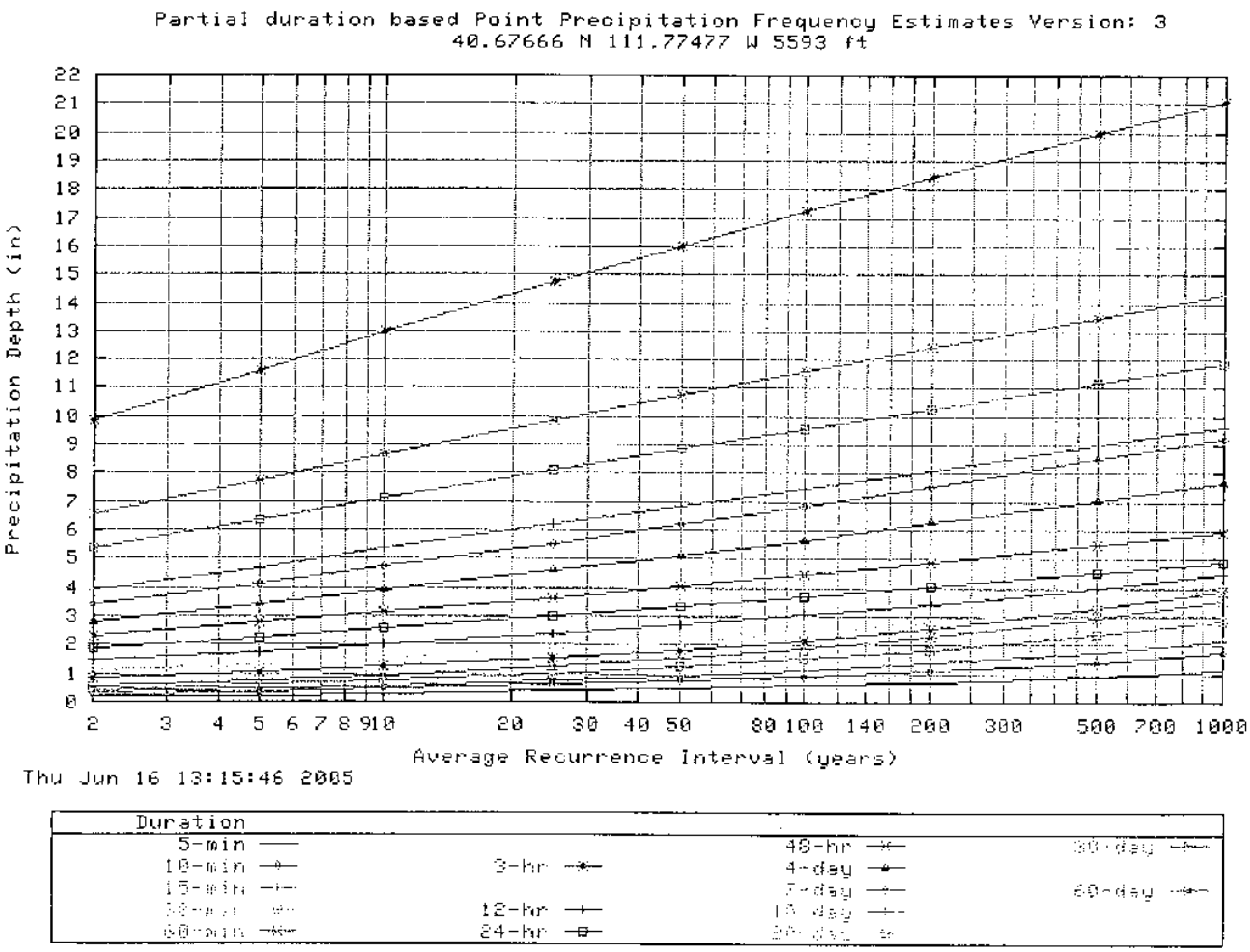
Precipitation Frequency Estimates (inches)

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
2	0.18	0.27	0.33	0.45	0.56	0.71	0.83	1.13	1.46	1.90	2.30	2.81	3.42	3.93	5.35	6.55	8.20	9.87
5	0.24	0.37	0.45	0.61	0.76	0.92	1.03	1.34	1.75	2.27	2.76	3.40	4.14	4.70	6.35	7.74	9.66	11.62
10	0.30	0.45	0.56	0.76	0.94	1.12	1.23	1.55	2.01	2.58	3.14	3.89	4.73	5.34	7.13	8.66	10.83	12.98
25	0.40	0.60	0.75	1.01	1.25	1.44	1.53	1.86	2.40	3.01	3.66	4.58	5.55	6.18	8.13	9.86	12.34	14.72
50	0.49	0.74	0.92	1.24	1.53	1.74	1.80	2.13	2.72	3.34	4.07	5.12	6.20	6.82	8.87	10.74	13.47	15.99
100	0.60	0.91	1.12	1.51	1.87	2.10	2.17	2.42	3.07	3.68	4.49	5.69	6.88	7.47	9.59	11.60	14.59	17.22
200	0.73	1.11	1.37	1.85	2.29	2.53	2.59	2.77	3.45	4.03	4.91	6.26	7.56	8.13	10.30	12.44	15.69	18.43
500	0.94	1.43	1.77	2.38	2.95	3.23	3.29	3.34	3.99	4.51	5.49	7.07	8.51	8.99	11.19	13.51	17.12	19.96
1000	1.14	1.73	2.15	2.89	3.58	3.87	3.93	3.97	4.44	4.87	5.93	7.69	9.25	9.64	11.85	14.29	18.20	21.09

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 of Urban Area (Below Neff's Canyon)

4/4

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 40.67949 N 111.78674 W 5180 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 3
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2003
Extracted: Fri May 6 2005

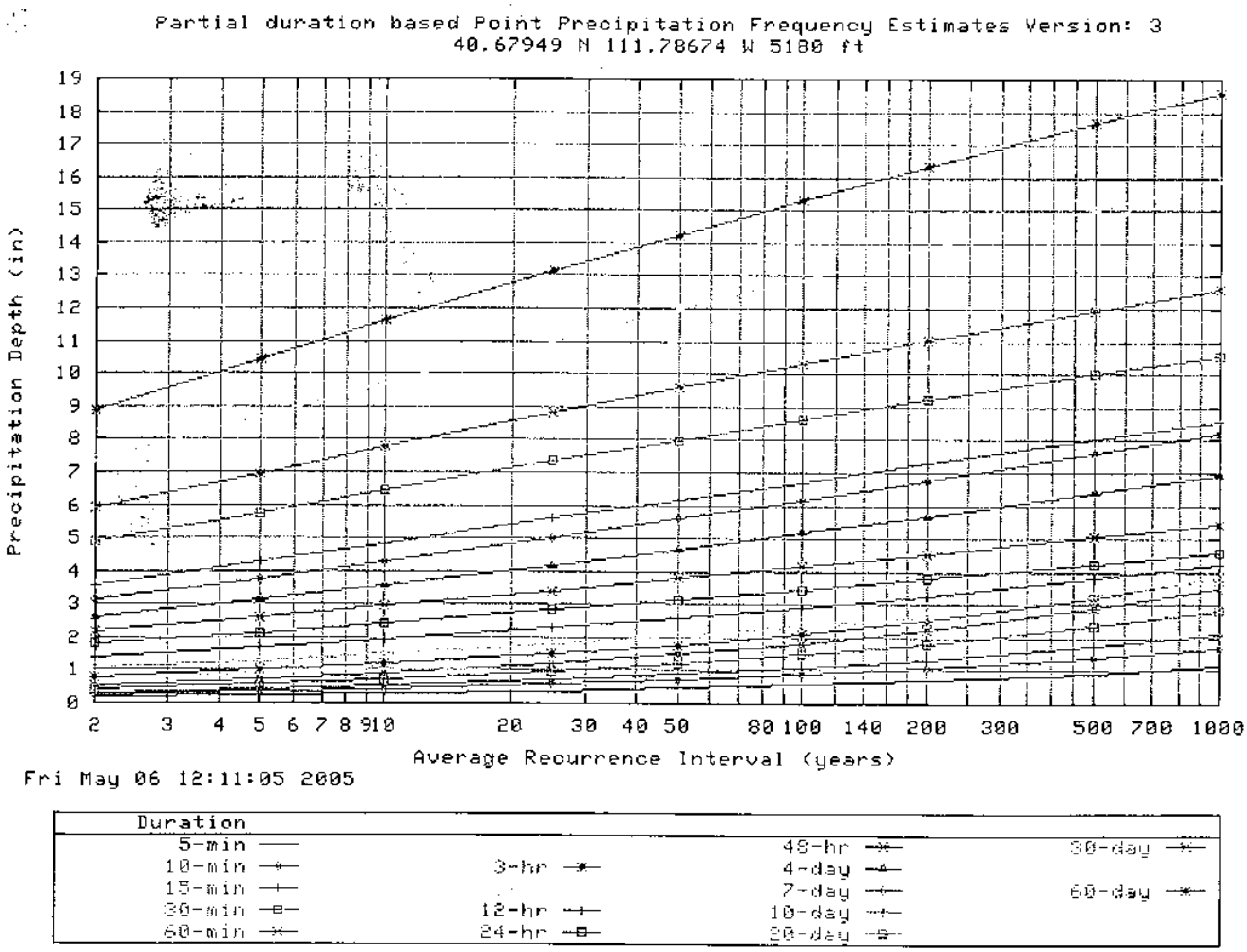
Confidence Limits | Seasonality | Location Maps | Other Info. | Grids | Maps | Help | Docs

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
2	0.17	0.26	0.32	0.44	0.54	0.70	0.81	1.08	1.38	1.79	2.16	2.60	3.13	3.58	4.86	5.91	7.36	8.87
5	0.23	0.36	0.44	0.59	0.74	0.90	1.00	1.29	1.66	2.14	2.58	3.13	3.77	4.27	5.76	6.96	8.66	10.43
10	0.29	0.44	0.55	0.74	0.92	1.09	1.19	1.49	1.91	2.43	2.93	3.57	4.30	4.84	6.44	7.77	9.68	11.63
25	0.39	0.59	0.73	0.99	1.22	1.41	1.49	1.79	2.28	2.83	3.40	4.19	5.02	5.58	7.33	8.81	11.00	13.16
50	0.48	0.73	0.90	1.21	1.50	1.70	1.76	2.04	2.58	3.14	3.78	4.67	5.59	6.14	7.98	9.59	11.97	14.26
100	0.58	0.89	1.10	1.49	1.84	2.06	2.11	2.33	2.92	3.46	4.15	5.17	6.18	6.71	8.62	10.33	12.93	15.33
200	0.71	1.08	1.34	1.81	2.24	2.48	2.53	2.68	3.27	3.79	4.53	5.68	6.78	7.27	9.22	11.04	13.86	16.36
500	0.92	1.40	1.74	2.34	2.90	3.17	3.21	3.25	3.80	4.23	5.05	6.39	7.59	8.01	9.99	11.94	15.04	17.65
1000	1.12	1.70	2.11	2.84	3.51	3.80	3.84	3.85	4.23	4.57	5.45	6.93	8.22	8.56	10.55	12.59	15.91	18.58

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.



PRECIPITATION VALUES FOR NEFFS CANYON FROM NOAA ATLAS II
GJP 2006

ANNUAL DATA SERIES
UPPER NEFFS CANYON

Return Period (Years)	6 (hr)	24 (hr)
10	1.80	3.00
100	2.60	4.40

CENTRAL NEFFS CANYON

Return Period (Years)	6 (hr)	24 (hr)
10	1.79	2.90
100	2.55	4.21

LOWER NEFFS CANYON

Return Period (Years)	6 (hr)	24 (hr)
10	1.70	2.80
100	2.45	4.05

SEASONAL (MAY - OCT) DATA SERIES
UPPER NEFFS CANYON

Return Period (Years)	6 (hr)	24 (hr)
10	1.60	2.60
100	2.40	4.00

CENTRAL NEFFS CANYON

Return Period (Years)	6 (hr)	24 (hr)
10	1.60	2.58
100	2.30	3.90

LOWER NEFFS CANYON

Return Period (Years)	6 (hr)	24 (hr)
10	1.51	2.40
100	2.25	3.80

RATIO SEASONAL/ANNUAL
UPPER NEFFS CANYON

Return Period (Years)	6 (hr)	24 (hr)
10	0.89	0.87
100	0.92	0.91

CENTRAL NEFFS CANYON

Return Period (Years)	6 (hr)	24 (hr)
10	0.89	0.89
100	0.90	0.93

LOWER NEFFS CANYON

Return Period (Years)	6 (hr)	24 (hr)
10	0.89	0.86
100	0.92	0.94

Summary: Ratio seasonal/annual varies from 0.90 to 0.94 for 100-year; and 0.86 to 0.89 for 10-year.
Conclusion: Use a factor of 0.94 for 100-year and 0.89 for 10-year.

NOAA 14 DATA ADJUSTED FOR SEASONAL AND AREAL REDUCTION

Seasonal adjustment 0.94
Areal reduction See Areal Reduction Sheet

Precipitation Zones and Depths for 100-year Storm Event

Zone	30 min (in)	1 hr (in)	3 hr (in)	6 hr (in)	12 hr (in)	24 hr (in)
Upper Neffs Canyon	1.20	1.58	1.98	2.32	3.10	3.97
Middle Neffs Canyon	1.20	1.56	1.95	2.26	3.01	3.77
Lower Neffs Canyon	1.16	1.51	1.86	2.12	2.74	3.32
Urban	1.14	1.49	1.80	2.04	2.60	3.12

Seasonal adjustment 0.89
Areal reduction See Areal Reduction Sheet

Precipitation Zones and Depths for 10-year Storm Event

Zone	30 min (in)	1 hr (in)	3 hr (in)	6 hr (in)	12 hr (in)	24 hr (in)
Upper Neffs Canyon	0.57	0.75	1.07	1.42	1.93	2.62
Middle Neffs Canyon	0.57	0.74	1.04	1.39	1.87	2.50
Lower Neffs Canyon	0.55	0.72	1.00	1.28	1.70	2.20
Urban	0.54	0.70	0.96	1.23	1.61	2.08

AREAL REDUCTION
Calculated by GLJ on 3/10/2006

Based on the Salt Lake Hydrology Model

Total Area **4.54** mi^2

Duration	Areal Reduction
30-min	0.82
1-hr	0.86
3-hr	0.91
6-hr	0.93
12-hr	0.95
24-hr	0.96

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Neff's Canyon Mountain Watershed Curve Number Summary
Computed - GLJ
July 26, 2005

Lower Basin

SOILTYPE	GROUP	VEGETATION	CONDITION	CN	AREA_ACRES	RATIO	COMPOSITE CN
Dromedary-Rock Outcrop Complex, 30 to 70%	D	Pinyon-Juniper	Good	71	235.491	0.280	19.9
Fewkes-Hades Complex, 30 to 60% Slopes	C	Oak-Aspen	Fair	57	41.152	0.049	2.8
ParkCity-Dromedary Gravelly Loams, 30 to 70%	B	Pinyon-Juniper	Good	41	158.983	0.189	7.8
Rock Outcrop	D	Herbaceous	Poor	93	29.818	0.035	3.3
Horrocks-Cutoff Complex, 15 to 30%	B	Oak-Aspen	Fair	48	31.371	0.037	1.8
Hades-Agassiz-Rock Outcrop Complex, 30 to 70%	D	Pinyon-Juniper	Good	71	34.739	0.041	2.9
Rock Outcrop	D	Herbaceous	Poor	93	99.873	0.119	11.1
Rock Outcrop	D	Oak-Aspen	Fair	63	76.552	0.091	5.7
Agassiz-Rock Outcrop Complex, 30 to 70% Slopes	D	Oak-Aspen	Fair	63	32.182	0.038	2.4
Agassiz-Rock Outcrop Complex, 30 to 70% Slopes	D	Oak-Aspen	Poor	79	22.990	0.027	2.2
Agassiz-Rock Outcrop Complex, 30 to 70% Slopes	D	Oak-Aspen	Fair	63	77.133	0.092	5.8
				TOTAL	840.284	1.000	65.6

Middle Basin

SOILTYPE	GROUP	VEGETATION	CONDITION	CN	AREA_ACRES	RATIO	COMPOSITE CN
Hades-Agassiz-Rock Outcrop Complex, 30 to 70%	D	Oak-Aspen	Fair	63	97.039	0.118003	7.4
Dromedary-Rock Outcrop Complex, 30 to 70%	D	Pinyon-Juniper	Good	71	191.104	0.232389	16.5
ParkCity-Dromedary Gravelly Loams, 30 to 70%	B	Pinyon-Juniper	Good	41	239.543	0.291292	11.9
Rock Outcrop	D	Herbaceous	Poor	93	199.488	0.242584	22.6
Dromedary-Rock Outcrop Complex, 30 to 70%	D	Oak-Aspen	Fair	63	1.729	0.002103	0.1
Agassiz-Rock Outcrop Complex, 30 to 70% Slopes	D	Oak-Aspen	Poor	79	40.187	0.048869	3.9
Agassiz-Rock Outcrop Complex, 30 to 70% Slopes	D	Oak-Aspen	Fair	63	52.972	0.064416	4.1
				TOTAL	822.062	1.000	66.5

Upper Basin

SOILTYPE	GROUP	VEGETATION	CONDITION	CN	AREA_ACRES	RATIO	COMPOSITE CN
Hades-Agassiz-Rock Outcrop Complex, 30 to 70%	D	Oak-Aspen	Fair	63	89.693	0.124003	7.8
ParkCity-Dromedary Gravelly Loams, 30 to 70%	B	Pinyon-Juniper	Good	41	243.009	0.335966	13.8
Rock Outcrop	D	Herbaceous	Poor	93	184.889	0.255614	23.8
Rock Outcrop - Starley Family Complex, 30 to 70%	D	Oak-Aspen	Fair	63	198.614	0.274589	17.3
Dromedary-Rock Outcrop Complex, 30 to 70%	D	Oak-Aspen	Fair	63	3.812	0.005270	0.3
Dromedary-Rock Outcrop Complex, 30 to 70%	D	Oak-Aspen	Fair	63	1.183	0.001636	0.1
Dromedary-Rock Outcrop Complex, 30 to 70%	D	Oak-Aspen	Fair	63	0.901	0.001246	0.1
Dromedary-Rock Outcrop Complex, 30 to 70%	D	Oak-Aspen	Fair	63	1.213	0.001677	0.1
				TOTAL	723.314	1.000	63.3

Regression Equation — $Lag = .0051 \times width^{.594} \times slope^{-.15} \times S_{nat}^{.313}$

$width = \frac{\text{Watershed Area}}{\text{Watershed Length}}$

$Slope = \frac{\text{max Elev. dif}}{\text{longest flow path}}$

$S_{nat} = \frac{1000}{CN} - 10$

From "Lag Time Characteristics for Small Watersheds in the U.S."

by M.J. Simas & R.H. Hawkins

Lower Basin —

Watershed Area = 36,610,472.3 ft²
Watershed Length = 10,850 ft

$Width = \frac{Area}{Length} = 3,374 \text{ ft}$

$Slope = \frac{9400 - 5560}{10,850} = .35 \text{ ft/ft}$

$S_{nat} = \frac{1,000}{65.6} - 10 = 5.2 \text{ in}$

$Lag = .0051 \times 3,374^{.594} \times .35^{-.15} \times 5.2^{.313}$

= 1.24 hours

= **74.8 minutes**

Middle Basin:

Watershed Area = 35,823,659.2 ft²
Watershed length = 11,800 ft

$$Width = \frac{Area}{Length} = 3036 \text{ ft}$$

$$Slope = \frac{9,770 - 6,100}{11,800} = .31 \text{ ft/ft}$$

$$S_{nat} = \frac{1000}{66.5} - 10 = 5.04 \text{ in}$$

$$Lag = .0051 \times 3,036^{.594} \times .31^{-.15} \times 5.04^{.313}$$

$= 1.18$ hrs

= **70.9 minutes**

Upper Basin:

Watershed Area = 31507800.6 ft²
Watershed length = 9,400 ft

$$Width = \frac{Area}{Length} = 3,352 \text{ ft}$$

$$Slope = \frac{9,660 - 6,840}{9,400} = .30 \text{ ft/ft}$$

$$S_{nat} = \frac{1000}{63.3} - 10 = 5.8 \text{ in}$$

$$Lag = .0051 \times 3,352^{.594} \times .30^{-.15} \times 5.8^{.313}$$

$= 1.32$ hrs

= **78.9 minutes**

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Transmission Losses @ Bottom of Neffs Canyon
100 Year - 24 Hour Event

"National Engineering Handbook", Section 4 - Hydrology, Chapter 19 - Transmission Losses

D = duration (hours)
P = inflow volume (acre-feet)

a(D) = -0.00465KD
k(D,P) = -1.09ln[1.0 - 0.0545KD/P]

D = 24 Hours   P = 156.92 acre-feet
K = 4 in/hr

a = -0.44640 acre-feet
k = 0.003640 $(\text{ft-mi})^{-1}$

b = regression slope for unit channel

b = 0.996366

$b(x,w) = e^{-kxw}$

x = length of reach (miles)
w = average width of flow (feet)

x = 2 miles
w = 10 feet

b(x,w) = 0.930

a(x,w) = a / 1 - b [1-b(x,w)]

a(x,w) = -8.63 acre-feet

$P_o(x,w) = -a(x,w)/b(x,w)$

P_o = 9.28 acre-feet

P = inflow volume (acre-feet)

P = 156.92 acre-feet

Q(x,w) = 137.3 acre-feet

q(x,w) = 12.1/D*(a(x,w) - [1-b(x,w)]P) + b(x,w)p
p = peak rate of inflow (cfs)

p = 335 cfs

q(x,w) = **302** cfs

The losses in cfs per 1000 feet of reach length

L = 3.17 cfs/1000ft

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SALT LAKE COUNTY
NEFFS CANYON CREEK MASTER PLAN
URBAN SUBBASINS
Time of Concentration

	SHEET FLOW						SHALLOW CONCENTRATED FLOW				CHANNEL FLOW					TIME	Tlag
	L	S (ft/ft)	n	P2	Tt (hrs)	Tt (min)	L	S (ft/ft)	V (fps)	T (min)	L	S (ft/ft)	N	V (fps)	T (min)	OF C (MIN	(minutes)
Urb-1	400	0.16	0.4	1.79	0.63	37.5	0				2200	0.13	0.016	9	4.1	41.6	25.0
Urb-2	400	0.16	0.4	1.79	0.63	37.5	0				2700	0.11	0.016	8	5.6	43.2	25.9
Urb-3	250	0.26	0.24	1.79	0.24	14.2	0				1700	0.12	0.016	8.5	3.3	17.5	10.5
Urb-4	400	0.16	0.13	1.79	0.25	15.3	0				413	0.02	0.016	4	1.7	17.0	10.2
Urb-5	400	0.15	0.13	1.79	0.26	15.8	0				405	0.01	0.016	3	2.3	18.1	10.8
Urb-6	400	0.15	0.24	1.79	0.43	25.8	0				960	0.06	0.016	7	2.3	28.1	16.9
Urb-7	224	0.13	0.13	1.79	0.18	10.7	175	0.11	6.5	0.448718	2000	0.05	0.04	8.5	3.9	15.0	9.0
Urb-8	244	0.11	0.13	1.79	0.20	12.2	0				1430	0.07	0.016	7	3.4	15.6	9.4

KINEMATIC WAVE PARAMETERS

	PLANE 2 - Imp & Unnconected			% of Area	PLANE 1 - Directly C		% of Area	SubCollector				Collector					
	L	S (ft/ft)			L	S (ft/ft)		L	S (ft/ft)	% Area		L	S (ft/ft)		b	z	n
Urb-1	400	0.16	0.4	86.1%	30	0.035	13.9%	900	0.10	0.33	0.015984	900	0.11	channel	4	2	0.04
Urb-2	400	0.16	0.4	83.2%	30	0.035	16.8%	1300	0.06	0.166667	0.021094	1700	0.1	road	2	50	0.016
Urb-3	250	0.26	0.24	80.9%	30	0.035	19.1%	1000	0.06	0.333333	0.0125	900	0.1		2	50	0.016
Urb-4	400	0.16	0.13	80.6%	30	0.035	19.4%	800	0.11	0.4	0.01125	400	0.04		2	50	0.016
Urb-5	400	0.15	0.13	84.1%	30	0.035	15.9%	800	0.11	0.4	0.008125	600	0.05		2	50	0.016
Urb-6	400	0.15	0.24	71.1%	200	0.065	28.9%					1400	0.1		2	50	0.016
Urb-7	224	0.13	0.13	74.9%	30	0.035	25.1%					1000	0.07		2	50	0.016
Urb-8	244	0.11	0.13	64.3%	30	0.035	35.7%	300	0.015	0.5	0.016406	1300	0.07		2	50	0.016

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SALT LAKE COUNTY
NEFFS CANYON CREEK MASTER PLAN
URBAN SUBBASINS

	AREA (sq miles)	AREA	No. of Homes		Units/Acre	% Impervi	Impervious Are	OVERALL Composite CN	DIRECTLY CONNECTED ROADS	DIRECTLY CONNECTED LOTS	DIRECTLY Connected Imper (acres)	% Directly Cc	UnConnec Impervious (acres)	Area Perv + unconnected	Pervious + Unconnected COMPOSITE CN
Urb-1	0.0484	31	41		1.32	32	9.92	70.1	2.7	2.4	4.3	13.9%	5.6	26.7	65.6
Urb-2	0.1266	81	137		1.69	35	28.35	71.4	5.7	7.9	13.6	16.8%	14.8	67.4	66.0
Urb-3	0.0375	24	45		1.88	38	9.12	72.6	2.0	2.6	4.6	19.1%	4.5	19.4	66.6
Urb-4	0.0281	18	34		1.89	38	6.84	72.6	1.5	2.0	3.5	19.4%	3.4	14.5	66.5
Urb-5	0.0203	13	17		1.31	32	4.16	70.1	1.1	1.0	2.1	15.9%	2.1	10.9	64.8
Urb-6	0.0469	30	29	+ school &	0.97	44.6	13.4	75.3	2.3	6.4	8.7	28.9%	4.7	21.3	66.0
Urb-7	0.0156	10	26		2.60	42	4.2	74.2	1.0	1.5	2.5	25.1%	1.7	7.5	66.3
Urb-8	0.0328	21	81		3.86	53	11.13	78.7	2.8	4.6	7.5	35.7%	3.6	13.5	68.0

school	103879.5	29497.77	3.06192	impervious acres
church		122402.15	2.80997	impervious acres

SOILS

		HSGroup	
SP	Stony terrace escarpments	na	
HWF	Horrocks extremely stony loam	C	soils are mostly HWF, therefore use C
HHF	Harkers soils	D	

Pervious Area Cover

Oak-Aspen, Type C, Good coı	CN=	57
Impervious	CN=	98

SALT LAKE COUNTY
NEFFS CANYON CREEK MASTER PLAN
URBAN SUBBASINS
Time of Concentration

	SHEET FLOW						SHALLOW CONCENTRATED FLOW				CHANNEL FLOW					TIME	Tlag
	L	S (ft/ft)	n	P2	Tt (hrs)	Tt (min)	L	S (ft/ft)	V (fps)	T (min)	L	S (ft/ft)	N	V (fps)	T (min)	OF C (MIN	(minutes)
Urb-1	400	0.16	0.4	1.79	0.63	37.5	0				2200	0.13	0.016	9	4.1	41.6	25.0
Urb-2	400	0.16	0.4	1.79	0.63	37.5	0				2700	0.11	0.016	8	5.6	43.2	25.9
Urb-3	250	0.26	0.24	1.79	0.24	14.2	0				1700	0.12	0.016	8.5	3.3	17.5	10.5
Urb-4	400	0.16	0.13	1.79	0.25	15.3	0				413	0.02	0.016	4	1.7	17.0	10.2
Urb-5	400	0.15	0.13	1.79	0.26	15.8	0				405	0.01	0.016	3	2.3	18.1	10.8
Urb-6	400	0.15	0.24	1.79	0.43	25.8	0				960	0.06	0.016	7	2.3	28.1	16.9
Urb-7	224	0.13	0.13	1.79	0.18	10.7	175	0.11	6.5	0.448718	2000	0.05	0.04	8.5	3.9	15.0	9.0
Urb-8	244	0.11	0.13	1.79	0.20	12.2	0				1430	0.07	0.016	7	3.4	15.6	9.4

KINEMATIC WAVE PARAMETERS

	PLANE 2 - Imp & Unnconected			% of Area	PLANE 1 - Directly C		% of Area	SubCollector				Collector					
	L	S (ft/ft)			L	S (ft/ft)		L	S (ft/ft)	% Area		L	S (ft/ft)		b	z	n
Urb-1	400	0.16	0.4	86.1%	30	0.035	13.9%	900	0.10	0.33	0.015984	900	0.11	channel	4	2	0.04
Urb-2	400	0.16	0.4	83.2%	30	0.035	16.8%	1300	0.06	0.166667	0.021094	1700	0.1	road	2	50	0.016
Urb-3	250	0.26	0.24	80.9%	30	0.035	19.1%	1000	0.06	0.333333	0.0125	900	0.1		2	50	0.016
Urb-4	400	0.16	0.13	80.6%	30	0.035	19.4%	800	0.11	0.4	0.01125	400	0.04		2	50	0.016
Urb-5	400	0.15	0.13	84.1%	30	0.035	15.9%	800	0.11	0.4	0.008125	600	0.05		2	50	0.016
Urb-6	400	0.15	0.24	71.1%	200	0.065	28.9%					1400	0.1		2	50	0.016
Urb-7	224	0.13	0.13	74.9%	30	0.035	25.1%					1000	0.07		2	50	0.016
Urb-8	244	0.11	0.13	64.3%	30	0.035	35.7%	300	0.015	0.5	0.016406	1300	0.07		2	50	0.016

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SALT LAKE COUNTY
NEFFS CANYON CREEK MASTER PLAN
URBAN SUBBASINS

	AREA (sq miles)	AREA	No. of Homes		Units/Acre	% Impervi	Impervious Are	OVERALL Composite CN	DIRECTLY CONNECTED ROADS	LOTS	DIRECTLY Connected Imper (acres)	% Directly Co	UnConnec Impervious (acres)	Area Perv + unconnected	Pervious + COMPOSI
Urb-1	0.0484	31	41		1.32	32	9.92	70.1	2.7	2.4	4.3	13.9%	5.6	26.7	65.6
Urb-2	0.1266	81	137		1.69	35	28.35	71.4	5.7	7.9	13.6	16.8%	14.8	67.4	66.0
Urb-3	0.0375	24	45		1.88	38	9.12	72.6	2.0	2.6	4.6	19.1%	4.5	19.4	66.6
Urb-4	0.0281	18	34		1.89	38	6.84	72.6	1.5	2.0	3.5	19.4%	3.4	14.5	66.5
Urb-5	0.0203	13	17		1.31	32	4.16	70.1	1.1	1.0	2.1	15.9%	2.1	10.9	64.8
Urb-6	0.0469	30	29	+ school &	0.97	44.6	13.4	75.3	2.3	6.4	8.7	28.9%	4.7	21.3	66.0
Urb-7	0.0156	10	26		2.60	42	4.2	74.2	1.0	1.5	2.5	25.1%	1.7	7.5	66.3
Urb-8	0.0328	21	81		3.86	53	11.13	78.7	2.8	4.6	7.5	35.7%	3.6	13.5	68.0

school	103879.5	29497.77	3.06192	impervious acres
church		122402.15	2.80997	impervious acres

SOILS

		HSGroup	
SP	Stony terrace escarpments	na	
HWF	Horrocks extremely stony loam	C	soils are mostly HWF, therefore use C
HHF	Harkers soils	D	

Pervious Area Cover

Oak-Aspen, Type C, Good co	CN=	57
Impervious	CN=	98

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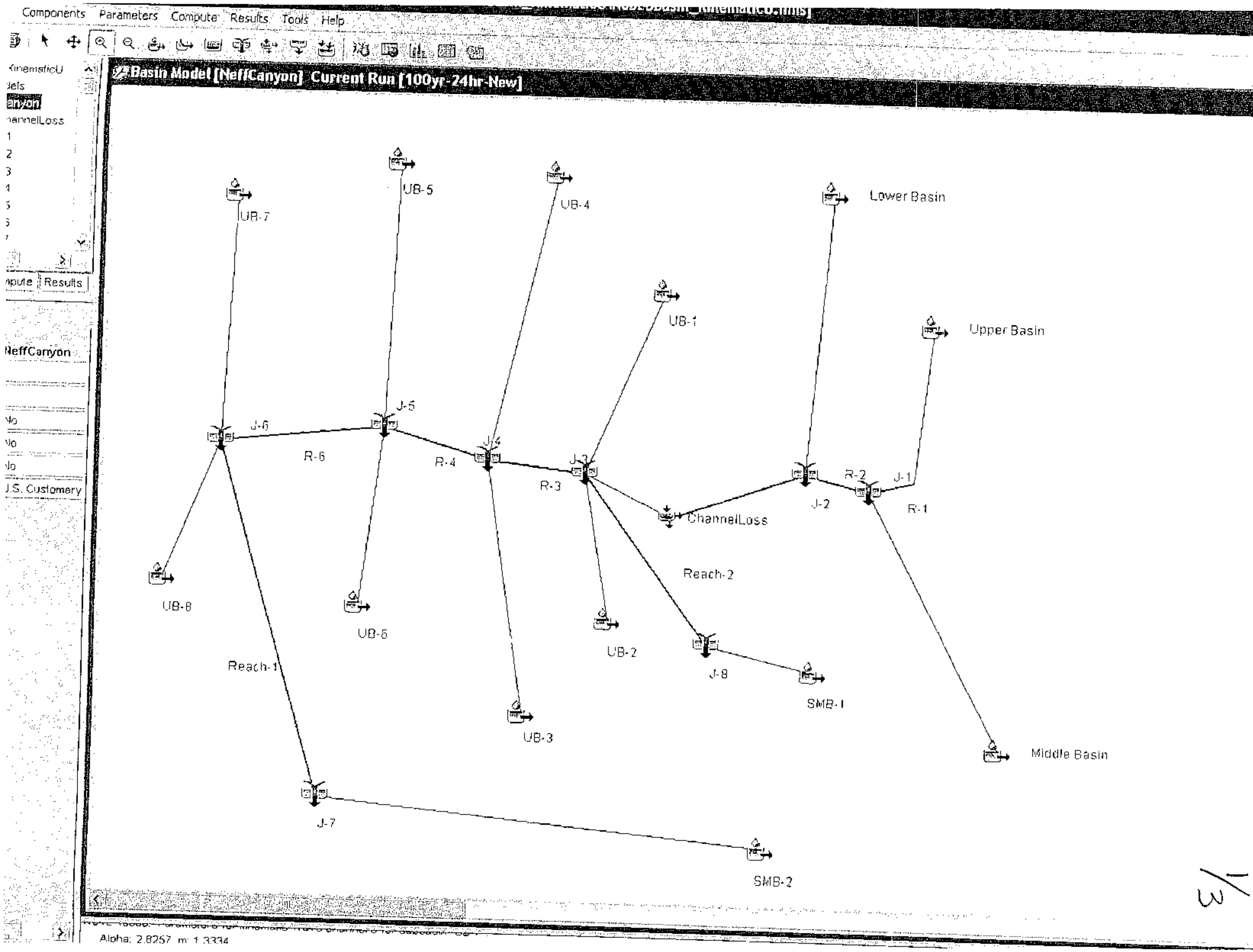
Components Parameters Compute Results Tools Help
Basin Model [NeffCanyon] Current Run [100yr-24hr-New]
NeffCanyon
U.S. Customary
UB-7
UB-5
UB-4
Lower Basin
UB-1
Upper Basin
J-6
J-5
J-4
J-3
J-2
J-1
R-6
R-4
R-3
R-2
R-1
ChannelLoss
Reach-2
UB-8
UB-6
UB-2
J-8
SMB-1
Reach-1
UB-3
Middle Basin
J-7
SMB-2
Alpha: 2.8257 m: 1.3334

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Project: NoDebBasin_KinematicU Simulation Run: 100yr-24hr-New

Start of Run: 01Aug2005, 12:00 Basin Model: NeffCanyon
End of Run: 02Aug2005, 18:00 Meteorologic Model: 100yr-24hr
Compute Time: 21Dec2007, 12:09:24 Control Specifications: 24hr

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
ChannelLoss	3.7280	300.7	02Aug2005, 04:47	136.8
J-1	2.4150	241.8	02Aug2005, 04:38	122.3
J-2	3.7280	336.1	02Aug2005, 04:43	170.4
J-3	4.0168	317.7	02Aug2005, 04:43	149.8
J-4	4.0824	321.7	02Aug2005, 04:45	153.5
J-5	4.1496	326.1	02Aug2005, 04:47	157.7
J-6	4.5654	348.0	02Aug2005, 04:46	174.2
J-7	0.3674	31.7	02Aug2005, 03:33	12.9
J-8	0.1138	9.9	02Aug2005, 03:32	4.0
Lower Basin	1.3130	94.4	02Aug2005, 04:42	48.1
Middle Basin	1.2850	135.1	02Aug2005, 04:31	67.1
R-1	1.1300	107.9	02Aug2005, 04:48	55.3
R-2	2.4150	241.8	02Aug2005, 04:43	122.3
R-3	4.0168	317.7	02Aug2005, 04:45	149.8
R-4	4.0824	321.7	02Aug2005, 04:48	153.5
R-5	3.7280	336.1	02Aug2005, 04:47	170.4
R-6	4.1496	326.1	02Aug2005, 04:52	157.7
Reach-1	0.3674	31.7	02Aug2005, 03:39	12.9
Reach-2	0.1138	9.9	02Aug2005, 03:36	4.0
SMB-1	0.1138	9.9	02Aug2005, 03:32	4.0
SMB-2	0.3674	31.7	02Aug2005, 03:33	12.9
UB-1	0.0484	4.6	02Aug2005, 03:31	2.3
UB-2	0.1266	12.9	02Aug2005, 03:31	6.7
UB-3	0.0375	4.3	02Aug2005, 03:31	2.1
UB-4	0.0281	3.2	02Aug2005, 03:30	1.6

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
UB-5	0.0203	2.0	02Aug2005, 03:31	1.0
UB-6	0.0469	6.0	02Aug2005, 03:30	3.2
UB-7	0.0156	1.9	02Aug2005, 03:30	1.0
UB-8	0.0328	4.9	02Aug2005, 03:31	2.6
Upper Basin	1.1300	107.9	02Aug2005, 04:43	55.3

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Snowmelt Calculations for Neffs Canyon
Client: Salt Lake County
Project #: 014.10.100
Computed: GLJ

Basin Size = 3.73 mi^2

$$Q_{10} = 14.13A^{0.94} \quad \text{where } R = 0.84$$
$$Q_{50} = 20.44A^{0.92} \quad \text{where } R = 0.84$$
$$Q_{100} = 22.57A^{0.91} \quad \text{where } R = 0.84$$

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

Q_{10} = 49 cfs
Q_{50} = 69 cfs
Q_{100} = 75 cfs

REFERENCE: "Hydrology Report, Flood Insurance Studies, 20 Utah Communities, F.I.A. Contract H-4790", Gingery and Associates, 1979.

APPENDIX C
HYDRAULICS

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HEC-RAS 3.1.3

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Hydrologic Engineering Center
US Army Corps of Engineers

Project:	Existing Neffs Canyon Creek	s:\...\10.100\14_10_NeffsCanyon\Model\ENC1.prj
Plan:	Existing Conditions	s:\...\10.100\14_10_NeffsCanyon\Model\ENC1.p01
Geometry:	Existing Neff's Canyon	s:\...\10.100\14_10_NeffsCanyon\Model\ENC1.g01
Steady Flow:	Flow1	s:\...\10.100\14_10_NeffsCanyon\Model\ENC1.f01
Unsteady Flow:		
Description:	Salt Lake County - Neff's Canyon Master Plan	US Customary Units

Profile Output Table - Culvert Only

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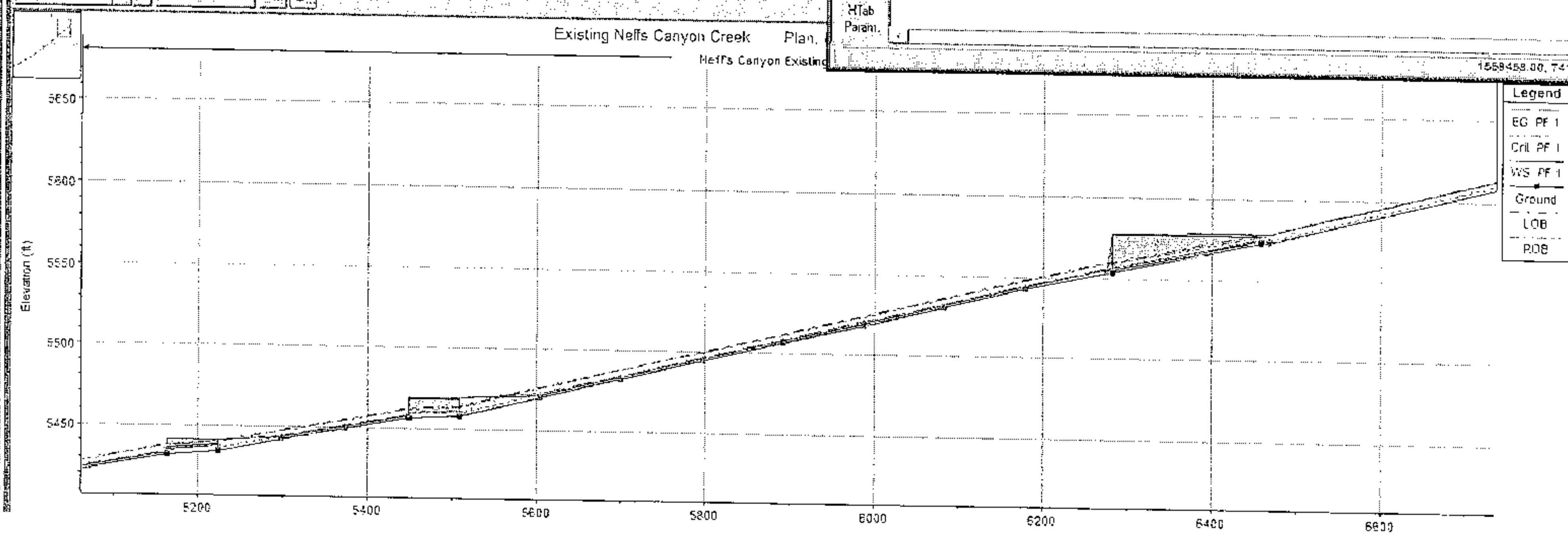
HEC-RAS Plan: EX-1 River: Neff's Canyon Reach: Existing

Reach	River Sta		Profile	E.G. US.	W.S. US.	E.G. IC	E.G. OC	Min El Weir Flow	Q Culv Group	Q Weir	Delta
				(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	
Existing Channel	6371.54	Culvert #1	PF 1	5578.82	5578.79	5578.82	5562.35	5577.73	55.79	73.21	
Existing Channel	5476	Culvert #1	PF 1	5468.75	5468.75	5468.66	5468.75	5468.21	101.45	28.55	
Existing Channel	5192	Culvert #1	PF 1	5440.86	5440.85	5440.86	5440.43	5441.01	130.00		
Existing Channel	4597	Culvert #1	PF 1	5382.13	5382.09	5382.13	5381.92	5381.01	61.69	68.31	

Profile Plot

File Options Help

Reaches ... Profiles ...

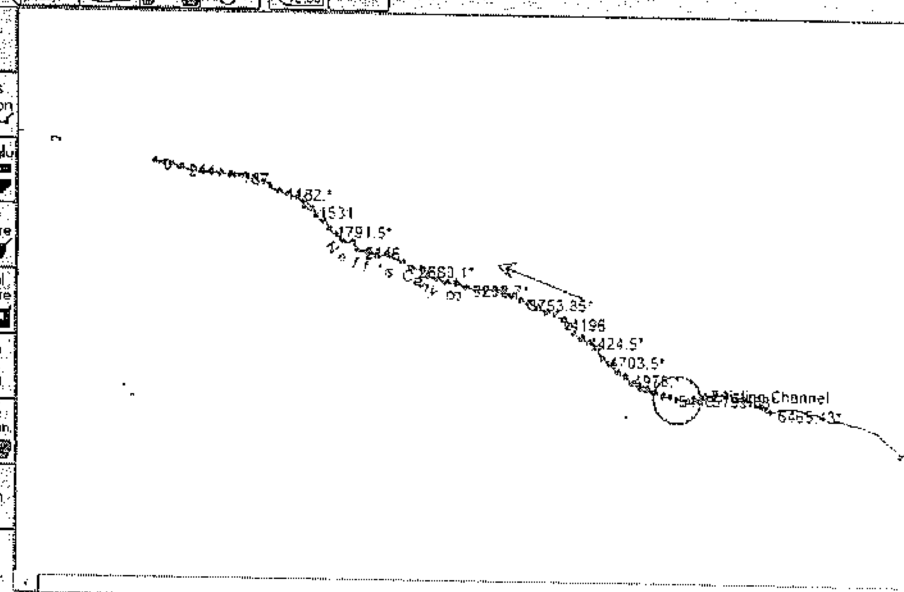


Geometric Data - Existing Neff's Canyon

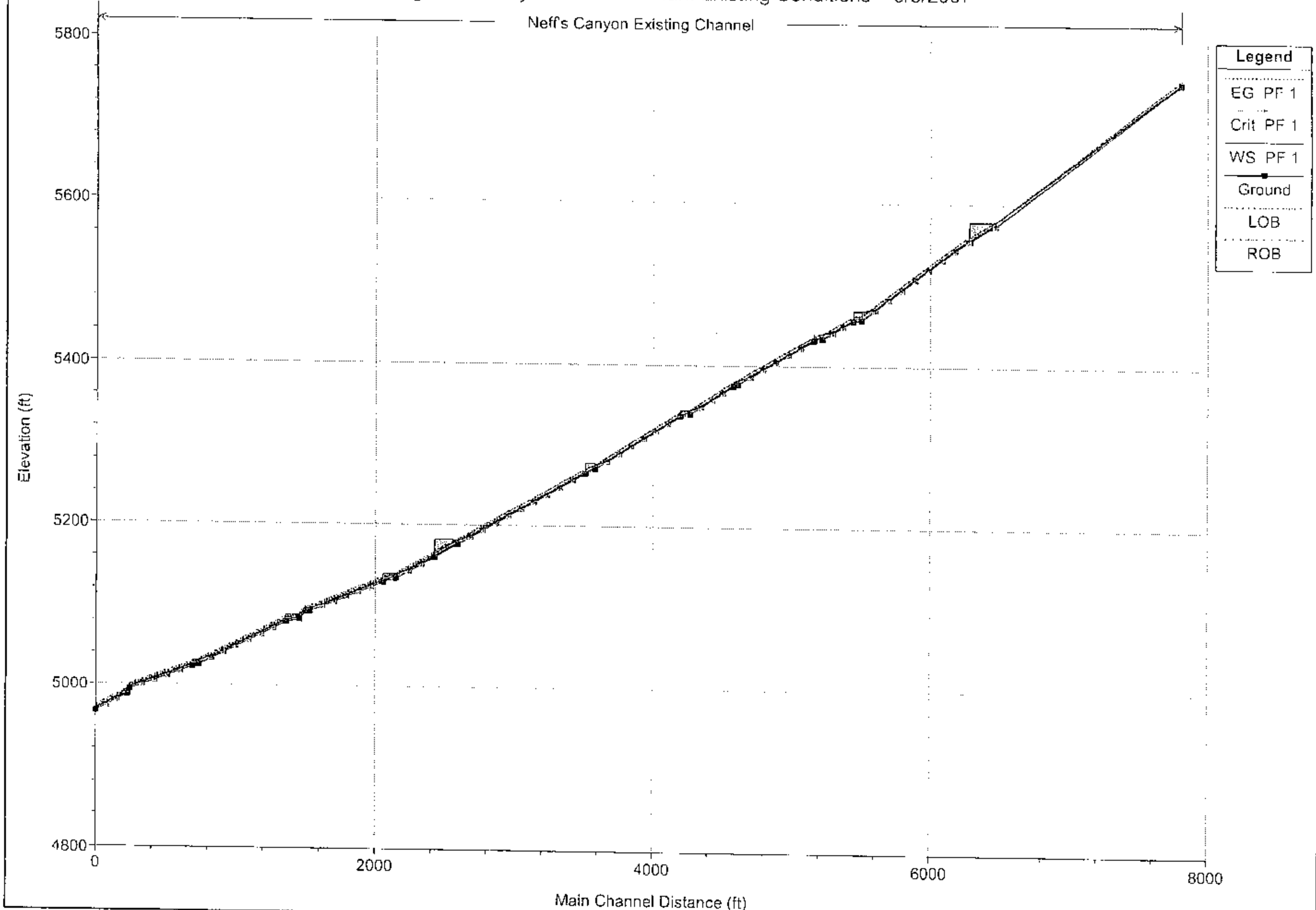
File Edit View Tables Tools Help

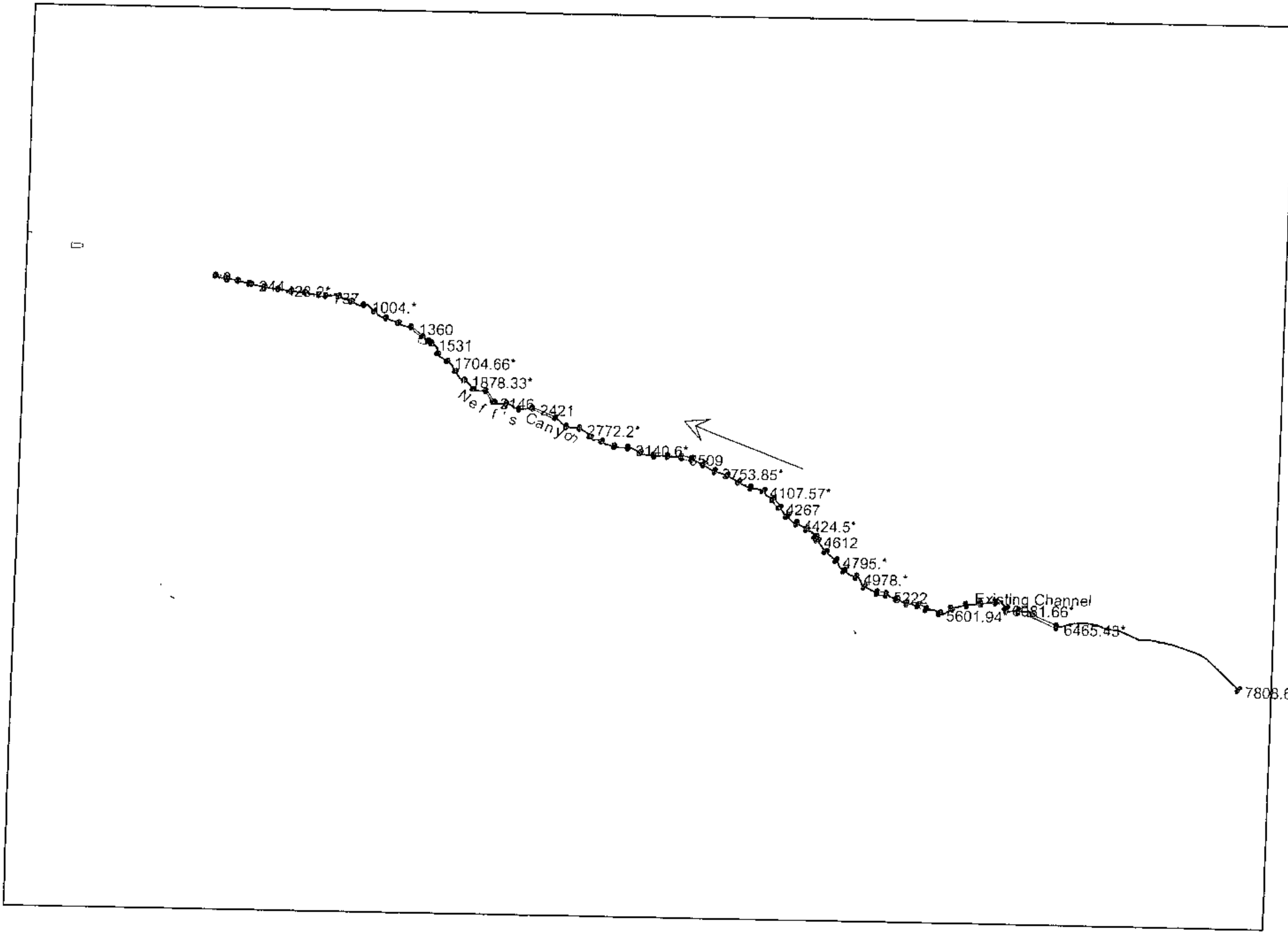
Tools Editors | River Reach | Storage Area | S.A. Conn. | Pump Station | RS 12.99

Junct. | Cross Section | Brdg/Culv | Inline Structure | Lateral Structure | Storage Area | Storage Area Conn. | Pump Station | HTab Param.



Existing Neffs Canyon Creek Plan: Existing Conditions 3/8/2007




0
244
737
1004.*
1360
1531
1704.66*
1878.33*
2421
Neff's Canyon
2772.2*
3509
3753.85*
4107.57*
4267
4424.5*
4612
4795.*
4978.*
5222
5601.94
Existing Channel
6465.43*
7808.65

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HEC-RAS Plan: EX 1 River: Neff's Canyon Reach: Existing Channel Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Existing Channel	7808.65	PF 1	130.00	5749.00	5750.68	5750.68	5751.38	0.082008	6.70	19.41	14.13	1.01
Existing Channel	6465.43*	PF 1	130.00	5573.20	5578.79	5574.87	5578.82	0.000858	1.31	99.61	25.99	0.12
Existing Channel	6371.54		Culvert									
Existing Channel	6273.55*	PF 1	130.00	5553.93	5555.61	5555.61	5556.31	0.081337	6.68	19.47	14.14	1.00
Existing Channel	6177.60*	PF 1	130.00	5542.59	5543.94	5544.27	5545.12	0.177140	8.72	14.90	13.12	1.44
Existing Channel	6081.66*	PF 1	130.00	5530.45	5532.06	5532.13	5532.83	0.095262	7.05	18.43	13.92	1.08
Existing Channel	5985.71*	PF 1	130.00	5518.31	5519.67	5519.99	5520.82	0.170379	8.61	15.10	13.16	1.42
Existing Channel	5889.77*	PF 1	130.00	5506.17	5507.77	5507.85	5508.55	0.098062	7.12	18.25	13.88	1.09
Existing Channel	5793.83*	PF 1	130.00	5494.02	5495.40	5495.70	5496.52	0.164756	8.51	15.28	13.20	1.39
Existing Channel	5697.88*	PF 1	130.00	5481.88	5483.47	5483.56	5484.27	0.100420	7.18	18.10	13.84	1.11
Existing Channel	5601.94*	PF 1	130.00	5469.74	5471.13	5471.42	5472.23	0.159955	8.42	15.43	13.24	1.38
Existing Channel	5506	PF 1	130.00	5457.60	5468.75	5459.28	5468.75	0.000066	0.53	244.04	26.30	0.03
Existing Channel	5476		Culvert									
Existing Channel	5446	PF 1	130.00	5456.30	5457.98	5457.98	5458.68	0.081841	6.69	19.43	14.13	1.01
Existing Channel	5371.33*	PF 1	130.00	5448.87	5450.37	5450.55	5451.28	0.121298	7.66	16.96	13.59	1.21
Existing Channel	5296.66*	PF 1	130.00	5441.43	5443.10	5443.11	5443.81	0.082771	6.72	19.35	14.12	1.01
Existing Channel	5222	PF 1	130.00	5434.00	5440.85	5435.68	5440.86	0.000384	0.99	130.98	26.30	0.08
Existing Channel	5192		Culvert									
Existing Channel	5161	PF 1	130.00	5431.70	5433.38	5433.38	5434.08	0.081840	6.69	19.43	14.13	0.08
Existing Channel	5069.5*	PF 1	130.00	5422.62	5424.12	5424.30	5425.03	0.121022	7.66	16.98	13.59	1.21
Existing Channel	4978.*	PF 1	130.00	5413.53	5415.21	5415.21	5415.91	0.082602	6.71	19.37	14.12	1.01
Existing Channel	4886.5*	PF 1	130.00	5404.45	5405.96	5406.13	5406.86	0.119790	7.63	17.04	13.61	1.20
Existing Channel	4795.*	PF 1	130.00	5395.37	5397.04	5397.05	5397.75	0.083198	6.73	19.32	14.11	1.01
Existing Channel	4703.5*	PF 1	130.00	5386.28	5387.79	5387.96	5388.69	0.118844	7.61	17.08	13.62	1.20
Existing Channel	4612	PF 1	130.00	5377.20	5382.09	5378.88	5382.13	0.001542	1.62	80.45	23.93	0.16
Existing Channel	4597		Culvert									
Existing Channel	4582	PF 1	130.00	5375.00	5376.68	5376.68	5377.38	0.081337	6.68	19.47	14.14	1.00
Existing Channel	4503.25*	PF 1	130.00	5366.15	5367.54	5367.83	5368.64	0.158589	8.40	15.48	13.25	1.37
Existing Channel	4424.5*	PF 1	130.00	5357.30	5358.97	5358.98	5359.68	0.083716	6.74	19.28	14.10	1.02
Existing Channel	4345.75*	PF 1	130.00	5348.45	5349.86	5350.13	5350.92	0.152711	8.29	15.68	13.30	1.35
Existing Channel	4267	PF 1	130.00	5339.60	5345.09	5341.28	5345.12	0.000964	1.36	95.47	25.62	0.12
Existing Channel	4232		Culvert									
Existing Channel	4196	PF 1	130.00	5336.80	5338.48	5338.48	5339.18	0.081841	6.69	19.43	14.13	1.01
Existing Channel	4107.57*	PF 1	130.00	5327.29	5328.72	5328.97	5329.75	0.144490	8.14	15.98	13.37	1.31
Existing Channel	4019.14*	PF 1	130.00	5317.77	5319.44	5319.45	5320.15	0.083112	6.73	19.32	14.11	1.01
Existing Channel	3930.71*	PF 1	130.00	5308.26	5309.70	5309.94	5310.71	0.140758	8.06	16.12	13.40	1.30
Existing Channel	3842.28*	PF 1	130.00	5298.74	5300.40	5300.42	5301.12	0.084761	6.77	19.19	14.08	1.02
Existing Channel	3753.85*	PF 1	130.00	5289.23	5290.68	5290.91	5291.67	0.137630	8.00	16.25	13.43	1.28
Existing Channel	3665.42*	PF 1	130.00	5279.71	5281.37	5281.39	5282.09	0.086271	6.81	19.08	14.06	1.03

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HEC-RAS Plan: EX 1 River: Neff's Canyon Reach: Existing Channel Profile: PF 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Existing Channel	3577	PF 1	130.00	5270.20	5275.57	5271.88	5275.60	0.001059	1.41	92.37	25.41	0.13
Existing Channel	3543		Culvert									
Existing Channel	3509	PF 1	130.00	5264.50	5266.18	5266.18	5266.88	0.081924	6.69	19.42	14.13	1.01
Existing Channel	3416.9*	PF 1	130.00	5255.63	5257.22	5257.37	5258.11	0.112197	7.56	17.20	13.16	1.17
Existing Channel	3324.8*	PF 1	130.00	5246.75	5248.55	5248.55	5249.28	0.082132	6.87	18.92	13.07	1.01
Existing Channel	3232.7*	PF 1	130.00	5237.88	5239.59	5239.74	5240.52	0.110933	7.73	16.82	12.14	1.16
Existing Channel	3140.6*	PF 1	130.00	5229.00	5230.94	5230.94	5231.71	0.082617	7.06	18.42	12.04	1.01
Existing Channel	3048.5*	PF 1	130.00	5220.13	5221.99	5222.14	5222.96	0.109793	7.90	16.46	11.15	1.15
Existing Channel	2956.4*	PF 1	130.00	5211.26	5213.36	5213.36	5214.18	0.084616	7.29	17.84	11.02	1.01
Existing Channel	2864.3*	PF 1	130.00	5202.38	5204.44	5204.57	5205.44	0.106689	8.01	16.22	10.23	1.12
Existing Channel	2772.2*	PF 1	130.00	5193.51	5195.81	5195.81	5196.69	0.086636	7.51	17.30	10.04	1.01
Existing Channel	2680.1*	PF 1	130.00	5184.63	5186.95	5187.05	5187.97	0.103559	8.10	16.05	9.36	1.09
Existing Channel	2588	PF 1	130.00	5175.76	5181.09	5178.31	5181.20	0.004818	2.62	49.70	14.33	0.25
Existing Channel	2505		Culvert									
Existing Channel	2421	PF 1	130.00	5159.46	5161.35	5162.02	5163.48	0.277425	11.71	11.10	7.77	0.25
Existing Channel	2329.33*	PF 1	130.00	5150.83	5153.39	5153.39	5154.32	0.089895	7.76	16.76	9.11	1.01
Existing Channel	2237.66*	PF 1	130.00	5142.19	5144.69	5144.75	5145.68	0.098467	8.02	16.21	8.99	1.05
Existing Channel	2146	PF 1	130.00	5133.56	5138.89	5136.11	5139.00	0.004818	2.62	49.70	14.33	0.25
Existing Channel	2099		Culvert									
Existing Channel	2052	PF 1	130.00	5128.46	5130.71	5131.02	5132.04	0.144937	9.24	14.06	8.50	0.25
Existing Channel	1965.16*	PF 1	130.00	5122.34	5124.96	5124.89	5125.83	0.081357	7.48	17.39	9.25	0.96
Existing Channel	1878.33*	PF 1	130.00	5116.23	5119.08	5118.79	5119.77	0.059745	6.67	19.49	9.69	0.83
Existing Channel	1791.5*	PF 1	130.00	5110.11	5112.70	5112.67	5113.60	0.085130	7.60	17.10	9.19	0.98
Existing Channel	1704.66*	PF 1	130.00	5103.99	5106.87	5106.54	5107.54	0.057223	6.57	19.80	9.76	0.81
Existing Channel	1617.83*	PF 1	130.00	5097.88	5100.44	5100.44	5101.37	0.089895	7.76	16.76	9.11	1.01
Existing Channel	1531	PF 1	130.00	5091.76	5095.80	5094.32	5096.05	0.015150	4.01	32.46	12.08	0.43
Existing Channel	1507	PF 1	130.00	5091.76	5094.32	5094.32	5095.25	0.089830	7.76	16.76	9.11	1.01
Existing Channel	1456	PF 1	130.00	5081.96	5087.29	5084.52	5087.40	0.004818	2.62	49.70	14.33	0.25
Existing Channel	1408		Culvert									
Existing Channel	1360	PF 1	130.00	5078.56	5081.09	5081.12	5082.05	0.093889	7.88	16.49	9.05	0.25
Existing Channel	1271.*	PF 1	130.00	5070.83	5073.43	5073.38	5074.32	0.084407	7.58	17.15	9.20	0.98
Existing Channel	1182.*	PF 1	130.00	5063.10	5065.66	5065.66	5066.59	0.089442	7.74	16.79	9.12	1.01
Existing Channel	1093.*	PF 1	130.00	5055.37	5057.97	5057.93	5058.86	0.084048	7.57	17.18	9.20	0.98
Existing Channel	1004.*	PF 1	130.00	5047.65	5050.21	5050.20	5051.14	0.089442	7.74	16.79	9.12	1.01
Existing Channel	915.*	PF 1	130.00	5039.92	5042.52	5042.48	5043.41	0.083988	7.57	17.18	9.21	0.98
Existing Channel	826.*	PF 1	130.00	5032.19	5034.75	5034.75	5035.68	0.089830	7.76	16.76	9.11	1.01
Existing Channel	737	PF 1	130.00	5024.46	5029.79	5027.02	5029.90	0.004818	2.62	49.70	14.33	0.25
Existing Channel	715		Culvert									
Existing Channel	692	PF 1	130.00	5022.19	5025.08		5025.74	0.056192	6.52	19.93	9.78	0.81

HEC-RAS Plan: EX 1 River: Neff's Canyon Reach: Existing Channel Profile: PF 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Existing Channel	602.4*	PF 1	130.00	5016.42	5019.10	5018.98	5019.92	0.075707	7.28	17.85	9.35	0.93
Existing Channel	512.8*	PF 1	130.00	5010.66	5013.60	5013.21	5014.23	0.053098	6.39	20.35	9.87	0.78
Existing Channel	423.2*	PF 1	130.00	5004.89	5007.52	5007.45	5008.38	0.081357	7.48	17.39	9.25	0.96
Existing Channel	333.6*	PF 1	130.00	4999.13	5002.12	5001.69	5002.72	0.049270	6.21	20.93	9.99	0.76
Existing Channel	244	PF 1	130.00	4993.36	4995.91	4995.91	4996.85	0.090219	7.77	16.74	9.11	1.01
Existing Channel	230	PF 1	130.00	4986.86	4988.19	4989.42	4993.45	0.978004	18.41	7.06	6.65	3.15
Existing Channel	153.333*	PF 1	130.00	4980.09	4982.65	4982.65	4983.58	0.089830	7.76	16.76	9.11	1.01
Existing Channel	76.6666*	PF 1	130.00	4973.33	4975.89	4975.89	4976.82	0.089765	7.75	16.77	9.11	1.01
Existing Channel	0	PF 1	130.00	4966.56	4969.05	4969.13	4970.06	0.099635	8.06	16.14	8.97	1.06

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HEC-RAS Plan: EX 1 River: Neff's Canyon Reach: Existing Channe Profile: PF 1

Reach	River Sta	Profile	E.G. US.	W.S. US	E.G. IC	E.G. OC	Min El Weir Flow	Q Culv Group	Q Weir	Delta WS	Culv Vel US	Culv Vel DS
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(ft)	(ft/s)	(ft/s)
Existing Channel	6371.54 Culvert #1	PF 1	5576.82	5576.79	5576.82	5562.35	5577.73	56.79	73.21	23.16	11.57	26.60
Existing Channel	5476 Culvert #1	PF 1	5466.75	5468.75	5468.66	5468.75	5468.21	101.45	28.55	10.77	14.35	14.35
Existing Channel	5192 Culvert #1	PF 1	5440.86	5440.85	5440.86	5440.43	5441.01	130.00		7.40	10.35	13.96
Existing Channel	4597 Culvert #1	PF 1	5382.13	5382.09	5382.13	5381.92	5381.01	61.69	68.31	5.40	8.73	14.14
Existing Channel	4232 Culvert #1	PF 1	5345.12	5345.09	5345.12	5344.66	5344.11	66.94	63.05	6.61	9.47	11.78
Existing Channel	3543 Culvert #1	PF 1	5275.60	5275.57	5275.11	5275.60	5278.61	130.00		9.39	9.58	17.49
Existing Channel	2505 Culvert #1	PF 1	5181.20	5181.09	5180.67	5181.20	5181.81	130.00		19.08	9.58	19.61
Existing Channel	2095 Culvert #1	PF 1	5139.00	5138.89	5138.58	5139.00	5139.11	130.00		7.61	9.56	15.45
Existing Channel	1406 Culvert #1	PF 1	5087.40	5087.29	5087.03	5087.40	5087.61	130.00		6.17	9.56	13.33
Existing Channel	715 Culvert #1	PF 1	5029.90	5029.79	5029.49	5029.90	5030.01	130.00		4.71	9.58	14.27

HEC-RAS Plan: EX 1 River: Neff's Canyon Reach: Existing Channel Profile: PF 1

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
Existing Channel	7808.65	PF 1	5751.38	5750.68	0.70	3.80	0.20		130.00		14.13
Existing Channel	6465.43*	PF 1	5578.82	5578.79	0.03				130.00		25.99
Existing Channel	6371.54		Culvert								
Existing Channel	6273.55*	PF 1	5556.31	5555.61	0.69	7.83	0.00		130.00		14.14
Existing Channel	6177.60*	PF 1	5545.12	5543.94	1.18	11.13	0.05		130.00		13.12
Existing Channel	6081.66*	PF 1	5532.83	5532.06	0.77	12.17	0.12		130.00		13.92
Existing Channel	5985.71*	PF 1	5520.82	5519.67	1.15	11.97	0.04		130.00		13.16
Existing Channel	5889.77*	PF 1	5508.55	5507.77	0.79	12.17	0.11		130.00		13.88
Existing Channel	5793.83*	PF 1	5496.52	5495.40	1.12	11.99	0.03		130.00		13.20
Existing Channel	5697.88*	PF 1	5484.27	5483.47	0.80	12.16	0.10		130.00		13.84
Existing Channel	5601.94*	PF 1	5472.23	5471.13	1.10	12.00	0.03		130.00		13.24
Existing Channel	5506	PF 1	5468.75	5468.75	0.00				130.00		26.30
Existing Channel	5476		Culvert								
Existing Channel	5446	PF 1	5458.68	5457.98	0.70	6.09	0.00		130.00		14.13
Existing Channel	5371.33*	PF 1	5451.28	5450.37	0.91	7.37	0.02		130.00		13.59
Existing Channel	5296.66*	PF 1	5443.81	5443.10	0.70	7.41	0.06		130.00		14.12
Existing Channel	5222	PF 1	5440.86	5440.85	0.02				130.00		26.30
Existing Channel	5192		Culvert								
Existing Channel	5161	PF 1	5434.08	5433.38	0.70				130.00		14.13
Existing Channel	5069.5*	PF 1	5425.03	5424.12	0.91	9.02	0.02		130.00		13.59
Existing Channel	4978.*	PF 1	5415.91	5415.21	0.70	9.07	0.06		130.00		14.12
Existing Channel	4886.5*	PF 1	5406.86	5405.96	0.90	9.02	0.02		130.00		13.61
Existing Channel	4795.*	PF 1	5397.75	5397.04	0.70	9.06	0.06		130.00		14.11
Existing Channel	4703.5*	PF 1	5388.69	5387.79	0.90	9.03	0.02		130.00		13.62
Existing Channel	4612	PF 1	5382.13	5382.09	0.04				130.00		23.93
Existing Channel	4597		Culvert								
Existing Channel	4582	PF 1	5377.38	5376.68	0.69	6.43	0.00		130.00		14.14
Existing Channel	4503.25*	PF 1	5368.64	5367.54	1.10	8.70	0.04		130.00		13.25
Existing Channel	4424.5*	PF 1	5359.68	5358.97	0.71	8.85	0.12		130.00		14.10
Existing Channel	4345.75*	PF 1	5350.92	5349.86	1.07	8.71	0.04		130.00		13.30
Existing Channel	4267	PF 1	5345.12	5345.09	0.03				130.00		25.62
Existing Channel	4232		Culvert								
Existing Channel	4196	PF 1	5339.18	5338.48	0.70	7.21	0.00		130.00		14.13
Existing Channel	4107.57*	PF 1	5329.75	5328.72	1.03	9.39	0.03		130.00		13.37
Existing Channel	4019.14*	PF 1	5320.15	5319.44	0.70	9.51	0.10		130.00		14.11
Existing Channel	3930.71*	PF 1	5310.71	5309.70	1.01	9.40	0.03		130.00		13.40
Existing Channel	3842.28*	PF 1	5301.12	5300.40	0.71	9.51	0.09		130.00		14.08
Existing Channel	3753.85*	PF 1	5291.67	5290.68	0.99	9.41	0.03		130.00		13.43
Existing Channel	3665.42*	PF 1	5282.09	5281.37	0.72	9.51	0.06		130.00		14.06
Existing Channel	3577	PF 1	5275.60	5275.57	0.03				130.00		25.41
Existing Channel	3543		Culvert								
Existing Channel	3509	PF 1	5266.88	5266.18	0.70	7.50	0.00		130.00		14.13
Existing Channel	3416.9*	PF 1	5258.11	5257.22	0.89	8.74	0.02		130.00		13.16
Existing Channel	3324.8*	PF 1	5249.28	5248.55	0.73	7.60	0.00		130.00		13.07
Existing Channel	3232.7*	PF 1	5240.52	5239.59	0.93	8.74	0.02		130.00		12.14
Existing Channel	3140.6*	PF 1	5231.71	5230.94	0.77	7.66	0.00		130.00		12.04
Existing Channel	3048.5*	PF 1	5222.96	5221.99	0.97	8.73	0.02		130.00		11.15
Existing Channel	2956.4*	PF 1	5214.18	5213.36	0.82	7.82	0.00		130.00		11.02
Existing Channel	2864.3*	PF 1	5205.44	5204.44	1.00	8.72	0.02		130.00		10.23
Existing Channel	2772.2*	PF 1	5196.69	5195.81	0.88	8.03	0.00		130.00		10.04
Existing Channel	2680.1*	PF 1	5187.97	5186.95	1.02	8.71	0.01		130.00		9.36
Existing Channel	2588	PF 1	5181.20	5181.09	0.11				130.00		14.33
Existing Channel	2505		Culvert								
Existing Channel	2421	PF 1	5163.48	5161.35	2.13				130.00		7.77
Existing Channel	2329.33*	PF 1	5154.32	5153.39	0.93	8.24	0.00		130.00		9.11
Existing Channel	2237.66*	PF 1	5145.68	5144.69	1.00	8.62	0.01		130.00		8.99
Existing Channel	2146	PF 1	5139.00	5138.89	0.11				130.00		14.33
Existing Channel	2099		Culvert								
Existing Channel	2052	PF 1	5132.04	5130.71	1.33				130.00		6.50
Existing Channel	1965.16*	PF 1	5125.83	5124.96	0.87	6.02	0.05		130.00		9.25
Existing Channel	1878.33*	PF 1	5119.77	5119.08	0.69	6.14	0.02		130.00		9.69
Existing Channel	1791.5*	PF 1	5113.60	5112.70	0.90	6.00	0.07		130.00		9.19
Existing Channel	1704.66*	PF 1	5107.54	5106.87	0.67	6.15	0.03		130.00		9.76
Existing Channel	1617.83*	PF 1	5101.37	5100.44	0.93	2.64	0.21		130.00		9.11
Existing Channel	1531	PF 1	5096.05	5095.80	0.25	0.73	0.07		130.00		12.08
Existing Channel	1507	PF 1	5095.25	5094.32	0.93	0.65	0.25		130.00		9.11
Existing Channel	1456	PF 1	5087.40	5087.29	0.11				130.00		14.33
Existing Channel	1408		Culvert								
Existing Channel	1360	PF 1	5082.05	5081.09	0.96				130.00		9.05
Existing Channel	1271.*	PF 1	5074.32	5073.43	0.89	7.73	0.00		130.00		9.20
Existing Channel	1182.*	PF 1	5066.59	5065.66	0.93	7.71	0.01		130.00		9.12
Existing Channel	1093.*	PF 1	5058.86	5057.97	0.89	7.71	0.00		130.00		9.20
Existing Channel	1004.*	PF 1	5051.14	5050.21	0.93	7.71	0.01		130.00		9.12
Existing Channel	915.*	PF 1	5043.41	5042.52	0.89	7.73	0.00		130.00		9.21

HEC-RAS Plan: EX 1 River: Neff's Canyon Reach: Existing Channel Profile: PF 1 (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
Existing Channel	826.*	PF 1	5035.68	5034.75	0.93	1.13	0.25		130.00		9.11
Existing Channel	737	PF 1	5029.90	5029.79	0.11				130.00		14.33
Existing Channel	715		Culvert								
Existing Channel	692	PF 1	5025.74	5025.08	0.66	5.81	0.02		130.00		9.78
Existing Channel	602.4*	PF 1	5019.92	5019.10	0.82	5.64	0.06		130.00		9.35
Existing Channel	512.8*	PF 1	5014.23	5013.60	0.63	5.82	0.02		130.00		9.87
Existing Channel	423.2*	PF 1	5008.38	5007.52	0.87	5.58	0.08		130.00		9.25
Existing Channel	333.6*	PF 1	5002.72	5002.12	0.60	5.84	0.03		130.00		9.99
Existing Channel	244	PF 1	4996.85	4995.91	0.94	1.25	0.01		130.00		9.11
Existing Channel	230	PF 1	4993.45	4988.19	5.26	2.97	0.43		130.00		6.65
Existing Channel	153.333*	PF 1	4983.58	4982.65	0.93	16.22	1.30		130.00		9.11
Existing Channel	76.6666*	PF 1	4976.82	4975.89	0.93				130.00		9.11
Existing Channel	0	PF 1	4970.06	4969.05	1.01	6.85	0.00		130.00		8.97

HDS 5 Nomograph Calculator
Dr. William S Grenney

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Headwater Depth for Concrete Pipe Culverts with Inlet Control

- ( ) Square Edge with Headwall
- (•) Groove End with Headwall
- ( ) Groove End Projecting

	Critical Depth (ft)
	Critical Velocity (ft/s)
300	Q = Discharge (cfs)
.06	Culvert Barrel Slope (ft/ft)
6	Culvert diameter (ft)
7.547	Headwater (ft)

Calc

Units: (•) English ( ) Metric

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Headwater Depth for Concrete Pipe Culverts with Inlet Control

- ( ) Square Edge with Headwall
- (•) Groove End with Headwall
- ( ) Groove End Projecting

[ ] } Calc	Critical Depth (ft)
[ ]	Critical Velocity (ft/s)
350	Q = Discharge (cfs)
.06	Culvert Barrel Slope (ft/ft)
6	Culvert diameter (ft)
8.734	Headwater (ft)

Calc

Units: (•) English ( ) Metric

SALT LAKE COUNTY
NEFFS CANYON CREEK
ALTERNATIVE CHANNEL ANALYSIS
JANUARY 2007

Data

Design flowrates	100-year	300	cfs
	10-year	70	cfs
	Low Flow	50	cfs
Channel slopes		0.12	ft/ft max
		0.06	ft/ft min

Alternatives:

- Trapezoidal riprap channel
- Composite trapezoidal channel (riprap lowflow with erosion control mat on upper slopes)
- Concrete low flow channel
- Pipe

RIPRAP CHANNEL

3 horizontal to 1 side slopes

Bottom W	Normal D	Channel D	riprap D50	
4	2.1	3	2	feet

Use Erosion control Mat & vegetation to total depth on slope

	Slope (ft/ft)	Flow (cfs)	Bottom W (ft)	Yo (ft)	Velocity (fps)	P (ft)	A (ft2)	T (ft)	Froude No.	Eo	AY^	M
Normal Depth	0.1	300	4	1.93	15.9	7.9	18.9	15.58	2.5	3.9	15.2	163.1
Sequent Depth		300	4	**4.2**	4.3	5.7	69.7	29.2	0.5	0.3	125.2	165.3
Normal Depth	0.07	300	4	2.11	13.8	8.2	21.8	16.66	2.1	2.9	19.2	147.4
Sequent Depth		300	4	**3.9**	4.9	4.0	61.2	27.4	0.6	0.4	101.9	147.6

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SALT LAKE COUNTY
NEFFS CANYON CREEK
ALTERNATIVE CHANNEL ANALYSIS (CONTINUED)
JANUARY 2007

COMPOSITE CHANNEL (riprap lowflow and erosion control mat on upper slopes)

Riprap Low Flow channel (70 cfs capacity with 0.5 foot freeboard) NO DROPS

3 horizontal to 1 side slopes

Slope range	Bottom W	Normal D	Channel D	riprap D50	
0.07 to 0.10	4	1.3	1.5	2	feet

riprap volume (Area with D + riprap thickness) - A channel

Area Channel = by + my^2 — 12.75 ft2

Area with D + riprap thickness

riprap thickness = D50 x 2 = 4

D + riprap thickness = 5.5

AREA = by + my^2 = — 112.75 ft2

Reduce for edge adjustment — 108.75 ft2

riprap volume — 96.0 ft3/ft

3.6 cy/ft

Erosion Control Mat on side slope

North American Green calculator:

Maximum channel slope 8% using the P550 mat

Yo= 2.44' — Calculated shear stress — 11.8 psf

Allowable shear stress — 12 psf

At 10% slope — **NOT STABLE**

Calculated shear stress — 16.2

	Slope (ft/ft)	Flow (cfs)	Bottom W (ft)	Yo (ft)	Velocity (fps)	P (ft)	A (ft2)	T (ft)	Froude No.	Eo	AY^	M
Normal Depth	0.1	300	4	2.44	10.9	8.9	27.6	18.64	1.6	1.8	28.3	129.5
Sequent Depth		300	4	**3.5**	5.9	4.0	50.8	25	0.7	0.5	75.5	130.6
Normal Depth	0.07	300	4	2.51	10.4	9.0	28.9	19.06	1.5	1.7	30.5	127.1
Sequent Depth		300	4	**3.4**	6.2	8.0	48.3	24.4	0.8	0.6	69.7	127.6

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COMPOSITE CHANNEL (riprap lowflow and erosion control mat on upper slopes) (CONTINUED)

For conceptual design assume design slope of 0.07 ft/ft between drops

Normal depth	2.5	feet
Channel Depth	4	feet
Calculated shear stress	10.8	
Allowable shear stress	12	

Riprap Low Flow channel (70 cfs capacity)

3 horizontal to 1 side slopes

Bottom W	Normal D	Channel D	riprap D50	
4	1.2	1.5	1.5	feet

riprap volume (Area with D + riprap thickness) - A channel

Area Channel = by + my^2 — 12.75 ft2

Area with D + riprap thickness

riprap thickness = D50 x 2 = 3

D + riprap thickness = 4.5

AREA = by + my^2 = 78.75 ft2

Reduce for edge adjustment 74.75 ft2

riprap volume **54.2 ft3/ft**

2.0 cy/ft

Drop analysis

Avg slope from Zarahemla to Wasatch

Delta Z	587.37	feet
Length	6275.7	feet
Avg Slope	0.093594	ft/ft

Assume 5' drop in grouted sloping boulder drops

Length of Drop

Slope	0.25	ft/ft 4:1
Slope L	20	ft
Basin L	15	ft - flat
Overall slc	0.142857	ft/ft

Drop overall slope - channel slope 0.07285714 ft/ft

Actual Delta z due to drop 2.55 feet

Drops needed = (total channel drop - channel L x slope)/actual delta z due to drop

58

Avg spacing = length x number of drops

108 feet

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ALTERNATIVE CHANNEL ANALYSIS (CONTINUED)
JANUARY 2007

CONCRETE LOW FLOW CHANNEL

	Bottom Wi	Depth	Side slope above low flow
Concrete Low Flow channel	2	1	3 H : 1 V

0 horizontal to 1 side slopes

	Slope (ft/ft)	Flow (cfs)	Bottom W (ft)	Yo (ft)	Velocity (fps)	P (ft)	A (ft2)	T (ft)	Froude No.	Eo	AY^	M
Normal Depth	0.07	50	2	0.72	16.7	6.6	3.0	6.32	4.3	4.3	0.9	26.8
USE 1' lowflow channel depth (with footing?) and 3:1 side slopes above lowflow channel												
Normal Depth	0.07	70	2	0.87	17.5	7.5	4.0	7.22	4.1	4.7	1.4	39.4
Normal Depth	0.07	300	2	2.08	17.5	15.2	17.1	14.48	2.8	4.8	13.3	176.4
Sequent Depth		300	2	**4.91**	3.7	33.1	82.1	31.46	0.4	0.2	142.5	176.5
Normal Depth	0.12	300	2	1.8	22.5	13.4	13.3	12.8	3.9	7.9	9.1	218.9
Sequent Depth		300	2	**5.45**	3.0	33.1	100.0	34.7	0.3	0.1	191.6	219.5
NAG calculator == SF<1 for P550												
Normal Depth	0.1	300	2	1.89	20.7	14.0	14.5	13.34	3.5	6.7	10.3	203.1
Sequent Depth		300	2	**5.26**	3.2	33.1	93.5	33.56	0.3	0.2	173.2	203.1

Use 10% max channel slope – check of the existing average channel slope between culverts indicates that using culverts to make up the differ
works except between Zarahemla and Abinadi; where an additional 5' drop will be needed.

PIPE ALTERNATIVE

Culvert 6 feet diameter
8 feet min. headwater depth at inlet

Pipe alternative (without debris basin) – reduce size to 5 feet diameter (see attached spread sheet)
Use minimum manhole and inlet depths of 9 feet to accomodate sequent depth
Based on conceptual pipe layout estimate 40 manholes
9 feet deep
TOTAL LENGTH downstream of Zarahemla 6120 feet

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CLIENT: SALT LAKE COUNTY
PROJECT: NEFFS CANYON
PIPE ALTERNATIVE ANALYSIS
10% Slope

PIPE	DESIGN FLOW (CFS)	SLOPE (ft/ft)	DIAMETER (FT)	MANNINGS N	DEPTH (FT)	COMPUT FLOW (CFS)	FLOW AREA (FT2)	VELOCITY (FPS)	Hv (feet)	FROUDE NO.	2nd Moment of Flow Area	Momentum	Sequent Depth (feet)
6 ft pipe alt	300	0.1	**6**	0.013	1.93	301	7.86	38.28	22.8	5.70	6.3	362.1	
Full pipe Momentum	300		6	0.013	6	301	28.27	10.64	1.8	0.00	84.8	183.7	higher than top of pipe
	Q (cfs)		B (ft)	q (cfs/ft)	y try								
Assume rectangular MH	300		6	50	8.91							362.4	9
Assume rectangular MH	300		8	37.5	8.94							362.1	9

PIPE	DESIGN FLOW (CFS)	SLOPE (ft/ft)	DIAMETER (FT)	MANNINGS N	DEPTH (FT)	COMPUT FLOW (CFS)	FLOW AREA (FT2)	VELOCITY (FPS)	Hv (feet)	FROUDE NO.	2nd Moment of Flow Area	Momentum	Sequent Depth (feet)
5 ft pipe alt	300	0.1	**5**	0.013	2.085	300	7.75	38.72	23.3	5.44	6.8	367.3	
Full pipe Momentum	300	0	5	0.013	4	300	16.84	17.83	4.9	1.53	30.6	196.6	higher than top of pipe
	Q (cfs)		B (ft)	q (cfs/ft)	y try								
Assume rectangular MH	300		6	50	8.95							367.1	9
Assume rectangular MH	300		8	37.5	8.985							367.5	9

PIPE	DESIGN FLOW (CFS)	SLOPE (ft/ft)	DIAMETER (FT)	MANNINGS N	DEPTH (FT)	COMPUT FLOW (CFS)	FLOW AREA (FT2)	VELOCITY (FPS)	Hv (feet)	FROUDE NO.	2nd Moment of Flow Area	Momentum	Sequent Depth (feet)
4.5 ft pipe alt	300	0.1	**4.5**	0.013	2.2	300	7.73	38.83	23.4	5.22	7.2	368.9	
Full pipe Momentum	300	0	4.5	0.013	4.5	300	15.90	18.87	5.5	0.00	35.8	211.5	higher than top of pipe
	Q (cfs)		B (ft)	q (cfs/ft)	y try								
Assume rectangular MH	300		6	50	8.965							368.9	9
Assume rectangular MH	300		8	37.5	9							369.4	9

APPENDIX D
COST ESTIMATES

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SALT LAKE COUNTY
NEFFS CANYON CREEK
ALTERNATIVE CHANNEL ANALYSIS
CONSTRUCTION COST ESTIMATE
January 2007

channel L	5591	feet
Existing culv	860	feet
New culvert	340	feet

RIPRAP CHANNEL ALTERNATIVE

DESCRIPTION	QUANTITY	Units	UNIT PRICE	TOTAL		Comparative cost per foot
RIPRAP CHANNEL (2' D50, 4.3 cy/ft)	24,083	cy	$70	$	1,685,790	
Erosion Mat & Seed	7,455	sy	$5	$	37,273	
CULVERTS (6' Dia., 8' depth)	1,025	ft	$343	$	351,575	
INLET STRUCTURES	11	each	$8,000	$	88,000	
Outlet Energy Structure & dissipation	11	each	$12,000	$	132,000	
TOTAL COMPARATIVE COST				**$**	**2,294,638**	$338 per foot

COMPOSITE CHANNEL (riprap lowflow and erosion control mat on upper slopes)
WITH DROP STRUCTURES to limit provide SF=1 during 100-year on side slopes

DESCRIPTION	QUANTITY	Units	UNIT PRICE	TOTAL		
RIPRAP CHANNEL low flow (1.5' D50, 2 cy/ft)	7,182	cy	$70	$	502,740	
Erosion Mat & Seed	11,182	sy	$8	$	89,456	
Drop Structures	50	each	$50,000	$	2,500,000	
CULVERTS (6' Dia., 8' depth)	1,025	ft	$343	$	351,575	
INLET STRUCTURES	11	each	$8,000	$	88,000	
Outlet Energy Structure & dissipation	11	each	$12,000	$	132,000	
TOTAL COMPARATIVE COST				**$**	**3,663,771**	$540 per foot

COMPOSITE CHANNEL (riprap lowflow and erosion control mat on upper slopes) (Continued)

WITH OUT DROP STRUCTURES – ALLOW EROSION DURING 100-YEAR

DESCRIPTION	QUANTITY	Units	UNIT PRICE	TOTAL	
RIPRAP CHANNEL low flow (2' D50, 3.6 cy/ft)	20,128	cy	$70	$ 1,408,932	
Erosion Mat & Seed	7,858	sy	$8	$ 62,863	
CULVERTS (6' Dia., 8' depth)	50	ft	$343	$ 17,150	
INLET STRUCTURES	11	each	$8,000	$ 88,000	
Outlet Energy Structure & dissipation	11	each	$12,000	$ 132,000	
TOTAL COMPARATIVE COST				**$ 1,708,945**	$252 per foot

PIPE ALTERNATIVE

DESCRIPTION	QUANTITY	Units	UNIT PRICE	TOTAL	
INLET STRUCTURE	1	each	$15,000	$ 15,000	
PIPE (5' DIA., 9' DEPTH)	6460	feet	317	$ 2,047,820	
Manholes (9' depth 8' diameter)	40	each	6050	$ 242,000	
TOTAL COMPARATIVE COST				**$ 2,304,820**	$339 per foot

CONCRETE LOW FLOW CHANNEL

DESCRIPTION	QUANTITY	Units	UNIT PRICE	TOTAL	
Concrete channel (4' B x 4.5 ft deep, assume 8" t)	4,431	cy	$400	$ 1,772,554	
Channel Excavation	7,455	cy	$5	$ 37,273	
Drop Structures (one between Zarahemla & Abina	1	each	$50,000	$ 50,000	
Erosion Mat & Seed	17,394	sy	$8	$ 139,154	
CULVERTS (6' Dia., 8' depth)	1,025	ft	$343	$ 351,575	
INLET STRUCTURES	11	each	$8,000	$ 88,000	
Outlet Energy Structure & dissipation	11	each	$8,000	$ 88,000	
TOTAL COMPARATIVE COST				**$ 2,526,556**	$372 per foot

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SALT LAKE COUNTY
NEFFS CANYON
UPPER DEBRIS BASIN ALTERNATIVE (LOCATED IN WILDERNESS AREA)
EARTHWORK - CONCEPTUAL ESTIMATE May 2006

	Cross Section	AREA CUT	AVG AREA	DELTA VOLUME		AREA FILL			
0	246.77	0.0				0.0			
toe_West	333.3	876.3	438	37,911		1,392.0	696	60,225	
Toe_East	419.4	3,711.8	2,294	197,517		1,558.1	1,475	127,002	
FL B	451.5	3,094.5	3,403	109,241		817.2	1,188	38,124	
Toe_East	511.4	2,350.1	2,722	163,063		386.9	602	36,064	
Toe_West	561.1	8,059.2	5,205	258,670		197.2	292	14,516	
0	707.8	0.0	4,030	591,142		0	99	14,465	
TOTAL (FT3)				1,357,543				290,395	
TOTAL (CY)				**50,279**	CUT			**10,755**	FILL

SALT LAKE COUNTY
NEFFS CANYON
LOWER DEBRIS BASIN ALTERNATIVE
(LOCATED ON FOREST SERVICE PROPERTY BELOW THE WILDERNESS AREA)
EARTHWORK - CONCEPTUAL ESTIMATE March 2006

Cross Section	AREA **CUT**	AVG AREA	DELTA VOLUME		AREA **FILL**	AVG AREA	DELTA VOLUME	
0	0				0			
64	939	470	30,048		93	46	2,960	
180.76	4,030	2,485	290,107		746	419	48,974	
298.59	2,698	3,364	396,402		1,878	1,312	154,627	
420.36	2,681	2,690	327,502		814	1,346	163,919	
479.04	2,427	2,554	149,882		93	454	26,621	
707.76	0	1,214	277,609		0	47	10,664	
TOTAL (FT3)			1,471,550				407,766	
TOTAL (CY)			**54,502**	CUT			**15,102**	FILL