J&K, INC.

Preliminary Drainage Analysis

Eagle River Station

COLORADO LICENSED
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May 5, 2011

I hereby certify that this report was prepared by me or under my Supervision and that I am a duly Registered Engineer under the laws of the State of Colorado.

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Job No. 11016

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1 INTRODUCTION

A regional drainage study was performed for the Eagle River Station project. This report summarizes methodology, input data, description of proposed drainage features, and provides a basis for the design of the storm drainage system.

The scope of our study includes off-site drainage basins that impact the development, and on-site basins defined for the historical conditions as well as the post-development design. The proposed disturbed area is about 100 acres and the offsite drainage area is 5.9 square miles. The total drainage area is divided into four major off-site basins, eight historical on-site basins, and five post-development on-site basins.

Offsite flows from this regional basin are concentrated at four locations along the north side of Interstate 70 and discharged onto the site. A prior study titled "Red Mountain Ranch, Preliminary Stormwater Control Plan and Pollution Control Plan", by Nolte Associates, Inc., dated January 2005, estimated the peak flows for the 100 year, 24 hour storm event to be 1140 cfs for the basin corresponding to Basin 1 in this report, 215 cfs for Basin 2, 183 cfs for Basin 3, and 5 cfs for Basin 4. These tributary flows have historically traversed the property in natural channels and discharged into the Eagle River. Onsite flows historically sheet flow to the south and concentrate at a series of bridges and culverts along US Highway 6 which discharge into the Eagle River.

The purpose of our study was to provide the data used to design drainage features and grading in a manner that controls flood waters from adversely affecting the proposed development.

2 LOCATION

The Eagle River Station project site is located in Sections 27, 28, 33 & 34, Township 4 South, Range 84 West of the 6th Principal Meridian, Eagle County, Colorado. The property is bordered by Interstate 70 to the north, and U.S. Highway 6 on the south.

3 METHODOLOGY

The project hydrology was analyzed using HEC HMS version 3.1.0.

The SCS Unit Hydrograph Transform and the SCS Curve Number Loss Method were used to calculate the watershed runoff hydrographs. Historical drainage basins contributing to the project outfall were delineated using a combination of the USGS Quad Sheets and topography from aerial mapping. Post-development drainage basins were delineated from the proposed site grading plans. Watershed hydrologic soil types, mapped by the County NRCS, were then delineated within the overall watershed. Vegetative cover type was delineated from aerial photography calibrated by field inspections (Appendix A).

Curve numbers were assigned for each combination of hydrologic soil type and vegetative cover type from Table 2-2, of the NRCS TR-55. A composite area weighted average curve number was computed for each sub-basin (Appendix B). The post-development model assumed 80% directly connected impervious area for all post development basins.

The time of concentration and lag time for each sub-basin was determined using methods outlined in NRCS TR-55 (Appendix D).

An SCS Type II Storm distribution was developed for the 100 year return interval. The NOAA Atlas 2, Volume III, provided precipitation estimates for the 24 hour duration period, and regional methods for extrapolating the other required frequencies and durations (Appendix E). The 100 year, 24hour, precipitation used in the model was 2.67 inches.

The 100 year, 24 hour, storm was the basis for determining the impact of stormwater runoff on the proposed development. This configuration was then processed through HEC-HMS.

4 RESULTS OF ANALYSIS

The tables below summarize the historical and post-development model results:

HISTORICAL MODEL	DRAINAGE AREA (AC.)	100YR / 24HR PEAK FLOW (CFS)
BASIN 1	2,839.3	396.2
BASIN 2	461.2	52.4
BASIN 3	379.1	48.2
BASIN 4	10.6	5.3
BASIN 5	8.3	3.5
BASIN 6	7.9	1.9
BASIN 7	10.7	3.4
BASIN 8	3.6	0.9
BASIN 9	10.0	1.7
BASIN 10	45.2	5.3
BASIN 11	4.1	0.7
BASIN 12	12.8	2.1
B1	2,839.3	396.2
B2	461.2	52.4
B3	379.1	48.2
B4	10.6	5.3
O1	387.4	48.8
O2	7.9	1.9
O3	2,853.6	396.9
O4	10.0	1.7
O5	510.5	55.6
O6	12.8	2.1

POST-DEVELOPMENT MODEL	DRAINAGE AREA (AC.)	100YR / 24HR PEAK FLOW (CFS)
BASIN 1	2,839.3	396.2
BASIN 2	461.2	52.4
BASIN 3	379.1	48.2
BASIN 4	10.6	5.3
BASIN 5	8.7	22.7
BASIN 6	10.1	24.3
BASIN 7	26.4	44.5
BASIN 8	37.0	75.8
BASIN 9	13.1	33.3
B1	3,218.4	427.1
B2	461.2	52.4
B3	379.1	48.2
B4	10.6	5.3
O1	8.7	22.7
O2	3,255.0	433.4
O3	511.3	107.1

The resulting flows and storm volumes at each basin and outfall are also reported in Appendix E.

As a check of our model calibration we have also compared the peak flow values for the major off-site basins to statistical data available for other basins in Eagle County (See Appendix F). The modeled flow values fall between the minimum and maximum flows for gaged basins of similar size in Eagle County.

The existing structures downstream of each outfall were analyzed for their ability to convey the 100year, 24 hour, storm flows resulting from the Post-Development model. The calculations for each are reported in Appendix G and summarized in the following table.

POST-DEVELOPMENT OUTFALL	STRUCTURE DESCRIPTION	DEPTH OF FLOW AT INLET(IN.)	PERCENT FULL	VELOCITY (FPS)
B1	Concrete Box Culvert (13' W x 14' H)	56.3	34%	24.6
B2	Elliptical CMP (48" H x 72" W)	27.1	59%	11.0
B3	Diversion Ditch (5' Deep w/ 3:1 Side Slopes)	19.3	32%	5.3
B4	CMP (24" Dia.)	13.3	59%	5.8
O1 at RR	Bridge Opening (13.5' Wx 6' H)	7.2	10%	3.8
O1 at US 6	Concrete Box Culvert (13' W x 7' H)	7.0	8%	7.0
O2 at RR	Bridge Opening (13.5' Wx 8' H)	59.0	61%	12.2
O2 at US 6	Bridge Opening (79' Wx 8' H)	17.0	18%	8.7
O3 at RR	Bridge Opening (10' Wx 8' H)	27.0	28%	8.1
O3 at US 6	Concrete Box Culvert (13' W x 7' H)	23.1	28%	11.3

It must be noted that debris flow could develop in the offsite basins during the 100 year, 24 hour storm event. It would be reasonable to assume a bulking factor of 2.5 to 3 to account for potential debris in the stormwater runoff. The structure calculations reported in Appendix G include rating tables to assist in evaluating increases in flow. If the flows were increased by a factor of 3 to account for debris, these structures would have the capacity to convey the extra runoff, however, it is entirely likely that the suspended debris would obstruct the inlets.

5 POLLUTION & EROSION CONTROL

5.1 Permanent Controls

Onsite flows will be captured through a system of inlet structures and downspout laterals. Best Management Practices will be employed to treat any flows with the potential for pollution. Polluted stormwater will be treated through the use of devices designed for the specific type of pollution likely. The exact design and specifications shall be incorporated into the final design construction drawings. The follows are some examples of the technologies under evaluation:

- Stormceptor®
- BaySaver®

- Vortechnics® - Vortechs® System
- The SNOUT®
- VortFilter®
- Aqua-Swirl®
- CDS SanSep
- Downstream Defender™
- Environment 21 - V2B1™
- Howland Swale©

Surface drainage will be treated in grass-lined swales prior to discharge at project outfalls. Straw bales installed in the roadside ditches at regular intervals will also provide initial means of erosion and sedimentation control until natural vegetation is well established. Permanent riprap and/or energy dissipation structures will be constructed at the outlet of the culverts where required. The riprap and energy dissipation will be designed to control erosion by decreasing discharge velocities at the discharge point of culverts prior to entering natural drainage ways.

Offsite flows to will be treated by new wetlands and existing wetlands prior to reaching the Eagle River.

The cut and fill slopes required for road construction will be seeded with native vegetation, which will require little moisture. Lot areas will be left in their natural state as much as possible until construction occurs. Cut-off trenches and straw mulch and/or netting will be employed to reduce erosion until permanent vegetation is established.

5.2 Temporary Controls

Temporary controls will be required for initial construction operation and for road and drainage construction and final landscaping. The installation of underground utilities including, but not limited to, sewer and water will require the control of erosion and sedimentation. The temporary controls will be maintained for a minimum period of one year or for one full growing season until re-seeded areas are well established.

A number of procedures will be implemented for temporary control of erosion and sedimentation during construction operations. These procedures are classified as follows:

Exposure of unstable earth will be minimized. The contractor will be limited to opening a maximum of 100 feet of trench along the pipeline route. This will reduce the volumetric flow of ground water required to be de-watered from the excavation. This will also reduce the surface area of the spoils pile, which will potentially be subjected to erosion during storm events.

Backfill compaction will be tightly controlled. This will reduce the erosion potential of backfilled areas by improving the cohesiveness of the soils. The contractor will be

required to meet 85-95% of maximum density compaction requirements, depending upon location as defined in the project specifications.

Storm water and dewatering will be controlled. The contractor will have some latitude in his approach here; however, the contract documents will require strict adherence to applicable County and State water quality requirements. We will provide the following suggestions for control:

The dewatering pipeline routes will be near or in new road or utility construction. Temporary ditches will handle high flows during storm events. The temporary ditches will be used to convey dewatering flows or surface runoff during storm events. If erosion begins to occur, ditch stabilization will involve the use of erosion control fabric, hay and/or mulch.

Water flowing down the ditch will pass through a filtering device, which will reduce sediment load prior to the water entering the natural surface watercourse. The filter system will be constructed of a hay-bale dam to reduce velocity and filter cloth fence for filtration.

A second alternative will be to construct sediment and control ponds on the downstream side of road, between the road and natural surface watercourse. The ponds will employ a combination of earth and hay-bale embankment or fabric water dams, and an outlet pipe or weir to the discharge point. As much as possible, discharge will be routed through natural or cultivated swales to achieve additional treatment prior to entering any natural watercourse or wetland area.

Field adjustments. The Engineer will be providing resident services and the Owner will be present during the majority of the construction. Field modification will be made as necessary to minimize erosion and sedimentation.

5.3 Mulch Stabilization

Mulch stabilization will be used to stabilize exposed soils with non-vegetative materials. The mulch will temporarily protect exposed soil surfaces from erosion damage and reduce off-site environmental damage. This practice will be applicable to areas subject to erosion, where the season and other conditions may not be suitable for growing an erosion-resistant cover or where stabilization is needed during construction or other short periods until more suitable protection can be applied.

Site preparation will basically involve grading disturbed areas as needed and feasible, to permit the use of conventional equipment for applying and anchoring mulch.

The contract will employ needed erosion control practices such as diversions, grade stabilization structures, and berms as required.

The protective materials for mulch stabilization may consist of the following alternatives:

1. Unrotted small grain straw or grass hay at 1.5 to 2 tons per acre is spread uniformly at 70 to 90 pounds per/1000 square feet anchored with a mulch anchoring tool, liquid mulch binders, or netting tie down.
2. Synthetic soil stabilizers may be used under suitable conditions and in sufficient quantities.
3. Wood fiber or paper fiber mulch at the rate of 1,500 pounds per acre may be applied by hydroseeding.
4. Mulch netting, such as paper, jute excelsior, cotton or plastic, may be used.

Mulch anchoring should be accomplished immediately after placement to minimize loss by wind or water. This may be done by one of the following Mulch Stabilization Methods, depending upon the size of the area, steepness of the slopes, and costs:

1. Peg and Twine – Drive 8 to 10 inch wooden pegs to within 2 to 3 inches of the soil surface every 4 feet in all directions. Stakes may be driven before or after applying mulch. Secure mulch to soil surface by stretching twine between pegs in a criss-cross and square pattern. Secure twine around each peg with two or more round turns.
2. Mulch Netting – Staple paper, jute, cotton, excelsior, or plastic netting to the soil surface. Do not use non-degradable netting in areas to be mowed. Netting is usually available in rolls 4 feet wide and up to 300 feet long.
3. Mulch Anchoring Tool – A tractor drawn implement especially designed to punch and anchor mulch into the surface soil. This practice affords maximum erosion control, but its use is limited to those slopes upon which the tractor can operate safely. Tool penetration should be about 3 to 4 inches. On sloping land, the operation should be done on the contour.

The Contractor will have some latitude in which of these methods to use.

5.4 Diversions

Diversions which are basically a channel with a supporting ridge on the lower side constructed across a slope will be constructed to divert water from areas where it is in excess to sites where it can be used or disposed of safely. It includes reducing slope lengths and diverting runoff.

Construction of these diversions will be limited to drainage areas up to 100 acres. The diversions will include temporary diversion, channels, interceptors, and diversion dikes as well as permanent diversion and level spreaders. Temporary diversions usually have a life expectancy of one year or less and the failure hazard is low. This practice will apply to sites where runoff is damaging: (1) cut or fill slopes or steeply sloping land or (2) critical sediment source areas in construction sites. The diversions will have stable outlets. This site will be graded in a way that the diversions can be maintained throughout its planned life.

The design criteria for temporary diversions will be based on peak runoff values determined by TR-55 for a design frequency of 2 years. Permissible velocities shall be limited as shown in the following table:

SOIL TEXTURE	PERMISSIBLE VELOCITY (FT/SEC)			
	BARE CHANNEL	2" TO 6" CHANNEL VEGETATION CONDITION		
		POOR	FAIR	GOOD
Sand, Silt, Sandy Loam & Silty Loan	1.5	1.5	2.0	3.0
Sandy Clay Loam	2.0	2.5	3.0	4.0
Clay	2.5	3.0	4.0	5.0

The shape of the channel cross section shall be such that the diversion can be parabolic, vee-shaped, or trapezoidal, and shall have stable side slopes. The cross section for temporary diversions must give consideration to soil type, frequency of operation, and type of equipment that is anticipated to be crossing the diversion. In no case should slopes be steeper than 2:1. Channel grade may be uniform or variable. The permissible velocity for soil type and vegetative cover will determine maximum grade.

A level lip spreader shall be used at diversion outlets discharging onto areas already stabilized. Diversion dikes for the temporary protection of cut or fill slopes shall be installed to divert runoff. Diverted runoff must be discharged onto a stabilized area or through a slope protection structure. A diversion dike above steep slopes may be used on drainage areas of five acres or less. Larger areas will require a diversion design.

The following is a list of basic diversion design criteria:

Embankment or ridge top width – 2-ft. minimum
Height (compacted fill) – 18 inches, unless otherwise noted on the plans. (Height measured from the up slope toe to top of the dike.)
Side slopes – 3:1 or flatter
Grade – dependent upon topography, but must have positive drainage of 0.25% to the outlet; may require vegetative or mechanical stabilization where grades are excessive.

5.5 General Notes

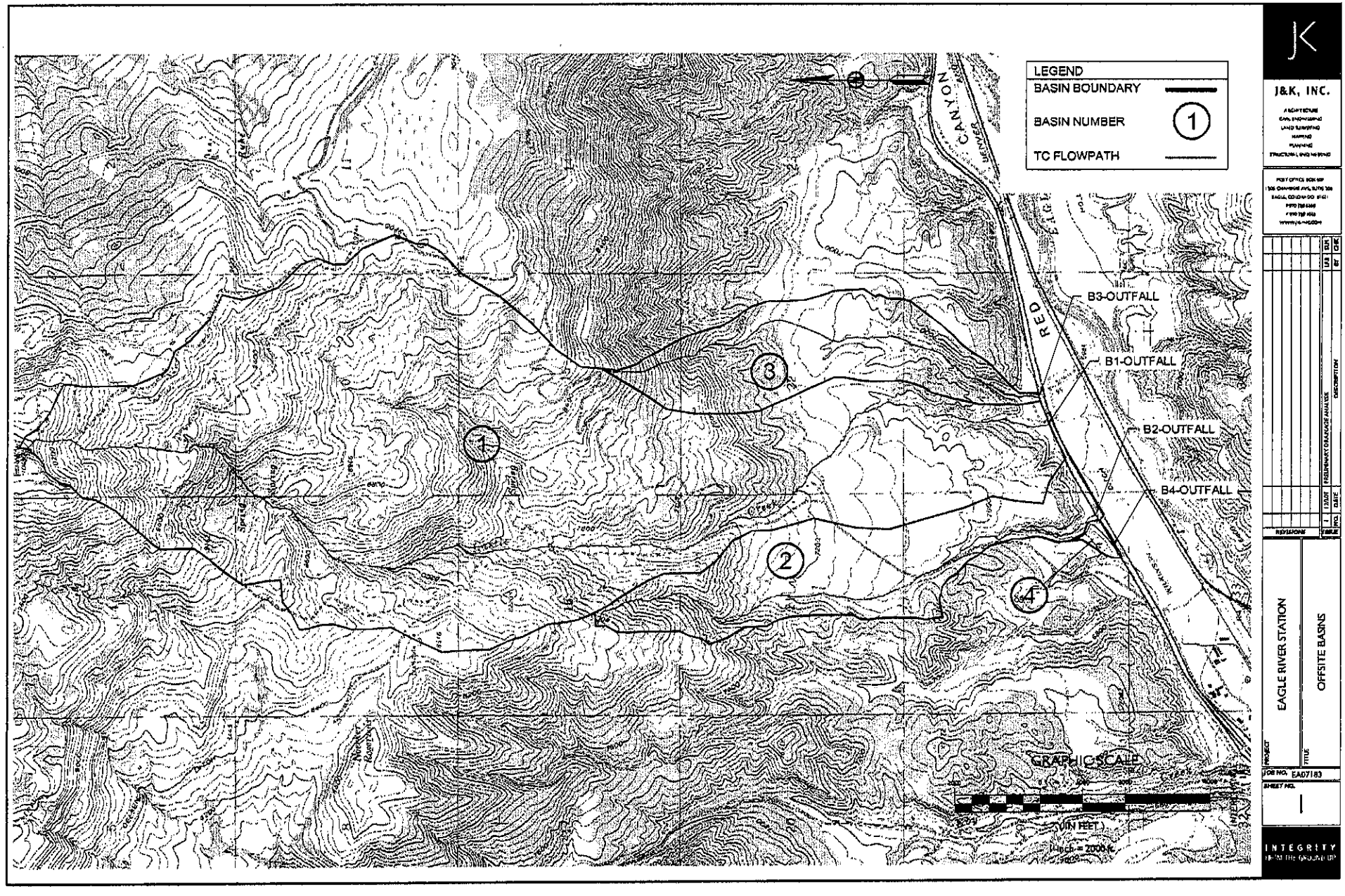
1. All diversions will have positive grade draining to a stabilized outlet.
2. Diverted runoff will outlet onto a stabilized undisturbed area, a prepared level spreader, or into a slope protective structure.
3. Periodic inspection and required maintenance will be provided.

6 CONCLUSION

In summary, the off-site drainage structures adjacent to the proposed development are adequate for conveyance of runoff from the 100 year, 24 hour, storm through the

proposed project. The proposed site grading provides for safe conveyance of the 100 year, 24 hour, storm through the site. The increase in runoff as a result of the proposed development will be conveyed directly to the Eagle River. Stormwater quality will be adequately addressed in the final design process.

7 APPENDIX A – FIGURES



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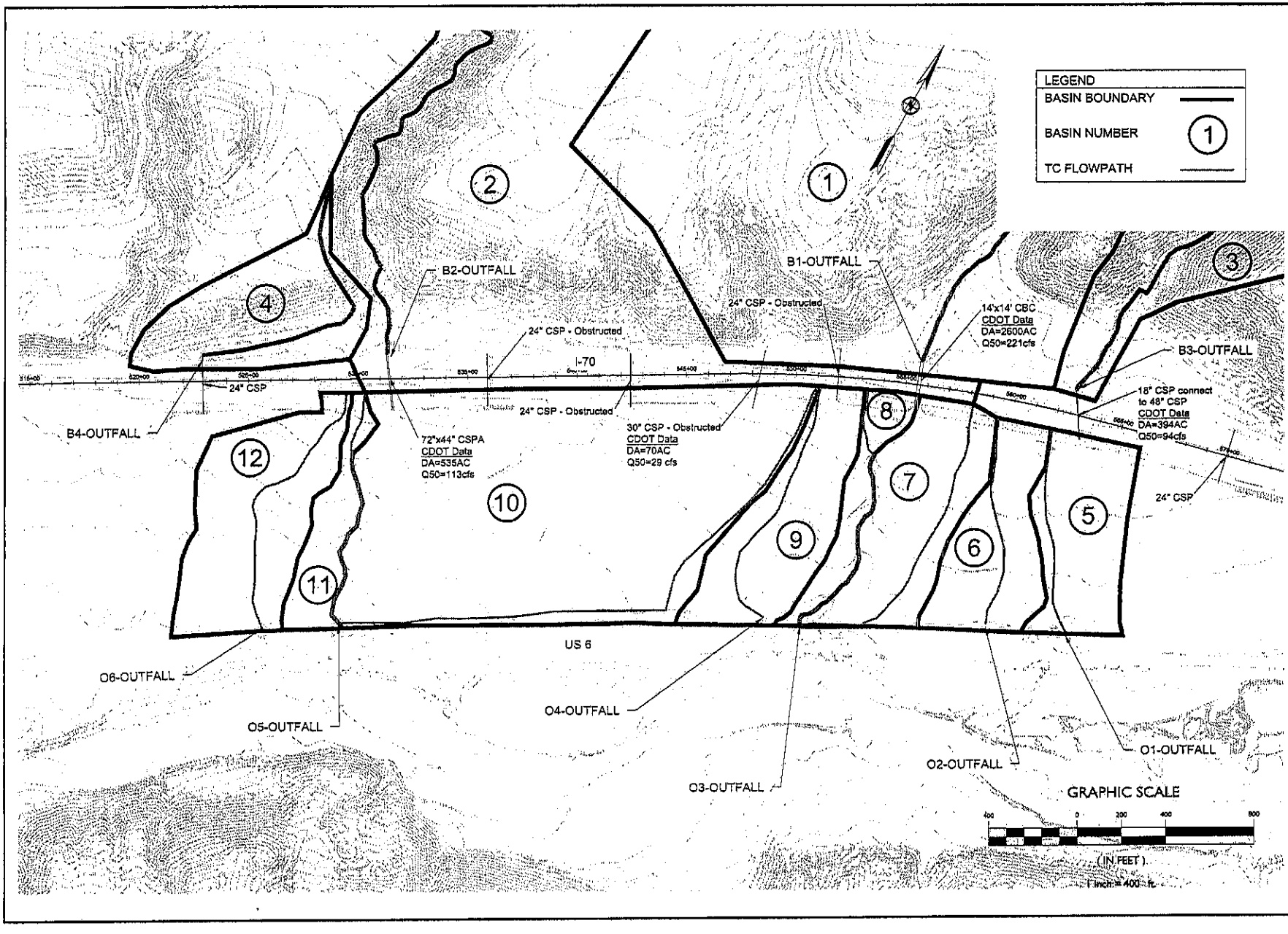

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REVISIONS				
NO.	DATE	DESCRIPTION	DRW	CHK
1	12/13/07	PRELIMINARY DRAINAGE ANALYSIS	LAB	SCH
2	2/28/08	Add CDOT Culverts		BT

PROJECT: EAGLE RIVER STATION

TITLE: PRE-DEVELOPMENT ONSITE BASINS

JOB NO. EA07183

SHEET NO. 2

INTEGRITY FROM THE GROUND UP

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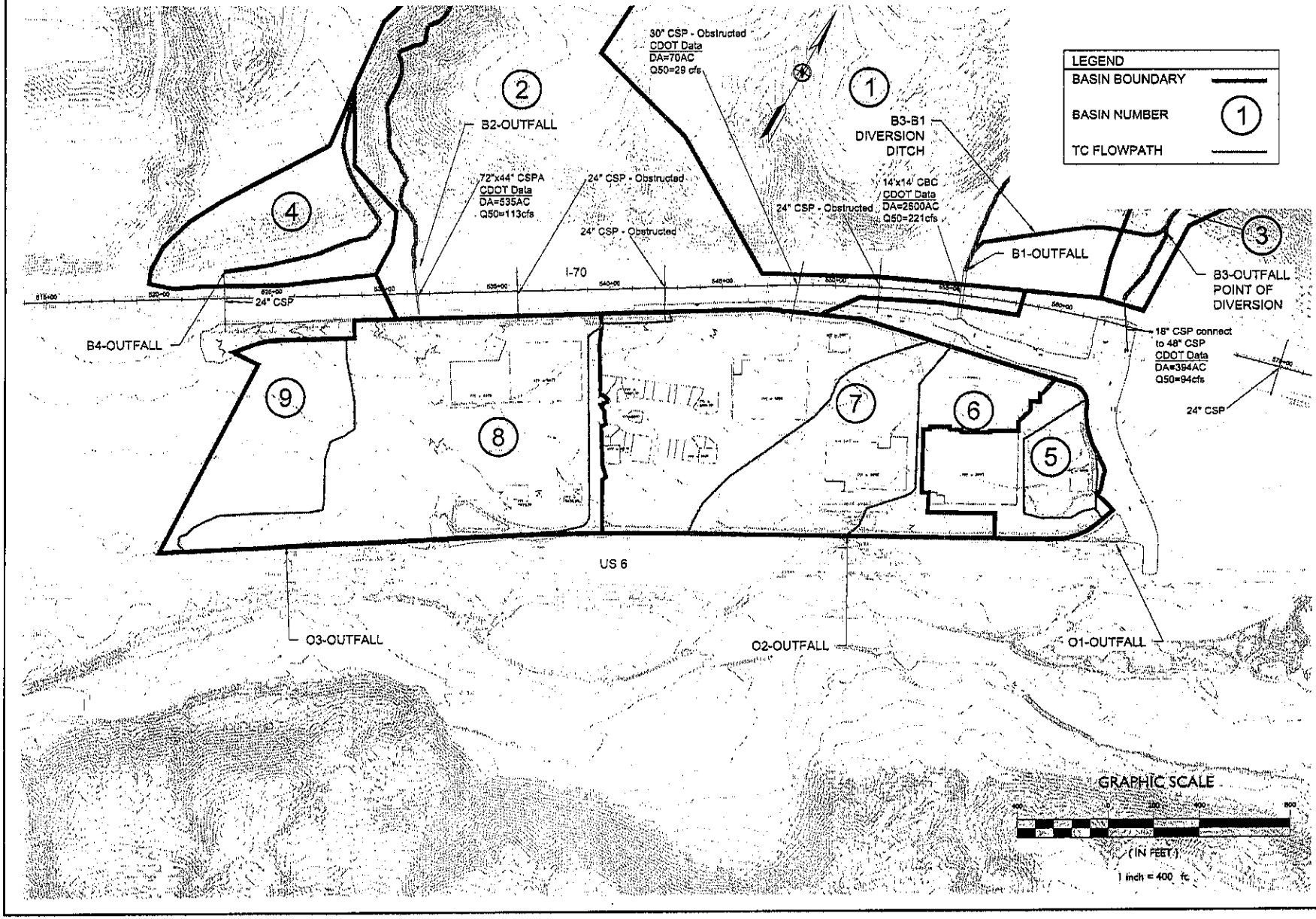

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REVISIONS					
3	5/20/11	Update Basin Grade Contours and TC Flowpath	AO	DJH	
2	3/1/10	Added CDOT Culverts & 1-70 Flowpath	ABD	DJB	
1	12/2/09	PRELIMINARY DRAINAGE ANALYSIS			
NO.	DATE	DESCRIPTION			

PROJECT: EAGLE RIVER STATION

TITLE: POST-DEVELOPMENT ONSITE BASINS

JOB NO. 11016

SHEET NO. 3

INTEGRITY FROM THE GROUND UP

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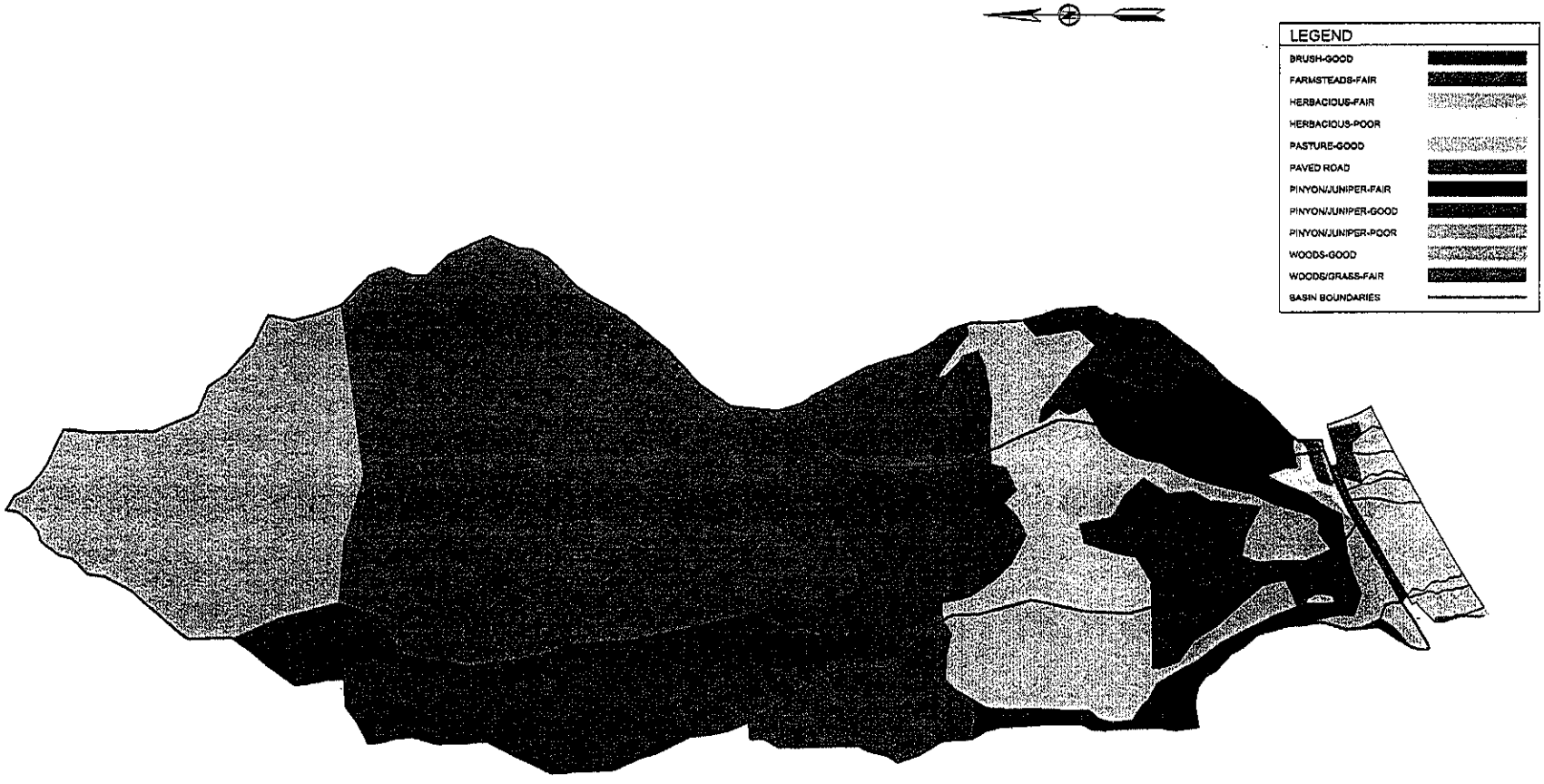

GRAPHIC SCALE

2000 0 1000 2000 4000

(IN FEET)

1 Inch = 2000 ft.

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REVISIONS					
REVISE	NO.	DATE	DESCRIPTION	DR.	CHK.
	1	12/2/07	PRELIMINARY DRAINAGE ANALYSIS	SLH	BT

PROJECT: EAGLE RIVER STATION

TITLE: VEGETATIVE COVER

JOB NO. EA07183

SHEET NO. 4

INTEGRITY FROM THE GROUND UP

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LEGEND

SOIL GROUP B	
SOIL GROUP C	
SOIL GROUP D	
BASIN BOUNDARIES	

GRAPHIC SCALE

2000 0 1000 2000 4000

(IN FEET)

1 inch = 2000 ft.

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REVISIONS				
ISSUE	NO.	DATE	DESCRIPTION	
	1	10/2007	PRELIMINARY DRAINAGE ANALYSIS	LAS / SLP
				BF / CHK

PROJECT: EAGLE RIVER STATION

TITLE: HYDROLOGIC SOIL GROUPS

JOB NO. EA07183

SHEET NO. 5

INTEGRITY FROM THE GROUND UP

8 APPENDIX B – CURVE NUMBER CALCULATIONS

PROJECT: Eagle River Station
JOB NO.: EA07183
PHASE: Historical

BASIN	VEGETATIVE COVER	HYDROLOGIC SOIL GROUP	AREA (SQ. MI.)	CN
1	Brush / Good	B	0.6204	48.00
1	Brush / Good	C	0.0268	65.00
1	Brush / Good	D	0.1105	73.00
1	Farmsteads / Fair	B	0.0043	74.00
1	Farmsteads / Fair	D	0.0010	86.00
1	Herbacious / Fair	B	0.0025	71.00
1	Herbacious / Poor	B	0.0054	80.00
1	Herbacious / Poor	D	0.0077	93.00
1	Pasture / Good	B	0.2045	61.00
1	Pasture / Good	C	0.0075	74.00
1	Paved-Road / Good	B	0.0024	89.00
1	Pinyon-Juniper / Fair	B	0.0485	58.00
1	Pinyon-Juniper / Fair	D	0.0597	80.00
1	Pinyon-Juniper / Good	B	0.1379	41.00
1	Pinyon-Juniper / Good	C	0.3333	61.00
1	Pinyon-Juniper / Good	D	0.0589	71.00
1	Pinyon-Juniper / Poor	B	0.1252	75.00
1	Pinyon-Juniper / Poor	D	0.0031	89.00
1	Woods / Good	B	0.1579	55.00
1	Woods / Good	D	0.9003	77.00
1	Woods-Grass / Fair	B	0.5384	65.00
1	Woods-Grass / Fair	C	0.1199	76.00
1	Woods-Grass / Fair	D	0.9603	82.00
1 Total			4.4364	68.26
2	Brush / Good	B	0.0763	48.00
2	Herbacious / Fair	B	0.0041	71.00
2	Herbacious / Fair	D	0.0030	89.00
2	Pasture / Good	B	0.2397	61.00
2	Pasture / Good	D	0.0017	80.00
2	Paved-Road / Good	B	0.0099	89.00
2	Paved-Road / Good	D	0.0032	93.00
2	Pinyon-Juniper / Fair	B	0.0603	58.00
2	Pinyon-Juniper / Fair	D	0.0520	80.00
2	Pinyon-Juniper / Good	B	0.0491	41.00
2	Pinyon-Juniper / Good	D	0.1520	71.00
2	Pinyon-Juniper / Poor	B	0.0525	75.00
2	Pinyon-Juniper / Poor	D	0.0168	89.00
2 Total			0.7206	63.90

PROJECT: Eagle River Station
JOB NO.: EA07183
PHASE: Historical

BASIN	VEGETATIVE COVER	HYDROLOGIC SOIL GROUP	AREA (SQ. MI.)	CN
3	Brush / Good	B	0.0887	48.00
3	Brush / Good	C	0.0023	65.00
3	Brush / Good	D	0.0190	73.00
3	Farmsteads / Fair	B	0.0019	74.00
3	Farmsteads / Fair	D	0.0000	86.00
3	Herbacious / Fair	B	0.0007	71.00
3	Herbacious / Fair	D	0.0000	89.00
3	Herbacious / Poor	B	0.0002	80.00
3	Herbacious / Poor	D	0.0004	93.00
3	Pasture / Good	B	0.1146	61.00
3	Pasture / Good	C	0.0005	74.00
3	Pinyon-Juniper / Fair	B	0.0337	58.00
3	Pinyon-Juniper / Fair	C	0.0311	73.00
3	Pinyon-Juniper / Fair	D	0.0662	80.00
3	Pinyon-Juniper / Good	B	0.0124	41.00
3	Pinyon-Juniper / Good	C	0.0908	61.00
3	Pinyon-Juniper / Good	D	0.1288	71.00
3	Pinyon-Juniper / Poor	B	0.0000	75.00
3	Pinyon-Juniper / Poor	D	0.0013	89.00
3 Total			0.5924	63.95
4	Brush / Good	B	0.0031	48.00
4	Herbacious / Fair	B	0.0054	71.00
4	Paved-Road / Good	B	0.0009	89.00
4	Pinyon-Juniper / Poor	B	0.0072	75.00
4 Total			0.0166	69.46
5	Farmsteads / Fair	B	0.0062	74.00
5	Pasture / Good	B	0.0067	61.00
5 Total			0.0129	67.26
6	Farmsteads / Fair	B	0.0027	74.00
6	Pasture / Good	B	0.0096	61.00
6 Total			0.0123	63.88
7	Farmsteads / Fair	B	0.0052	74.00
7	Pasture / Good	B	0.0111	61.00
7	Paved-Road / Good	B	0.0003	89.00
7 Total			0.0167	65.56
8	Farmsteads / Fair	B	0.0005	74.00
8	Pasture / Good	B	0.0047	61.00
8	Paved-Road / Good	B	0.0004	89.00
8 Total			0.0056	64.16

PROJECT: Eagle River Station
JOB NO.: EA07183
PHASE: Historical

BASIN	VEGETATIVE COVER	HYDROLOGIC SOIL GROUP	AREA (SQ. MI.)	CN
9	Pasture / Good	B	0.0154	61.00
9	Paved-Road / Good	B	0.0002	89.00
9 Total			0.0156	61.43
10	Pasture / Good	B	0.0692	61.00
10	Pasture / Good	D	0.0001	80.00
10	Paved-Road / Good	B	0.0013	89.00
10	Paved-Road / Good	D	0.0001	93.00
10 Total			0.0707	61.59
11	Pasture / Good	B	0.0064	61.00
11	Paved-Road / Good	B	0.0000	89.00
11 Total			0.0064	61.17
12	Farmsteads / Fair	B	0.0009	74.00
12	Pasture / Good	B	0.0190	61.00
12	Paved-Road / Good	B	0.0001	89.00
12 Total			0.0200	61.71

PROJECT: Eagle River Station
JOB NO.: EA07183
PHASE: Post-Development

BASIN	VEGETATIVE COVER	HYDROLOGIC SOIL GROUP	AREA (SQ. MI.)	CN
5	Open Space / Good	B	0.0136	61.00
5 Total			0.0136	61.00
6	Open Space / Good	B	0.0158	61.00
6 Total			0.0158	61.00
7	Open Space / Good	B	0.0406	61.00
7	Paved-Road / Good	B	0.0007	89.00
7 Total			0.0413	61.47
8	Open Space / Good	B	0.0567	61.00
8	Open Space / Good	D	0.0001	80.00
8	Paved-Road / Good	B	0.0008	89.00
8	Paved-Road / Good	D	0.0001	93.00
8 Total			0.0578	61.50
9	Open Space / Good	B	0.0205	61.00
9 Total			0.0205	61.00

Curve Number Reference

Cover Type / Condition	Curve Numbers by Hydrologic Soil Group B	C	D
Brush / Good	48.00	65.00	73.00
Farmsteads / Fair	74.00	82.00	86.00
Herbacious / Fair	71.00	81.00	89.00
Herbacious / Poor	80.00	87.00	93.00
Pasture / Good	61.00	74.00	80.00
Pinyon-Juniper / Fair	58.00	73.00	80.00
Pinyon-Juniper / Good	41.00	61.00	71.00
Pinyon-Juniper / Poor	75.00	85.00	89.00
Woods / Good	55.00	70.00	77.00
Woods-Grass / Fair	65.00	76.00	82.00
Paved-Road / Good	89.00	92.00	93.00
Open Space / Good	61.00	74.00	80.00

9 APPENDIX C – TIME OF CONCENTRATION CALCULATIONS

PROJECT: Eagle River Station
JOB NO.: EA07183
PHASE: Historical

Segment	Flow Type	Begin Sta.	End Sta.	L (ft)	Begin El. (ft)	End El. (ft)	s (ft/ft)	n	P_2 (in)	a (ft^2)	P_w (ft)	T_t (hr)	T_t (min)
Basin 1													
A	1-Sheet Flow	0	153	153	10,487	10,454	0.219	0.130	1.24	n/a	n/a	0.126	7.6
B	2-Shallow Concentrated - Unpaved	153	572	419	10,454	10,359	0.225	n/a	n/a	n/a	n/a	0.015	0.9
C	2-Shallow Concentrated - Unpaved	572	2,810	2,238	10,359	9,632	0.325	n/a	n/a	n/a	n/a	0.068	4.1
D	2-Shallow Concentrated - Unpaved	2,810	4,584	1,774	9,632	9,310	0.181	n/a	n/a	n/a	n/a	0.072	4.3
E	2-Shallow Concentrated - Unpaved	4,584	5,114	530	9,310	9,119	0.361	n/a	n/a	n/a	n/a	0.015	0.9
F	2-Shallow Concentrated - Unpaved	5,114	8,229	3,115	9,119	8,514	0.194	n/a	n/a	n/a	n/a	0.122	7.3
G	2-Shallow Concentrated - Unpaved	8,229	29,072	20,843	8,514	6,716	0.086	n/a	n/a	n/a	n/a	1.221	73.3
											TOTAL Tc	**1.639**	**98.3**
											T_{LAG} = 0.6 x T_c =	**0.983**	**59.0**
Basin 2													
A	1-Sheet Flow	0	146	146	8,045	7,989	0.380	0.130	1.24	n/a	n/a	0.098	5.9
B	2-Shallow Concentrated - Unpaved	146	268	122	7,989	7,950	0.319	n/a	n/a	n/a	n/a	0.004	0.2
C	2-Shallow Concentrated - Unpaved	268	692	423	7,950	7,857	0.220	n/a	n/a	n/a	n/a	0.016	0.9
D	2-Shallow Concentrated - Unpaved	692	1,607	916	7,857	7,635	0.243	n/a	n/a	n/a	n/a	0.032	1.9
E	2-Shallow Concentrated - Unpaved	1,607	3,167	1,559	7,635	7,458	0.113	n/a	n/a	n/a	n/a	0.080	4.8
F	2-Shallow Concentrated - Unpaved	3,167	8,299	5,132	7,458	7,038	0.082	n/a	n/a	n/a	n/a	0.309	18.5
G	2-Shallow Concentrated - Unpaved	8,299	9,772	1,473	7,038	6,997	0.028	n/a	n/a	n/a	n/a	0.152	9.1
H	2-Shallow Concentrated - Unpaved	9,772	14,202	4,431	6,997	6,702	0.067	n/a	n/a	n/a	n/a	0.295	17.7
											TOTAL Tc	**0.985**	**59.1**
											T_{LAG} = 0.6 x T_c =	**0.591**	**35.5**
Basin 3													
A	1-Sheet Flow	0	139	139	8,347	8,315	0.229	0.130	1.24	n/a	n/a	0.115	6.9
B	2-Shallow Concentrated - Unpaved	139	922	783	8,315	8,003	0.398	n/a	n/a	n/a	n/a	0.021	1.3
C	2-Shallow Concentrated - Unpaved	922	2,482	1,561	8,003	7,272	0.468	n/a	n/a	n/a	n/a	0.039	2.4
D	2-Shallow Concentrated - Unpaved	2,482	3,135	653	7,272	7,187	0.132	n/a	n/a	n/a	n/a	0.031	1.9
E	2-Shallow Concentrated - Unpaved	3,135	6,133	2,997	7,187	6,990	0.066	n/a	n/a	n/a	n/a	0.201	12.1
F	2-Shallow Concentrated - Unpaved	6,133	6,249	116	6,990	6,969	0.180	n/a	n/a	n/a	n/a	0.005	0.3
G	2-Shallow Concentrated - Unpaved	6,249	8,749	2,500	6,969	6,876	0.037	n/a	n/a	n/a	n/a	0.223	13.4
H	2-Shallow Concentrated - Unpaved	8,749	8,920	170	6,876	6,838	0.221	n/a	n/a	n/a	n/a	0.006	0.4
I	2-Shallow Concentrated - Unpaved	8,920	11,389	2,469	6,838	6,724	0.046	n/a	n/a	n/a	n/a	0.197	11.8
											TOTAL Tc	**0.839**	**50.3**
											T_{LAG} = 0.6 x T_c =	**0.503**	**30.2**
Basin 4													
A	1-Sheet Flow	0	146	146	6,832	6,824	0.053	0.130	1.24	n/a	n/a	0.215	12.9
B	2-Shallow Concentrated - Unpaved	146	422	276	6,824	6,807	0.063	n/a	n/a	n/a	n/a	0.019	1.1
C	2-Shallow Concentrated - Unpaved	422	605	183	6,807	6,725	0.447	n/a	n/a	n/a	n/a	0.005	0.3
D	2-Shallow Concentrated - Unpaved	605	844	239	6,725	6,708	0.073	n/a	n/a	n/a	n/a	0.015	0.9
E	2-Shallow Concentrated - Unpaved	844	921	77	6,708	6,706	0.021	n/a	n/a	n/a	n/a	0.009	0.5
F	2-Shallow Concentrated - Unpaved	921	1,123	202	6,706	6,694	0.059	n/a	n/a	n/a	n/a	0.014	0.9
G	2-Shallow Concentrated - Unpaved	1,123	1,362	239	6,694	6,692	0.011	n/a	n/a	n/a	n/a	0.040	2.4
											TOTAL Tc	**0.317**	**19.0**
											T_{LAG} = 0.6 x T_c =	**0.190**	**11.4**
Basin 5													
A	1-Sheet Flow	0	147	147	6,719	6,710	0.066	0.130	1.24	n/a	n/a	0.197	11.8
B	2-Shallow Concentrated - Unpaved	147	233	86	6,710	6,708	0.023	n/a	n/a	n/a	n/a	0.010	0.6
C	2-Shallow Concentrated - Unpaved	233	516	283	6,708	6,696	0.042	n/a	n/a	n/a	n/a	0.024	1.4
D	2-Shallow Concentrated - Unpaved	516	881	365	6,696	6,683	0.035	n/a	n/a	n/a	n/a	0.034	2.0
E	2-Shallow Concentrated - Unpaved	881	944	63	6,683	6,672	0.167	n/a	n/a	n/a	n/a	0.003	0.2
F	2-Shallow Concentrated - Unpaved	944	961	18	6,672	6,672	0.039	n/a	n/a	n/a	n/a	0.002	0.1
											TOTAL Tc	**0.268**	**16.1**
											T_{LAG} = 0.6 x T_c =	**0.161**	**9.7**

PROJECT: Eagle River Station
JOB NO.: EA07183
PHASE: Historical

Segment	Flow Type	Begin Sta.	End Sta.	L (ft)	Begin El. (ft)	End El. (ft)	s (ft/ft)	n	P_2 (in)	a (ft^2)	P_W (ft)	T_t (hr)	T_t (min)
Basin 6													
A	1-Sheet Flow	0	151	151	6,719	6,708	0.078	0.130	1.24	n/a	n/a	0.188	11.3
B	2-Shallow Concentrated - Unpaved	151	289	138	6,708	6,707	0.002	n/a	n/a	n/a	n/a	0.057	3.4
C	2-Shallow Concentrated - Unpaved	289	328	39	6,707	6,706	0.046	n/a	n/a	n/a	n/a	0.003	0.2
D	2-Shallow Concentrated - Unpaved	328	708	380	6,706	6,691	0.039	n/a	n/a	n/a	n/a	0.033	2.0
E	2-Shallow Concentrated - Unpaved	708	813	105	6,691	6,684	0.066	n/a	n/a	n/a	n/a	0.007	0.4
F	2-Shallow Concentrated - Unpaved	813	968	155	6,684	6,679	0.031	n/a	n/a	n/a	n/a	0.015	0.9
G	2-Shallow Concentrated - Unpaved	968	975	7	6,679	6,676	0.377	n/a	n/a	n/a	n/a	0.000	0.0
											TOTAL Tc	**0.304**	**18.3**
											T_{LAG} = 0.6 x T_c =	**0.183**	**11.0**
Basin 7													
A	1-Sheet Flow	0	143	143	6,722	6,707	0.104	0.130	1.24	n/a	n/a	0.161	9.7
B	2-Shallow Concentrated - Unpaved	143	351	208	6,707	6,706	0.009	n/a	n/a	n/a	n/a	0.037	2.2
C	2-Shallow Concentrated - Unpaved	351	921	570	6,706	6,681	0.042	n/a	n/a	n/a	n/a	0.048	2.9
D	2-Shallow Concentrated - Unpaved	921	1,238	317	6,681	6,672	0.029	n/a	n/a	n/a	n/a	0.032	1.9
E	2-Shallow Concentrated - Unpaved	1,238	1,396	158	6,672	6,669	0.018	n/a	n/a	n/a	n/a	0.020	1.2
F	2-Shallow Concentrated - Unpaved	1,396	1,456	60	6,669	6,657	0.209	n/a	n/a	n/a	n/a	0.002	0.1
											TOTAL Tc	**0.300**	**18.0**
											T_{LAG} = 0.6 x T_c =	**0.180**	**10.8**
Basin 8													
A	1-Sheet Flow	0	161	161	6,720	6,705	0.093	0.130	1.24	n/a	n/a	0.185	11.1
B	2-Shallow Concentrated - Unpaved	161	279	118	6,705	6,702	0.022	n/a	n/a	n/a	n/a	0.014	0.8
C	2-Shallow Concentrated - Unpaved	279	313	34	6,702	6,698	0.131	n/a	n/a	n/a	n/a	0.002	0.1
D	2-Shallow Concentrated - Unpaved	313	337	24	6,698	6,698	0.014	n/a	n/a	n/a	n/a	0.004	0.2
E	2-Shallow Concentrated - Unpaved	337	349	12	6,698	6,696	0.129	n/a	n/a	n/a	n/a	0.001	0.0
F	2-Shallow Concentrated - Unpaved	349	508	158	6,696	6,694	0.013	n/a	n/a	n/a	n/a	0.023	1.4
G	2-Shallow Concentrated - Unpaved	349	1,022	672	6,696	6,670	0.039	n/a	n/a	n/a	n/a	0.058	3.5
H	2-Shallow Concentrated - Unpaved	508	1,067	559	6,694	6,670	0.043	n/a	n/a	n/a	n/a	0.046	2.8
I	2-Shallow Concentrated - Unpaved	1,022	1,257	235	6,670	6,656	0.057	n/a	n/a	n/a	n/a	0.017	1.0
											TOTAL Tc	**0.350**	**21.0**
											T_{LAG} = 0.6 x T_c =	**0.210**	**12.6**
Basin 9													
A	1-Sheet Flow	0	148	148	6,717	6,704	0.085	0.130	1.24	n/a	n/a	0.179	10.8
B	2-Shallow Concentrated - Unpaved	148	668	521	6,704	6,688	0.032	n/a	n/a	n/a	n/a	0.050	3.0
C	2-Shallow Concentrated - Unpaved	668	1,151	483	6,688	6,668	0.039	n/a	n/a	n/a	n/a	0.042	2.5
D	2-Shallow Concentrated - Unpaved	1,151	1,175	24	6,668	6,663	0.217	n/a	n/a	n/a	n/a	0.001	0.1
E	2-Shallow Concentrated - Unpaved	1,175	1,229	54	6,663	6,660	0.071	n/a	n/a	n/a	n/a	0.003	0.2
											TOTAL Tc	**0.276**	**16.6**
											T_{LAG} = 0.6 x T_c =	**0.166**	**9.9**
Basin 10													
A	1-Sheet Flow	0	151	151	6,716	6,703	0.087	0.130	1.24	n/a	n/a	0.180	10.8
B	2-Shallow Concentrated - Unpaved	151	1,248	1,098	6,703	6,670	0.030	n/a	n/a	n/a	n/a	0.109	6.5
C	2-Shallow Concentrated - Unpaved	1,248	1,731	482	6,670	6,667	0.007	n/a	n/a	n/a	n/a	0.102	6.1
D	2-Shallow Concentrated - Unpaved	1,731	2,683	953	6,667	6,646	0.022	n/a	n/a	n/a	n/a	0.112	6.7
E	2-Shallow Concentrated - Unpaved	2,683	2,761	78	6,646	6,640	0.083	n/a	n/a	n/a	n/a	0.005	0.3
											TOTAL Tc	**0.508**	**30.5**
											T_{LAG} = 0.6 x T_c =	**0.305**	**18.3**
Basin 11													
A	1-Sheet Flow	0	150	150	6,698	6,688	0.066	0.130	1.24	n/a	n/a	0.201	12.0
B	2-Shallow Concentrated - Unpaved	150	426	276	6,688	6,672	0.060	n/a	n/a	n/a	n/a	0.019	1.2
C	2-Shallow Concentrated - Unpaved	426	603	177	6,672	6,666	0.034	n/a	n/a	n/a	n/a	0.016	1.0
D	2-Shallow Concentrated - Unpaved	603	637	35	6,666	6,660	0.167	n/a	n/a	n/a	n/a	0.001	0.1
E	2-Shallow Concentrated - Unpaved	637	661	24	6,660	6,659	0.026	n/a	n/a	n/a	n/a	0.003	0.2
F	2-Shallow Concentrated - Unpaved	661	906	245	6,659	6,647	0.048	n/a	n/a	n/a	n/a	0.019	1.2
G	2-Shallow Concentrated - Unpaved	906	1,098	191	6,647	6,642	0.029	n/a	n/a	n/a	n/a	0.019	1.2
H	2-Shallow Concentrated - Unpaved	1,098	1,134	36	6,642	6,640	0.059	n/a	n/a	n/a	n/a	0.003	0.2
											TOTAL Tc	**0.281**	**16.9**
											T_{LAG} = 0.6 x T_c =	**0.169**	**10.1**

PROJECT: Eagle River Station
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Segment	Flow Type	Begin Sta.	End Sta.	L (ft)	Begin El. (ft)	End El. (ft)	s (ft/ft)	n	P_2 (in)	a (ft^2)	P_w (ft)	T_t (hr)	T_t (min)
Basin 12													
A	1-Sheet Flow	0	154	154	6,698	6,688	0.065	0.130	1.24	n/a	n/a	0.206	12.4
B	2-Shallow Concentrated - Unpaved	154	340	186	6,688	6,680	0.043	n/a	n/a	n/a	n/a	0.016	0.9
C	2-Shallow Concentrated - Unpaved	340	386	46	6,680	6,674	0.133	n/a	n/a	n/a	n/a	0.002	0.1
D	2-Shallow Concentrated - Unpaved	386	729	344	6,674	6,668	0.017	n/a	n/a	n/a	n/a	0.045	2.7
E	2-Shallow Concentrated - Unpaved	729	792	63	6,668	6,662	0.091	n/a	n/a	n/a	n/a	0.004	0.2
F	2-Shallow Concentrated - Unpaved	792	1,241	449	6,662	6,646	0.036	n/a	n/a	n/a	n/a	0.041	2.4
G	2-Shallow Concentrated - Unpaved	1,241	1,268	27	6,646	6,640	0.226	n/a	n/a	n/a	n/a	0.001	0.1
H	2-Shallow Concentrated - Unpaved	1,268	1,286	19	6,640	6,639	0.005	n/a	n/a	n/a	n/a	0.004	0.3
											TOTAL Tc	**0.318**	**19.1**
											T_{LAG} = 0.6 x T_c =	**0.191**	**11.5**
B3-O1													
A	1-Sheet Flow	0	250	250	6,724	6,710	0.056	0.130	1.24	n/a	n/a	0.323	19.4
B	2-Shallow Concentrated - Unpaved	250	430	180	6,710	6,708	0.010	n/a	n/a	n/a	n/a	0.032	1.9
C	2-Shallow Concentrated - Unpaved	430	1,088	658	6,708	6,683	0.038	n/a	n/a	n/a	n/a	0.058	3.5
D	2-Shallow Concentrated - Unpaved	1,088	1,154	66	6,683	6,672	0.170	n/a	n/a	n/a	n/a	0.003	0.2
E	2-Shallow Concentrated - Unpaved	1,154	1,169	15	6,672	6,671	0.007	n/a	n/a	n/a	n/a	0.003	0.2
											TOTAL Tc	**0.418**	**25.1**
											T_{LAG} = 0.6 x T_c =	**0.251**	**15.1**
B1-O3													
A	1-Sheet Flow	0	215	215	6,729	6,704	0.120	0.130	1.24	n/a	n/a	0.211	12.6
B	2-Shallow Concentrated - Unpaved	215	313	98	6,704	6,703	0.004	n/a	n/a	n/a	n/a	0.027	1.6
C	2-Shallow Concentrated - Unpaved	313	721	408	6,703	6,693	0.024	n/a	n/a	n/a	n/a	0.046	2.7
D	2-Shallow Concentrated - Unpaved	721	772	51	6,693	6,688	0.101	n/a	n/a	n/a	n/a	0.003	0.2
E	2-Shallow Concentrated - Unpaved	772	887	114	6,688	6,684	0.035	n/a	n/a	n/a	n/a	0.010	0.6
F	2-Shallow Concentrated - Unpaved	887	1,230	343	6,684	6,670	0.043	n/a	n/a	n/a	n/a	0.029	1.7
G	2-Shallow Concentrated - Unpaved	1,230	1,281	51	6,670	6,669	0.017	n/a	n/a	n/a	n/a	0.007	0.4
H	2-Shallow Concentrated - Unpaved	1,281	1,471	189	6,669	6,656	0.067	n/a	n/a	n/a	n/a	0.013	0.8
											TOTAL Tc	**0.345**	**20.7**
											T_{LAG} = 0.6 x T_c =	**0.207**	**12.4**
B2-O5													
A	2-Shallow Concentrated - Unpaved	0	240	240	6,702	6,696	0.025	0.130	1.24	n/a	n/a	0.026	1.6
B	2-Shallow Concentrated - Unpaved	240	258	18	6,696	6,693	0.124	n/a	n/a	n/a	n/a	0.001	0.1
C	2-Shallow Concentrated - Unpaved	258	857	599	6,693	6,665	0.047	n/a	n/a	n/a	n/a	0.047	2.8
D	2-Shallow Concentrated - Unpaved	857	884	27	6,665	6,660	0.166	n/a	n/a	n/a	n/a	0.001	0.1
E	2-Shallow Concentrated - Unpaved	884	1,193	310	6,660	6,646	0.048	n/a	n/a	n/a	n/a	0.024	1.5
F	2-Shallow Concentrated - Unpaved	1,193	1,354	161	6,646	6,642	0.026	n/a	n/a	n/a	n/a	0.017	1.0
G	2-Shallow Concentrated - Unpaved	1,354	1,370	15	6,642	6,640	0.132	n/a	n/a	n/a	n/a	0.001	0.0
H	2-Shallow Concentrated - Unpaved	1,370	1,386	16	6,640	6,639	0.006	n/a	n/a	n/a	n/a	0.004	0.2
											TOTAL Tc	**0.121**	**7.3**
											T_{LAG} = 0.6 x T_c =	**0.073**	**4.4**

PROJECT: Eagle River Station
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PHASE: Post-Development

Segment	Flow Type	Begin Sta.	End Sta.	L (ft)	Begin El. (ft)	End El. (ft)	s (ft/ft)	n	P_2 (in)	a (ft^2)	P_w (ft)	T_t (hr)	T_t (min)
Basin 1													
A	1-Sheet Flow	0	153	153	10,487	10,454	0.219	0.130	1.24	n/a	n/a	0.126	7.6
B	2-Shallow Concentrated - Unpaved	153	572	419	10,454	10,359	0.225	n/a	n/a	n/a	n/a	0.015	0.9
C	2-Shallow Concentrated - Unpaved	572	2,810	2,238	10,359	9,632	0.325	n/a	n/a	n/a	n/a	0.068	4.1
D	2-Shallow Concentrated - Unpaved	2,810	4,584	1,774	9,632	9,310	0.181	n/a	n/a	n/a	n/a	0.072	4.3
E	2-Shallow Concentrated - Unpaved	4,584	5,114	530	9,310	9,119	0.361	n/a	n/a	n/a	n/a	0.015	0.9
F	2-Shallow Concentrated - Unpaved	5,114	8,229	3,115	9,119	8,514	0.194	n/a	n/a	n/a	n/a	0.122	7.3
G	2-Shallow Concentrated - Unpaved	8,229	29,072	20,843	8,514	6,716	0.086	n/a	n/a	n/a	n/a	1.221	73.3
											TOTAL Tc	**1.639**	**98.3**
											T_{LAG} = 0.6 x T_c =	**0.983**	**59.0**
Basin 2													
A	1-Sheet Flow	0	146	146	8,045	7,989	0.380	0.130	1.24	n/a	n/a	0.098	5.9
B	2-Shallow Concentrated - Unpaved	146	268	122	7,989	7,950	0.319	n/a	n/a	n/a	n/a	0.004	0.2
C	2-Shallow Concentrated - Unpaved	268	692	423	7,950	7,857	0.220	n/a	n/a	n/a	n/a	0.016	0.9
D	2-Shallow Concentrated - Unpaved	692	1,607	916	7,857	7,635	0.243	n/a	n/a	n/a	n/a	0.032	1.9
E	2-Shallow Concentrated - Unpaved	1,607	3,167	1,559	7,635	7,458	0.113	n/a	n/a	n/a	n/a	0.080	4.8
F	2-Shallow Concentrated - Unpaved	3,167	8,299	5,132	7,458	7,038	0.082	n/a	n/a	n/a	n/a	0.309	18.5
G	2-Shallow Concentrated - Unpaved	8,299	9,772	1,473	7,038	6,997	0.028	n/a	n/a	n/a	n/a	0.152	9.1
H	2-Shallow Concentrated - Unpaved	9,772	14,202	4,431	6,997	6,702	0.067	n/a	n/a	n/a	n/a	0.295	17.7
											TOTAL Tc	**0.985**	**59.1**
											T_{LAG} = 0.6 x T_c =	**0.591**	**35.5**
Basin 3													
A	1-Sheet Flow	0	139	139	8,347	8,315	0.229	0.130	1.24	n/a	n/a	0.115	6.9
B	2-Shallow Concentrated - Unpaved	139	922	783	8,315	8,003	0.398	n/a	n/a	n/a	n/a	0.021	1.3
C	2-Shallow Concentrated - Unpaved	922	2,482	1,561	8,003	7,272	0.468	n/a	n/a	n/a	n/a	0.039	2.4
D	2-Shallow Concentrated - Unpaved	2,482	3,135	653	7,272	7,187	0.132	n/a	n/a	n/a	n/a	0.031	1.9
E	2-Shallow Concentrated - Unpaved	3,135	6,133	2,997	7,187	6,990	0.066	n/a	n/a	n/a	n/a	0.201	12.1
F	2-Shallow Concentrated - Unpaved	6,133	6,249	116	6,990	6,969	0.180	n/a	n/a	n/a	n/a	0.005	0.3
G	2-Shallow Concentrated - Unpaved	6,249	8,749	2,500	6,969	6,876	0.037	n/a	n/a	n/a	n/a	0.223	13.4
H	2-Shallow Concentrated - Unpaved	8,749	8,920	170	6,876	6,838	0.221	n/a	n/a	n/a	n/a	0.006	0.4
I	2-Shallow Concentrated - Unpaved	8,920	11,389	2,469	6,838	6,724	0.046	n/a	n/a	n/a	n/a	0.197	11.8
											TOTAL Tc	**0.839**	**50.3**
											T_{LAG} = 0.6 x T_c =	**0.503**	**30.2**
Basin 4													
A	1-Sheet Flow	0	146	146	6,832	6,824	0.053	0.130	1.24	n/a	n/a	0.215	12.9
B	2-Shallow Concentrated - Unpaved	146	422	276	6,824	6,807	0.063	n/a	n/a	n/a	n/a	0.019	1.1
C	2-Shallow Concentrated - Unpaved	422	605	183	6,807	6,725	0.447	n/a	n/a	n/a	n/a	0.005	0.3
D	2-Shallow Concentrated - Unpaved	605	844	239	6,725	6,708	0.073	n/a	n/a	n/a	n/a	0.015	0.9
E	2-Shallow Concentrated - Unpaved	844	921	77	6,708	6,706	0.021	n/a	n/a	n/a	n/a	0.009	0.5
F	2-Shallow Concentrated - Unpaved	921	1,123	202	6,706	6,694	0.059	n/a	n/a	n/a	n/a	0.014	0.9
G	2-Shallow Concentrated - Unpaved	1,123	1,362	239	6,694	6,692	0.011	n/a	n/a	n/a	n/a	0.040	2.4
											TOTAL Tc	**0.317**	**19.0**
											T_{LAG} = 0.6 x T_c =	**0.190**	**11.4**
Basin 5													
A	1-Sheet Flow	0	156	156	6,715	6,706	0.059	0.011	1.24	n/a	n/a	0.030	1.8
B	3-Shallow Concentrated - Paved	156	263	107	6,706	6,699	0.066	n/a	n/a	n/a	n/a	0.006	0.3
C	3-Shallow Concentrated - Paved	263	355	92	6,699	6,697	0.021	n/a	n/a	n/a	n/a	0.009	0.5
D	3-Shallow Concentrated - Paved	355	455	100	6,697	6,691	0.058	n/a	n/a	n/a	n/a	0.006	0.3
E	3-Shallow Concentrated - Paved	455	581	126	6,691	6,690	0.008	n/a	n/a	n/a	n/a	0.019	1.2
F	3-Shallow Concentrated - Paved	581	1,226	644	6,690	6,685	0.007	n/a	n/a	n/a	n/a	0.103	6.2
											TOTAL Tc	**0.173**	**10.4**
											T_{LAG} = 0.6 x T_c =	**0.104**	**6.2**

PROJECT: Eagle River Station
JOB NO.: EA07183
PHASE: Post-Development

Segment	Flow Type	Begin Sta.	End Sta.	L (ft)	Begin El. (ft)	End El. (ft)	s (ft/ft)	n	P_2 (in)	a (ft^2)	P_w (ft)	T_t (hr)	T_t (min)
Basin 6													
A	1-Sheet Flow	0	155	155	6,715	6,692	0.149	0.011	1.24	n/a	n/a	0.021	1.2
B	3-Shallow Concentrated - Paved	155	529	374	6,692	6,692	0.001	n/a	n/a	n/a	n/a	0.165	9.9
C	3-Shallow Concentrated - Paved	529	1,066	537	6,692	6,678	0.026	n/a	n/a	n/a	n/a	0.045	2.7
											TOTAL Tc	**0.231**	**13.9**
											T_{LAG} = 0.6 x T_c =	**0.139**	**8.3**
Basin 7													
A	1-Sheet Flow	0	145	145	6,715	6,692	0.161	0.011	1.24	n/a	n/a	0.019	1.1
B	3-Shallow Concentrated - Paved	145	506	361	6,692	6,692	0.001	n/a	n/a	n/a	n/a	0.156	9.4
C	3-Shallow Concentrated - Paved	506	555	49	6,692	6,688	0.074	n/a	n/a	n/a	n/a	0.002	0.1
D	3-Shallow Concentrated - Paved	555	1,587	1,032	6,688	6,677	0.011	n/a	n/a	n/a	n/a	0.136	8.2
E	3-Shallow Concentrated - Paved	1,587	1,997	410	6,677	6,677	0.001	n/a	n/a	n/a	n/a	0.192	11.5
											TOTAL Tc	**0.505**	**30.3**
											T_{LAG} = 0.6 x T_c =	**0.303**	**18.2**
Basin 8													
A	1-Sheet Flow	0	152	152	6,705	6,685	0.133	0.011	1.24	n/a	n/a	0.021	1.3
B	3-Shallow Concentrated - Paved	152	478	327	6,685	6,681	0.011	n/a	n/a	n/a	n/a	0.044	2.6
C	3-Shallow Concentrated - Paved	478	738	259	6,681	6,674	0.028	n/a	n/a	n/a	n/a	0.021	1.3
D	3-Shallow Concentrated - Paved	738	1,224	486	6,674	6,672	0.004	n/a	n/a	n/a	n/a	0.107	6.4
E	3-Shallow Concentrated - Paved	1,224	1,633	409	6,672	6,666	0.014	n/a	n/a	n/a	n/a	0.047	2.8
F	3-Shallow Concentrated - Paved	1,633	2,100	468	6,666	6,650	0.034	n/a	n/a	n/a	n/a	0.035	2.1
G	3-Shallow Concentrated - Paved	2,100	2,610	510	6,650	6,646	0.009	n/a	n/a	n/a	n/a	0.074	4.5
											TOTAL Tc	**0.348**	**20.9**
											T_{LAG} = 0.6 x T_c =	**0.209**	**12.5**
Basin 9													
A	1-Sheet Flow	0	163	163	6,693	6,684	0.052	0.011	1.24	n/a	n/a	0.033	2.0
B	3-Shallow Concentrated - Paved	163	413	251	6,684	6,674	0.040	n/a	n/a	n/a	n/a	0.017	1.0
C	3-Shallow Concentrated - Paved	413	989	575	6,674	6,671	0.005	n/a	n/a	n/a	n/a	0.106	6.4
D	3-Shallow Concentrated - Paved	989	1,333	344	6,671	6,659	0.033	n/a	n/a	n/a	n/a	0.026	1.6
E	3-Shallow Concentrated - Paved	1,333	1,493	159	6,659	6,652	0.047	n/a	n/a	n/a	n/a	0.010	0.6
											TOTAL Tc	**0.192**	**11.5**
											T_{LAG} = 0.6 x T_c =	**0.115**	**6.9**
B3-B1													
A	2-Shallow Concentrated - Unpaved	0	528	528	6,738	6,720	0.033	0.011	1.24	n/a	n/a	0.050	3.0
B	2-Shallow Concentrated - Unpaved	528	874	346	6,720	6,717	0.010	n/a	n/a	n/a	n/a	0.060	3.6
											TOTAL Tc	**0.109**	**6.6**
											T_{LAG} = 0.6 x T_c =	**0.066**	**3.9**
B1-O2													
A	2-Shallow Concentrated - Unpaved	0	30	30	6,717	6,716	0.051	0.011	1.24	n/a	n/a	0.002	0.1
B	2-Shallow Concentrated - Unpaved	30	159	130	6,716	6,716	0.002	n/a	n/a	n/a	n/a	0.046	2.7
C	2-Shallow Concentrated - Unpaved	159	370	211	6,716	6,708	0.038	n/a	n/a	n/a	n/a	0.019	1.1
D	2-Shallow Concentrated - Unpaved	370	475	106	6,708	6,695	0.115	n/a	n/a	n/a	n/a	0.005	0.3
E	2-Shallow Concentrated - Unpaved	475	1,459	983	6,695	6,678	0.018	n/a	n/a	n/a	n/a	0.128	7.7
											TOTAL Tc	**0.199**	**12.0**
											T_{LAG} = 0.6 x T_c =	**0.120**	**7.2**
B2-O3													
A	3-Shallow Concentrated - Paved	0	256	256	6,702	6,688	0.053	0.011	1.24	n/a	n/a	0.015	0.9
B	3-Shallow Concentrated - Paved	256	310	54	6,688	6,681	0.125	n/a	n/a	n/a	n/a	0.002	0.1
C	3-Shallow Concentrated - Paved	310	866	556	6,681	6,670	0.020	n/a	n/a	n/a	n/a	0.053	3.2
D	3-Shallow Concentrated - Paved	866	1,222	356	6,670	6,656	0.039	n/a	n/a	n/a	n/a	0.025	1.5
											TOTAL Tc	**0.095**	**5.7**
											T_{LAG} = 0.6 x T_c =	**0.057**	**3.4**

SHEET FLOW:

$$T_t = \frac{0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

WHERE:

$T_t =$ Time of Concentration for flow segment t (hours)
$n =$ Manning's roughness coefficient
$L =$ Flow length (feet)
$P_2 =$ Two year 24 hour rainfall (inches)
$s =$ Land slope (feet per foot)

SHALLOW CONCENTRATED FLOW:

$$T_t = \frac{L}{3600V}$$

WHERE:

$T_t =$ Time of Concentration for flow segment t (hours)
$L =$ Flow length (feet)
$V = 16.1345s^{0.5}$ Velocity for unpaved surface (feet per second)
$V = 20.3182s^{0.5}$ Velocity for paved surface (feet per second)
$s =$ Land slope (feet per foot)

CHANNEL & PIPE FLOW:

$$T_t = \frac{L}{3600V}$$

WHERE:

$T_t =$ Time of Concentration for flow segment t (hours)
$L =$ Flow length (feet)
$V = \frac{1.49r^{2/3}s^{1/2}}{n}$ Velocity (feet per second)
$r = \frac{a}{P_w}$ Hydraulic radius (feet)
$a =$ Cross sectional flow area (square feet)
$P_w =$ Wetted perimeter (feet)
$s =$ Land slope (feet per foot)
$n =$ Manning's roughness coefficient

Roughness Coefficient Guidelines

MANNING'S ROUGHNESS COEFFICIENTS	
Surface Descriptions	**n[1]**
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover< 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prarie	0.15
Dense grasses[2]	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information compiled by Engman (1986).

[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue gama grass, and native mixtures.

[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

10 APPENDIX D – NOAA PRECIPITATION

Precipitation Frequency Data Output

NOAA Atlas 2
Colorado 39.703628?N 106.802869?W
Site-specific Estimates

Map	Precipitation (inches)	Precipitation Intensity (in/hr)
2-year 6-hour	0.82	0.14
2-year 24-hour	1.24	0.05
100-year 6-hour	1.93	0.32
100-year 24-hour	2.67	0.11

Hydrometeorological Design Studies Center - NOAA/National Weather Service
1325 East-West Highway - Silver Spring, MD 20910 - (301) 713-1669
Mon Sep 24 15:28:42 2007

NOAA Atlas 2 - Volume III (Colorado)

Region #2 Depth Duration

San Juan, Upper Rio Grande, Upper Colorado & Gunnison River Basins, and Green River Basin below Confluence with Yampa

Site Description: Eagle River Station- Offsite Drainage Report
Job Number: EA07183

Latitude: 39.70363 N
Longitude: -106.80287 W
Site Elevation: 8000

NOAA Link: http://www.nws.noaa.gov/oh/hdsc/noaaatlas2.htm

Site Specific Precipitation from NOAA Atlas Maps

Duration	2 YR	5 YR	10 YR	25 YR	50 YR	100 YR
6 HR	0.82	1.10	1.28	1.51	1.72	1.93
24 HR	1.24	1.60	1.83	2.12	2.40	2.67

Duration		Precipitation Depth Extrapolated for All Durations					
Minutes	Hours	2 YR	5 YR	10 YR	25 YR	50 YR	100 YR
5	0.083	0.14	0.22	0.27	0.33	0.39	0.45
10	0.167	0.22	0.34	0.42	0.52	0.61	0.70
15	0.25	0.28	0.43	0.53	0.65	0.77	0.88
30	0.5	0.39	0.60	0.74	0.91	1.07	1.22
60	1	0.50	0.76	0.93	1.15	1.35	1.55
120	2	0.61	0.88	1.05	1.27	1.48	1.68
180	3	0.68	0.95	1.13	1.35	1.56	1.77
360	6	0.82	1.10	1.28	1.51	1.72	1.93
720	12	1.02	1.34	1.55	1.80	2.05	2.29
1440	24	1.24	1.60	1.83	2.12	2.40	2.67

11 APPENDIX E – HEC-HMS MODEL RESULTS

Project: EA07183-ERS Simulation Run: 100yr-HIST

Start of Run: 01Jul2007, 00:00 Basin Model: Historical
End of Run: 03Jul2007, 00:00 Meteorologic Model: 100yr/24hr
Compute Time: 29Nov2007, 13:11:51 Control Specifications: Control 1

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
01	4.4364	396.2	01Jul2007, 13:04	112.1
02	0.7206	52.4	01Jul2007, 12:39	12.7
03	0.5924	48.2	01Jul2007, 12:32	10.5
04	0.0166	5.3	01Jul2007, 12:07	0.5
05	0.0129	3.5	01Jul2007, 12:05	0.3
06	0.0123	1.9	01Jul2007, 12:08	0.2
07	0.0167	3.4	01Jul2007, 12:07	0.3
08	0.0056	0.9	01Jul2007, 12:09	0.1
09	0.0156	1.7	01Jul2007, 12:07	0.2
10	0.0707	5.3	01Jul2007, 12:17	1.0
11	0.0064	0.7	01Jul2007, 12:07	0.1
12	0.0200	2.1	01Jul2007, 12:09	0.3
B1	4.4364	396.2	01Jul2007, 13:04	112.1
B1-O3	4.4364	396.2	01Jul2007, 13:16	112.1
B2	0.7206	52.4	01Jul2007, 12:39	12.7
B2-O5	0.7206	52.4	01Jul2007, 12:43	12.7
B3	0.5924	48.2	01Jul2007, 12:32	10.5
B3-O1	0.5924	48.2	01Jul2007, 12:47	10.5
B4	0.0166	5.3	01Jul2007, 12:07	0.5
O1	0.6053	48.8	01Jul2007, 12:47	10.8
O2	0.0123	1.9	01Jul2007, 12:08	0.2
O3	4.4587	396.9	01Jul2007, 13:16	112.6
O4	0.0156	1.7	01Jul2007, 12:07	0.2
O5	0.7977	55.6	01Jul2007, 12:42	13.8
O6	0.0200	2.1	01Jul2007, 12:09	0.3

Project: EA07183-ERS Simulation Run: 100yr POST

Start of Run: 01Jul2007, 00:00 Basin Model: Post-Develo
End of Run: 03Jul2007, 00:00 Meteorologic Model: 100yr/24hr
Compute Time: 02Dec2007, 14:53:11 Control Specifications: Control 1

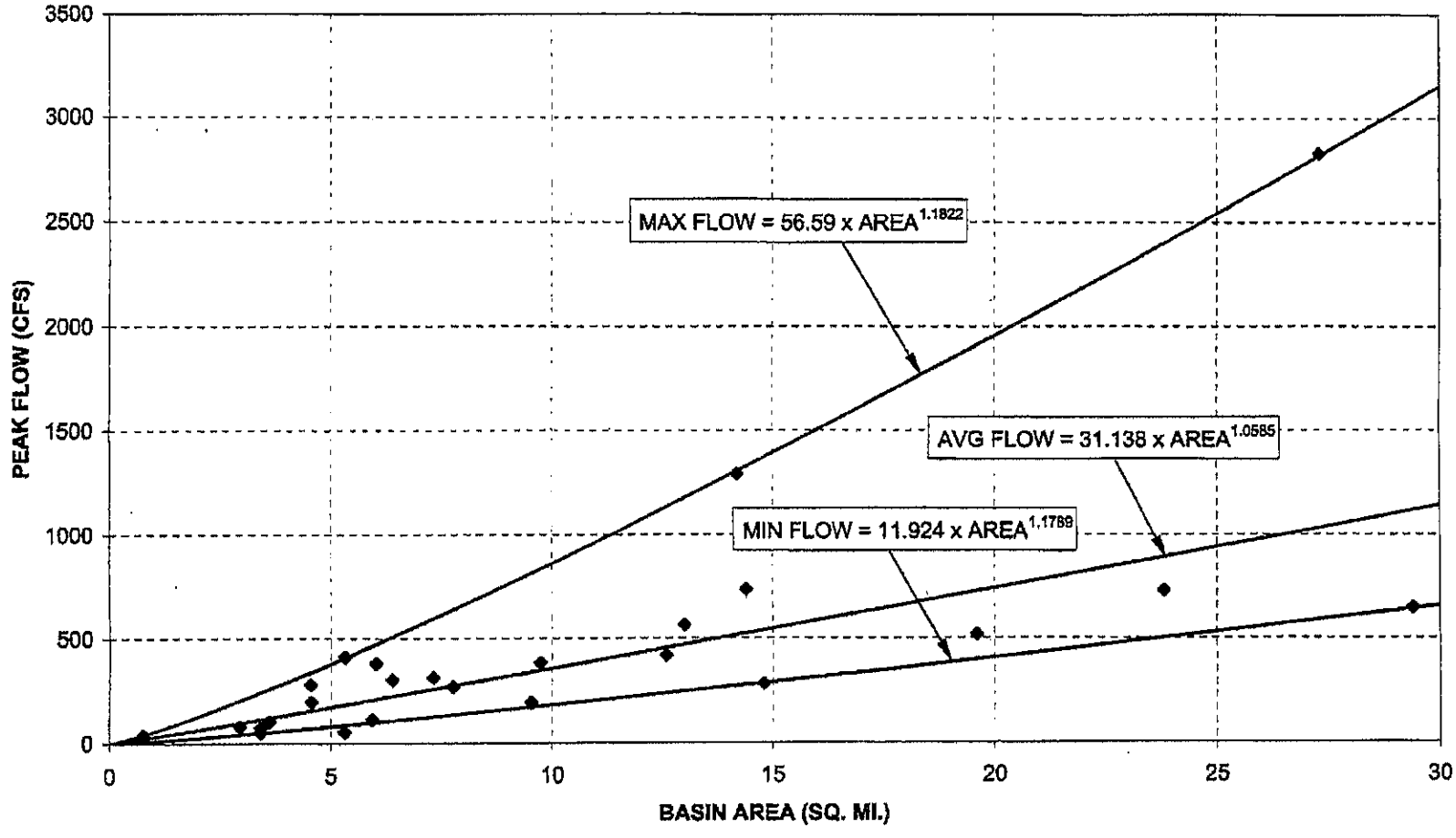
Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
1	4.4364	396.2	01Jul2007, 13:04	112.11
2	0.7206	52.4	01Jul2007, 12:39	12.68
3	0.5924	48.2	01Jul2007, 12:32	10.47
4	0.0166	5.3	01Jul2007, 12:07	0.46
5	0.0136	22.7	01Jul2007, 11:59	1.59
6	0.0158	24.3	01Jul2007, 12:01	1.84
7	0.0413	44.5	01Jul2007, 12:10	4.82
8	0.0578	75.8	01Jul2007, 12:05	6.75
9	0.0205	33.3	01Jul2007, 12:00	2.39
B1	5.0288	427.1	01Jul2007, 13:02	122.58
B1-O2	5.0288	427.1	01Jul2007, 13:09	122.58
B2	0.7206	52.4	01Jul2007, 12:39	12.68
B2-O3	0.7206	52.4	01Jul2007, 12:42	12.68
B3	0.5924	48.2	01Jul2007, 12:32	10.47
B3-B1	0.5924	48.2	01Jul2007, 12:35	10.47
B4	0.0166	5.3	01Jul2007, 12:07	0.46
O1	0.0136	22.7	01Jul2007, 11:59	1.59
O2	5.0859	433.4	01Jul2007, 13:09	129.24
O3	0.7989	107.1	01Jul2007, 12:03	21.82

12 APPENDIX F – STATISTICAL ANALYSIS

DRAINAGE BASINS IN EAGLE COUNTY

100YR FLOW FROM LOG-PEARSON STATISTICAL ANALYSIS
OF GAGED DATA FOR BASINS LESS THAN 30 SQ. MI.



13 APPENDIX G – STRUCTURE CALCULATIONS

B1 Outfall at I-70
13'W x 14'H Box Culvert

Culvert Calculator

All calculator output should be verified prior to design use

Entered Data:

Shape	Rectangular
Number of Barrels	1
Solving for	Headwater
Chart Number	8
Scale Number	1
Chart Description	BOX CULVERT WITH FLARED WINGWALLS NO INLET TOP EDGE BEVEL
Scale Description	WINGWALLS FLARED 30 TO 75 DEGREES
Overtopping	Off
Flowrate	427.1000 cfs
Manning's n	0.0150
Roadway Elevation	6731.0000 ft
Inlet Elevation	6714.2600 ft
Outlet Elevation	6703.0500 ft
Height	168.0000 in
Width	156.0000 in
Length	210.0000 ft
Entrance Loss	0.4000
Tailwater	0.0100 ft

Computed Results:

Headwater	6718.9523 ft Inlet Control
Slope	0.0534 ft/ft
Velocity	24.5533 fps

Messages:

Inlet head > Outlet head.
Computing Inlet Control headwater.
Solving Inlet Equation 26.
Solving Inlet Equation 28.
Headwater: 6718.9523 ft

DIS-CHARGE Flow cfs	HEAD-WATER ELEV. ft	INLET CONTROL DEPTH ft	OUTLET CONTROL DEPTH ft	FLOW TYPE	NORMAL DEPTH in	CRITICAL DEPTH in	OUTLET VEL. fps	OUTLET DEPTH ft	TAILWATER VEL. fps	TAILWATER DEPTH ft
250.00	6717.41	3.15	0.05	NA	11.41	27.08	20.22	0.95	0.00	0.01
500.00	6719.53	5.27	0.05	NA	17.78	42.99	25.96	1.48	0.00	0.01
750.00	6721.33	7.07	0.05	NA	23.18	56.33	29.87	1.93	0.00	0.01
1000.00	6722.95	8.69	0.05	NA	28.07	68.24	32.89	2.34	0.00	0.01
1250.00	6724.45	10.19	0.94	NA	32.64	79.19	35.36	2.72	0.00	0.01
1500.00	6725.87	11.61	2.43	NA	36.97	89.42	37.45	3.08	0.00	0.01

B2 Outfall at I-70
48" x 72" Elliptical CMP
(Approximated by circular of equivalent area)

Culvert Calculator

All calculator output should be verified prior to design use

Entered Data:

Shape	Circular
Number of Barrels	1
Solving for	Headwater
Chart Number	2
Scale Number	1
Chart Description	CORRUGATED METAL PIPE CULVERT
Scale Description	HEADWALL
Overtopping	Off
Flowrate	52.4000 cfs
Manning's n	0.0240
Roadway Elevation	6707.5000 ft
Inlet Elevation	6697.5000 ft
Outlet Elevation	6687.3200 ft
Diameter	58.8000 in
Length	258.0000 ft
Entrance Loss	0.5000
Tailwater	0.0100 ft

Computed Results:

Headwater	6700.2766 ft Inlet Control
Slope	0.0395 ft/ft
Velocity	10.9620 fps

Messages:

Inlet head > Outlet head.
Computing Inlet Control headwater.
Solving Inlet Equation 26.
Solving Inlet Equation 28.
Headwater: 6700.2766 ft

DIS-CHARGE Flow cfs	HEAD-WATER ELEV. ft	INLET CONTROL DEPTH ft	OUTLET CONTROL DEPTH ft	FLOW TYPE	NORMAL DEPTH in	CRITICAL DEPTH in	OUTLET VEL. fps	OUTLET DEPTH ft	TAILWATER VEL. fps	TAILWATER DEPTH ft
20.00	6699.09	1.59	0.05	NA	10.91	14.90	8.29	0.91	0.00	0.01
40.00	6699.87	2.37	0.05	NA	15.41	21.30	10.15	1.28	0.00	0.01
60.00	6700.51	3.01	0.05	NA	18.99	26.31	11.39	1.58	0.00	0.01
80.00	6701.10	3.60	0.05	NA	22.12	30.58	12.33	1.84	0.00	0.01
100.00	6701.67	4.17	0.05	NA	24.99	34.37	13.10	2.08	0.00	0.01
120.00	6702.23	4.73	0.05	NA	27.70	37.79	13.74	2.31	0.00	0.01
140.00	6702.80	5.30	0.05	NA	30.32	40.91	14.28	2.53	0.00	0.01
160.00	6703.59	6.09	0.61	NA	32.89	43.74	14.75	2.74	0.00	0.01

B3 Outfall Diversion Ditch to B1
5' Deep w/ 3:1 Side Slopes & 1% Flowline Slope

Channel Calculator

Given Input Data:

Shape	Trapezoidal
Solving for	Depth of Flow
Flowrate	48.2000 cfs
Slope	0.0100 ft/ft
Manning's n	0.0200
Height	60.0000 in
Bottom width	0.0000 in
Left slope	0.3333 ft/ft (V/H)
Right slope	0.3330 ft/ft (V/H)

Computed Results:

Depth	19.3048 in
Velocity	6.2047 fps
Full Flowrate	991.6213 cfs
Flow area	7.7683 ft2
Flow perimeter	122.1545 in
Hydraulic radius	9.1576 in
Top width	115.8923 in
Area	75.0413 ft2
Perimeter	379.6613 in
Percent full	32.1746 %

Critical Information

Critical depth	20.9007 in
Critical slope	0.0065 ft/ft
Critical velocity	5.2933 fps
Critical area	9.1058 ft2
Critical perimeter	132.2532 in
Critical hydraulic radius	9.9146 in
Critical top width	125.4733 in
Specific energy	2.2070 ft
Minimum energy	2.6126 ft
Froude number	1.2197
Flow condition	Supercritical

Channel Rating Curve Data

Depth - in	Flowrate - cfs
0.00	0.00
6.00	2.14
12.00	13.57
18.00	39.99
24.00	86.13
30.00	156.17
36.00	253.95
42.00	383.07
48.00	546.91
54.00	748.73
60.00	991.62

B4 Outfall at I-70
24" CMP

Culvert Calculator

All calculator output should be verified prior to design use

Entered Data:

Shape	Circular
Number of Barrels	1
Solving for	Headwater
Chart Number	2
Scale Number	1
Chart Description	CORRUGATED METAL PIPE CULVERT
Scale Description	HEADWALL
Overtopping	Off
Flowrate	5.3000 cfs
Manning's n	0.0240
Roadway Elevation	6703.5000 ft
Inlet Elevation	6687.6700 ft
Outlet Elevation	6678.8800 ft
Diameter	24.0000 in
Length	269.0000 ft
Entrance Loss	0.5000
Tailwater	0.0100 ft

Computed Results:

Headwater	6688.7762 ft Inlet Control
Slope	0.0327 ft/ft
Velocity	5.7940 fps

Messages:

Inlet head > Outlet head.
Computing Inlet Control headwater.
Solving Inlet Equation 26.
Solving Inlet Equation 28.
Headwater: 6688.7762 ft

DIS-CHARGE Flow cfs	HEAD-WATER ELEV. ft	INLET CONTROL DEPTH ft	OUTLET CONTROL DEPTH ft	FLOW TYPE	NORMAL DEPTH in	CRITICAL DEPTH in	OUTLET VEL. fps	OUTLET DEPTH ft	TAILWATER VEL. fps	TAILWATER DEPTH ft
5.00	6688.74	1.07	0.05	NA	7.75	9.45	5.70	0.65	0.00	0.01
10.00	6689.31	1.64	0.05	NA	11.30	13.58	6.88	0.94	0.00	0.01
15.00	6689.85	2.18	0.05	NA	14.46	16.75	7.58	1.21	0.00	0.01
20.00	6690.55	2.88	1.50	NA	17.83	19.27	7.99	1.49	0.00	0.01

O1 Outfall at Railroad
13.5'W x 6'H Bridge Opening
(Approximated by box culvert of equivalent area)

Culvert Calculator

All calculator output should be verified prior to design use

Entered Data:

Shape	Rectangular
Number of Barrels	1
Solving for	Headwater
Chart Number	8
Scale Number	1
Chart Description	BOX CULVERT WITH FLARED WINGWALLS NO INLET TOP EDGE BEVEL
Scale Description	WINGWALLS FLARED 30 TO 75 DEGREES
Overtopping	Off
Flowrate	22.7000 cfs
Manning's n	0.0350
Roadway Elevation	6682.7400 ft
Inlet Elevation	6672.7600 ft
Outlet Elevation	6672.3100 ft
Height	72.0000 in
Width	162.0000 in
Length	15.0000 ft
Entrance Loss	0.0000
Tailwater	0.0100 ft

Computed Results:

Headwater	6673.3570 ft Outlet Control
Slope	0.0300 ft/ft
Velocity	3.7821 fps

Messages:

Outlet head > Inlet head.
Computing Outlet Control headwater.
Outlet not submerged.
Normal Depth: 5.0706 in
Critical Depth: 5.3351 in
Normal depth <= critical depth.
Flow is supercritical.
Since culvert is supercritical no profile generated.
Depth = critical depth.
Headwater: 6673.3570 ft

DIS-CHARGE Flow cfs	HEAD-WATER ELEV. ft	INLET CONTROL DEPTH ft	OUTLET CONTROL DEPTH ft	FLOW TYPE	NORMAL DEPTH in	CRITICAL DEPTH in	OUTLET VEL. fps	OUTLET DEPTH ft	TAILWATER VEL. fps	TAILWATER DEPTH ft
10.00	6673.14	0.30	0.38	NA	3.07	5.34	2.88	0.26	0.00	0.01
20.00	6673.31	0.54	0.55	NA	4.69	5.34	3.63	0.39	0.00	0.01
30.00	6673.50	0.74	0.72	NA	6.02	6.42	4.43	0.50	0.00	0.01
40.00	6673.67	0.91	0.87	NA	7.19	7.78	4.94	0.60	0.00	0.01
50.00	6673.84	1.08	1.02	NA	8.26	9.03	5.38	0.69	0.00	0.01
60.00	6673.99	1.23	1.15	NA	9.26	10.20	5.76	0.77	0.00	0.01
70.00	6674.14	1.38	1.29	NA	10.20	11.30	6.10	0.85	0.00	0.01
80.00	6674.28	1.52	1.41	NA	11.09	12.36	6.41	0.92	0.00	0.01
90.00	6674.41	1.65	1.54	NA	11.95	13.36	6.69	1.00	0.00	0.01
100.00	6674.54	1.78	1.65	NA	12.77	14.34	6.96	1.06	0.00	0.01

01 Outfall at US Highway 6
13'W x 7'H Box Culvert

Culvert Calculator

All calculator output should be verified prior to design use

Entered Data:

Shape	Rectangular
Number of Barrels	1
Solving for	Headwater
Chart Number	8
Scale Number	1
Chart Description	BOX CULVERT WITH FLARED WINGWALLS NO INLET TOP EDGE BEVEL
Scale Description	WINGWALLS FLARED 30 TO 75 DEGREES
Overtopping	Off
Flowrate	22.7000 cfs
Manning's n	0.0150
Roadway Elevation	6679.3000 ft
Inlet Elevation	6669.6200 ft
Outlet Elevation	6666.0500 ft
Height	84.0000 in
Width	156.0000 in
Length	105.0000 ft
Entrance Loss	0.0000
Tailwater	0.0100 ft

Computed Results:

Headwater	6670.2020 ft Inlet Control
Slope	0.0340 ft/ft
Velocity	7.0389 fps

Messages:

Inlet head > Outlet head.
Computing Inlet Control headwater.
Solving Inlet Equation 26.
Solving Inlet Equation 28.
Headwater: 6670.2020 ft

DIS-CHARGE Flow cfs	HEAD-WATER ELEV. ft	INLET CONTROL DEPTH ft	OUTLET CONTROL DEPTH ft	FLOW TYPE	NORMAL DEPTH in	CRITICAL DEPTH in	OUTLET VEL. fps	OUTLET DEPTH ft	TAILWATER VEL. fps	TAILWATER DEPTH ft
10.00	6669.90	0.28	0.05	NA	1.81	3.17	5.10	0.15	0.00	0.01
20.00	6670.14	0.52	0.05	NA	2.76	5.03	6.70	0.23	0.00	0.01
30.00	6670.35	0.73	0.05	NA	3.53	6.59	7.85	0.29	0.00	0.01
40.00	6670.53	0.91	0.05	NA	4.21	7.98	8.78	0.35	0.00	0.01
50.00	6670.70	1.08	0.05	NA	4.82	9.26	9.57	0.40	0.00	0.01
60.00	6670.85	1.23	0.05	NA	5.40	10.46	10.26	0.45	0.00	0.01
70.00	6671.00	1.38	0.05	NA	5.94	11.59	10.89	0.49	0.00	0.01
80.00	6671.15	1.53	0.05	NA	6.45	12.67	11.46	0.54	0.00	0.01
90.00	6671.28	1.66	0.05	NA	6.93	13.70	11.98	0.58	0.00	0.01
100.00	6671.41	1.79	0.05	NA	7.40	14.70	12.47	0.62	0.00	0.01

O2 Outfall at Railroad
Channel under Bridge: 62'W x 8'D with 5:1 Side Slopes

Channel Calculator

Given Input Data:

Shape	Trapezoidal
Solving for	Depth of Flow
Flowrate	433.4000 cfs
Slope	0.0036 ft/ft
Manning's n	0.0175
Height	96.0000 in
Bottom width	0.0000 in
Left slope	0.2000 ft/ft (V/H)
Right slope	0.2000 ft/ft (V/H)

Computed Results:

Depth	41.5062 in
Velocity	7.2453 fps
Full Flowrate	4054.8756 cfs
Flow area	59.8182 ft2
Flow perimeter	423.2819 in
Hydraulic radius	20.3501 in
Top width	415.0620 in
Area	320.0000 ft2
Perimeter	979.0117 in
Percent full	43.2356 %

Critical Information

Critical depth	41.0255 in
Critical slope	0.0038 ft/ft
Critical velocity	7.4161 fps
Critical area	58.4407 ft2
Critical perimeter	418.3796 in
Critical hydraulic radius	20.1144 in
Critical top width	410.2549 in
Specific energy	4.2746 ft
Minimum energy	5.1282 ft
Froude number	0.9713
Flow condition	Subcritical

Channel Rating Curve Data

Depth - in	Flowrate - cfs
0	0.00
12	15.83
24	100.57
36	296.52
48	638.60
60	1157.86
72	1882.81
84	2840.09
9	4054.88

O2 Outfall at US Highway 6
79'W x 8'H Bridge Opening
(Approximated by box culvert of equivalent area)

Culvert Calculator

All calculator output should be verified prior to design use

Entered Data:

Shape	Rectangular
Number of Barrels	1
Solving for	Headwater
Chart Number	8
Scale Number	1
Chart Description	BOX CULVERT WITH FLARED WINGWALLS NO INLET TOP EDGE BEVEL
Scale Description	WINGWALLS FLARED 30 TO 75 DEGREES
Overtopping	Off
Flowrate	433.4000 cfs
Manning's n	0.0200
Roadway Elevation	6664.2000 ft
Inlet Elevation	6651.9400 ft
Outlet Elevation	6651.0600 ft
Height	96.0000 in
Width	948.0000 in
Length	34.0000 ft
Entrance Loss	0.0000
Tailwater	0.0100 ft

Computed Results:

Headwater	6653.3538 ft Inlet Control
Slope	0.0259 ft/ft
Velocity	8.7039 fps

Messages:

Inlet head > Outlet head.
Computing Inlet Control headwater.
Solving Inlet Equation 26.
Solving Inlet Equation 28.
Headwater: 6653.3538 ft

DIS-CHARGE Flow cfs	HEAD-WATER ELEV. ft	INLET CONTROL DEPTH ft	OUTLET CONTROL DEPTH ft	FLOW TYPE	NORMAL DEPTH in	CRITICAL DEPTH in	OUTLET VEL. fps	OUTLET DEPTH ft	TAILWATER VEL. fps	TAILWATER DEPTH ft
250.00	6652.88	0.94	0.37	NA	5.43	8.13	7.00	0.45	0.00	0.01
750.00	6654.04	2.10	1.42	NA	10.54	16.92	10.81	0.88	0.00	0.01
1000.00	6654.51	2.57	1.86	NA	12.54	20.49	12.11	1.05	0.00	0.01
1250.00	6654.95	3.01	2.26	NA	14.36	23.78	13.22	1.20	0.00	0.01
1500.00	6655.37	3.43	2.64	NA	16.04	26.85	14.20	1.34	0.00	0.01

O3 Outfall at Railroad
10'W x 8'H Bridge Opening
(Approximated by box culvert of equivalent area)

Culvert Calculator

All calculator output should be verified prior to design use

Entered Data:

Shape	Rectangular
Number of Barrels	1
Solving for	Headwater
Chart Number	8
Scale Number	1
Chart Description	BOX CULVERT WITH FLARED WINGWALLS NO INLET TOP EDGE BEVEL
Scale Description	WINGWALLS FLARED 30 TO 75 DEGREES
Overtopping	Off
Flowrate	107.1000 cfs
Manning's n	0.0350
Roadway Elevation	6649.3600 ft
Inlet Elevation	6636.5800 ft
Outlet Elevation	6636.0700 ft
Height	96.0000 in
Width	120.0000 in
Length	15.0000 ft
Entrance Loss	0.0000
Tailwater	0.0100 ft

Computed Results:

Headwater	6638.8339 ft Inlet Control
Slope	0.0340 ft/ft
Velocity	8.0809 fps

Messages:

Inlet head > Outlet head.
Computing Inlet Control headwater.
Solving Inlet Equation 26.
Solving Inlet Equation 28.
Headwater: 6638.8339 ft

DIS-CHARGE Flow cfs	HEAD-WATER ELEV. ft	INLET CONTROL DEPTH ft	OUTLET CONTROL DEPTH ft	FLOW TYPE	NORMAL DEPTH in	CRITICAL DEPTH in	OUTLET VEL. fps	OUTLET DEPTH ft	TAILWATER VEL. fps	TAILWATER DEPTH ft
50.00	6637.87	1.29	1.21	NA	9.73	11.03	6.16	0.81	0.00	0.01
100.00	6638.72	2.14	2.01	NA	15.21	17.51	7.89	1.27	0.00	0.01
150.00	6639.45	2.87	2.69	NA	19.87	22.95	9.06	1.66	0.00	0.01
200.00	6640.10	3.52	3.30	NA	24.10	27.80	9.96	2.01	0.00	0.01
250.00	6640.71	4.13	3.86	NA	28.07	32.26	10.69	2.34	0.00	0.01
300.00	6641.27	4.69	4.39	NA	31.84	36.43	11.31	2.65	0.00	0.01
350.00	6641.81	5.23	4.89	NA	35.48	40.37	11.84	2.96	0.00	0.01
400.00	6642.33	5.75	5.37	NA	39.00	44.13	12.31	3.25	0.00	0.01

O3 Outfall at US Highway 6
8'W x 7'H Box Culvert

Culvert Calculator

All calculator output should be verified prior to design use

Entered Data:

Shape	Rectangular
Number of Barrels	1
Solving for	Headwater
Chart Number	8
Scale Number	1
Chart Description	BOX CULVERT WITH FLARED WINGWALLS NO INLET TOP EDGE BEVEL
Scale Description	WINGWALLS FLARED 30 TO 75 DEGREES
Overtopping	Off
Flowrate	107.1000 cfs
Manning's n	0.0150
Roadway Elevation	6643.3000 ft
Inlet Elevation	6632.0160 ft
Outlet Elevation	6630.7550 ft
Height	84.0000 in
Width	96.0000 in
Length	56.0000 ft
Entrance Loss	0.0000
Tailwater	0.0100 ft

Computed Results:

Headwater	6634.7278 ft Inlet Control
Slope	0.0225 ft/ft
Velocity	13.0106 fps

Messages:

Inlet head > Outlet head.
Computing Inlet Control headwater.
Solving Inlet Equation 26.
Solving Inlet Equation 28.
Headwater: 6634.7278 ft

DIS-CHARGE Flow cfs	HEAD-WATER ELEV. ft	INLET CONTROL DEPTH ft	OUTLET CONTROL DEPTH ft	FLOW TYPE	NORMAL DEPTH in	CRITICAL DEPTH in	OUTLET VEL. fps	OUTLET DEPTH ft	TAILWATER VEL. fps	TAILWATER DEPTH ft
50.00	6634.23	1.58	2.21	NA	7.56	21.27	5.86	0.63	0.00	0.01
100.00	6635.28	2.58	3.26	NA	11.81	21.27	7.38	0.98	0.00	0.01
150.00	6636.16	3.43	4.14	NA	15.42	21.27	8.45	1.28	0.00	0.01
200.00	6636.95	4.20	4.93	NA	18.69	21.27	9.30	1.56	0.00	0.01
250.00	6637.67	4.91	5.65	NA	21.76	21.27	10.02	1.81	0.00	0.01
300.00	6638.35	5.57	6.33	NA	24.68	21.27	10.65	2.06	0.00	0.01
350.00	6638.99	6.21	6.97	NA	27.48	21.27	11.21	2.29	0.00	0.01
400.00	6639.59	6.81	7.57	NA	30.20	21.27	11.72	2.52	0.00	0.01