THE TOWN OF MAMMOTH LAKES CALIFORNIA

2005 STORM DRAIN Master Plan Update

May 26, 2005
(Revision 0D)

VT-M01-100-01

BOYLE ENGINEERING CORPORATION

Town of Mammoth Lakes
2005 Storm Drain Master Plan Update

Town of Mammoth Lakes

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Section 1- Introduction

Objectives

This 2005 Storm Drain Master Plan for the Town of Mammoth Lakes (Town) updates the existing 1984 study for Mono County. This Master Plan sets forth to attain the following objectives:

1. Assess the adequacy of the existing conveyance structures of the storm drain system in the Town.
2. Make specific recommendations for future improvements to the storm drain system.
3. Recommend and assess the impact of specific detention facilities as specified by the Town. The intent of these facilities is to reduce the drainage burden on downstream storm drain system.
4. Provide a basis for the cost estimates and financing necessary to make the storm drain and detention improvements recommended in (2) and (3) above.
5. Review the area's hydrology for both winter rain and snow and summer rain events.
6. Provide a concise and simple hydrologic methodology necessary for developers to plan and design specific design improvements and assess the impact of development on downstream constituents. This methodology will be designed so that it will be compatible with methods adopted in the 1984 study.

Overview

This Master Plan Update includes a review of the entire Town drainage basin area. The bases for the analysis was:

(1) Geographic Information System (GIS) data that was collected and developed by Triad Holmes Associates (under a separate contract with the Town of Mammoth Lakes), and

(2) The existing General Plan zoning.

This information was used to develop and review the hydrology information from the previous report. The storm water plan retains many of the existing natural channels where possible because it is both cost effective and environmentally beneficial. Areas of known flooding and erosion problems were also considered in developing the plan, as identified by City staff.

The Mammoth area drainage basin eventually flows into the Owens River system. Within the Town limits there two watershed basins. The southern portion of the community drains the Lakes Basin to Mammoth Creek. The northern portion of the community drains Mammoth Mountain and most of the drainage from Meridian Boulevard northward to Murphy Gulch. During high runoff periods, Murphy Gulch eventually flows into Mammoth Creek. The Master Plan divides the basins into sub-areas for analysis, five in the southern area, and eight in the northern area.

Storm water runoff flow were developed for the 20-year and 100-year flows. Existing facilities within each drainage area were evaluated for flow capacity, street capacity, and existing flooding problems. In areas where there are existing channels, pipes and streets the facilities were reviewed for a 20-year storm. The added capacity of the street was considered for the 100-year storm events.

The Master Plan also reviews several areas for the use of detention basin to equalize storm water flows by capturing the pipe flows and releasing them over a longer period of time. Detention facilities would allow for the use of smaller pipelines and other conduits. Three areas were evaluated for detention including the Little Eagle Lodge area, Minaret and Forest Trail area, and Canyon Lodge area. The analysis indicates that the cost of the detention facilities would be considerably greater than the cost of installing larger storm drainage piping. This is because there is not a large detention area that can be created with a relatively inexpensive facility like a dam. At Canyon Lodge the parking lot and surrounding area was evaluated using a infiltrator system. This type of system is substantially more expensive than an open dam or basin type structure because of the excavation and paving required. Other benefits that may come into play with detention facilities includes less disruptions of the public during construction and possible groundwater recharge. In the event a large grant became available it could change the feasibility of using a detention facility.

Costs were developed for all of the proposed improvements using current bid data from recent projects and supplier cost data for pipe sizes not recently installed in projects by the Town.

In this report, the major subjects are organized as follows in order to achieve the aforementioned objective: Description of Study Area, Hydrology and Hydrologic Procedures, Potential Detention Basin Improvements, Storm Drain Design Scenarios, Cost Analysis, Analysis of Water Quality Regulations, Summary of Recommendations, and Financial Options.

The engineering basis for all calculations included in this report are based on well-established principles of statistics, hydrology, and hydraulics. A special effort has been made to simplify design procedures together with a sufficient awareness of the safety of the community using statistical techniques for designing facilities for an average return period. In this way, the goals of developers, as well as citizens of the Town of Mammoth can be met with respect to drainage concerns.

The Need for Storm Water Control

The Town of Mammoth is becoming increasingly urbanized. As land development occurs, there is an increase in impervious surfaces and an increase in runoff from rainfall during fall and spring thunder storms and the spring snow melt. Past development activities in the community, which were conducted under limited development control, have created significant runoff and erosion problems. Many developments have changed flow patterns and enlarged runoff volumes. The largely uncontrolled runoff is accelerating erosion thereby increasing sediment and other pollutants in Mammoth and Hot Creeks, impacting fish populations.

As the town has continued to develop, erosion and drainage problems which were just minor inconveniences in the past, have become more significant, creating flooding and water quality degradation. At present, only portions of the community are served by an integrated storm drainage system. Numerous natural or man-made surface channels traverse the majority of the community, and drainage problems are wide spread.

Capital Improvement Program

The 1984 Storm Drain Master Plan was prepared under the direction of the Mono County Public Works Department. That master plan set forth an improvement program to rehabilitate existing developed areas and established policies, standards, and procedures for new development. In terms of current dollars, the expenditure program proposed in 1984 would have cost $37 million (plus interest, if bonding were used). The current program is more modest, with a current cost of approximately $14.5 million. In addition, it is recommended that another $4 million be budgeted for water quality improvement projects in order to maintain compliance with the Town's Memorandum of Understanding with the Lahontan Regional Water Quality Control Board.

This plan update accounts for changes that have occurred since 1984. In particular, it takes into account pipelines and other storm drainage facilities that have since been constructed, and reflects the current general plan. One contrast with the previous plan is that this one proposes substantially fewer pipes. The number of pipes included in the previous plan was believed to be impossible to construct from financial and environmental perspectives. This plan relies to a greater extent on sheet flow, natural channels, and street curb and gutters to convey flows. New storm drain pipelines are only shown where large collection areas drain into the town, or where town staff has identified existing flooding or erosion problems.

The proposed Capital Improvement Program included in this report is intended to provide *general* guidelines and priorities. More detailed project budgets and priorities are expected to be developed by town staff in consultation with the community, based on more detailed analyses and the changing needs of the community.

Section 2 – Description of Study Area

A. General

Geographic Location and Population

The watershed referred to as the Mammoth Basin (Basin) in this study is a distinct hydrologic area on the eastern slope of the Sierra Nevada in central eastern California (see **Figure 2-1**). It is situated in southwestern Mono County at approximately latitude 37° 38’ and longitude 118° 59’. In particular, the Basin contains the relatively remote resort community of Mammoth Lakes (population 7,500[1]). The nearest major population centers nearest to the Town are Bishop (population 17,000) 40 miles to the south, and Carson City, Nevada (population 55,000) 120 miles to the north. With the exception of approximately 2,600 acres of private lands which comprise the Mammoth Lakes community, the Basin consists primarily of wilderness and semi-wilderness lands under the jurisdiction of the Inyo National Forest. The Basin provides recreational opportunities for approximately 2.7 million tourists and vacationers annually.

Hydrologic Setting

The Basin watershed encompasses approximately 71 square miles and includes the entire watershed of Mammoth Creek, which is eventually tributary to the Owens River via Hot Creek (see **Figure 2-2**). Mammoth Creek and Hot Creek are the same stream, but the name changes to Hat Creek downstream of the U.S. Highway 395 crossing due to historical precedent. Watershed boundaries are physically defined by the Mammoth Crest divide of the Sierra Nevada on the south and west, by the Dry Creek drainage divide on the north, and by the Convict Creek drainage divide on the east. The general trend of the Basin is generally northeasterly, extending from Mammoth Crest at elevation 11,053 on the southwest, to the Hot Creek Gorge in the Upper Owens Valley at elevation 6,960 on the northeast. The total flow length of the Mammoth Creek/Hot Creek drainage system is approximately 18 miles.

[1] From State of California, Department of Finance, Demographic Research Unit, www.dof.ca.gov

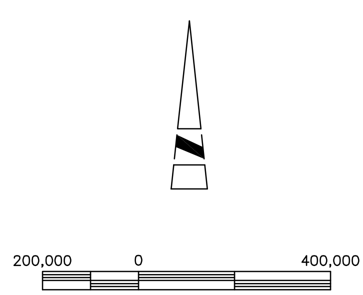

FIGURE 2-1
LOCATION MAP

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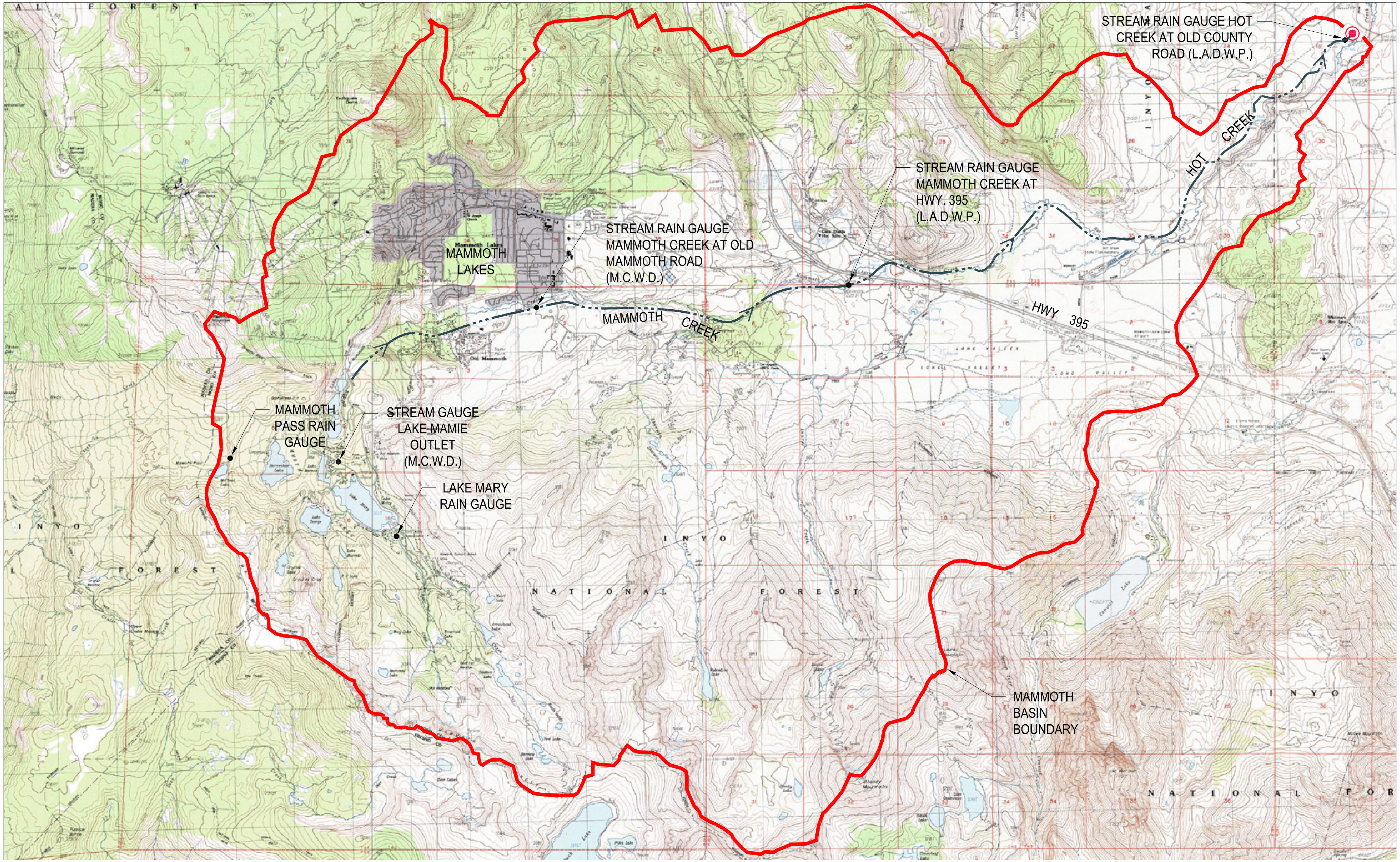
DATE: May 31, 2005 4:29pm XREFS:



LEGEND

- WATERSHED BOUNDARY
- FLOWLINE
- WATERSHED COLLECTION POINT

3000' 1500' 0 3000' 6000'
SCALE IN FEET

BOYLE

REV	DATE	DESCRIPTION	APPR
6			
5			
4			
3			
2			
1	—		

TOWN OF MAMMOTH LAKES

MAMMOTH BASIN WATERSHED BOUNDARY

VT-M01-100-01 MAY 2005 FIGURE 2-2

The Basin includes a complex drainage system comprised of lakes and interconnecting surface streams in the higher elevations of its southwestern portion. All of these lakes and streams are eventually tributary by either surface flow or underground flow to Mammoth Creek.

B. Topography

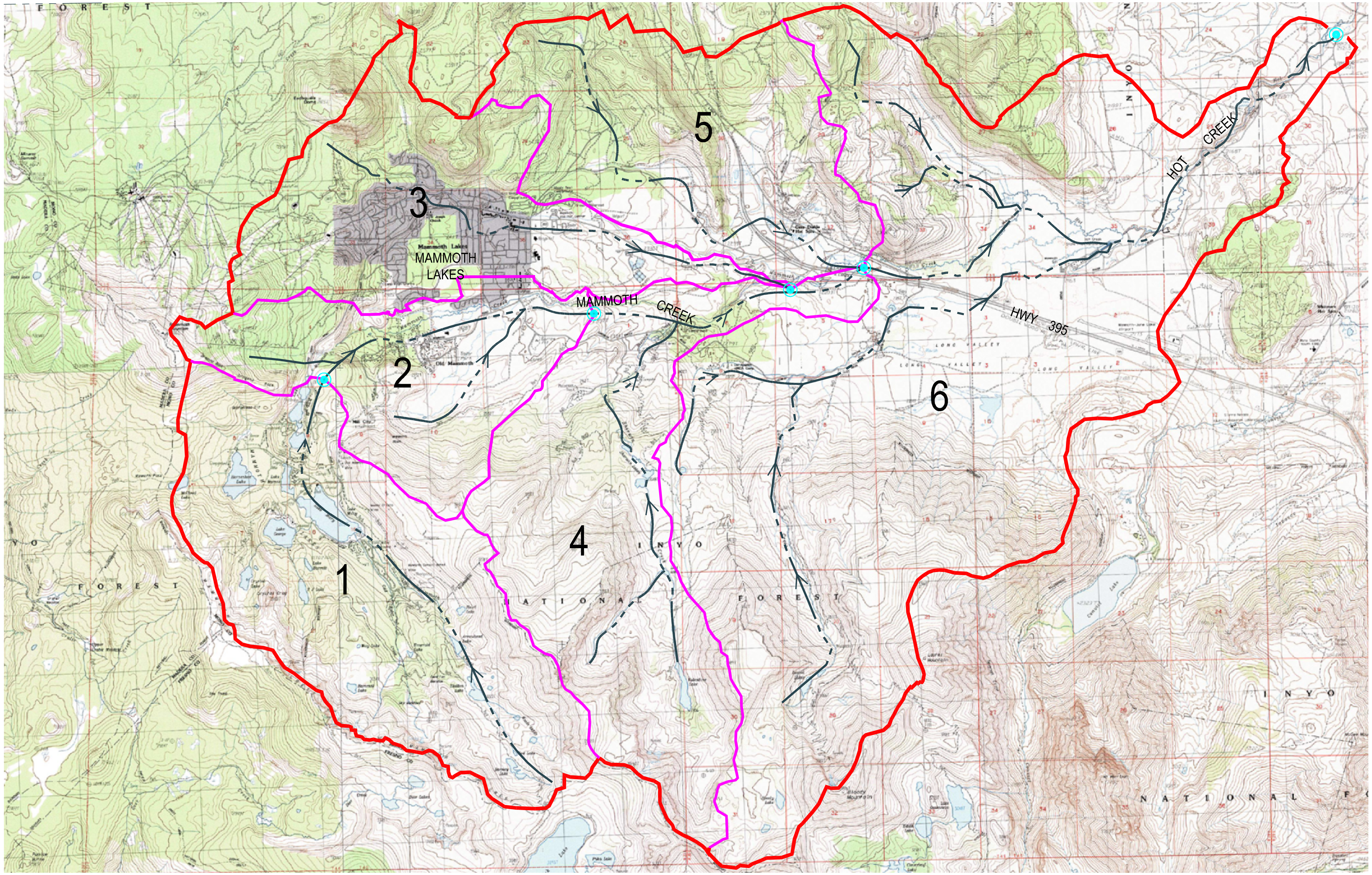
Major Watersheds

The Basin contains six distinct major watersheds below as shown in **Figure 2-3**.

Watersheds 1 through 5 comprise the major tributary areas of Mammoth Creek upstream of State Highway 395. Downstream of Highway 395 (where the stream name changes to Hot Creek), all of the remaining Basin area has been lumped into Watershed 6. **Table 2-1** below summarizes all of the Mammoth Basin Watersheds.

Table 2-1. Mammoth Basin Watersheds

Watershed	Descriptive Name	Area, Acres
1	Lake Mary Basin	6,920
2	Old Mammoth	2,710
3	Murphy Gulch	5,120
4	Sherwin Creek	7,310
5	Casa Diablo	5,050
Subtotal	Mammoth Creek	27,110
6	Hot Creek and Laurel Creek	17,990
Total Basin		45,100



LEGEND

- WATERSHED BOUNDARY MAJOR
- WATERSHED BOUNDARIES
- FLOWLINE
- WATERSHED COLLECTION POINT

3000' 1500' 0 3000' 6000'
SCALE IN FEET

BOYLE

REV	DATE	DESCRIPTION	APPR
6			
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4			
3			
2			
1	–		

TOWN OF MAMMOTH LAKES

MAJOR WATERSHED BOUNDARIES

VT-M01-100-01 MAY 2005 FIGURE 2-3

Watershed 1 encompasses the Lake Mary Basin, which is the most distinct and complex tributary area within the Mammoth Creek drainage system. It is the only watershed for which lake storage is a significant factor because it contains the largest and most numerous lakes within the Mammoth Basin. Watershed 2 is immediately downstream of Watershed 1, and includes portions of the Mammoth Lakes community and Mammoth Mountain, which are directly tributary to Mammoth Creek. Watershed 3 encompasses a separate drainage system, known as Murphy Gulch, which is eventually tributary to Mammoth Creek near Highway 395. This watershed contains most of the more intensely developed areas of the Mammoth Lakes community, which is a major area of focus in this report. Watersheds 4 through 6 are natural watersheds, which are part of the Mammoth Basin, having drainage contributions downstream of the Town.

The rocky mountain slopes are precipitous with considerable variation in relief, while the valley floor is relatively flat with moderate slopes of 0 to 10 percent, although valley flows are typically steep in a hydraulic sense. Approximately 40 percent of the Basin consists of land, which has a slope steeper than 30 percent.

Drainage Subareas

Watersheds 2 and 3 contain all of the private land holdings of the Mammoth Lakes community, and are the primary areas of interest in this study. These two watersheds have been further divided into more detailed drainage subareas as shown on **Figure 2-4**. Watershed 2 contains five distinct drainage subareas labeled 2.1 through 2.5, which are directly tributary to the mainstream channel of Mammoth Creek. Watershed 3 has been subdivided into eight areas, labeled 3.1 through 3.8.

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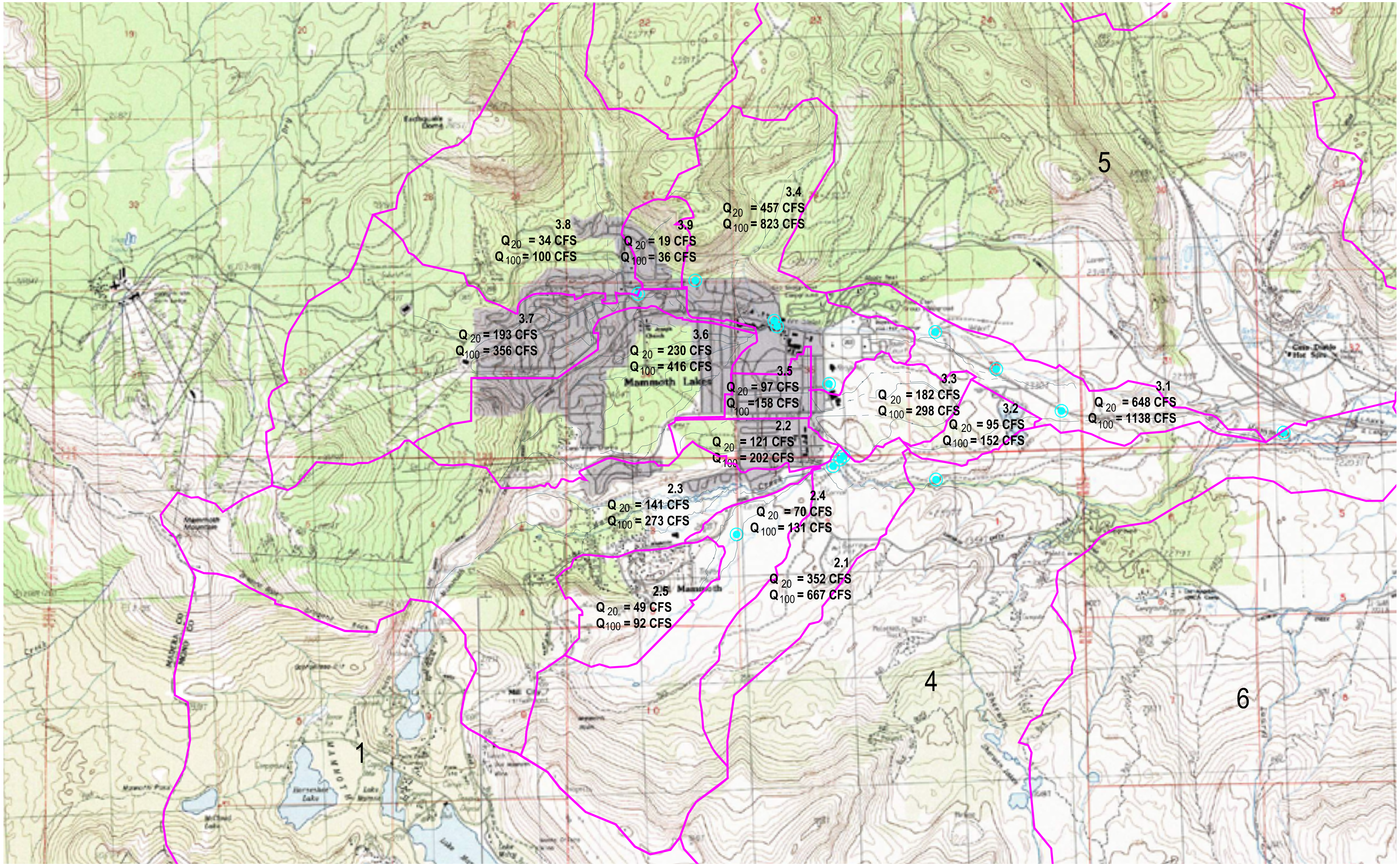
DATE: Jun 10, 2005 11:00am XREFS: Basins-Hatch (Sub Areas)FOR FIGURES



NOTES:

1. FLOWS SHOWN ARE TOTALS FOR FUTURE BUILD OUT CONDITIONS.

LEGEND

WATERSHED BOUNDARY

WATERSHED COLLECTION POINT

1600' 800' 0 1600' 3200'
SCALE IN FEET

REV	DATE	DESCRIPTION	APPR
6			
5			
4			
3			
2			
1	–		

BOYLE

TOWN OF MAMMOTH LAKES

DETAILED DRAINAGE SUBAREAS

VT-M01-100-01 JUNE 2005 FIGURE 2-4

C. Land Use

Land Use Designations

The Mammoth Lakes community is characterized by a mixture of commercial use, open space, commercial, low-density residential, and high-density residential uses. All of the developed areas of the community are concentrated within Watersheds 2 and 3. The Land Use Plan within the community is presented on **Exhibit 1** and viewed as a map including drainage subareas in **Exhibit 2**. Approximately 35 percent of the total land area of the community is presently undeveloped. Due to the limited supply of private land in the Mammoth Lakes area and the pressures created by increasing recreational demands, it can be anticipated that relatively little land is developable. Although existing land uses are revised under the Land Use Plan, the changes are not expected to significantly affect the amount of impervious surface associated with various developments.

Section 3 – Hydrology and Hydrologic Procedures

A. Overview

The previous storm drain master plan [1] and related design manual [2] for the Town were created in 1984. A subsequent review [3] performed in 1990 expressed several concerns regarding hydrologic methodologies within the aforementioned documents. Since the Town has a reason to expect a reliable hydrologic methodology developed by its consultants within a reasonable standard of care, this present study has been made to clarify, update or develop any variations in hydrologic methodology that are required accordingly.

It is important to understand that the nature of engineering hydrology is inherently probabilistic and that related hydrologic calculations are typically estimates. Except for the most fundamental engineering equations, the various parameters that are determined as part of a hydrologic analysis are typically subject to statistical variance, especially in the study of rare events. Even some of the most basic elements of drainage, such as in the computation of the time of concentration[2] for a watershed have numerous methods of derivation [4]. In several respects, certain limitations involving data availability have remained unchanged from 1984. A review of Los Angeles Department of Water and Power (LADWP) records and USGS records determined that there was not sufficient data necessary to make accurate estimates of infrequent events in the usual way, particularly coupled with the hydrologic complexities of the Basin.

The 1984 study, as provided by the Town, was reviewed and it was concluded that the scope and detail of this report was generally satisfactory. Additionally, certain implications were observed to be possible according to the results obtained in 1984 and are addressed below.

The results of the 1984 study were analyzed in the 1990 review provided by Kennedy-Jenks Consultants (KJC). The KJC report demonstrated that seemingly disparate results can be obtained when applying different analytical methods in this very rugged area, where steep slopes, frequent snow pack, highly variable soil materials, and highly variable vegetative cover exist along with a scarcity of actual

[2] The time of concentration (t_c) for a watershed is generally defined as the time necessary for the entire watershed to contribute runoff to a given concentration point on a stream or flow path.

runoff data. In the KJC study, three methods were applied to Master Plan area III-6, with the following results:

Method	100-year Peak Discharge
1984 Master Plan Estimate	280 cfs
Placer County Method	500 cfs
HEC-1 (w/24 hour storm)	523 cfs

The above results belie the belief that reportedly is common among developers in the area that the 1984 Master Plan was too conservative in its estimate of flows. However, there is some validity in the belief that the 1984 Master Plan may have overstated the flows within Mammoth Creek, Murphy Gulch, and Canyon Boulevard, which drain large areas. The general approach to the 1984 Master Plan was to provide two procedures for calculation of runoff. One was for small, urbanized basins, and was based on the rational method. The other was intended for larger natural areas, and used the flow-frequency method, derived from stream flow data from Mammoth Creek. This two-method approach was selected so that the majority of problems would be relatively simple to solve. However, where large off-site areas contributed to flows within the urban areas, use of the first method might result in flows that are substantially greater than would be produced by a more detailed analysis. When calculated flows were compared with FEMA estimates for Mammoth Creek, for instance, the FEMA estimates were considerably lower.

For this master plan update, the methodology proposed in the 1984 Master Plan was reviewed in depth and determined to be reasonable. However, to simplify calculations and provide a better estimate of flows within the major conveyances (Mammoth Creek, Canyon Boulevand, and Murphy Gulch), several changes in the calculation procedures have been proposed—in particular the use of "cfs/acre" values have been proposed for the calculation of peak runoff, along with a reduction factor to account for attenuation within larger basins.

For the sake of clarity, the hydrologic methods in this report have been classed as either Procedure A or Procedure B as described below. Generally, Procedure A is applicable to smaller watersheds in the Town while Procedure B applies to large natural watershed tributary to major streams.

B. Procedure A Development

Two types of rare event precipitation-runoff conditions pertain to the meteorological characteristics of the Town and need to be considered jointly. They are subject to two physically distinct events: a rainfall-only condition and the rainfall-on-snow condition, referred to as the summer and winter conditions, respectively. The idea that one should consider each condition separately and then choose the most extreme result is a sound one and will be adopted in this study as well.

The methodology used to determine peak flows is based on the Rational Formula

$$Q = CiA$$

Where:

Q	=	the discharge measured in cfs
C	=	the runoff coefficient, having no physical dimensions
i	=	the rainfall intensity measured in inches per hour
A	=	the area of the watershed basin measured in acres

The above formula is simply a version of the "continuity equation" in the study of hydraulics. Any consistent set of units may be chosen, however the customary units for Q, i, and A are cubic feet per second (cfs), inches per hour (in/hr), and acres (ac) respectively. For this particular choice of units, the product CiA is to be multiplied by a small correction factor of 1.008, which is often neglected in view of the probabilistic nature of hydrologic calculations mentioned above.

It was observed from the 1984 study that flows within the local storm drains experience little attenuation. In other words, individual hydrographs from individual storm drains have nearly coincidental (in time) peaks when a flow confluence occurs. This finding from the 1984 study helps to provide a simple way to determine peak discharge values. Additionally, the assumption of no attenuation is a conservative one.

While it is true that any point on a stream has a watershed area associated with it, one should not compare watersheds having widely ranging area values. Former procedures specified in the 1984 study allow for areas within the town to have an area anywhere between 0 and 1,600 acres, which is too much of a variation. Problems with comparing a 10 acre subarea with a 1000 acre subarea are obvious in that calculated times of concentrations (t_c) would be vastly different. Hence for this updated study a standard of 40-80 acres is taken as the range of watershed size used to apply cfs/acre peak values[3]. In practice, developers within subareas (if more than one subarea is involved a weighted average should be taken) of this order of magnitude can design systems for their projects using the cfs/acre values that are called out in this study (see **Table 3-1A**).

Another fact that applies to storm drains in the Town is that peak flows within the local storm drain system occur at a time much earlier than offsite flows in major streams. Hence, storm drain design in the Town is mainly independent of offsite drainage and drainage methodology (with the exception of conveyance structures that route large offsite watersheds). For those properties that are affected by large offste watersheds, a reduction factor may be applied, as shown in **Table 3-1B**.

In order to develop a "cfs/acre" approach in lieu of a detailed hydrograph for storm drain flows, a lower bound for cfs/acre value within the Mammoth Basin was first established for comparative purposes. By the term "lower bound", we mean that the estimates made by the following analysis are expected to be less than cfs/acre values that actually apply within the Town for the purpose of pipe design. Such an estimate has some value, since it acts as a safeguard against the use of values that would result in the design of conveyance systems that are inadequate for a given return period.

From the Federal Emergency Management Agency (FEMA) Flood Insurance study [6], it was estimated that the 100-year[4] discharge rate for Mammoth Creek was 640 cubic feet per second (cfs) for a tributary watershed area of 13.12 square miles (8,397 acres) at a stream location taken 650 feet downstream of Old Mammoth Road. Hence for this

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[3] This standard is used in several communities within the State of California, including Los Angeles [5] and Ventura Counties.

[4] A 10-year storm is defined as a storm event that is equaled or exceeded every 10 years on average. Another way to define a 10-year storm is to say that the probability of an event of having a 10-year magnitude or more has a 1/10 chance in a given year. Likewise, a 100-year storm is defined as a storm that is equaled or exceeded every 100 years on average. The 100-year storm can alternatively be defined by saying that the probability of an event of having a 100-year magnitude or more has a 1/100 chance in a given year [7].

watershed, a cfs/acre ratio is equal to 640/8397 ≈ 0.076 cfs/acre for 100-year conditions. This value is clearly low since it includes an extremely large and predominantly natural watershed (consisting of subareas including portions of the Town) subject to the attenuation process. From the same study, it was estimated that the 100-year discharge rate for Mammoth Creek increased from 350 cfs to 610 cfs between Waterford Street upstream and a point 650 feet upstream of Minaret Road downstream. The increase in the watershed area between these two stations is given as 0.49 square miles (314 acres) and lies within the Town. For this watershed from Waterford Street to 650 feet upstream of Minaret Road, the cfs/acre ratio is equal to (610 – 350)/314 ≈ 0.828 cfs/acre for 100-year conditions.

Next, a statistical analysis was made of the cfs/acre data contained in the 1984 study. Not surprisingly, a strong dependence (on cfs/acre rates) was found on the degree of natural land cover. This data was applied to the individual subareas delineated in this study for the purpose of obtaining a reasonable estimate of cfs/acre value for particular land use types, and were adjusted for consistency. These values were conservatively estimated to be those as given in **Table 3-1** below:

Table 3-1A. Applicable cfs/acre Values by Land Use Type

Land Use Type	20-Year	100-Year
Natural	0.23	0.43
Single Family Residence	0.65	1.30
High Density Residence	1.14	1.90
Commercial	1.22	1.93

Table 3-1B. Reduction Factors for Large Basins

Drainage Area (acres)	Reduction Factor
80	1.00
100	0.97
200	0.88
500	0.77
1,000	0.69
2,000	0.63
5,000	0.55
7,744	0.52

The values for the tables above were determined primarily for the purpose of determining the discharge values within the elements of the storm drain system as outlined in Section 5.

C. Procedure B Development

Procedure B is intended for use in larger, natural areas. A flow-frequency analysis approach was adopted, based on the flow data available and the ease with which it could be applied. Sufficient concurrent precipitation and runoff data were not available to develop a hydrograph method with reasonable accuracy.

The flow out of a large, natural basin in the Mammoth Lakes area has two principal components--snowmelt and rain flood flows. In general, flow records indicate that the peak flows in Mammoth Creek at Highway 395 are produced by snowmelt. Extreme rainfall events may produce short-term peaks on an annual hydrograph, which is dominated by flows produced by snowmelt. This situation is typical of major basins on the eastern side of the Sierra Nevada.

The mean daily flow records for Hot Creek at Highway 395 were used to develop the flow-frequency relationships. Snowmelt flows were segregated from rain flood flows by plotting flow-frequency relationships separately for rainy and non-rainy periods.

Rain Flood Flows

To calculate rain flood flows from specific tributary subareas, a procedure for transferring the flow-frequency relationships developed for Hot Creek at Highway 395 to other areas had to be developed. These types of procedures have been developed by the U.S. Geological Survey, U.S. Army Corps of Engineers, and others. The procedure used here was one developed by the U.S. Army Corps of Engineers. The variables involved are a linear elevation factor, an exponential function of tributary area, and an exponential function of mean annual precipitation. The Hot Creek Basin characteristics and Hot Creek rain flood frequency curve were used to define a coefficient, C, to be used in calculating the maximum mean daily rain flood flow. The resulting equation for mean daily design flow has the form:

$$Q = CKA^{0.85}P^{2}$$

Where:

C = a constant related to design exceedence interval and found from a graph
K = a linear elevation factor computed from the mean basin elevation and two constants
A = the basin area
P = the mean annual precipitation in the tributary area.

Peak runoff will be significantly greater than mean daily flow unless the stream system is highly regulated.

Data on instantaneous peak flows in Hot Creek are not available. A peaking factor of 1.7 was therefore adopted based on data from other similar watersheds in the same general area. The calculated mean daily design flow is multiplied by the peaking factor to obtain a peak flow. One of the major tributary areas in the Hot Creek Basin is highly regulated.

This area is the Lake Mary Basin, shown as Basin 1 on **Figure 2-3**. Streams in this area flow through a number of lakes, and outflow from the basin is regulated. Therefore, the peaking factor adopted for flows, which originate in this basin is 1.15.

Snowmelt Flows

The maximum mean daily flow-frequency relationship of the Hot Creek gage was used to develop a procedure for estimating mean daily snowmelt flow frequencies for subbasins of Mammoth Creek. Snowmelt season peak flows are primarily a function of the size of the snow-covered area, which is melting when the peak flows are produced. The procedure therefore is based on calculation of a melt band area. The melt band is the area contained within the tributary area, which is undergoing snowmelt at a particular time. The area is bounded by a "top of melt" elevation contour and a "bottom of melt" elevation contour, or the basin outlet. The runoff produced per unit area is taken as a function of only the design exceedence interval. The area contributing to the flow (melt band area) therefore determines the design mean daily flow.

The procedure requires that an area elevation curve be developed for the basin, or at least that the area within the basin between elevation contours be determined from topographic mapping. **Figure 3-3** through **Figure 3-5** show the graphs developed for calculation of mean daily snowmelt flows. The melt band width is determined for a particular design exceedence interval by considering the elevation of the top of the melt band, and the melt band width. Design runoff per unit area for the exceedence interval is then multiplied by the area within the melt band. A flow adjustment factor, based on elevation, compensates for changes in runoff efficiency due to factors such as shade produced by vegetation, soil types, and steepness. The factor is related directly to elevation of the top of the basin based on typical hydrologic characteristics of subbasins within the Mammoth basin. As for the rain flood flow calculations, the calculated mean daily flows should be multiplied by a peaking factor of 1.7 for all tributary areas except Basin 1, and 1.15 for Basin 1 flows.

Calculations

Procedure B methodology was applied to major Watersheds 1, 4, 5, and 6 using a spreadsheet approach. These values will also be utilized for the analysis of “offsite” flows into the in-town subareas. The details of Procedure B are outlined as follows:

1. Determine the appropriate design exceedence interval from **Table 3-2**.

Table 3-2. Exceedence Intervals for Design

Type of Facility	Exceedence Interval, Years
Diversion dikes on slopes	50
Runoff interceptor ditches on slope terrace	20
Temporary straw bale sediment barriers	5
Temporary filter berms and filter inlets	5
Temporary siltation berms[a]	5
Temporary flexible downdrains	10
Chutes and flumes	100
Storm drainage inlets (non-sump)	20
Storm drainage inlets (sump)	50
Curb and gutter	10
Storm drains in streets Less than 48 inches in diameter Greater than or equal to 48 inches in diameter	 20 50
Open channels and storm drains not in streets Less than 50 cfs capacity Greater than 50 cfs capacity	 50 100
Roadside drainage ditches	20
Slotted drains	20
Culverts	100
Infiltration facilities in parking lots[b]	20
Dry wells[b]	20
Permanent sediment retention or flow detention basins[c]	10, 50, 100
Temporary sediment retention basins[c]	5, 10, 20

[a]The 24-hour precipitation volume shall be used to compute storage volume required-

[b]The facilities shall provide for retention of the one-hour precipitation volume for this exceedence interval.

[c]Submit calculations to County Public Works director for review for all three exceedence intervals. (See text in this chapter for procedure to calculate runoff hydrograph.

2. Calculate the mean daily rain flood design flow from the equation $Q = CKA^{0.85}P^{2}$ where C is a constant related to exceedence interval as shown on **Figure 3-1**, K is given from the equation $K = \frac{12{,}000\,\text{ft} - \text{Mean Basin Elevation}}{4{,}000}$, A is the basin area in square miles, and P is the mean annual precipitation in inches as shown on **Figure 3-2**. Conservative interpolation between isohyetal lines is acceptable.

3. Calculate the peak rain flood flows as follows: (1) for the Lake Mary Basin (Watershed 1), Q peak = 1.15 X Mean Daily Flow; (2) for all other basins, Q = 1.7 X Mean Daily Flow.

4. Calculate the peak snowmelt flows as follows: (1) determine the approximate maximum elevation of the basin. One or two percent of the basin area can be above the selected approximate maximum for basins with steep upper portions, In any case, the maximum value should not exceed 11,200 feet; (2) use **Figure 3-3** to find the highest elevation of melt corresponding to the selected exceedence interval; (3) use **Figure 3-4** to find the width of the melt band for the selected exceedence interval. In conjunction with the highest elevation of melt from (2), this sets the lowest elevation of melt; (4) if the lowest elevation of melt is below the lowest point in the basin, raise the highest elevation of the melt until the full melt band falls within the basin; (5) determine the area of the basin (in square miles) that lies within the melt band; (6) use **Figure 3-5** to find the runoff rate per unit area that corresponds to the exceedence interval; (7) select a flow adjustment factor from **Figure 3-6**; and (8) find the design mean daily flow rate from: Q = (flow adjustment factor) X (runoff rate) X (area of melt band).

5. Find the peak flow as follows: (1) for the Lake Mary Basin (Watershed 1), Q peak = 1.15 X Mean Daily Flow; (2) for all other basins, Q = 1.7 X Mean Daily Flow.

6. Select the peak design flow as the larger of the two Q peaks, as shown on **Table 3-3,** from Steps 3 through 5 above.

7. **Table 3-4** and **Table 3-5** summarize the results for Procedure B as it is applied for both Rain Flow and Snowmelt scenarios, respectively.

Table 3-3
Design Flows - Procedure B

	Design Flow for Peak Rain = Q = CK(A^0.85)p^2						
	Design Flow for Peak Snowmelt = Q = Design Mean Daily Flow Rate * Area of snowmelt * Adj. Factor						
Watershed	Q10- rain	Q10-snow	Q20-rain	Q20-snow	Q100-rain	Q100-snow	C for Q Rain values from Figure 3-1
Subarea 1	54	70	81	72	166	83	c for Q10 0.0072
Subarea 2	20	59	31	60	63	69	c for Q20 0.0108
Subarea 3	34	0	51	0	103	0	c for Q100 0.022
Subarea 4	38	69	57	71	117	82	
Subarea 5	25	28	37	28	75	33	
Subarea 6	63	243	95	248	193	286	

Choose the larger of the two (rain or snow) and that is the design flow

	Design Flow		
Watershed	**Q10 (cfs)**	**Q20 (cfs)**	**Q100 (cfs)**
Subarea 1	70	81	166
Subarea 2	59	60	69
Subarea 3	34	51	103
Subarea 4	69	71	117
Subarea 5	28	37	75
Subarea 6	243	248	286

Table 3-4
Rain Flow Calculations - Procedure B

5/31/2005

Area				Soil Type				K				P				
				A	B	C	D	K = (12,000 - Mean Elevatio) / 4,000				Mean annual precipitation (in) per Figure 1-10				
Watershed	**Area (ft^2)**	**Area (ac)**	**Area (mi^2)**	**Area (%)**				Mean Elevation = (M1L1 + M2L2+etc.) / (L1+L2+etc.)							p	p^2
Subarea 1	296,834,110	6,814	**10.6**	**0.0%**	**53.2%**	**36.3%**	**10.6%**	**Subarea 1**	feet	Mean Elevation	k	**Subarea 1 (Precipitation in inches)**	**Area (s.f.)**	**%**	39.80	**1584**
Soil Type A	0	0						elev, M1	10843	**9455**	**0.64**	25	25,416,358	0.09		
Soil Type B	157,834,150	3,623						Length, L1	2452			35	125,223,731	0.42		
Soil Type C	107,636,760	2,471						elev, M2	9588			40	54,872,553	0.18		
Soil Type D	31,363,200	720						Length, L2	17495			45	44,403,160	0.15		
								elev, M3	8752			55	42,616,498	0.14		
								Length, L3	8142			60	4,301,810	0.01		
													TOTAL % =	1.00		
Subarea 2	149,169,119	3,424	**5.4**	**0.0%**	**77.0%**	**14.0%**	**9.0%**	**Subarea 2**				**Subarea 2 (Precipitation in inches)**	**Area (s.f.)**	**%**	28.39	**806**
Soil Type A	0	0						elev, M1	9920	**8607**	**0.85**	17	56,331,834	0.38		
Soil Type B	114,930,959	2,638						Length, L1	7408			25	43,848,544	0.29		
Soil Type C	20,865,240	479						elev, M2	8438			35	23,502,756	0.16		
Soil Type D	13,372,920	307						Length, L2	5862			45	7,927,136	0.05		
								elev, M3	7864			55	10,410,481	0.07		
								Length, L3	11748			60	7,148,368	0.05		
													TOTAL % =	1.00		
Subarea 3	212,946,497	4,889	**7.6**	**0.0%**	**100.0%**	**0.0%**	**0.0%**	**Subarea 3**				**Subarea 3 (Precipitation in inches)**	**Area (s.f.)**	**%**	28.42	**808**
Soil Type A	0	0						elev, M1	8842	**7864**	**1.03**	17	64,459,670	0.30		
Soil Type B	212,946,497	4,889						Length, L1	3498			25	66,077,946	0.31		
Soil Type C	0	0						elev, M2	8206			35	45,827,473	0.22		
Soil Type D	0	0						Length, L2	3117			40	2,540,968	0.01		
								elev, M3	7670			45	27,363,494	0.13		
								Length, L3	23097			50	114,016	0.00		
												55	6,562,930	0.03		
													TOTAL % =	1.00		
Subarea 4	276,476,525	6,347	**9.9**	**0.0%**	**49.8%**	**43.4%**	**6.9%**	**Subarea 4**				**Subarea 4 (Precipitation in inches)**	**Area (s.f.)**	**%**	29.59	**875**
Soil Type A	0	0						elev, M1	11173	**8541**	**0.86**	17	59,620,073	0.22		
Soil Type B	137,607,245	3,159						Length, L1	2380			25	65,713,746	0.24		
Soil Type C	119,920,680	2,753						elev, M2	10105			35	104,376,610	0.38		
Soil Type D	18,948,600	435						Length, L2	4130			40	46,766,096	0.17		
								elev, M3	8826				TOTAL % =	1.00		
								Length, L3	17588							
								elev, M4	7581							
								Length, L4	18460							
Subarea 5	215,067,543	4,937	**7.7**	**9.8%**	**90.2%**	**0.0%**	**0.0%**	**Subarea 5**				**Subarea 5 (Precipitation in inches)**	**Area (s.f.)**	**%**	23.88	**570**
Soil Type A	21,039,480	483						elev, M1	8280	**7780**	**1.05**	17	59,583,489	0.28		
Soil Type B	194,028,063	4,454						Length, L1	12439			25	134,616,092	0.63		
Soil Type C	0	0						elev, M2	7506			35	20,707,373	0.10		
Soil Type D	0	0						Length, L2	22696			40	836,804	0.00		
													TOTAL % =	1.00		
Subarea 6	791,260,703	18,165	**28.4**	**26.1%**	**48.9%**	**19.5%**	**5.5%**	**Subarea 6**				**Subarea 6 (Precipitation in inches)**	**Area (s.f.)**	**%**	22.56	**509**
Soil Type A	206,213,040	4,734						elev, M1	11170	**7978**	**1.01**	10	81,254,941	0.10		
Soil Type B	386,849,663	8,881						Length, L1	7817			12.5	131,634,736	0.17		
Soil Type C	154,289,520	3,542						elev, M2	8628			17	230,614,565	0.29		
Soil Type D	43,908,480	1,008						Length, L2	17969			25	108,000,082	0.14		
								elev, M3	7291			30	6,449,168	0.01		
								Length, L3	9570			35	151,430,082	0.19		
								elev, M4	7043			40	81,877,129	0.10		
								Length, L4	32115				TOTAL % =	1.00		

Table 3-5
Snowmelt Flow Calculations - Procedure B

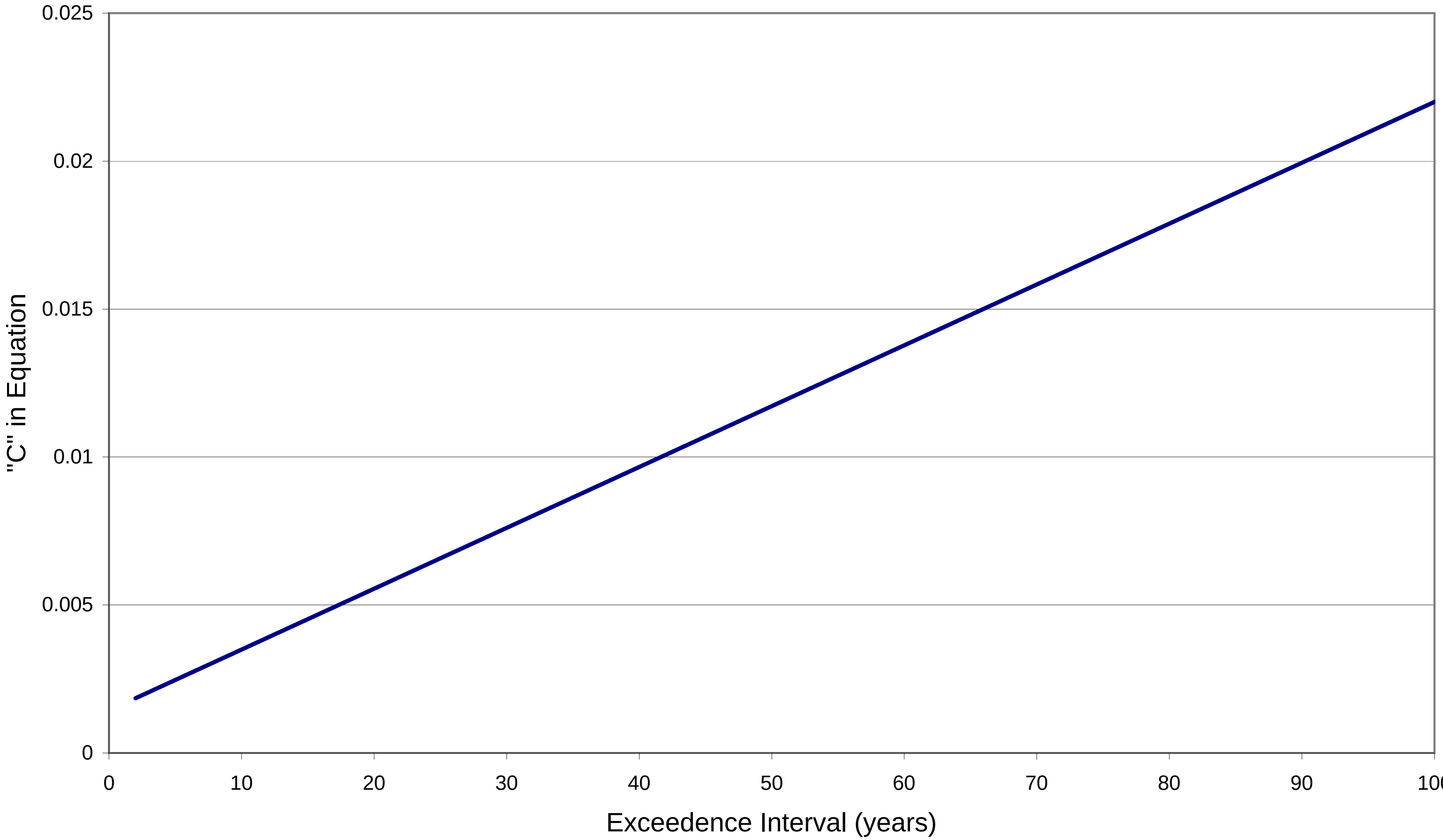
Watershed	Peak Snow Melt Q peak = 1.15 * Mean Daily Flow (Basin I only) Q peak = 1.7 * Mean Daily Flow (All other basins)
Subarea 1	
Q10	124.8
Q20	160.4
Q100	218.6
Subarea 2	
Q10	0.0
Q20	0.0
Q100	0.0
Subarea 3	
Q10	0.0
Q20	0.0
Q100	0.0
Subarea 4	
Q10	107.2
Q20	128.5
Q100	168.9
Subarea 5	
Q10	105.6
Q20	108.9
Q100	126.8
Subarea 6	
Q10	74.9
Q20	112.2
Q100	172.2

Actual Max and Min Elevations in Basin			Q10	Q20	Q100
	Subarea 1				
11,473	Top of Melt Band Elevation		10,923	10,473	10,423
8,540	Bottom of Melt Band Elevation		9,673	9,193	8,823
	Area of Melt Band (mi^2)		5.32	6.68	7.92
	Flow Adjustment	1.000			
	Design Mean Daily Flow Rate		109	139	190
	Subarea 2				
10,980	Top of Melt Band Elevation		10,430	9,980	9,930
7,713	Bottom of Melt Band Elevation		9,180	8,700	8,330
	Area of Melt Band (mi^2)		0.00	0.00	0.00
	Flow Adjustment	0.850			
	Design Mean Daily Flow Rate		0	0	0
	Subarea 3				
9,352	Top of Melt Band Elevation		8,802	8,539	8,859
7,259	Bottom of Melt Band Elevation		7,552	7,259	7,259
	Area of Melt Band (mi^2)		0.00	0.00	0.00
	Flow Adjustment	0.450			
	Design Mean Daily Flow Rate		0	0	0
	Subarea 4				
11,837	Top of Melt Band Elevation		11,287	10,837	10,787
7,211	Bottom of Melt Band Elevation		10,037	9,557	9,187
	Area of Melt Band (mi^2)		3.09	3.62	4.14
	Flow Adjustment	1.000			
	Design Mean Daily Flow Rate		63	76	99
	Subarea 5				
8,759	Top of Melt Band Elevation		8,461	8,491	8,811
7,211	Bottom of Melt Band Elevation		7,211	7,211	7,211
	Area of Melt Band (mi^2)		7.61	7.67	7.77
	Flow Adjustment	0.400			
	Design Mean Daily Flow Rate		62	64	75
	Subarea 6				
12,510	Top of Melt Band Elevation		11,960	11,510	11,460
6,930	Bottom of Melt Band Elevation		10,710	10,230	9,860
	Area of Melt Band (mi^2)		2.16	3.16	4.22
	Flow Adjustment	1.000			
	Design Mean Daily Flow Rate		44	66	101

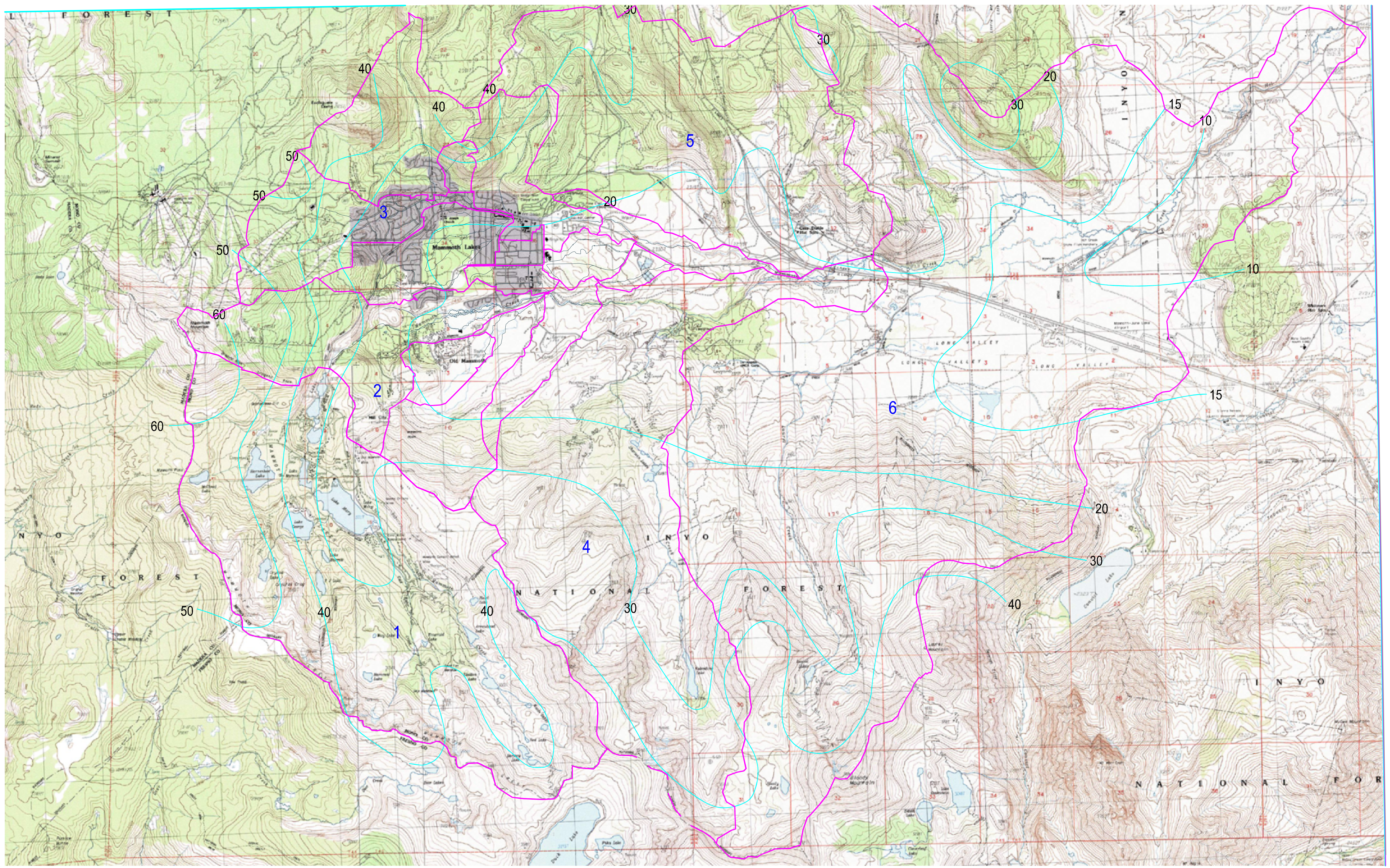
	Q10	Q20	Q100
melt band diff.	550	1000	1050
melt band width	1250	1280	1600
runoff (cfs/mi^2)	20.4	20.88	24

max elev	flow adj.
8,750	0.400
9,000	0.400
9,250	0.450
9,500	0.500
9,750	0.550
10,000	0.625
10,250	0.700
10,500	0.775
10,750	0.850
11,000	0.950
11,250	1.000

Figure 3-1
Coefficient "C" for Rainflood Frequency Equation



DWG: F:\ellison\M0110001 - Mammoth Storm\CAD\Exhibits\Figure 3-2 Precipitationdpi.dwg USER: kmarin
DATE: Jun 10, 2005 10:45am XREFS: Basins-Hatch (Sub Areas)FOR FIGURES



LEGEND

MAJOR WATERSHED BOUNDARY

15 ISOHYET

I WATERSHED DESIGNATION

3000' 1500' 0 3000' 6000'

SCALE IN FEET

REV	DATE	DESCRIPTION	APPR
6			
5			
4			
3			
2			
1	–		

BOYLE

TOWN OF MAMMOTH LAKES
STORM DRAIN MASTER PLAN

MEAN ANNUAL PRECIPITATION ISOHYETS

VT-M01-100-01 JUNE 2005 FIGURE 3-2

Figure 3-3
Highest Elevation of Melt Band

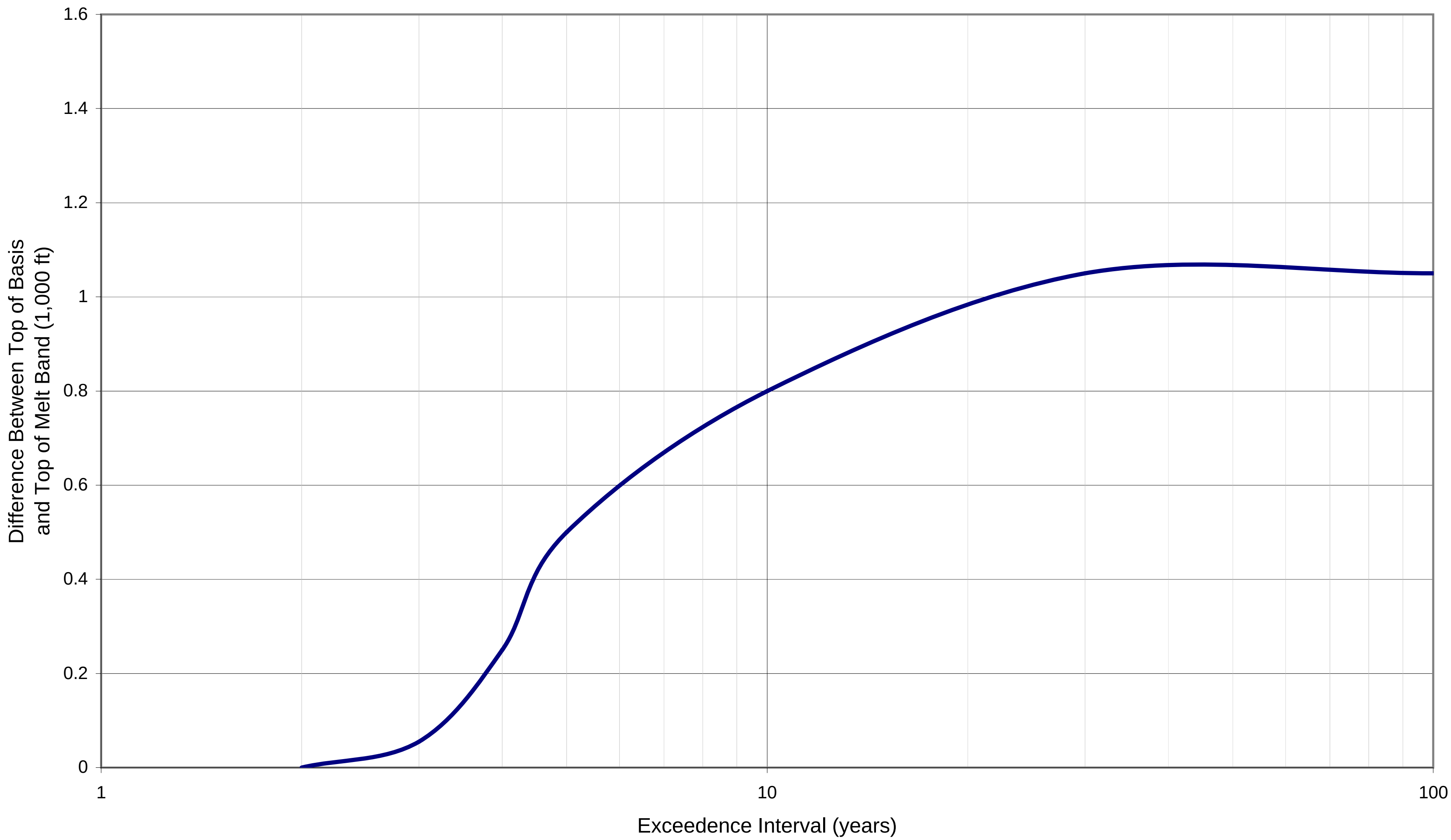


Figure 3-4
Width of Melt Band

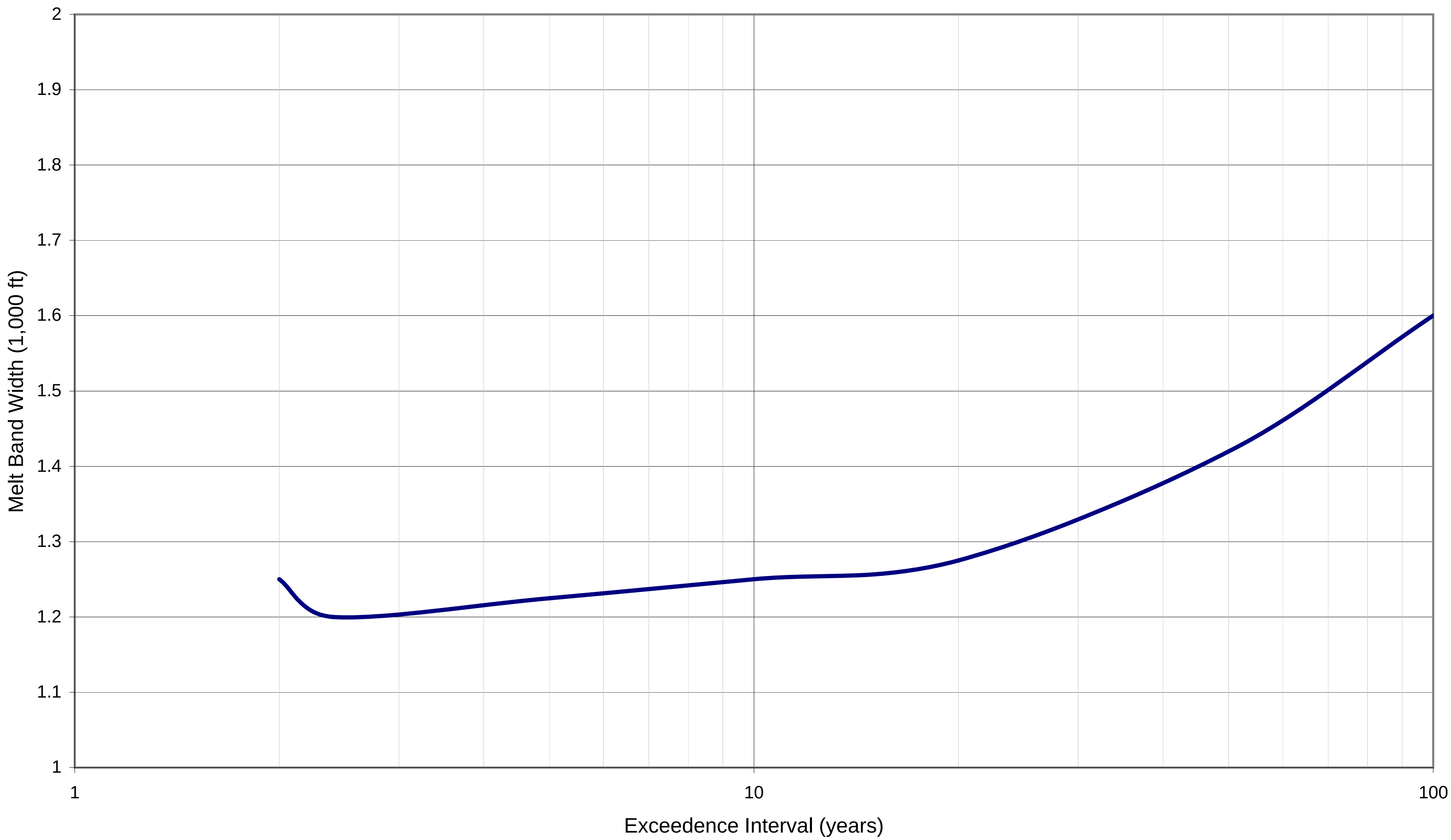


Figure 3-5
Runoff Rate

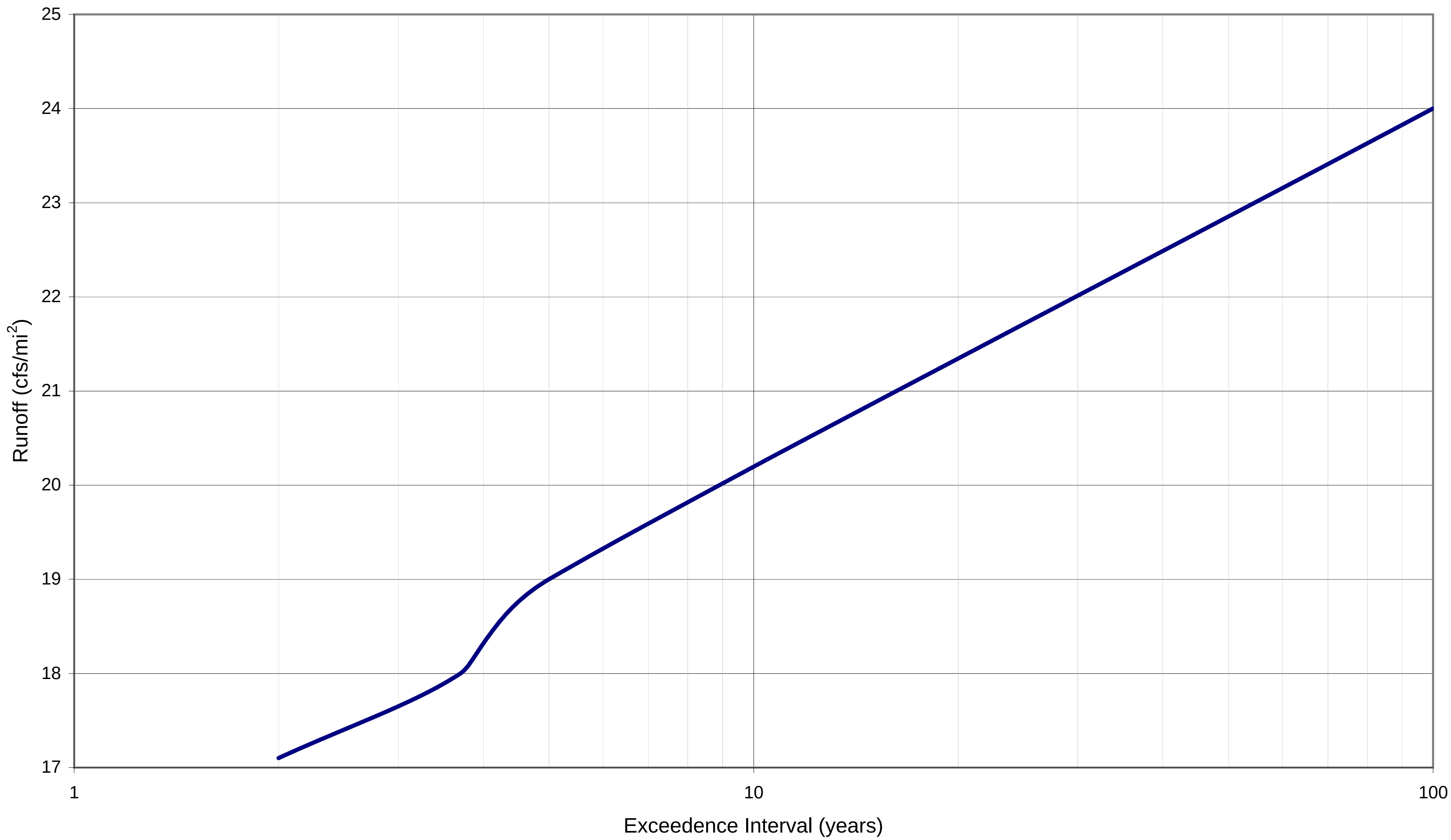
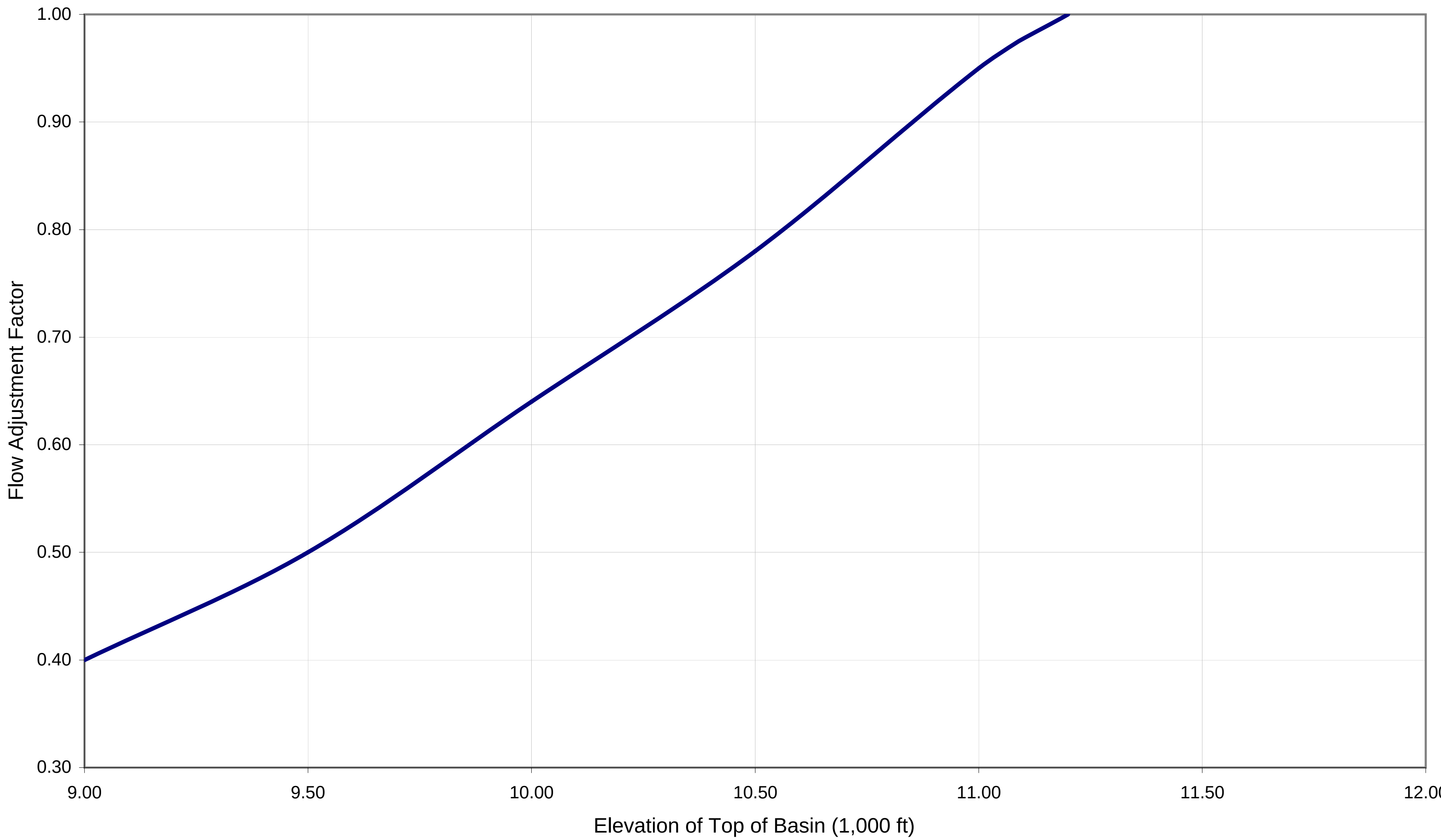


Figure 3-6
Flow Adjustment Factor



D. Benefits of Detention/Retention Basins

Detention basins act as filters that reduce adverse flooding impacts associated with a storm event or a series of events. This reduction is accomplished by decreasing the peak flow to downstream watersheds and/or by delaying the time at which downstream hydraulic systems are impacted. Such a delay allows a longer period for downstream watersheds to drain, effectively increasing the ability of downstream drainage systems to accommodate runoff generated upstream. The combined effects of flow reduction and time delay are created by utilizing available storage volume in the basin and by designing the hydraulic outflow structures from the basin.

Downstream benefits associated with the combined action of discharge reduction and time delay due to the presence of a detention basin may include: (1) lowering the water surface elevation in streams, hence decreasing the magnitude of risks associated with flooding; (2) reducing or eliminating the need to replace and enlarge existing hydraulic facilities as the result of increased runoff generated by proposed development upstream of the basin; (3) mitigating downstream damage associated with streambed erosion, sediment transport, or pollution transport.

These benefits can provide significant economic savings to the community and often outweigh basin costs associated with engineering design, construction, and property acquisition. Since communities are often politically adverse to the notion of constructing stream improvements using concrete-lined channels as a means of improving flow conveyance, the use of detention basins can offer an alternative compatible with the ecologic goals of the community. To quote the United States Environmental Protection Agency: “A practice becoming more prevalent is to site developments around man-made ponds, lakes, or wetlands created to control flooding and reduce the impacts of urban runoff on neighboring natural streams, lakes, or coastal areas. When designed and sited correctly, artificial lakes or wetlands can help developers reduce negative environmental impacts caused by the development process and increase the value of the property. Certain urban runoff management controls can be incorporated into a development in a way that provides aesthetic and economic benefits. Urban runoff controls that are pleasing to the eye and safe for children can lead to increased property values. Because the beauty of natural surroundings can increase real property values and enhance the quality of life, beautification of land areas adjacent to waterways and detention ponds should be considered an integral part of planning by developers."

Currently, the Town of Mammoth Lakes requires that all new developments retain on-site the runoff produced from a one-hour 20-year storm event. This practice is consistent with what many cities are now requiring. It mitigates the downstream impact of the development, both within the city and more importantly within the natural channels beyond the city, where excessive runoff can result in significant erosion and damage to habitat. Retention of runoff also reduces the sediment and nutrient material that is washed from roofs, roads, and other hard surfaces. It is recommended that this requirement for on-site retention continue.

We do not recommend, however, that retention be required for 100-year storm events, except under extraordinary circumstances. This larger retention volume needed for a 100-year event would rarely if ever be used within the expected lifetime of the development. Moreover, research has shown that nearly all the sediment and pollutants carried in storm runoff is flushed during the initial portion of the storm event. Thus a facility designed to retain the 20-year event will capture most of the pollutants. Only if a development is expected to greatly increase runoff and cause significant adverse impacts on the environment should retention of the 100-year event be considered. In accordance with the provisions of the City's planning ordinances and the California Environmental Quality Act, storm runoff is just one of the environmental impacts that needs to be considered if when a large development is being considered. The impacts of such large developments need be reviewed on a case-by-case basis.

E. Development of a Hydrograph Procedure for Detention Basin Design

In some cases, not only the peak flow rate but also the volume of runoff corresponding to a design storm condition must be calculated. This is true in the design of storage facilities, as in the case of sediment retention and flow detention basins. The U.S. Soil Conservation Service unit hydrograph method was adopted for use in this analysis. This procedure permits construction of a runoff hydrograph from a known precipitation pattern.

A design precipitation pattern for a given exceedence interval and basin time of concentration may be constructed using the following procedures. Basically, the precipitation pattern is built up in unit time steps from the center of a 24-hour period outward in both directions.

A unit hydrograph can be constructed using the standard design hydrograph shape from the U.S. Soil Conservation Service methodology, and the calculated basin time of concentration. Incremental precipitation volumes are multiplied by the unit hydrograph ordinates and the resulting hydrographs superimposed to find a storm runoff hydrograph. In order to first determine the applicable tc for a detention basin, use the following procedure.

For the overland flow path (if it exists), measure the overland flow distance L_0 from the most remote point in the drainage basin to the point where runoff enters a defined open channel, gutter, or pipe. Determine the overland flow slope S_0 by dividing the change in overland flow elevation (between the most remote point in the drainage basin and the place where runoff from that point enters a defined open channel, gutter, or pipe) by the overland flow distance L_0.

For the case of channelized flow, measure the channelized length L_C from the point at which channelization begins (as defined in the above paragraph) to the concentration point of the watershed basin. Determine the channelized slope S_C by dividing the change in overland flow elevation (between the most remote point in the drainage basin and the place where runoff from that point enters a defined open channel, gutter, or pipe) by the overland flow distance L_0.

Determine the overland component of the time of concentration t_{co} from **Figure 3-7** for both winter and summer storms. If overland flow paths consist of discrete portions having markedly different slopes, find the separate overland times of concentration and sum them to determine t_{co}. In a similar manner to the overland case, determine the channelized component of the time of concentration t_{cc} from **Figure 3-8** (which is to be applied for both winter and summer storms). If channelized flow paths consist of discrete portions having markedly different slopes or conveyance types, find the separate overland times of concentration and sum them to determine t_{cc}. Determine the watershed time of concentration t_c by summing t_{co} and t_{cc}, i.e. $t_c = t_{co} +$

t_{cc}. If the value of t_c is calculated to be less five minutes, take the value of t_c to be five minutes.

Using the appropriate exceedence interval, determine the precipitation intensities for winter and summer storms (P_W and P_S) measured in inches/hour, which correspond to the total time of concentration t_c from **Figure 3-9** and **Figure 3-10**. Also find the one-hour design storm precipitation (not the precipitation intensity) for the same exceedence interval.

If the tributary area includes open space, landscaped, or unimproved areas, determine the natural area runoff coefficient, Cn, from **Figure 3-11** to **Figure 3-13,** based on the one-hour design precipitation and the soil type as shown on the Soils Map, **Exhibit 3**. Cn is calculated by Cn = RF x RR x NF.

For the watershed, determine the area in acres that fall into each of the categories listed in **Table 3-6** below and compute a weighted coefficient of runoff C (as defined in the Rational formula) for both winter and summer storms.

Table 3-6. "C" Factors for Use in Detention Basin Design

Type of Area or Surface	Coefficient, C
Roofs	0.90
Paving, asphalt or concrete	0.90
Aggregate driveways and walks	0.80
Corporation yards, unpaved	0.75
Landscaped, open, or undeveloped areas	Cn

Figure 3-7
Overland Flow T_{co} Component

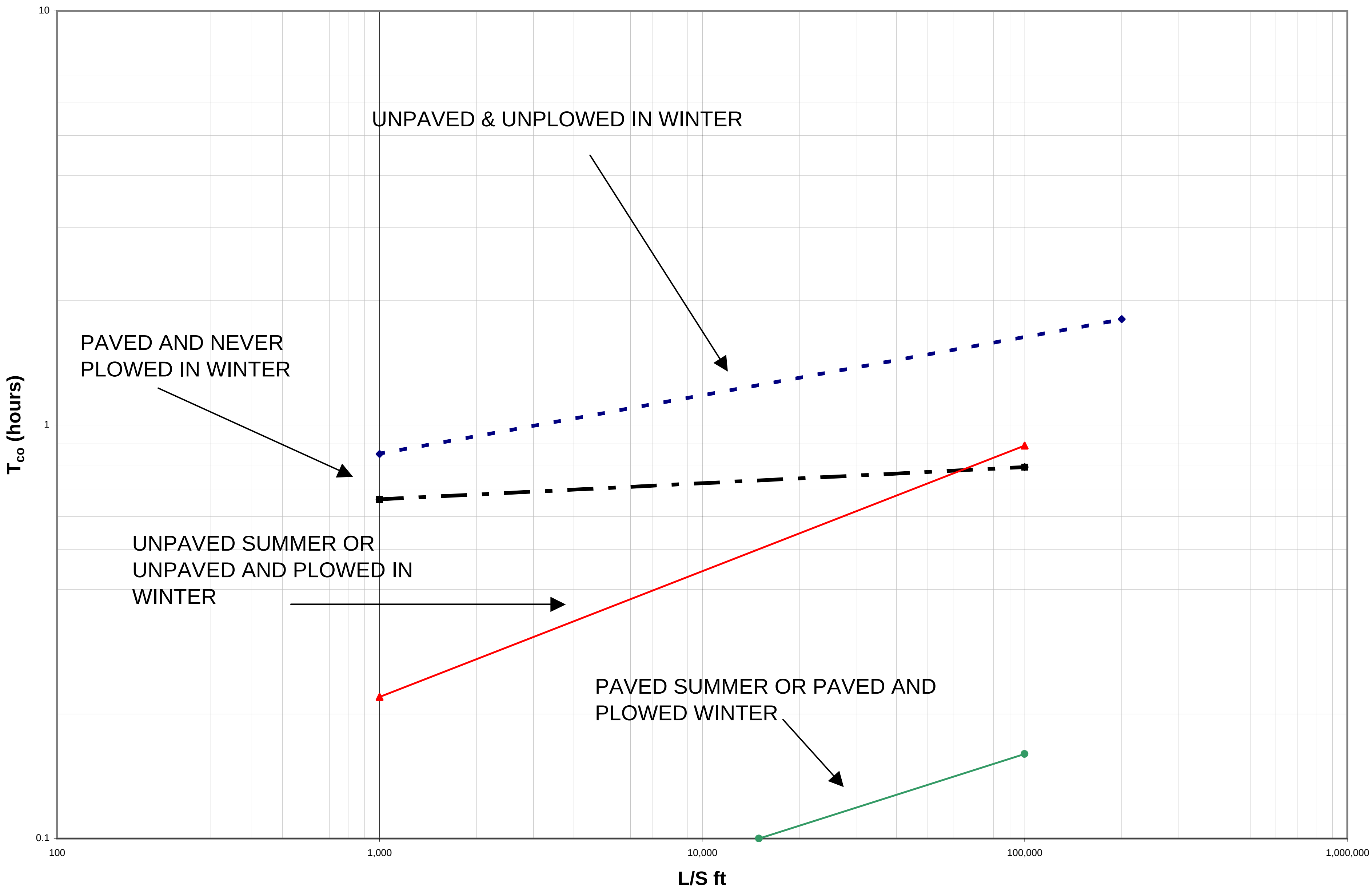


Figure 3-8
Channel Flow T_{cc} Component

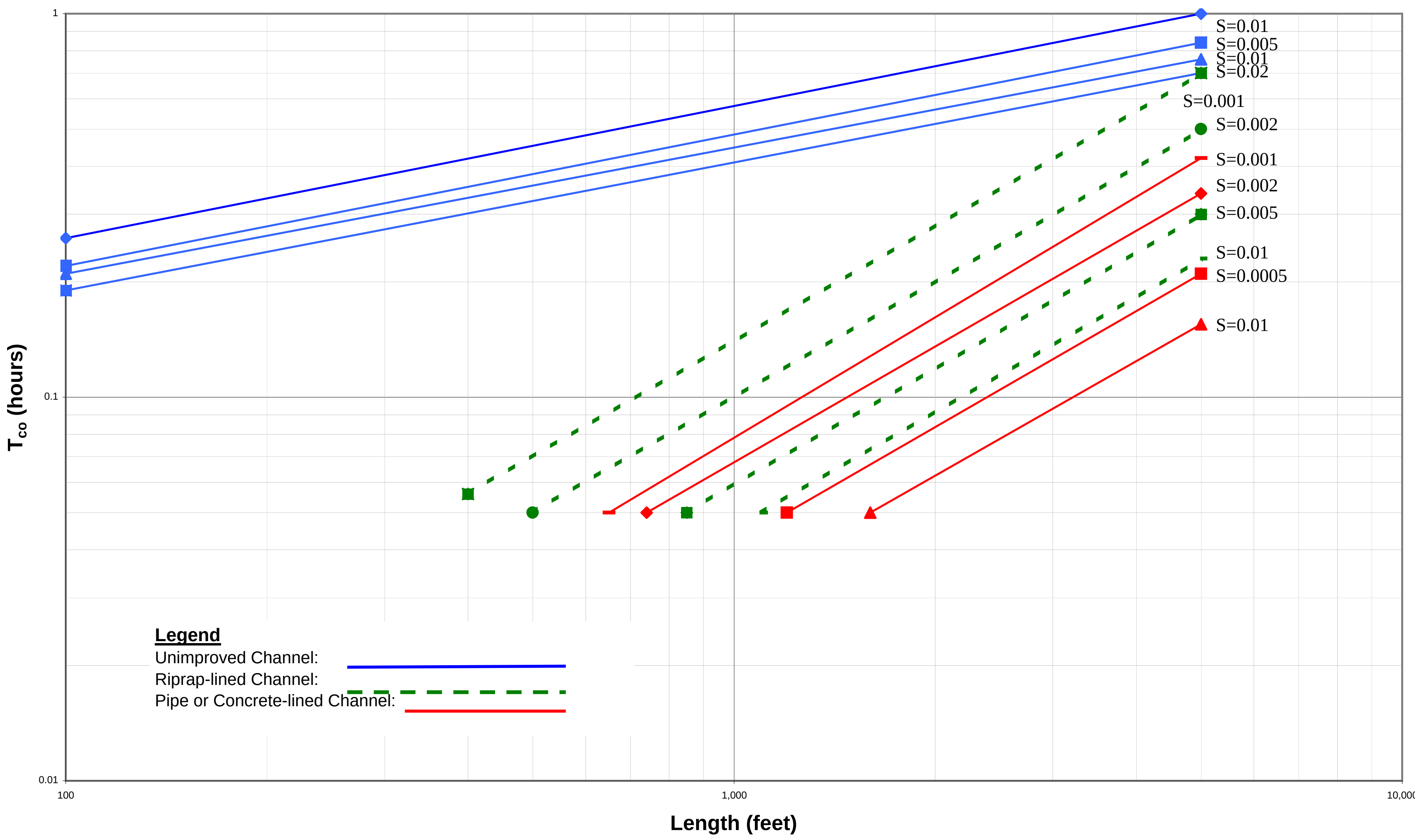


Figure 3-9
Winter Precipitation Design Curve, Pw

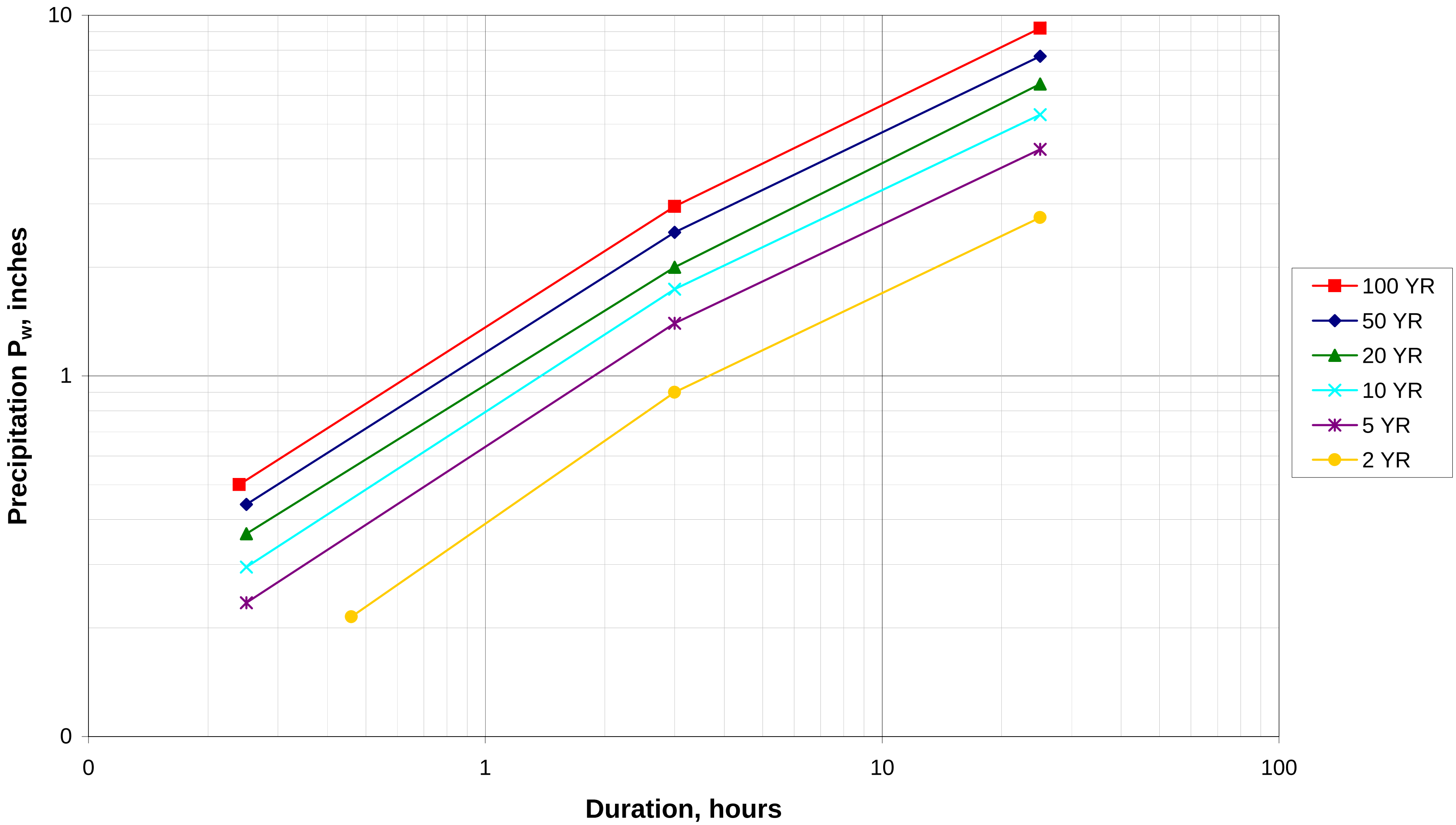


Figure 3-10
Summer Precipitation Design Curve, Ps

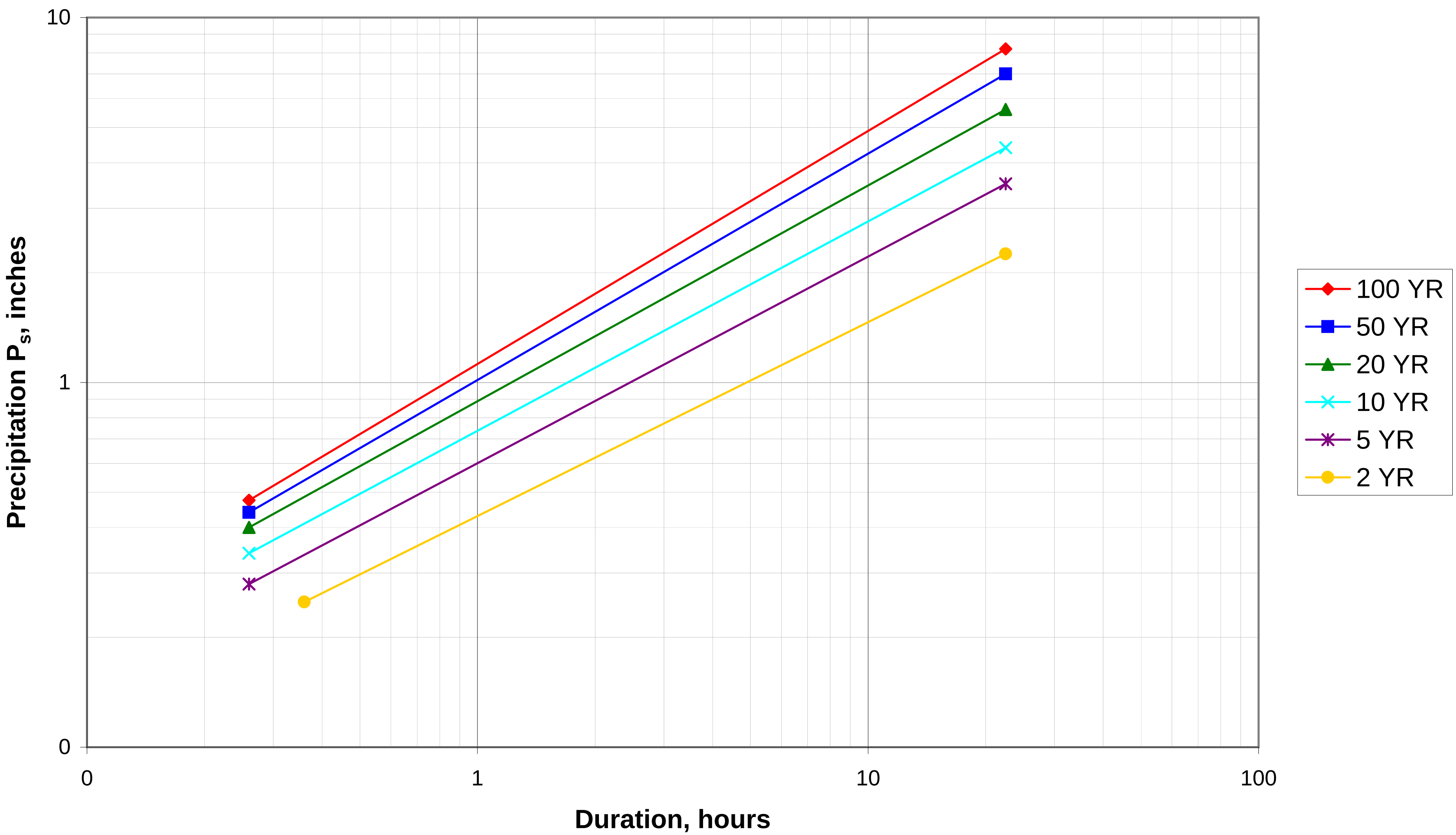


Figure 3-11
Natural Area Runoff Factor, RF

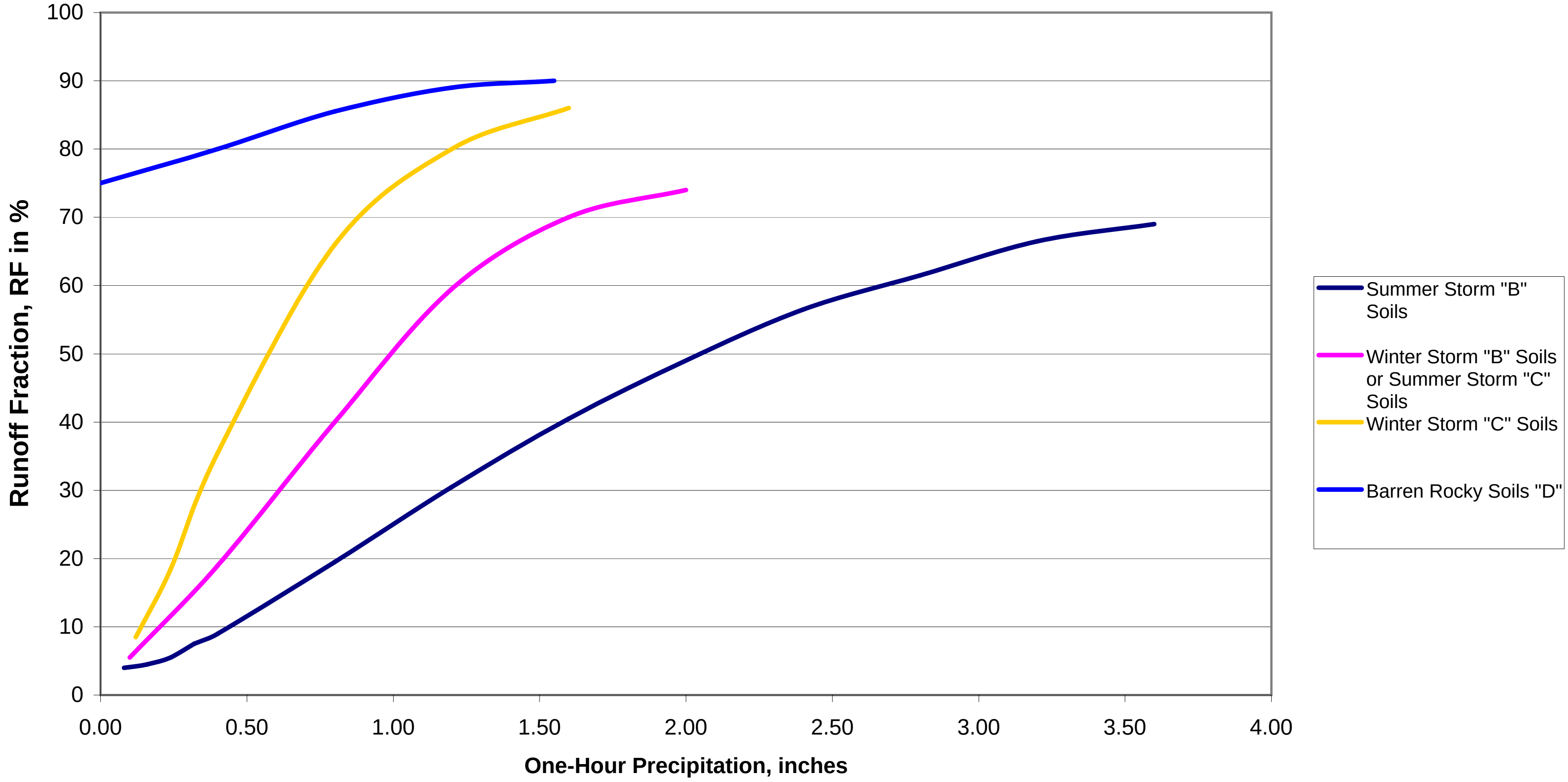


Figure 3-12
Reduction Ratio, RR

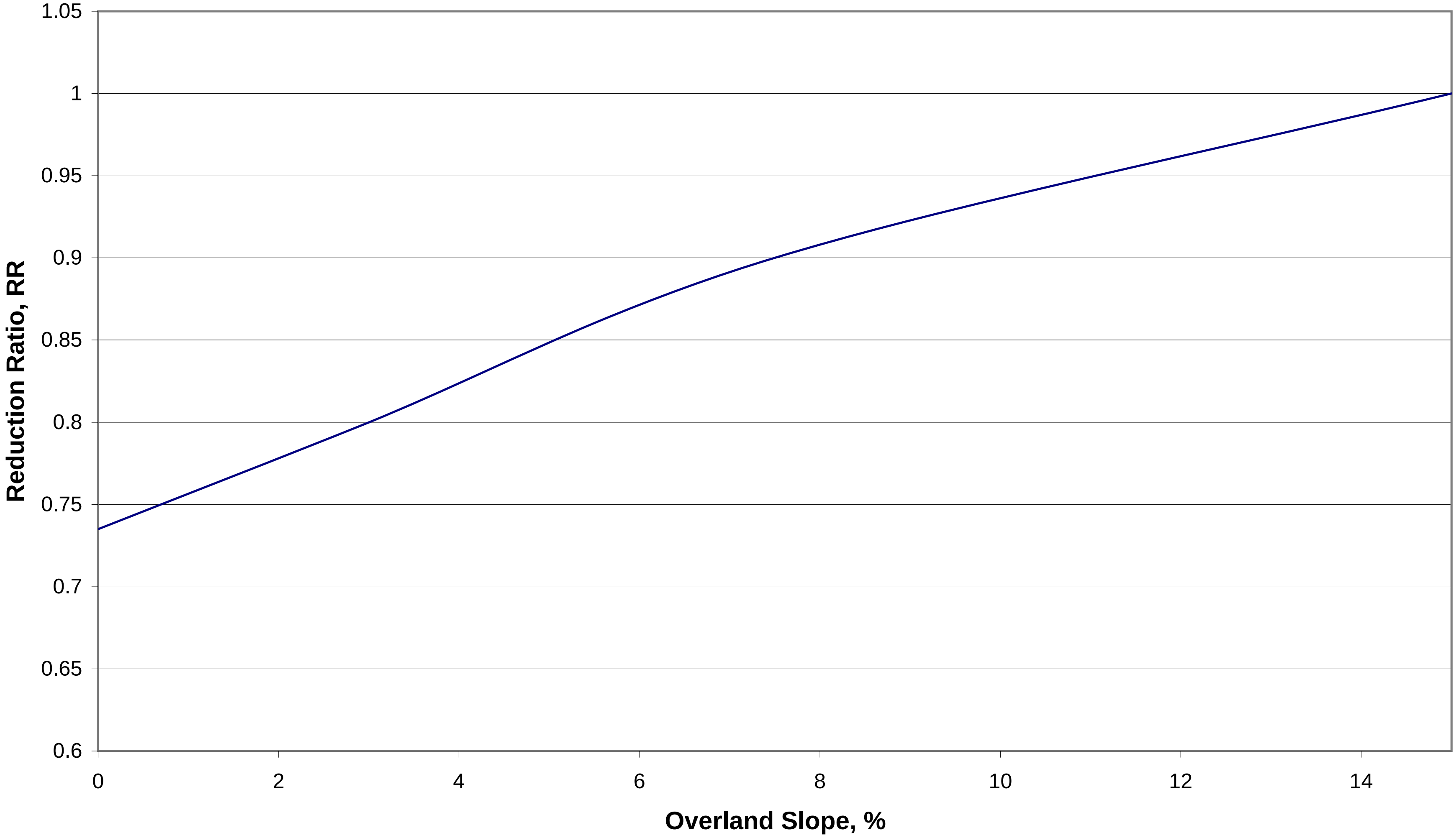
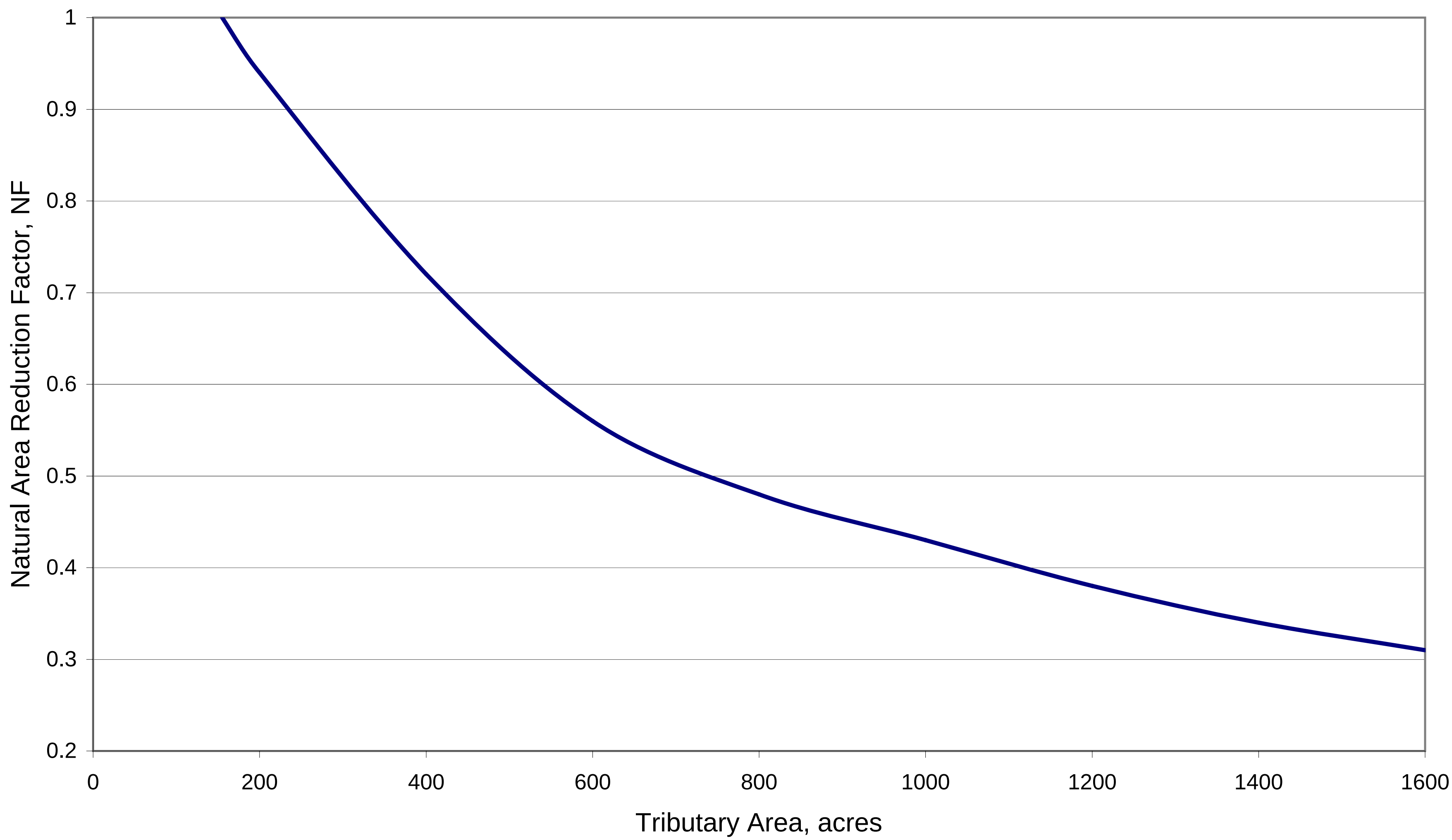


FIGURE 3-13
Natural Area Size Factor, NF



Calculate the peak runoff for winter and summer storms using the Rational Formula

$$Q = 1.008 \cdot C \cdot P \cdot A$$

Where:

1.008 = an adjustment for consistency of dimensions
Q = the design peak discharge in cubic feet per second
A = the total basin area measured in acres
P = the precipitation intensity for winter of summer conditions in inches/hour.

From the largest of the calculated discharge values for winter and summer, choose the larger value as the design discharge Q for the appropriate exceedence period.

Development of a Unit Hydrograph

1. Determine the area A, time of concentration t_c, and weighted C values for the basin.
2. Compute the unit rainfall excess time interval D from the equation $D = 0.133t_c$, where t_c is measured in hours.
3. Compute the time to peak T_p from the equation $T_p = D/2 + 0.6t_c$.
4. Compute the peak flow q_p for a volume of runoff equal to one inch from the equation $q_p = 484T_pA$ where A is the area in square miles, T_p is the time to peak in hours, and q_p is the peak flow in cfs.
5. Compute the coordinates of the unit hydrograph from the t/T_p and q/q_p ratios in **Table 3-7**.
6. Tabulate the ordinates of the unit hydrograph in intervals of D from a plot of the coordinates formed in Step 5.
7. Check the volume of the unit hydrograph by summing the ordinates and multiplying by D. Compare this to the volume computed from the equation V = 645.33 X A where V is the

computed volume in cfs-hours and A is the area in Square miles. If the two volumes do not check, adjust the coordinates of the unit hydrograph uniformly to obtain a reasonable balance.

Table 3-7. Ratios for Dimensionless Unit Hydrograph

Time Ratios (t/T_p)	Discharge Ratios (q/q_p)
0	.000
.1	.030
.2	.100
.3	.190
.4	.310
.5	.470
.6	.660
.7	.820
.8	.930
.9	.990
1.0	1.000
1.1	.990
1.2	.930
1.3	.860
1.4	.780
1.5	.680
1.6	.560
1.7	.460
1.8	.390
1.9	330
2.0	.280
2.2	.207
2.4	.147
2.6	.107
2.8	0.77
3.0	.055
3.2	.040
3.4	.029
3.6	.021
3.8	.015
4.0	.011
4.5	.005
5.0	.000

Development of a Unit Hydrograph

The following steps are used to convert the unit hydrograph into a storm runoff hydrograph. The procedure must be applied independently to summer and winter conditions:

1. Determine the 1-, 3-, 6-, 12-, and 24-hour precipitation volume for winter and summer rainfall at the selected exceedence interval from **Figure 3-9** and **Figure 3-10**.

2. Plot rainfall graphs for the design storms using the volumes from Step 1. The graphs should be constructed by plotting the 1-hour volume at the center of the graph and working outward so that the volumes under the graphs correspond to the rainfall volumes obtained in Step 1.

3. Convert the plot from Step 2 into a tabulation of incremental precipitation volumes for time intervals of D.

4. Compute a loss volume, V, from the 1-hour precipitation volume and the weighted "C" factor computed in Procedure A. Note, that this must be done for winter and summer conditions.

   The loss volume is calculated from,

   $$V = (1-C)\ PD$$

   Where:

   V = loss volume, inches
   C = weighted C from Procedure A
   P = 1-hour precipitation volume from **Figure 3-9**
   D = time interval, hours

5. Subtract V from each of the incremental precipitation volumes from Step 3 to find the incremental excess precipitation volumes.

6. Use the tabulation of the unit hydrograph in intervals of D and the tabulation from Step 5 to compute a runoff hydrograph. If the intervals of D are represented by Di, and the corresponding incremental precipitation volumes, unit hydrograph ordinates,

and runoff hydrograph ordinates are represented by Ri, Hi, and RHi, the following equation can be used to compute the runoff hydrograph ordinates:

$RHi = (R_1 \times Hi) + (R_2 \times Hi-1) + (R_3 \times Hi-2)\ldots + (Ri \times H_1)$

The computer runoff hydrograph ordinates should be plotted against time (t = I x D to obtain a runoff hydrograph. Required volumes for storage facilities can be found by computing the area under the curve for a particular maximum flow rate.

Sample Detention Basin Hydrograph Calculation

The following example illustrates the methodology required to calculate peak runoff rates and hydrograph for the purpose of detention basin design.

1. Assumed Basin Characteristics:
   a. A = 230 acres
   b. L_o = 2,500 feet
   c. S_o = 0.05 foot/foot
   d. S = 0.05 foot/foot
   e. L_c = 250 feet, unimproved
   f. S_c = 0.02 foot/foot
   g. 10 percent paved; 2 percent roofs; 88 percent natural
   h. “B” soils
2. Procedure:
   a. Calculate t_{co}: L_o/S = 2,500/0.05 = 50,000

      From **Figure 3-7**:

      Winter t_{co} = 1.34 hours (unpaved, unplowed)

      Summer t_{co} = 0.72 hour (unpaved)
   b. Calculate t_{cc}:

      From **Figure 3-8**: t_{cc} = 0.26 hour
   c. Find time of concentration:

      Winter t_c = 1.60 hours
      Summer t_c = 0.98 hour

d. Find one-hour precipitation and precipitation intensities for the time of concentration from **Figure 3-9** and **Figure 3-10** for the appropriate exceedence interval. Assume design is for storm drain in street - - use 20-year exceedence interval.

Winter: Precipitation (1 hour) = 0.90 inches;

P_w (1.6 hours) = 0.80 inch/hour

Summer: Precipitation (1 hour) = 0.90 inch;

P_s (0.98 hour) = 0.90 inch/hour

e. Find Cn from **Figure 3-11** through **Figure 3-13** and **Exhibit 3**:

Winter: RF = 0.45, RR = 0.85, NF = 0.90

Cn = 0.45 X 0.85 X 0.90 = 0.34

Summer: RF = 0.22, RR = 0.85, NF = 0.90

Cn = 0.22 X 0.85 X 0.90 = 0.17

f. Find weighted average runoff coefficient, C

		Coefficient	
Surface	**Fraction of Total Area**	**Winter**	**Summer**
Paved	0.10	0.9	0.9
Roofs	0.02	0.9	0.9
Natural	0.88	0.34	0.17

Є Winter = (0.1) (0.9) + (0.02) (0.9) + (0.88) (0.34) = 0.41

Є Summer = (0.1) (0.9) + (0.02) (0.9) + (0.88) (0.17) = 0.26

g. Find peak flow:

Q Winter = (1.008) (0.41) (0.8) (230) = 76.0 cfs
Q Summer = (1.008) (0.26) (0.9) (230) = 54.3 cfs
Q Design = 76.0 cfs

Section 4 – Potential Detention Basin Improvements

A. Approach

The Town of Mammoth Lakes has specified three area of interest as potential detention sites. These sites shall be referred to as Detention Areas A, B, and C in this study. **Figure 4-1** through **Figure 4-3** illustrate their planned location within the Town together with their planned extents. The approximate values of the watershed tributary areas associated with these sites are given below in **Table 4-1**:

Table 4-1. Potential Basins and Tributary Areas

Basin Designation	Tributary Area (acres)	Proposed Basin Type
A	755	Underground
B	1070	Surface
C	40	Surface

B. Detention Basin A - Analysis

Using the Hydrologic Procedures outlined in Section 3, we first determine the 20-year hydrograph for Detention Basin A:

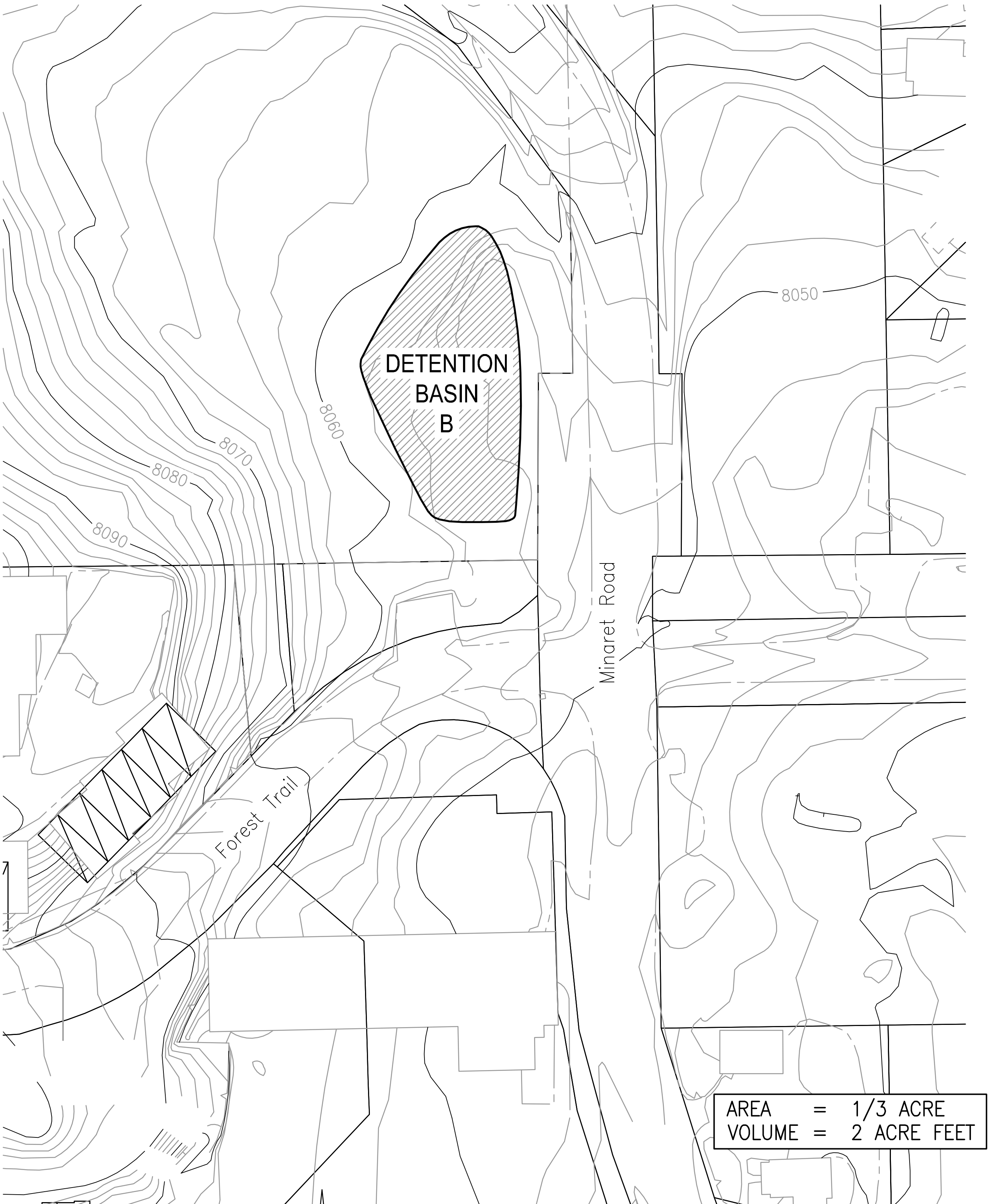
Using Procedure A, determine the tributary area of the detention basin, time of concentration t_c, and weighted C values for the basin as described in Section 3.D: The tributary area to the basin is 755 acres. Using Reference [4], it is estimated that the average velocity for the overland flow path is 1.4 feet per second over a total length of 6,330 feet, which yields an estimated $t_c = 1.26$ hours.

1. Compute the unit rainfall excess time interval D from the equation $D = 0.133t_c$, where t_c is measured in hours: For Detention Basin A, D = 0.133(1.26) = 0.167 hours.

2. Compute the time to peak T_p from the equation $T_p = D/2 + 0.6t_c$: For Detention Basin A, T_p = 0.167/2 + (0.6)(1.26) = 0.837 hours.

DWG: F:\ellison\M0110001 – Mammoth Storm\CAD\Exhibits\Figure 4-1.dwg USER: kmarin
DATE: May 31, 2005 5:01pm XREFS: SD Pipes Basins-Hatch (thin lines) basemap 2162p3 BLDG ONLY 2162p3 TOPO ONLY

TOWN OF MAMMOTH LAKES		
DETENTION BASIN A		
VT-M01-100-01	MAY 2005	FIGURE 4-1



150 0 50 100
SCALE IN FEET

BOYLE

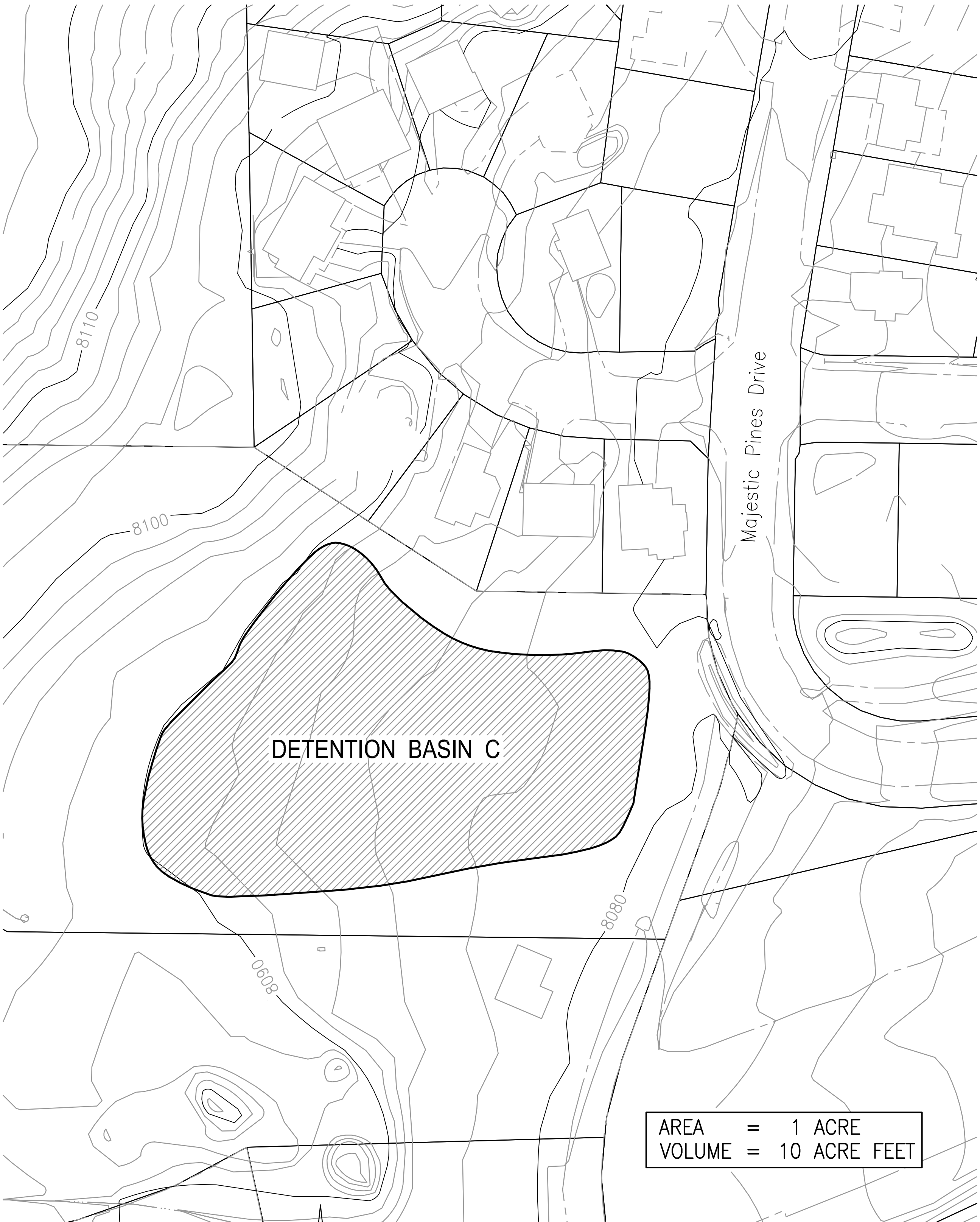
TOWN OF MAMMOTH LAKES

DETENTION BASIN B

VT-M01-100-01 JANUARY 2005 FIGURE 4-2

DWG: F:\ellison\M0110001 – Mammoth Storm\CAD\Exhibits\Figure 4-2.dwg USER: kmarin
DATE: May 31, 2005 5:02pm XREFS: SD Pipes Basins-Hatch (thin lines) basemap 2162p3 BLDG ONLY 2162p3 TOPO ONLY

DWG: F:\ellison\M0110001 – Mammoth Storm\CAD\Exhibits\Figure 4-3.dwg USER: kmarin
DATE: May 31, 2005 5:05pm XREFS: SD Pipes Basins-Hatch (thin lines) basemap 2162p3 BLDG ONLY 2162p3 TOPO ONLY



150 0 50 100
SCALE IN FEET

BOYLE

TOWN OF MAMMOTH LAKES		
DETENTION BASIN C		
VT-M01-100-01	MAY 2005	FIGURE 4-3

3. Compute the peak flow q_p for a volume of runoff equal to one inch from the equation $q_p = 484T_pA$ where A is the area in square miles, T_p is the time to peak in hours, and q_p is the peak flow in cfs: For Detention Basin A, q_p = (484)(0.837)(755)/640 = 478 cfs.

4. Compute the coordinates of the unit hydrograph from the t/ T_p and q/q_p ratios in **Table 3-7**: For Detention Basin A and for the parameters T_p and q_p computed above, **Table 4-2** represents the unit hydrograph.

Table 4-2. Unit Hydrograph

t (hrs)	q (cfs)	t (hrs)	q (cfs)
0.000	0	1.423	220
0.084	14	1.507	186
0.167	48	1.590	158
0.251	91	1.674	134
0.335	148	1.842	99
0.419	225	2.009	70
0.502	315	2.176	51
0.586	392	2.344	37
0.670	444	2.511	26
0.753	473	2.679	19
0.837	478	2.846	14
0.921	473	3.014	10
1.005	444	3.181	7
1.088	411	3.348	5
1.172	373	3.767	2
1.256	325	4.185	0
1.339	268		

5. Tabulate the ordinates of the unit hydrograph in intervals of D from a plot of the coordinates formed in step 5: For Detention Basin A and for the parameter D computed above as D = 0.167 hours, the unit graph is given by **Table 4-3**.

Table 4-3. Adjusted Unit Hydrograph – Basin A

Index	t (hrs)	q (cfs)	Index	t (hrs)	q (cfs)
0	0.000	0	18	3.007	10
1	0.167	48	19	3.174	7
2	0.334	148	20	3.341	5
3	0.501	315	21	3.508	3
4	0.668	445	22	3.675	2
5	0.835	478	23	3.842	1
6	1.002	445	24	4.009	1
7	1.169	374	25	4.176	0
8	1.336	269	26	4.343	0
9	1.503	187	27	4.510	0
10	1.670	134	28	4.677	0
11	1.837	100	29	4.844	0
12	2.005	70	30	5.011	0
13	2.172	51	31	5.178	0
14	2.339	37	32	5.345	0
15	2.506	26	33	5.512	0
17	2.840	14			

6. Check the volume of the unit hydrograph by summing the ordinates and multiplying by D. Compare this to the volume computed from the equation V = 645.33 X A where V is the computed volume in cfs-hours and A is the area in Square miles. If the two volumes do not check, adjust the coordinates of the unit hydrograph uniformly to obtain a reasonable balance: In the case of Detention Basin A, the sum of the ordinates of the unit hydrograph obtained in Step 6 is 3,140 cfs. Multiplying this result by D = 0.167 hours gives a value of approximately 530 cfs-hours.

Development of the Runoff Hydrograph for Detention Basin A

For Detention Area A, we determined the 1-, 3-, 6-, 12-, and 24-hour precipitation volume for winter and summer rainfall at the selected exceedence interval from **Figure 3-9** and **Figure 3-10**. In the case of Detention Basin A, these values are:

	Winter Precipitation (in.)
P20 1 hr	0.94
P20 3 hr	2.00
P20 6 hr	2.72
P20 12 hr	4.00
P20 24 hr	5.70

From these values, the loss volume was calculated to be

$$V = (1-C)\ PD = (1-0.242)\ 0.9 * 0.167 = 0.114 \text{ inches}$$

Where:

V = loss volume, inches
C = weighted C from Procedure A
P = 1-hour precipitation volume from **Figure 3-9**
D = time interval, hours

The runoff hydrograph is shown in **Figure 4-4**. The volume of the 20-year hydrograph is computed to be 11.40 acre-feet. From the Brown and Caldwell Study, the 100-year graph has an approximate peak of 232 cfs, so that the assumption of identical hydrograph shapes gives the 100-year hydrograph, which has a volume of 26.44 acre-feet. Assuming that the basin is to (absent a detailed basin analysis) be sized according to the volume above the 20-year hydrograph, the required basin volume would be 26.44 – 11.40 = 15.4 acre-feet, which is sufficient to retain the 20-year discharge as well.

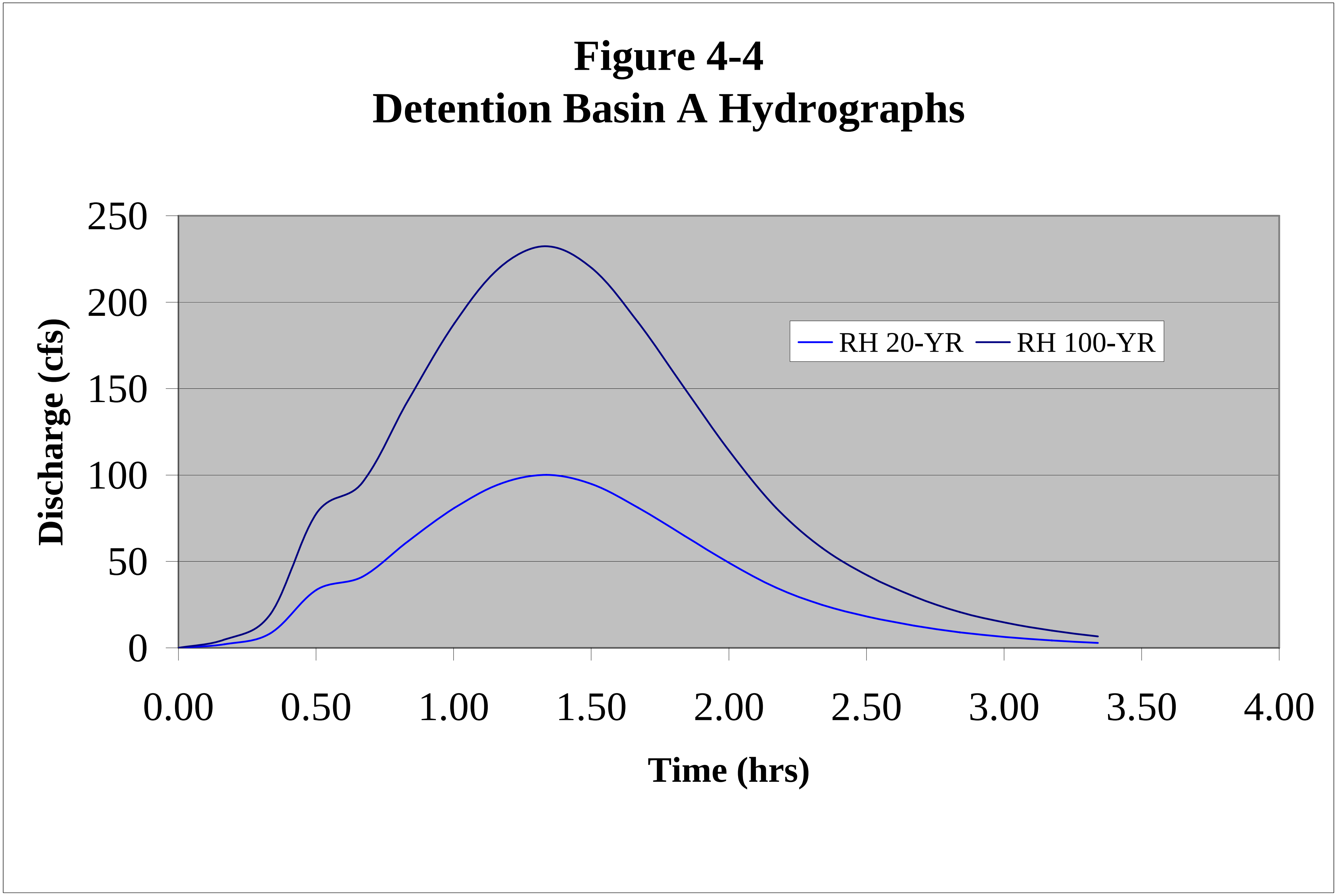


Figure 4-4
Detention Basin A Hydrographs
250
200
150
100
50
0
Discharge (cfs)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Time (hrs)
RH 20-YR
RH 100-YR

C. Detention Basin A – Discussion and Results

In the case of underground detention, some storage-related parameters need to be evaluated. The problem is to determine the relative volume (acre feet of storage per acre) that can be created.

Perhaps the simplest method of creating underground detention is with a gallery of buried pipes, connected with inlet and outlet manifolds. These pipes can either be perforated or non-perforated. If perforated, they can be surrounded by gravel, increasing the available storage volume. Another common method of creating underground detention basins utilizes arch-type structures, underlain and surrounded by gravel.[5] A third method creates voids using modular block structures.[6] All three methods are made to withstand H-20 truck loading.

A special consideration for Detention Basin A is that all the areas slope significantly, with as much as 20 feet of elevation difference from one end to the other. Without special design features, these slopes could equate to 8 psi of pressure at the lower ends of the basins, more than many detention pipelines are made to withstand. Moreover, if applied to an arch or perforated pipeline, 8 psi of pressure could create more than 1000 psf of uplift force, easily raising the pavement and "floating" the basin material.

Utilizing a pipe gallery of profile-wall High Density Polyethylene (HDPE) pipe, as much as 2.6 acre-feet of storage can be created per acre, as follows:

- 60-inch (5-ft) diameter HDPE pipe in parallel rows is assumed
- A centerline-to-centerline spacing of 1.5 diameters (or 7.5 feet) on center is assumed, per ADS (Advanced Drainage Systems, Inc) guidelines.

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[5] "Storm Tech" is one of the brand names offering this system.

[6] "Rainstore" is one of the brand names offering this system. This system promises as much as 7.7 acre-ft/acre of storage.

- The volume of water per linear foot of pipe is therefore, $\frac{\pi(5)^2}{4} = 19.63$ cubic feet

- The footprint at 1.5 D spacing is 5 feet * 1.5 = 7.5 square feet per foot of pipe, so that the combined volume per foot of pipe in the footprint = 19.63/7.5 = 2.6 cubic feet per square foot of area = 2.6 acre feet per acre.

The Town has indicated that approximately 10 acres of area may available for underground detention, by using various open spaces and the parking lot near the base of the chair lift. If 15 acre feet of storage can be created in this area, which appears to be a reasonable goal, this basin would have the benefit of retaining or detaining enough water that a 100-year event would be essentially changed to a 20-year event. If a pipe gallery type system is used, about 6 acres of area would be needed. The anticipated cost for a detention basin of this size is five to eight million dollars, including engineering and environmental documentation costs.[7]

Appendices G through H show the hydraulic results both with and without Detention Basin A. Because virtually all of the existing pipelines downstream of Basin A are already sized to handle a 20-year event, only a few of the existing deficiencies would be eliminated through the use of this basin. The potential cost savings of the avoided projects is about $0.3 million including engineering and contingency. However, the basin would have environmental benefits, diminishing the need to use Canyon Boulevard as a stormwater conduit, and reducing the peak flows in channels downstream.

[7] This is based on preliminary information obtained from the system's manufacturers, plus estimates for grading and paving.

D. Detention Basins B and C - Analysis

Both Basins B and C would be conventional uncovered basins created by berms and excavation. An order of magnitude analysis and examination of **Figure 4-2** and **Figure 4-3** together with **Table 4-1** shows that the concept of runoff detention for both Detention Areas B and C would not be particularly effective for separate reasons.

In the case of Basin B, the available volume for detention is approximately 2 acre-feet, which is on the order of 1/10 of that available for Area A, so that there would not exist significant potential for attenuation of the inflow peak.

In the case of Basin C, the available volume for detention is approximately 10 acre-feet, which is much greater than that of Area B. However, the tributary drainage area to Basin C is only on the order of 1/10 of that available for Area A, so that there would not exist significant potential for attenuation of the inflow peak.

Section 5 – Analysis of Existing Storm Drain

A. Approach

The purpose of this section is to assess the adequacy of storm drain systems under three general scenarios, namely existing conditions, future conditions, and "improved" conditions. The latter condition will be defined as the future condition together with impacts due to the construction of a detention facility at Area A as discussed in Section 4 of this study. In the future and improved scenarios, future land uses are considered in order to account for planned development. In all storm drain scenarios, the 20-year and 100-year return periods are considered.

The initial step taken to evaluate the performance of the storm drain system is to create a complete catalogue of the existing storm drain facilities. This inventory is given in **Appendix A**. **Appendix A** gives critical information including identification numbers, lengths, slopes, invert elevations, pipe roughness, and design flow capacities.

Design flow capacities were calculated using the standard 94% y/D ratio criterion. Each pipe was analyzed as an independent segment and Manning's equation $Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$ was used to determine if the pipe meets the required capacity. A Manning's "n" of 0.013 was used for all pipes, except corrugated metal. For corrugated metal pipes, 0.024 was used.

Based on the detailed subareas within Watersheds 2 and 3, whose characteristics are detailed in **Appendix B** the appropriate cfs/acre values were used within each subarea together with the tributary area to the inlets to each of the pipes listed in **Appendix A**. Discharge values based on the mathematical product of cfs/acre values and tributary area result in the 20- and 100-year discharge values that must be accommodated by each pipe.

Two separate criteria were applied to assess whether or not each pipe is considered to be adequately sized: (1) each pipe is to have adequate capacity to convey the 20-year discharge; and (2) in the cases of storm drain flows under streets, the combined street capacity and storm drain capacity is to have the necessary capacity to convey the 100-year flow.

In the case where inadequate pipes are encountered, the pipes are identified and enlarged accordingly to meet the adequacy criteria for the future and improved condition scenarios.

Existing Conditions

Appendix A represents the existing storm drain system. **Appendix E** and **Appendix F** compares the design flow capacities versus the tributary discharge values for each pipe for the 20- and 100- year events and identifies each pipe concerning adequacy. The overall finding is 50 of 445 did not meet the required capacity for the 20-year event. The 100-year event was analyzed on a select group of pipes. The selection was made on the basis that only pipe that ran parallel to street were analyzed for the 100-year capacity issue, namely that the criterion is that top of curb street flow plus pipe flow needs to meet the required capacity. The analysis found that 16 of 82 pipes are undersized for the 100-year event.

Future Conditions

Using the future land uses as dictated by the 2004 General Plan (**Exhibit 1**) and the results indicated by **Appendix C**, **Appendix G** and **Appendix H** were constructed to illustrate the elements of a storm drain system necessary to convey flows under the adequacy criteria. In particular, pipe enlargements necessary to effect satisfactory storm drain performance are given and form the basis of the cost estimates related to those improvements. Summary hydraulic findings with respect to **Appendix C** are: 58 of 445 did not meet the required capacity for the 20-year event. The 100-year event analysis determined the 26 of 82 pipes are undersized.

Future Conditions with Detention Basin

Using the future land uses as dictated by the 2004 General Plan (**Exhibit 1**) and the results indicated by **Appendix D**, **Appendix I** and **Appendix J** were constructed to illustrate the elements of a storm drain system necessary to convey flows under the adequacy criteria including the effect of the Detention Basin A considered in Section 4. **Appendix K** and **Appendix L** were constructed to illustrate the elements of a storm drain system necessary to convey flows under the adequacy criteria excluding the effect of the detention basins considered in Section 4. In particular, pipe enlargements necessary to effect satisfactory storm drain performance are given and form the basis of the cost estimates related to the Improved Conditions scenario. Summary hydraulic findings with respect to **Appendix D** are: 51 of

445 did not meet the required capacity for the 20-year event. The 100-year event analysis determined the 20 of 82 pipes are undersized.

B. CMP Considerations

Appendix O contains a list of corrugated metal pipelines (CMP) that fail to transmit the required 20-year flows, simply due to the fact that this type of pipe material is inherently very rough. The pipelines in this table would otherwise be considered to be adequately sized if constructed of concrete, PVC, HDPE, or other materials that are not corrugated. The replacement of the pipelines on this list has <u>not</u> been included in the capital improvement program proposed herein for two reasons: (1) the replacement of a CMP pipeline with another of similar size would provide only marginal benefit to the Town and might be hard to justify to laypersons, and (2) the actual performance of CMP performance is greatly influenced by its condition, which can only be ascertained through a pipe-by-pipe inspection.

Many other cities have experienced significant problems with aged CMP culverts and storm drainage pipelines. Corrosion of the pipelines, which are sometimes partially submerged year-round, can result in losses of strength and erosion of material from beneath roads and other structures. Frequently, the first sign of a problem is a “sink hole”. Pipelines that are 40 to 50 years old are prime candidates for such problems. It is therefore recommended that the Town budget for a condition assessment survey in the next few years, to determine the condition of their aged CMP and to budget a replacement program according.

Section 6 – Cost Analysis

A. Cost Data

This section summarizes and analyzes the estimated costs for improvements to the Storm Drain System within the Town of Mammoth Lakes. The costs shown here are derived from the various tables presented in the Appendices. These opinions of costs are based on the following assumptions:

- Costs were derived, in part, from bid tabulations provided by the Town, for storm drain and other recent projects.
- Cost opinions generally derive form the completed costs of similar projects, with adjustments for inflation, size, complexity, and location.
- Cost opinions are in 2005 dollars.
- Cost opinions are "budget-level" and may not fully account for site-specific conditions that will affect the actual costs. The general margin of error is approximately +20 percent, -15 percent.
- Engineering, project administration, inspection, and construction management expenses have been included at 20 percent of the construction cost.
- Contingency of 15 percent has been included.

The opinions of probable cost prepared by Boyle Engineering represent our judgment as a design professional and are supplied for the general guidance of the Town. Since Boyle has no control over the cost of labor and material, or over competitive bidding or market conditions, Boyle does not guarantee the accuracy of such opinions as compared to contractor bids or actual costs.

Table 6-1 shows the Unit Costs applied to the improvements outlined in this report.

Table 6-1. Planning-Level Unit Costs

Pipe Size and Type	Constructed in Unpaved Street ($/LF)	Constructed in Paved Street ($/LF)
18-inch HDPE	134	153
24-inch HDPE	150	171
30-inch HDPE	171	194
36-inch HDPE	201	226
42-inch HDPE	229	256
48-inch HDPE	336	381
54-inch RCP	412	459
60-inch RCP	450	499
72-inch RCP	546	599
84-inch RCP	664	721
96-inch RCP	872	933
Curb and Gutter (both sides)		80

These costs are based on the following assumptions:

- Project length is 1,000 feet of more
- 3-feet of bury to top of storm piping
- Manholes spaced at 300 feet
- Two catch basins for every 300 feet of pipeline
- Four feet of paving required for curb and gutter, each side

Details for Table are found in **Appendix M.**

B. Costs to Correct Existing Pipeline Deficiencies

Table 6-2 shows the estimated costs to correct existing pipelines deficiencies, based on the hydrologic and hydraulic analysis presented in Appendices I through L.

These costs are based on the build-out condition. As indicated in Section 5, and as illustrated in the various Appendices, there is no appreciable difference in runoff between the existing and future condition. This is because: the town is largely built out and also because the basins upstream from town are relatively large compared to the town areas.

Two costs are presented for each deficiency: the cost to construct a replacement pipeline and the cost to construct a parallel pipeline. Without a site-specific analysis, it is unknown which condition may apply. It is recommended that the cost for a replacement pipeline be budgeted, as this is more conservative. Similarly, for the generation of these costs figures, it has been assumed that the pipelines will be constructed within existing paved streets.

Table 6-2. Cost to Correct Existing Pipeline Deficiencies

Existing Pipe Improvements	Replacement Pipeline Cost ($)	Parallel Pipeline Cost ($)
Pipeline upgrades, w/o detention	2.10 M	1.55 M
Contingency (15%)	.31 M	.23 M
Engineering/Admin (20%)	.42 M	.31 M
Total w/o detention	**2.83 M**	**2.09 M**
Pipeline upgrades, w/ detention	1.88 M	1.37 M
Contingency (15%)	.28 M	.21 M
Engineering/Admin (20%)	.38 M	.27 M
Total with detention	**2.54 M**	**1.85 M**
Net benefit of Detention	**.29 M**	**.24 M**

Not all of the above improvements should be considered as priorities for replacement. In some cases, minor hydraulic deficiencies may be overcome through the surcharging of manholes and operating the pipelines under pressure. The recommendations presented in Section 8 have taken this factor into consideration in some cases. In other cases, a more detailed hydraulic analysis of these deficiencies may be warranted, prior to implementation of the improvement.

C. Benefit/Cost of Detention Basin A

As can be seen from **Table 6-2**, the net benefit of constructing Detention Basin A is approximately $390,000 to $840,000 in avoided *replacement* pipeline costs. The construction of a detention basin will offer virtually no savings in *new* pipeline costs; although a new pipeline is proposed along Canyon Drive, its size would be unaffected by the construction of Detention Basin A.[8]

Section 4 presented the concepts for Detention Basin A and outlined costs for this facility, the details of which are found in Appendix M. The estimated cost to construct the basin, based on this opinion of cost is $ 5 million to $ 8 million. Thus, based on pipeline cost savings alone, construction of this basin is not recommended.

D. Other Pipeline Improvements

Table 6-3 shows the estimated costs for other pipeline improvements. These are based primarily on: (1) a comparison of the existing infrastructure with the hydraulic improvements outlined in the previous master plan, and (2) discussions with Town staff regarding areas prone to flooding. These proposed improvements have been sized in accordance with the hydrologic analysis of this report, assuming that Detention Basin A is not constructed.[9] Again, these costs are based on the build-out condition.

[8] A gap currently exists in the storm drainage system in Canyon Drive, wherein water from a storm drain is deposited onto the street, creating a potentially hazardous situation. The deposition of this water is also a chronic problem in the winter, when the water freezes and covers half the street. Because of this, a new pipeline, sized for the 20-year event, is recommended even if Detention Basin A is constructed. The Canyon Drive drainage carries very significant flows.

[9] Because the general criteria for this Master Plan is to size pipelines to handle the 20-year event, no appreciable difference in cost would be expected if detention is applied. The proposed detention basin would primarily effect the 100-year event. However, with detention, the need for of these improvements would be reduced significantly.

Table 6-3. Other Pipeline Improvements

Pipe ID	Pipeline Basin Location	Length (ft)	Pipeline Size (inches)	Pipeline Cost ($)
1	3.9	245	18	$37,485
2	3.9	385	18	$58,905
3	3.9	105	18	$16,065
4	3.9	105	18	$16,065
5	3.9	980	18	$149,940
6	3.9	840	18	$128,520
7	3.7.1	245	24	$41,895
8	3.7.1	140	30	$27,160
9	3.7.1	280	30	$54,320
10	3.7.7	330	24	$56,430
11	3.7.4	735	24	$125,685
12	3.7.4	140	24	$23,940
13	3.7.4	140	30	$27,160
14	3.7.4	455	30	$88,270
15	3.7.4	210	42	$53,760
16	3.7.4	280	36	$63,280
17	3.7.6	700	24	$ 119,700
18	3.7.2	1855	18	$283,815
19	3.7.2	385	18	$58,905
20	3.7.2	210	18	$32,130
21	3.5.1	315	36	$71,190
22	3.5.1	4200	42	$1,075,200
23	3.5.1	665	42	$170,240
24	3.4	1400	18	$214,200

Table 6-3. Other Pipeline Improvements (cont.)

Pipe ID	Pipeline Basin Location	Length (ft)	Pipeline Size (inches)	Pipeline Cost ($)
25	3.4	140	18	$21,420
26	3.4	930	24	$159,030
27	3.4	280	24	$47,880
28	3.4	108	24	$18,468
29	3.4	140	30	$27,160
30	3.4	420	24	$71,820
31	3.7.2	440	18	$67,320
32	3.8	775	36	$175,150
33	3.6.10	1540	24	$263,340
34	3.6.10	1235	18	$188,955
35	3.6.10	840	18	$128,520
36	3.6.10	1410	18	$215,730
Subtotal				$4,379,000
Contingency (15%)				$656,900
Engineering/Admin (20%)				$875,800
Total				**$5,911,700**

E. Cost Summary

Table 6-4 summarizes the costs presented in **Table 6-2** and **Table 6-3** and also includes an estimated cost for new curb and gutter shown on Plates 8.1 through 8.20. Those plates show curb and gutter on streets that have been identified as basin and sub-basin flow paths. The proposed curb and gutter is recommended in these areas to help convey flows, particularly in the 100-year event.

Table 6-4. Summary of Proposed Capital Improvements

Item	Cost ($)
Cost to Correct Existing Pipeline Deficiencies	$2,830,000
Other Pipeline Improvements	$5,912,000
Curb and Gutter (1)	$3,520,000
CMP Condition Assessment (2)	$50,000
CMP Replacement Program (3)	$1,520,000
Total	**$13,832,000**

Notes:

(1) Where curb and gutter has been recommended, it is for streets that have been identified as basin or sub-basin flow paths.

(2) See discussion in Section 5

(3) Based on replacing 30% of CMP inventory in the next 15 years. Estimate to be confirmed following condition assessment survey. See Appendix P.

Section 7 – Analysis of Water Quality Regulations

A. Background

Elimination of localized flooding and concern for protection of the water quality of Mammoth and Hot Creeks are the two primary factors what precipitated the preparation of the 1984 master plan. The improvements proposed in that master plan report were designed to control the runoff and erosion in Mammoth Lakes that is the cause of these problems.

The headwaters of Mammoth Creek, fed by snowmelt and storm runoff, are near the Sierra Nevada crest at an elevation of over 11,000 feet. Mammoth Creek flows through a series of high mountain lakes, past the Mammoth Mountain ski area, and through the southern portion of the Town of Mammoth Lakes. Murphy Gulch receives the drainage from the northern portion of Mammoth Mountain and Mammoth Lakes, and it then flows into Mammoth Creek. Downstream from Mammoth Lakes, Mammoth Creek and the discharge from the Hot Creek Fish Hatchery combine to form Hot Creek. Hot Creek, one of the most productive trout streams in California, has been classified as a Wild Trout Stream. Hot Creek flows into the Owens River and Crowley Lake.

According to the 1984 Master Plan, the California Department of Fish and Game (DFG) reported reductions in the number of brown trout produced naturally in the wild trout habitat of Hot Creek. This may be due to increased turbidity in the stream, but the data were inconclusive. The increased turbidity in Hot Creek may be partially attributed to the development that occurred in the Mammoth Lakes area. Previously natural ground surfaces have been covered by pavement and buildings, which has increased runoff and subsequent erosion. Sediment materials settle out and cover stream spawning gravels and also contain nutrients that may be biostimulatory.

Control and retention of storm water in the Town of Mammoth Lakes is one method of reducing the sediment and nutrient load in the creek, thereby improving beneficial use of the water.

B. Present Storm Water Regulations

In 1990, the United States Environmental Protection Agency (EPA) promulgated regulations for permitting storm water discharges. The regulations were the result of 1987 amendments to the federal Clean Water Act (CWA) which established a framework for regulating storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program. The regulations were installed in two phases. Phase I included permitting requirements for industrial sites including construction projects disturbing 5 or more acres and medium to large municipal storm water collection systems (serving populations 100,000 or more). Phase II of the regulation was promulgated in 1999. The intent of Phase II is to regulate through the NPDES process small municipal storm water collection systems and construction site disturbing between one and five acres. To this end, the State Water Resources Control Board (SWRCB) has issued a General NPDES Permit for Small Municipal Separate Storm Sewer Systems.

Municipalities that are regulated under the General Permit were required to file a Notice of Intent (NOI) and a Storm Water Management Plan (SWMP) which outlines the Best Management Practices (BMPs) employed by the municipality. Best Management Practices are intended to reduce runoff, improve water quality and encourage infiltration. Although The Town of Mammoth Lakes is not included in the "General Permit" at this time, the Lahontan Regional Water Quality Control Board (RWQCB) has issued a Memo of Understanding to the Town of Mammoth Lakes requiring implementation of BMP in the community. Additionally, the Town must comply with the Water Quality Control Plan for the Lahontan Region North and South Basins.

C. Memorandum of Understanding with the Regional Water Quality Control Board

In 1991, the Lohantan Regional Water Quality Control Board and the Town of Mammoth lakes adopted a memorandum of understanding (MOU) regarding storm water objectives and control measures. Per the MOU, the Town was granted the authority to issue construction permits for all developments less than 5 acres and provide site inspection. This MOU includes guidelines for the control and prevention of pollution from storm water, as follows:

1. Drainage collection, retention, and infiltration facilities shall be constructed and maintained to prevent transport of the runoff from a 20-year, 1-hour design storm from the project site.[10]

[10] The 20-year, 1-hour design storm for the Mammoth Lakes area is equal to 1.0 inch (2.5 cm).

2. Surplus or waste material shall not be place in drainage ways or within the 100-year flood plain of surface waters.

3. All loose piles of soil, silt, clay, sand, debris, or earthen materials shall be protected in a reasonable manner to prevent any discharge to waters of the State.

4. Dewatering shall be done in a manner so as to prevent the discharge of earthen material from the site.

5. All disturbed areas shall be stabilized by appropriate soil stabilization measures by October 15th of each year.

6. All work performed between October 15th and May 1st of each year shall be conducted in such a manner that the project can be winterized within 48 hours.

7. Where possible, existing drainage patterns shall not be significantly modified.

8. After completion of a construction project, all surplus or waste earthen material shall be removed from the site and deposited at a legal point of disposal.

9. Drainage swales disturbed by construction activities shall be stabilized by the addition of crushed rock or riprap as necessary or other appropriate stabilization methods.

10. All construction areas shall be protected by fencing or other means to prevent unnecessary disturbance.

11. During construction, temporary erosion control facilities (e.g., impermeable dikes, filter fences, hay bales, etc.) shall be used as necessary to prevent discharge or earthen materials from the site during periods of precipitation or runoff.

12. Revegetated areas shall be continually maintained in order to assure adequate growth and root development. Physical erosion control facilities shall be placed on a routine maintenance and inspection program to provide continued erosion control integrity.

13. Where construction activities involve the crossing and or alteration of a stream channel, such activities shall be timed to occur during the period in which streamflow is expected to be lowest for the year.

A copy of this memorandum can be found in Appendix Q.

D. Future Storm Water Regulations

The State Water Resources Control Board is intending to develop a statewide policy for implementation of the storm water program. The policy is intended to provide guidance to staff at the state and region boards in the implementation of the storm water program. The policy will include guidance for permitting (NPDES), evaluation for permit compliance and assessment of management plans. Presently, the State Water Resources Control Board is conducting public meetings (meetings are scheduled for January 2005) to discuss the issues needing to be addressed by the policy.

The following is the list of issues to be discussed at the January 2005 meeting:

- Cross program Issues such as the relationship of storm water to other water quality programs like Total Mass Daily Loads (TMDL), groundwater protection requirements, etc.

- Monitoring Issues such as type of monitoring (Chemical, Physical, etc.), use of monitoring to determine compliance, etc.

- Compliance Issues such as standards used by the RWQCB to assess compliance, necessary time to allow a permittee to put in place and implement a program, etc.

- Standards Issues such as use of quantitative parameters to measure compliance and application of water quality standards to storm water in wet weather conditions

- Permitting Issues such as consistency among Regional Boards, cross boundary problems, etc.

The storm water program is in its infancy and as the program develops, water quality protection for both surface and groundwater will be driving forces for future storm water policies and regulation. In light of future policies, the Town of Mammoth Lakes must continue to implement BMPs. Likewise it would be prudent to maintain a good working relationship with the Lahontan Regional Water Quality Control Board.

Section 8 – Summary of Recommendations

A. Recommended Capital Improvements

Plate 8-1 through **Plate 8-19** depict capital improvements that are recommended for the 20-year and 100-year flood events. In general, 20-year basin flows are expected to be conveyed in pipelines, culverts, natural channels, and man-made channels, while the streets are expected to help convey the 100-year flows[11].

The improvements shown in these plates are conceptual in nature, and require additional engineering and analysis in their implementation. The sizing of facilities is based on the analytical methods presented herein, and is expected to provide general protection to the Town; however, these facilities are not expected to protect all properties. By their nature, Master Plans only provide a general analysis of the problems and a broad overview of the needed facilities, based solely on information that is readily available. As such, this plan has been prepared to the standard of care provided by other professional engineers practicing in this region.

Table 8-1 lists the Projects that are considered priorities. These priorities are based on the hydraulic analysis and the experience of knowledgeable City staff. Projects not shown in this table, while still recommended, have lower priorities.

Table 8-1. Capital Improvements

Description	Estimated Cost ($)
PRIORITY 1 PROJECTS	
New Storm Drain Pipes	$2,570,000
CMP Condition Assessment	$50,000
Total Priority 1	**$2,620,000**

[11] These plates do not show all the deficiencies that may be listed in the Appendix tables. If a pipeline was determined to be only marginally deficient, it's replacement may not be shown on the plates. Examples include pipelines that "fail" only because they are CMP, or pipelines that "fail" due to a short segment that has a relatively flat slope.

Table 8-1. Capital Improvements

Description	Estimated Cost ($)
PRIORITY 2 PROJECTS	
New Storm Drain Pipes	$1,810,000
Existing Deficient Storm Drain Pipes	$130,000
Curb and Gutter	$3,520,000
CMP Replacement Program	$1,520,000
Total Priority 2	**$6,980,000**
Total Capital Improvement Program	**$9,600,000**

C. Recommended for Water Quality Improvements

The following recommendations are provided for improving the quality of storm water in the Town of Mammoth Lakes. These are discussed in greater detail in Section 7.

1. Continued development and enforcement of best management practices (BMPs), to reduce sediment and pollutants entering storm channels.

2. The use of on-site retention/detention facilities for new developments, to mitigate increases in storm runoff caused by the development.

3. Where feasible, design retention/detention facilities to promote groundwater recharge.

Section 9 – Financing Options

Background

The Town of Mammoth Lakes (Town) is a general law city incorporated in August 1984. The Town's Public Works Department is responsible for construction, operation and maintenance of the public storm drainage system. According to staff, the storm drainage system currently relies on the following primary funding sources:

- General fund
- Statewide Transportation Improvement Program (STIP)
- Transient occupancy taxes (TOT)
- Developer impact fees (DIF)
- Loans, grants and fund-matching programs

This section examines various long-term financing alternatives for the Town's storm water program, including construction of identified Master Plan facilities.

Proposition 218

Since the late 1970s, California voters have taken considerable measures to reduce the taxation power of government. The passage of Proposition 13 in 1978 marked the start of a continuing "taxpayer revolt" against government taxation. A number of initiatives have subsequently been passed to fill substantive and procedural issues not formally addressed by Proposition 13. Proposition 218, passed by the California voters in 1996, has greatly affected local government finance.

Proposition 218, a voter initiative passed by the California voters in November 1996, amended Article XIIIC and added Article XIIID to the California Constitution. Passed almost 20 years after the enactment of Proposition 13, Proposition 218 represents the latest phase of a continuing effort to reduce the taxation power of government. Though Proposition 218 contains a number of provisions that are arguably uncertain or unclear, proponents claim they now have the "right to vote on all taxes, no matter what they are called or into what fund they are placed." [1] Under Proposition 218, charter and general law cities alike became subject to new substantive and procedural provisions related to taxes, assessments, and fees or charges.

Funding Mechanisms

Most public agency funding mechanisms generally fall into one of three categories: taxes, assessments, or fees/charges. A basic summary of these funding mechanisms and associated statutory requirements is shown in Table 9-1.

Table 9-1. Funding Mechanisms

	Statutory Requirements			
Funding Mechanism	**Vote**	**Nexus**	**Definition/Purpose**	**Examples**
General Taxes	Majority	N/A	General governmental purpose(s).	Ad-valorem property tax; Transient occupancy tax; Utility user's tax
Special Taxes	Super-majority (two-thirds)	N/A	Specific governmental purpose(s).	County sales tax; Mello-Roos tax; Other special taxes (e.g., library, fire, police)
Assessments	Majority (dollar-weighted)	Strict apportionment of "special benefit"	Improvements/services providing "special benefit" (see Assessment Acts).	Assessment district; Facility benefit assessment; Other special districts (see Assessment Acts)
"Property Related" Fees/Charges	Majority	Reasonable apportionment of cost of service	Fees/charges imposed "as an incident of property ownership." Electric, gas and developer fees/charges expressly excluded.	Drainage/storm water fees (*Salinas* decision); Other "property-related" fees
Fees/Charges (not "property related")	N/A	Reasonable apportionment of cost of service	Fees/charges *not* imposed "as an incident of property ownership."	Developer impact fees; Electric and gas fees

These terms (i.e., taxes, assessments, and fees/charges) have legal significance and were expressly defined in Proposition 218. A brief discussion of these funding mechanisms follows.

General & Special Taxes

"Taxes are government's most flexible revenue raising tool. A tax is a charge on an individual or business that pays for governmental services or facilities that benefit the public broadly. There need not be any direct relationship between how much tax a person pays and how much service he or she receives from government. Example of taxes include the property tax, sales tax, business license tax, hotel occupancy tax, and utility users tax.” [2]

Taxes are categorized as either “general” or “special.” A general tax is one imposed for “general governmental purposes” [3], while a special tax is “any tax imposed for specific purposes, including a tax imposed for specific purposes, which is placed into a general fund.” [4] Under Proposition 218, all new and increased general taxes must be approved by a majority vote. [5], and new or increased special taxes must be approved by a two-thirds vote. [6] The distinction between general and special taxes is important in that it dictates whether a majority or two-thirds vote is required. [7]

Assessments

An assessment is “any levy or charge upon real property by an agency for a special benefit conferred upon the real property[,]... includ[ing], but...not limited to, ‘special assessment[s],’ ‘benefit assessment[s],’ ‘maintenance assessment[s]’ and ‘special assessment tax[es].’” [8] With the passage of Proposition 218, all new or increased assessments must comply with the following general provisions:

- “Only special benefits are assessable, and an agency shall separate the general benefits from the special benefits.” [9] Thus, it must be determined whether the project provides special benefits over and above the general benefit provided to the public at large [10], since only special benefits are assessable. [11]
- “No assessment [can] be imposed...which exceeds the reasonable cost of...proportional special benefit....” [12] In other words, all assessments must be proportional to benefit.
- Publicly-owned parcels are no longer “exempt from assessment unless the agency can demonstrate by clear and convincing evidence that those publicly owned parcels in fact receive no special benefit.” [13] Thus, Proposition 218 requires that public parcels pay their proportionate “fair share” of the assessments.

- The assessment must receive majority voter approval. Each vote "shall be weighted according to the financial obligation of...[each] property." [14]

The following California code provisions (commonly referred to as the "Assessment Acts") provide for a broad range of permissible improvements and/or services:

- Park & Playground Act of 1909
- Improvement Act of 1911
  (includes drainage systems and flood control facilities).
- Municipal Improvement Act of 1913
  (includes drainage systems and flood control facilities).
- Improvement Bond Act of 1915
  (provides vehicle for issuing bonds).
- Street Lighting Act of 1919
- Municipal Lighting Maintenance District Act of 1927
- Street Lighting Act of 1931
- Tree Planting Act of 1931
- Parking District Law of 1943
- Pedestrian Mall Law of 1960
- Parking District Law of 1951
- Landscaping & Lighting Act of 1972
- Benefit Assessment Act of 1982
  (includes drainage systems and flood control facilities).
- Community Rehabilitation District Law of 1985
  (includes storm drainage facilities)
- Parking & Business Improvement Area Law of 1989
- Property & Business Improvement District Law of 1994
- Fire Suppression Assessment

- Geologic Hazard Abatement District
- Integrated Financing District Act
  (provides alternative method for collecting assessments).
- Permanent Road Divisions Law
- Open Space Maintenance Act

Fees or Charges

A fee or charge is “any levy other than an ad valorem tax, a special tax, or an assessment, imposed by an agency upon a parcel or upon a person as an incident of property ownership, including a user fee or charge for a property related service.” [15] Under Proposition 218, new or increased fees must comply with the following requirements:

- “Revenues derived from the fee...shall not exceed the funds required to provide the property related service” [16] and “shall not be used for any purpose other than that for which the fee or charge was imposed.” [17] This provision basically prohibits the use of such fees to supplement the agency’s general fund.
- The fee imposed on a given parcel “shall not exceed the proportional cost of the service attributable to the parcel.” [18]
- “No fee...may be imposed for a service unless that service is actually used by, or immediately available to, the owner of the property in question. Fees or charges based on potential or future use of a service are not permitted.” [19]
- “No fee...may be imposed for general governmental services including, but not limited to, police, fire, ambulance or library services, where the service is available to the public at large in substantially the same manner as it is to property owners.” [20]

Proposition 218, expressly exempts water, sewer, and refuse collection services from its voter approval requirements. In *Howard Jarvis Taxpayers Association v. City of Salinas*, the Appellate Court generally concluded that new or increased storm water (or drainage) fees are not statutorily exempt from voter approval requirements.

Other Considerations

Joint Powers Authority (JPA)

Given that jurisdictional boundaries do not necessarily coincide with unique hydrologic basins, the Town may wish to consider entering into an agreement (under the Joint Exercise of Powers Act) with other neighboring agencies and/or Regional Water Quality Control Board permittees to exercise joint powers over a regional storm water program. Such an approach may make more sense for NPDES (water quality) purposes, as opposed to general drainage (water quantity) purposes.

Statewide Community Infrastructure Program

If considerable revenue from future developer impact fees in the area is anticipated, the Town may wish to consider joining the Statewide Community Infrastructure Program (SCIP). SCIP, sponsored by the League of California Cities (League) and the California State Association of Counties (CSAC), is a development impact fee financing program. SCIP offers tax-exempt pooled bond financing that provides economies of scale while greatly reducing cost of issuance and improving interest rates for projects of any size. Utilizing SCIP, developers can be reimbursed for fees paid in order to obtain a building permit, or fees can be funded prior to obtaining a building permit. SCIP offers the following impact fee financing alternatives:

- ***Reimbursement Program***: local agency receives impact fees at issuance of building permit; property owner is reimbursed by SCIP for eligible amount from bond proceeds.

- ***Pre-Funding Program***: impact fees set at time of approval of Tentative Map; local agency receives funds from SCIP after issuance of bonds.

Both of these programs involve the establishment of an assessment district into which applicant properties (or developments) will be required to annex. The property owner is reimbursed for the financed fees, and the bonds are payable through assessment installments levied on the landowner's property.

The California Statewide Communities Development Authority, a joint powers authority sponsored by the League and CSAC, funds these programs through the issuance of 30-year limited obligation bonds authorized by the Improvement Bond Act of 1915, with assessment liens imposed under the Municipal Improvement Act of 1913.

Some advantages of SCIP include:

- Pre-funding program can provide up front financing
- Better economies of scale due to pooled financing
- Tax-exempt financing available to smaller projects
- An alternative to fee deferral programs
- Lower costs and interest rates due to size and diversity
- SCIP handles all administration

Local agencies can become a member of SCIP by passing a resolution. After passage of the requisite resolution, individual developers or property owners can apply to SCIP for participation in eligible programs.

Recommendations

It is recommended that the Town continue to utilize all currently available revenue sources, and consider some of the following available options:

Taxes

Many agencies rely on tax revenues to finance a portion of their storm water activities. This form of funding is quite reliable, administratively efficient, and can be used for a broad range of services/purposes. However, the imposition of new or increased taxes triggers vote requirements. Unless the Town wishes to undergo ballot proceedings, they may wish to merely continue to use the currently allocated share of tax revenues.

Assessments

Most of the agencies that utilize assessment revenues for storm water financing purposes formed their assessment districts prior to the passage of Proposition 218. Creating new assessment districts to finance storm water activities requires a definitive showing that the facilities provide "special benefit" over and above that which is provided to the public at large. Arguably, storm water management falls under the government's core health, safety and welfare function. As such, it is a challenge to make the required showing of "special benefit" associated with many storm water facilities. Similarly, special benefits may accrue to all properties within a hydrologic basin, well beyond the jurisdictional limits of the public agency. For these reasons, it is generally recommended that any proposed use of assessment revenue to finance storm water activities be examined on a case-by-case basis.

Fees or Charges

Like the Town, many agencies use fees to finance a portion of the storm water programs. Some of these fees are not "property related" in that they are imposed as part of the approval or permitting processes (e.g., developer impact fees), not merely as an incident of ownership. Fees like these, which are imposed as a precondition of development, do not require voter approval, but must meet the requirements set forth in the Mitigation Fee Act (Government Code §66000, et seq.).

The Town may wish to consider forming a storm water utility, and imposing a "property related" fee to finance the storm water program. While such fees could be imposed on virtually all parcels of land, the creation and levy of the fee will likely require voter approval under Proposition 218 and the recent *City of Salinas* decision.

References

1. See Stacey Simon, *A Vote of no Confidence: Proposition 218, Local Government, and Quality of Life in California*, 25 ECOLOGY L.Q. 530 (1998).

2. See STATE OF CALIFORNIA LEGISLATIVE ANALYST'S OFFICE, UNDERSTANDING PROPOSITION 218 at 7 (December 1996).

3. Cal. Const. art. XIII C, § 1(a).

4. Cal. Const. art. XIII C, § 1(d).

5. See Cal. Const. art. XIII C, § 2(b).

6. See Cal. Const. art. XIII C, § 2(d).

7. See Cal. Const. art. XIII C, §§ 2(b), 2(d).

8. Cal. Const. art. XIII D, § 2(b).

9. Cal. Const. art. XIII D, § 4(a).

10. See Cal. Const. art. XIII D, § 1(i).

11. See Cal. Const. art. XIII D, § 4(a).

12. Id.

13. Id.

14. Cal. Const. art. XIII D, § 4(e).

15. Cal. Const. art. XIII D, § 2(e).

16. Cal. Const. art. XIII D, § 6(b)(1).

17. Cal. Const. art. XIII D, § 6(b)(2).

18. Cal. Const. art. XIII D, § 6(b)(3).

19. Cal. Const. art. XIII D, § 6(b)(4).

20. Cal. Const. art. XIII D, § 6(b)(5).

References

1. Mammoth Lakes Storm Drainage Master Plan, Brown and Caldwell and Triad Engineering, July 1984

2. Design Manual - Mammoth Lakes Storm Drainage and Erosion Control, Brown and Caldwell and Triad Engineering, July 1984

3. Storm Drainage Master Plan Report – Town of Mammoth Lakes, Kennedy/Jenks/Chilton, K/J/C/907012.00, September 1990

4. Hydrologic Analysis and Design, by Richard H McCuen, Prentice-Hall, 1998

5. Hydrology Manual, Los Angeles County Department of Public Works, December 1991

6. Flood Insurance Study, Town of Mammoth Lakes, California, Federal Emergency Management Agency, September 30, 1992

7. Probability Concepts in Engineering Planning and Design, by Alfredo H.S. Ang and Wilson H. Tang, John Wiley and Sons, 1975

Appendices

A. Inventory of Existing Storm Drain Pipes
B. Hydrologic Tables - Existing Conditions
C. Hydrologic Tables - Future Conditions w/o Detention Basins
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E. Analysis of Pipe Capacities – Existing Conditions, 20-Year Event
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I. Pipeline Improvements Required for 20-Year Event, with Detention Basin A
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APPENDIX A

Inventory of Existing Storm Drain Pipes

Inventory of Existing Storm Drain Pipes

Pipe ID	Length (ft)	Section Size (in)	Constructed Slope (ft/ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Calculated Capacity 94% full (cfs)
2100100	108	60	0.016852	7,837.50	7,835.68	364
2100400	104	36	0.007788	7,867.50	7,866.69	63
2101500	480	24	0.013396	7,888.28	7,881.85	28
2102300	83	18	0.012048	7,881.50	7,880.50	12
2102400	57	30	0.017544	7,884.50	7,883.50	58
2102500	68	12	0.014706	7,885.00	7,884.00	5
2102800	92	18	0.050543	7,892.76	7,888.11	25
2102900	78	18	0.038462	7,893.00	7,890.00	22
2103200	94	24	0.004043	7,873.88	7,873.50	15
2103300	95	24	0.004000	7,873.88	7,873.50	15
2103401	106	30	0.034151	7,877.60	7,873.98	82
2103403	33	18	0.050000	7,879.25	7,877.60	25
2103405	66	30	0.019697	7,878.90	7,877.60	62
2103407	27	24	0.023333	7,879.53	7,878.90	37
2103409	40	24	0.008750	7,879.88	7,879.53	23
2103410	5	24	0.002000	7,879.89	7,879.88	11
2103411	165	18	0.010242	7,881.57	7,879.88	11
2103413	201	18	0.012338	7,884.05	7,881.57	13
2103415	49	18	0.019388	7,885.00	7,884.05	16
2103416	41	18	0.024390	7,886.00	7,885.00	18
2103418	142	18	0.003169	7,884.50	7,884.05	6
2103420	42	18	0.011905	7,885.00	7,884.50	12
2103422	72	12	0.006111	7,884.49	7,884.05	3
2103424	54	12	0.005926	7,884.81	7,884.49	3
2103426	60	12	0.003167	7,885.00	7,884.81	2
2103428	197	18	0.020558	7,885.00	7,880.95	16
2103430	68	18	0.014706	7,886.00	7,885.00	14
2103500	260	24	0.004077	7,875.04	7,873.98	16
2103502	307	24	0.011922	7,876.34	7,880.00	27
2103504	109	24	0.004495	7,876.83	7,876.34	16
2103506	25	18	0.009200	7,877.06	7,876.83	11
2103508	88	18	0.006818	7,877.66	7,877.06	9
2103511	106	12	0.040943	7,882.00	7,877.66	8
2103513	85	18	0.006353	7,878.20	7,877.66	9
2103515	76	12	0.012632	7,876.00	7,875.04	4
2103517	92	12	0.011304	7,877.04	7,876.00	4
2103519	26	12	0.013077	7,877.38	7,877.04	4
2103600	116	12	0.019052	7,881.91	7,879.70	5
2103602	24	12	0.014583	7,882.25	7,881.90	5
2103605	41	18	0.097561	7,898.00	7,894.00	35
2103701	21	18	0.023810	7,878.50	7,878.00	17
2103703	108	18	0.006481	7,879.20	7,878.50	9

Inventory of Existing Storm Drain Pipes

Pipe ID	Length (ft)	Section Size (in)	Constructed Slope (ft/ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Calculated Capacity 94% full (cfs)
2103705	103	18	0.011262	7,880.36	7,879.20	12
2103707	129	18	0.011550	7,882.40	7,880.91	12
2103709	64	18	0.001094	7,883.43	7,883.50	4
2103711	77	18	0.008831	7,884.25	7,883.57	11
2103713	95	18	0.015684	7,885.84	7,884.35	14
2103715	98	18	0.041633	7,890.02	7,885.94	23
2103717	82	18	0.044024	7,893.73	7,890.12	24
2103719	96	18	0.042917	7,897.85	7,893.73	23
2103721	106	18	0.044340	7,902.55	7,897.85	24
2103723	109	18	0.040917	7,907.11	7,902.65	23
2103725	109	18	0.044771	7,912.09	7,907.21	24
2103727	101	18	0.027129	7,914.93	7,912.19	19
2103729	81	18	0.026790	7,917.10	7,914.93	18
2103731	89	18	0.006742	7,917.80	7,917.20	9
2103733	59	18	0.035932	7,919.92	7,917.80	21
2103735	67	18	0.018358	7,921.25	7,920.02	15
2103737	57	18	0.032281	7,920.00	7,918.16	20
2103800	40	18	0.045500	7,888.00	7,886.18	24
2200300	735	36	0.001224	7,839.90	7,839.00	25
2200500	5	36	0.020000	7,840.00	7,839.90	101
2200700	57	36	0.017544	7,841.00	7,840.00	95
2200900	138	18	0.022391	7,844.09	7,841.00	17
2201100	251	18	0.011952	7,843.00	7,840.00	12
2201300	185	18	0.021622	7,847.00	7,843.00	17
2201500	72	18	0.013889	7,848.00	7,847.00	13
2201700	240	18	0.012500	7,846.00	7,843.00	13
2201900	212	18	0.004717	7,847.00	7,846.00	8
2202000	44	18	0.136364	7,853.00	7,847.00	42
2202400	98	36	0.015306	7,839.60	7,838.10	89
2202500	97	72	0.022680	7,838.80	7,836.60	686
2202900	97	96	0.016701	7,865.62	7,864.00	1268
2203400	129	24	0.007752	7,920.00	7,919.00	21
2203500	39	24	0.025641	7,932.00	7,931.00	39
2205300	80	24	0.025000	7,942.00	7,940.00	38
2205500	70	24	0.034286	8,034.40	8,032.00	45
2205700	43	24	0.093023	8,038.50	8,034.50	74
2205900	41	18	0.024390	7,840.00	7,839.00	18
2206000	86	18	0.013837	7,839.19	7,838.00	13
2206200	66	36	0.015152	7,882.00	7,881.00	88
2206300	124	24	0.020161	7,866.50	7,864.00	35
2300300	33	36	0.030303	7,893.00	7,892.00	125
2300500	40	36	0.025000	7,905.00	7,904.00	113

Inventory of Existing Storm Drain Pipes

Pipe ID	Length (ft)	Section Size (in)	Constructed Slope (ft/ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Calculated Capacity 94% full (cfs)
2300701	51	24	0.039216	7,930.00	7,928.00	48
2300702	51	24	0.039216	7,930.00	7,928.00	48
2300703	51	24	0.039216	7,930.00	7,928.00	48
2300704	51	24	0.039216	7,930.00	7,928.00	48
2301100	33	24	0.015152	7,917.50	7,917.00	30
2301200	48	18	0.010417	7,917.50	7,918.00	12
2301400	38	18	0.013158	7,929.00	7,928.50	13
2301500	55	18	0.009091	7,929.50	7,929.00	11
2301600	65	18	0.003846	7,933.00	7,932.75	7
2301700	72	18	0.003472	7,933.25	7,933.00	7
2301800	52	18	0.019231	7,934.50	7,933.50	16
2301900	20	18	0.014500	7,935.75	7,935.46	14
2302000	68	36	0.006912	7,936.50	7,936.03	60
2302200	35	36	0.042857	7,938.00	7,936.50	149
2302400	66	36	0.030303	7,940.00	7,938.00	125
2302600	62	36	0.032258	7,942.00	7,940.00	129
2302800	58	24	0.172414	7,952.00	7,942.00	101
2303000	24	24	0.010417	7,952.25	7,952.00	25
2303200	40	24	0.012500	7,952.75	7,952.25	27
2303400	66	18	0.015152	7,958.00	7,957.00	14
2303500	62	18	0.016129	7,959.00	7,958.00	14
2303600	71	18	0.014085	7,959.00	7,958.00	13
2303700	66	18	0.015152	7,959.00	7,958.00	14
2303800	71	18	0.014085	7,958.00	7,957.00	13
2303900	60	18	0.008333	7,990.50	7,990.00	10
2304100	45	18	0.011111	7,989.50	7,990.00	12
2304200	84	18	0.005952	7,990.50	7,990.00	9
2304400	26	18	0.038462	8,002.00	8,001.00	22
2304500	36	42	0.023333	7,973.09	7,972.25	165
2304600	33	30	0.036061	7,971.70	7,970.51	84
2304700	34	30	0.042353	7,972.68	7,971.24	91
2304900	32	24	0.031250	7,998.50	7,997.50	43
2305000	31	60	0.022258	7,970.76	7,970.07	418
2305100	39	24	0.060000	7,975.25	7,972.91	60
2305300	85	24	0.011765	7,979.00	7,978.00	26
2305400	31	18	0.016129	7,981.50	7,981.00	14
2305600	63	24	0.015873	8,000.00	7,999.00	31
2305800	58	24	0.087414	8,008.88	8,003.81	72
2305900	70	18	1028.671429	80,041.00	8,034.00	3624
2306200	122	30	0.084918	8,068.40	8,058.04	129
2306400	86	30	0.024186	8,070.68	8,068.60	69
2306600	211	30	0.048910	8,081.20	8,070.88	98

Inventory of Existing Storm Drain Pipes

Pipe ID	Length (ft)	Section Size (in)	Constructed Slope (ft/ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Calculated Capacity 94% full (cfs)
2306800	124	30	0.109677	8,095.00	8,081.40	146
2307100	77	30	0.077922	8,101.00	8,095.00	123
2307200	14	30	0.035714	8,095.50	8,095.00	83
2307300	100	24	0.043000	8,070.30	8,066.00	50
2307500	436	24	0.044725	8,090.00	8,070.50	51
2307800	8	24	0.250000	8,265.00	8,263.00	122
2308000	57	24	0.017544	8,264.00	8,263.00	32
2308200	121	24	1.586777	8,072.00	8,264.00	307
2308400	69	24	0.014493	8,275.00	8,274.00	29
2308700	56	24	0.178571	8,330.00	8,320.00	103
2308900	27	24	0.370370	8,340.00	8,330.00	148
2309100	38	24	0.013158	8,340.50	8,340.00	28
2309302	41	18	0.121951	8,313.00	8,308.00	39
2309303	632	36	0.061709	8,345.00	8,306.00	178
2309305	71	18	0.007042	8,347.50	8,347.00	9
2309307	55	18	0.009091	8,348.00	8,347.50	11
2309309	19	18	0.026316	8,347.50	8,348.00	18
2309402	83	18	0.265060	8,308.00	8,286.00	58
2309404	99	18	0.020202	8,310.00	8,308.00	16
2309406	474	36	0.006329	8,311.00	8,308.00	57
2309408	17	18	0.176471	8,315.00	8,312.00	47
2309410	16	18	0.187500	8,315.00	8,312.00	49
2309502	23	18	0.130435	8,307.00	8,304.00	41
3200201	221	36	0.009050	7,638.00	7,636.00	68
3200202	221	36	0.009050	7,638.00	7,636.00	68
3200401	142	36	0.005211	7,639.24	7,638.50	52
3200402	143	36	0.005175	7,639.24	7,638.50	52
3200600	82	24	0.143293	7,651.00	7,639.25	92
3200800	261	36	0.042835	7,650.42	7,639.24	148
3201000	384	36	0.050990	7,670.00	7,650.42	162
3201200	546	30	0.032967	7,688.00	7,670.00	80
3201400	43	18	0.011628	7,688.50	7,688.00	12
3201600	384	30	0.014323	7,694.00	7,688.50	53
3201800	335	30	0.022687	7,703.10	7,695.50	66
3202000	602	30	0.017276	7,713.50	7,703.10	58
3202200	259	30	0.085328	7,735.60	7,713.50	129
3202400	128	30	0.034375	7,740.00	7,735.60	82
3202700	43	24	0.058140	7,766.00	7,763.50	59
3203001	119	30	0.006723	7,765.10	7,764.30	36
3203002	119	30	0.006723	7,765.10	7,764.30	36
3203201	91	24	0.005495	7,765.60	7,765.10	18
3203202	94	24	0.007447	7,765.80	7,765.10	21

Inventory of Existing Storm Drain Pipes

Pipe ID	Length (ft)	Section Size (in)	Constructed Slope (ft/ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Calculated Capacity 94% full (cfs)
3203501	51	24	0.011765	7,778.70	7,778.10	26
3203502	51	24	0.011765	7,778.70	7,778.10	26
3203700	20	24	0.050000	7,810.00	7,809.00	54
3203900	86	24	0.040698	7,813.50	7,810.00	49
3204100	106	24	0.009811	7,814.54	7,813.50	24
3204400	70	18	0.221429	7,830.00	7,814.50	53
3204600	62	18	0.010161	7,766.45	7,765.82	11
3204800	46	18	0.013043	7,767.10	7,766.50	13
3205200	37	24	0.012162	7,788.49	7,788.04	27
3205400	48	24	0.020833	7,693.00	7,692.00	35
3205600	81	24	0.049383	7,714.00	7,710.00	54
3206100	44	30	0.102273	7,728.70	7,724.20	141
3206200	107	24	0.009346	7,747.00	7,746.00	24
3206600	83	24	0.006024	7,755.50	7,755.00	19
3206900	62	24	0.028871	7,783.79	7,782.00	41
3207200	12	18	0.158333	7,785.90	7,784.00	45
3207500	90	12	0.010000	7,901.10	7,900.20	4
3207700	36	12	0.011667	7,901.52	7,901.10	4
3300100	115	18	0.008696	7,808.00	7,807.00	11
3300300	145	24	0.075862	7,811.00	7,800.00	67
3300400	87	24	0.091954	7,808.00	7,800.00	74
3300600	39	24	0.025641	7,809.00	7,808.00	39
3300800	28	18	0.178571	7,820.00	7,815.00	48
3301000	121	48	0.013967	7,798.69	7,797.00	183
3301100	121	48	0.013967	7,798.69	7,797.00	183
3301200	53	18	0.018868	7,799.00	7,798.00	16
3301400	44	18	0.022727	7,809.00	7,808.00	17
3301600	260	36	0.050423	7,824.50	7,811.39	161
3301800	210	36	0.033333	7,826.50	7,819.50	131
3302000	34	36	0.029412	7,827.50	7,826.50	123
3302200	244	36	0.016393	7,831.50	7,827.50	92
3302400	39	36	0.025641	7,832.50	7,831.50	115
3302600	156	36	0.009615	7,834.00	7,832.50	70
3302800	70	36	0.028571	7,842.50	7,840.50	121
3303000	66	36	0.030303	7,848.00	7,846.00	125
3303200	120	24	0.008333	7,850.00	7,849.00	22
3303400	331	24	0.010574	7,836.00	7,832.50	25
3303600	319	24	0.006270	7,842.00	7,840.00	19
3303800	104	24	0.009615	7,843.00	7,842.00	24
3400100	68	42	0.013235	7,702.30	7,701.40	125
3400500	56	42	0.026429	7,766.66	7,765.18	176
3400701	43	30	0.023256	7,778.00	7,777.00	67

Inventory of Existing Storm Drain Pipes

Pipe ID	Length (ft)	Section Size (in)	Constructed Slope (ft/ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Calculated Capacity 94% full (cfs)
3400702	42	30	0.023810	7,778.00	7,777.00	68
3400703	41	30	0.024390	7,778.00	7,777.00	69
3400900	373	72	0.018901	7,762.60	7,755.55	626
3401100	615	72	0.016537	7,772.77	7,762.60	586
3401300	558	72	0.017527	7,782.55	7,772.77	603
3401500	435	72	0.010368	7,787.06	7,782.55	464
3401700	441	72	0.025828	7,798.45	7,787.06	732
3401900	478	66	0.020481	7,808.24	7,798.45	517
3402100	6	24	1.626667	7,818.00	7,808.24	310
3402300	82	66	0.019024	7,809.80	7,808.24	498
3402500	93	18	0.129032	7,827.00	7,815.00	41
3402700	153	18	0.006536	7,825.00	7,824.00	9
3402800	59	18	0.016949	7,829.00	7,828.00	15
3402900	594	66	0.023131	7,823.54	7,809.80	549
3403100	681	60	0.035389	7,848.00	7,823.90	527
3403300	712	60	0.033006	7,871.50	7,848.00	509
3403500	701	54	0.049215	7,906.00	7,871.50	469
3403700	330	60	0.066667	7,928.00	7,906.00	723
3403901	42	24	0.023810	7,799.00	7,798.00	38
3403902	42	18	0.014524	7,799.00	7,798.39	14
3500100	60	72	0.018833	7,824.67	7,823.54	625
3500300	55	72	0.010000	7,825.42	7,824.87	456
3500500	46	72	0.009130	7,826.04	7,825.62	435
3500800	157	72	0.013822	7,827.79	7,825.62	536
3501000	158	72	0.050633	7,837.00	7,829.00	1025
3501200	190	18	0.010526	7,840.00	7,838.00	12
3501300	15	24	0.333333	7,835.00	7,830.00	140
3501400	248	48	0.006089	7,871.74	7,870.23	121
3501600	105	12	0.009524	7,841.00	7,840.00	4
3501800	274	48	0.006934	7,884.13	7,882.23	129
3502000	276	48	0.018188	7,889.40	7,884.38	208
3502200	61	48	0.010164	7,890.26	7,889.64	156
3502400	3	18	0.666667	7,902.00	7,900.00	92
3502600	285	42	0.030667	7,899.00	7,890.26	190
3502800	3	24	0.333333	7,900.00	7,899.00	140
3503000	88	24	0.022727	7,897.00	7,895.00	37
3503100	230	42	0.002174	7,899.50	7,899.00	50
3503300	276	42	0.022826	7,906.00	7,899.70	164
3503500	59	36	0.031356	7,909.45	7,907.60	127
3503700	19	36	0.095789	7,940.88	7,939.06	222
3503900	62	24	0.043548	7,956.00	7,953.30	51
3504000	47	24	0.057447	7,956.00	7,953.30	58

Inventory of Existing Storm Drain Pipes

Pipe ID	Length (ft)	Section Size (in)	Constructed Slope (ft/ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Calculated Capacity 94% full (cfs)
3504200	104	24	0.038462	7,960.00	7,956.00	48
3504400	37	24	0.063243	7,958.34	7,956.00	61
3504600	102	24	0.040294	7,966.90	7,962.79	49
3504800	26	24	0.033462	7,984.50	7,983.63	45
3505000	73	24	0.020548	7,886.00	7,884.50	35
3505200	32	24	0.044375	7,987.42	7,986.00	51
3505500	21	24	0.047619	7,995.03	7,994.03	53
3506400	23	24	0.043478	8,048.00	8,047.00	51
3506500	235	24	0.055319	8,059.00	8,046.00	57
3506601	154	24	0.051948	8,067.00	8,059.00	55
3506700	46	24	0.021739	8,060.00	8,059.00	36
3506900	170	24	0.011765	8,062.00	8,060.00	26
3507100	164	24	0.030488	8,067.00	8,062.00	42
3507300	173	24	0.023121	8,071.00	8,067.00	37
3507700	93	18	0.055806	8,077.19	8,072.00	27
3507800	79	18	0.082658	8,078.53	8,072.00	32
3507900	54	18	0.018519	8,073.00	8,072.00	15
3508100	25	18	0.080000	8,074.00	8,072.00	32
3508400	54	24	0.037037	7,972.00	7,970.00	47
3508600	76	24	0.039474	7,877.00	7,874.00	48
3508800	67	24	0.014925	7,885.00	7,884.00	30
3509000	47	24	0.021277	7,887.00	7,886.00	35
3509201	22	24	0.022727	7,901.00	7,900.50	37
3509202	22	24	0.022727	7,901.00	7,900.50	37
3509401	47	36	0.021277	7,907.00	7,906.00	105
3509402	47	36	0.021277	7,907.00	7,906.00	105
3509403	47	36	0.021277	7,907.00	7,906.00	105
3509600	185	24	0.008108	7,875.50	7,874.00	22
3509900	127	24	0.011811	7,884.00	7,882.50	26
3510100	56	24	0.008929	7,892.50	7,892.00	23
3510400	77	24	0.015844	7,885.00	7,883.78	31
3510600	53	24	0.022264	7,893.00	7,891.82	36
3510800	73	24	0.013699	7,895.50	7,894.50	28
3511101	124	24	0.047581	7,971.00	7,965.10	53
3511102	123	24	0.056098	7,971.40	7,964.50	58
3511300	243	18	0.036872	8,063.00	8,054.04	22
3511500	24	18	0.025000	8,066.00	8,065.40	18
3511700	68	18	0.028971	8,075.00	8,073.03	19
3511900	122	24	0.024590	8,058.00	8,055.00	38
3512100	58	24	0.017241	8,059.00	8,058.00	32
3512300	52	24	0.038462	7,873.00	7,871.00	48
3512500	66	24	0.030303	7,879.00	7,877.00	42

Inventory of Existing Storm Drain Pipes

Pipe ID	Length (ft)	Section Size (in)	Constructed Slope (ft/ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Calculated Capacity 94% full (cfs)
3512700	48	24	0.020833	7,893.50	7,892.50	35
3512900	50	24	0.020000	7,908.00	7,907.00	34
3513100	23	24	0.043478	7,904.00	7,903.00	51
3513300	152	36	0.013158	7,941.00	7,939.00	82
3513301	151	36	0.026490	7,944.00	7,940.00	117
3513302	151	36	0.026490	7,944.00	7,940.00	117
3513501	103	24	0.025631	7,954.64	7,952.00	39
3513502	102	24	0.024608	7,954.51	7,952.00	38
3513900	18	24	0.055556	8,003.00	8,002.00	57
3514200	50	24	0.036000	8,010.30	8,008.50	46
3514300	186	24	0.090860	8,027.40	8,010.50	73
3514500	122	24	0.089344	8,038.50	8,027.60	73
3514700	7	18	0.185714	8,040.00	8,038.70	49
3514800	122	24	0.088525	8,049.50	8,038.70	72
3515000	7	18	0.042857	8,050.00	8,049.70	23
3515100	122	24	0.092459	8,060.98	8,049.70	74
3515300	7	18	0.010000	8,061.25	8,061.18	11
3515401	723	24	0.075380	8,063.00	8,008.50	67
3515500	97	24	0.257732	8,088.00	8,063.00	124
3515700	189	24	0.248677	8,135.00	8,088.00	121
3515900	46	24	0.004783	8,136.14	8,135.92	17
3516100	86	24	0.005000	8,136.77	8,136.34	17
3516300	371	24	0.053747	8,157.65	8,137.71	56
3516500	38	24	0.090526	8,161.44	8,158.00	73
3516600	272	24	0.059669	8,174.13	8,157.90	59
3516800	56	24	0.006429	8,175.91	8,175.55	20
3517000	321	24	0.041869	8,187.82	8,174.38	50
3517200	43	24	0.051163	8,192.20	8,190.00	55
3517400	335	24	0.047701	8,204.00	8,188.02	53
3517600	226	24	0.045575	8,214.50	8,204.20	52
3517800	39	36	0.038462	8,216.00	8,214.50	141
3518000	20	36	0.100000	8,218.00	8,216.00	227
3518100	540	24	0.051481	8,243.00	8,215.20	55
3518300	38	36	0.026316	8,244.00	8,243.00	116
3518500	84	24	0.053690	7,994.66	7,990.15	56
3518700	96	24	0.094063	8,003.89	7,994.86	75
3518900	39	24	0.274872	8,015.00	8,004.28	128
3519000	123	24	0.095610	8,015.94	8,004.18	75
3519200	225	24	0.143111	8,048.50	8,016.30	92
3519400	83	24	0.433735	8,084.50	8,048.50	160
3519600	44	24	0.238636	8,095.00	8,084.50	119
3520600	65	24	0.103231	7,983.73	7,977.02	78

Inventory of Existing Storm Drain Pipes

Pipe ID	Length (ft)	Section Size (in)	Constructed Slope (ft/ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Calculated Capacity 94% full (cfs)
3520800	71	24	0.133944	8,015.00	8,005.49	89
3521300	73	24	0.039726	8,020.72	8,017.82	49
3521500	55	24	0.054545	8,050.00	8,047.00	57
3521600	122	24	0.008197	8,112.00	8,111.00	22
3521700	38	24	0.013158	8,021.00	8,020.50	28
3521800	72	18	0.013889	8,039.00	8,038.00	13
3522000	21	30	0.047619	7,981.00	7,980.00	96
3522200	63	30	0.015873	7,982.00	7,981.00	56
3522400	22	30	0.044091	7,982.97	7,982.00	93
3522500	78	12	0.019615	7,984.50	7,982.97	5
3522501	47	12	0.021915	7,984.00	7,982.97	6
3522600	55	18	0.005455	7,981.50	7,981.20	8
3522800	276	18	0.015942	7,985.90	7,981.50	14
3523000	158	18	0.045570	7,993.10	7,985.90	24
3523200	166	18	0.054217	8,002.10	7,993.10	26
3523400	53	18	0.026415	8,003.50	8,002.10	18
3523600	119	18	0.034454	8,006.20	8,002.10	21
3524101	173	36	0.052023	7,915.50	7,906.50	164
3524102	173	36	0.052023	7,915.50	7,906.50	164
3524103	173	36	0.052023	7,915.50	7,906.50	164
3524301	199	36	0.040201	7,924.00	7,916.00	144
3524302	199	36	0.040201	7,924.00	7,916.00	144
3524303	199	36	0.040201	7,924.00	7,916.00	144
3524400	90	36	88.588889	7,973.00	0.00	6753
3524600	63	24	0.060317	7,977.00	7,973.20	60
3524900	188	24	0.058511	8,007.00	7,996.00	59
3525500	183	18	0.043716	7,949.00	7,941.00	24
3525700	86	36	0.040698	7,958.50	7,955.00	145
3526300	174	24	0.068966	8,012.00	8,000.00	64
3526500	5	24	0.200000	8,013.00	8,012.00	109
3526800	37	24	0.054054	8,015.00	8,013.00	57
3527000	133	24	0.030075	8,019.00	8,015.00	42
3527200	318	24	0.041226	8,031.11	8,018.00	49
3527400	73	24	0.035205	8,033.83	8,031.26	46
3527600	41	24	0.072195	8,036.91	8,033.95	65
3527800	88	36	0.034091	8,045.00	8,042.00	132
3528000	39	24	0.025641	8,046.00	8,045.00	39
3528200	202	18	0.065842	8,058.30	8,045.00	29
3528400	51	18	0.080392	8,062.50	8,058.40	32
3600100	144	30	0.758681	7,825.75	7,935.00	384
3600300	166	30	0.018072	7,938.00	7,935.00	59
3600400	84	36	0.107143	7,989.00	7,980.00	235

Inventory of Existing Storm Drain Pipes

Pipe ID	Length (ft)	Section Size (in)	Constructed Slope (ft/ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Calculated Capacity 94% full (cfs)
3600600	73	24	0.027397	7,991.00	7,989.00	40
3600800	162	36	0.092593	8,004.00	7,989.00	218
3601000	89	36	0.022472	8,006.00	8,004.00	108
3601200	77	18	0.019481	8,035.00	8,033.50	16
3601300	65	24	0.076923	8,047.00	8,042.00	67
3601500	58	24	0.017241	8,099.00	8,098.00	32
3601600	44	18	0.022727	8,117.00	8,116.00	17
3700100	156	60	0.718077	7,937.77	7,825.75	2374
3700300	638	54	0.203370	7,955.50	7,825.75	954
3700500	612	54	0.069444	7,998.00	7,955.50	557
3700700	573	54	0.022862	8,011.10	7,998.00	320
3700900	106	72	0.016038	8,012.80	8,011.10	577
3701000	25	54	0.032000	8,013.60	8,012.80	378
3701100	41	72	0.039024	8,014.40	8,012.80	900
3701300	179	72	0.030112	8,019.79	8,014.40	791
3701500	396	72	0.023763	8,029.20	8,019.79	702
3701601	9	18	0.111111	8,042.00	8,041.00	38
3701700	20	72	0.005000	8,029.30	8,029.20	322
3701801	29	24	0.034483	8,043.00	8,042.00	45
3701803	3	24	0.166667	8,043.00	8,042.50	99
3701806	92	18	0.032609	8,045.00	8,042.00	20
3701901	21	72	0.006190	8,029.43	8,029.30	358
3702000	206	72	0.027039	8,035.00	8,029.43	749
3702200	55	72	0.018182	8,036.00	8,035.00	614
3702400	25	72	0.040000	8,037.00	8,036.00	911
3702600	94	72	0.021277	8,039.00	8,037.00	665
3702800	194	72	0.030928	8,045.00	8,039.00	801
3703000	147	72	0.006803	8,046.00	8,045.00	376
3703200	17	72	0.117647	8,066.00	8,064.00	1563
3703400	45	72	0.088889	8,055.00	8,051.00	1358
3703600	15	72	0.066667	8,056.00	8,055.00	1176
3703800	40	72	0.100000	8,060.00	8,056.00	1441
3704000	21	72	0.214286	8,064.50	8,060.00	2109
3704200	24	72	0.083333	8,078.00	8,076.00	1315
3704400	43	48	0.127907	8,074.50	8,069.00	553
3704500	294	42	0.059524	8,092.00	8,074.50	264
3704700	119	36	0.052521	8,098.25	8,092.00	164
3704900	286	36	0.048951	8,112.50	8,098.50	159
3705100	248	30	0.054435	8,126.50	8,113.00	103
3705500	84	24	0.023810	8,267.00	8,265.00	38
3705700	56	24	0.071429	8,271.00	8,267.00	65
3705900	430	24	0.040698	8,288.50	8,271.00	49

Inventory of Existing Storm Drain Pipes

Pipe ID	Length (ft)	Section Size (in)	Constructed Slope (ft/ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Calculated Capacity 94% full (cfs)
3706100	195	24	0.033333	8,295.00	8,288.50	44
3706300	83	24	0.012048	8,296.00	8,295.00	27
3706500	329	24	0.111945	8,332.83	8,296.00	81
3706600	112	30	0.022321	7,958.00	7,955.50	66
3706700	33	24	0.030303	8,048.00	8,047.00	42
3706900	37	24	0.040541	8,052.50	8,054.00	49
3707100	35	24	0.028571	8,128.00	8,127.00	41
3707300	11	24	0.045455	8,066.00	8,065.50	52
3707500	38	24	0.052632	8,071.00	8,069.00	56
3707700	15	24	0.133333	8,072.00	8,070.00	89
3707900	40	24	0.075000	8,079.00	8,076.00	67
3708000	41	24	0.073171	8,079.00	8,076.00	66
3708100	23	24	0.065217	8,076.00	8,074.50	62
3708300	30	24	0.050000	8,076.00	8,074.50	54
3708500	10	24	0.290000	8,079.40	8,076.50	131
3708700	24	24	0.041667	8,093.00	8,092.00	50
3708900	14	24	0.071429	8,093.00	8,092.00	65
3709400	149	18	0.040940	8,326.10	8,320.00	23
3709600	106	18	0.006132	8,331.00	8,330.35	9
3709800	137	18	0.008029	8,325.00	8,326.10	10
3710100	61	24	0.011967	8,264.00	8,263.27	27
3710300	46	18	0.021739	8,265.00	8,264.00	17
3710500	196	24	0.306122	8,320.00	8,260.00	135
3710700	64	24	0.062500	8,324.00	8,320.00	61
4000300	75	36	0.080000	7,816.00	7,810.00	203

APPENDIX B

Hydrologic Tables: Existing Conditions

Hydrologic Table - Existing Conditions

Sub Area Number	Total Area (Acres)	Total Area (mi2)	% Natural	% HD Res	% LD Res	% Commercial	20-yr (cfs/acre)	100-yr (cfs/acre)	Area Runoff 20-yr (cfs)	Total Runoff 20-yr (cfs)	Area Runoff 100-yr (cfs)	Total Runoff 100-yr (cfs)	Total Contributing Area (acres)	Sub-area Area Adjustment	Cumlative Area Adjustment	Adjusted Area Runoff 20-yr (cfs)	Adjusted Total Runoff 20-yr (cfs)	Adjusted Area Runoff 100-yr (cfs)	Adjusted Total Runoff 100-yr (cfs)
2.1	443	0.69	100	0	0	0	0.08	0.15	36	492	68	912	3473	0.77	0.55	28	352	52	667
2.2.1	33	0.05	15	0	0	85	1.07	1.71	35	121	56	202	117	1.00	0.88	35	106	56	178
2.2.2	42	0.07	0	40	45	15	0.93	1.63	39	39	69	69	42	1.00	1.00	39	39	69	69
2.2.3	42	0.07	0	75	10	15	1.10	1.84	46	46	77	77	42	1.00	1.00	46	46	77	77
2.2	117								121	121	202	202	117	0.88	0.88	106	106	178	178
2.3.1	393	0.61	65	10	22	3	0.09	0.16	35	224	65	434	1751	0.77	0.63	27	222	50	439
2.3.2	622	0.97	95	0	5	0	0.07	0.12	41	158	77	310	1042	0.69	0.63	29	180	53	361
2.3.3	316	0.49	100	0	0	0	0.10	0.19	32	32	59	59	316	0.77	0.77	24	24	46	46
2.3.4	420	0.66	100	0	0	0	0.08	0.16	35	35	66	66	420	0.77	0.77	27	27	51	51
2.3	1751								143	224	268	434	1751	0.63	0.63	90	141	169	273
2.4	871	1.36	97	3	0	0	0.05	0.10	47	111	88	208	1162	0.69	0.63	33	70	61	131
2.5.1	171	0.27	75	0	25	0	0.15	0.27	25	63	46	120	291	0.88	0.77	22	49	41	92
2.5.2	22	0.03	10	0	90	0	0.61	1.21	13	39	27	73	120	1.00	0.88	13	34	27	64
2.5.3	98	0.15	97	3	0	0	0.26	0.47	25	25	46	46	98	0.97	0.97	24	24	45	45
2.5	291								63	63	120	120	291	0.77	0.77	49	49	92	92
3.1	359	0.56	100	0	0	0	0.09	0.17	33	1055	62	1878	4531	0.77	0.55	26	580	48	1033
3.2	111	0.17	65	0	0	35	0.58	0.96	64	64	106	106	111	0.88	0.88	56	56	93	93
3.3.1	58	0.09	45	0	10	45	0.72	1.19	42	128	69	213	177	1.00	0.88	42	112	69	187
3.3.2	28	0.04	0	0	5	95	1.19	1.90	33	74	53	122	68	1.00	1.00	33	74	53	122
3.3.3	51	0.08	100	0	0	0	0.23	0.43	12	12	22	22	51	1.00	1.00	12	12	22	22
3.3.4	40	0.06	0	0	35	65	1.02	1.71	41	41	68	68	40	1.00	1.00	41	41	68	68
3.3	177								128	128	213	213	177	0.88	0.88	112	112	187	187
3.4	770	1.20	75	0	10	15	0.06	0.11	45	830	84	1497	3884	0.69	0.55	31	457	58	823
3.5.1	45	0.07	0	40	0	60	1.19	1.92	53	100	86	163	85	1.00	0.97	53	97	86	158
3.5.2	40	0.06	0	75	0	25	1.16	1.91	46	46	76	76	40	1.00	1.00	46	46	76	76
3.5	85								100	100	163	163	85	0.97	0.97	97	97	158	158
3.6.1	99	0.15	15	80	0	5	1.01	1.68	100	334	166	603	713	0.97	0.69	97	230	161	416
3.6.2	55	0.09	30	70	0	0	0.87	1.46	48	134	80	251	244	1.00	0.77	48	103	80	193
3.6.3	47	0.07	100	0	0	0	0.23	0.43	11	11	20	20	47	1.00	1.00	11	11	20	20
3.6.4	45	0.07	100	0	0	0	0.23	0.43	10	65	19	119	247	1.00	0.77	10	50	19	92
3.6.5	76	0.12	80	0	20	0	0.31	0.60	24	24	46	46	76	1.00	1.00	24	24	46	46
3.6.6	55	0.09	100	0	0	0	0.23	0.43	13	87	24	171	189	1.00	0.88	13	76	24	150
3.6.7	40	0.06	20	40	40	0	0.76	1.37	30	55	55	100	202	1.00	0.77	30	42	55	77
3.6.8	52	0.08	60	0	40	0	0.40	0.78	21	21	40	40	52	1.00	1.00	21	21	40	40
3.6.9	82	0.13	0	0	100	0	0.65	1.30	53	53	107	107	82	0.97	0.97	52	52	103	103
3.6.10	162	0.25	80	10	10	0	0.15	0.28	24	24	45	45	162	0.88	0.88	21	21	40	40
3.6	713								310	334	557	603	713	0.69	0.69	214	230	385	416
3.7.1	40	0.06	0	0	80	20	0.76	1.43	31	351	57	647	2316	1.00	0.55	31	193	57	356
3.7.2	79	0.12	0	50	50	0	0.90	1.60	71	301	126	552	2176	1.00	0.55	71	165	126	304
3.7.3	29	0.05	0	35	65	0	0.82	1.51	24	177	44	326	922	1.00	0.69	24	122	44	225
3.7.4	81	0.13	2	38	60	0	0.83	1.51	67	153	122	282	893	0.97	0.69	65	105	119	195
3.7.5	176	0.28	100	0	0	0	0.14	0.27	25	25	47	47	176	0.88	0.88	22	22	41	41
3.7.6	505	0.79	98	0	2	0	0.08	0.14	38	38	71	71	505	0.69	0.69	26	26	49	49
3.7.7	131	0.20	85	0	15	0	0.17	0.32	22	61	42	113	636	0.88	0.69	20	42	37	78
3.7	1041								278	351	510	647	2316	0.63	0.55	175	193	321	356
3.8	1175	1.84	95	0	3	2	0.05	0.08	53	53	100	100	1175	0.63	0.63	34	34	63	63
3.9	100	0.16	90	0	10	0	0.20	0.38	20	20	38	38	100	0.97	0.97	19	19	36	36
L.M.									81	81	166	166							

APPENDIX C

Hydrologic Tables:
Future Conditions w/o Detention Basins

Hydrologic Table - Future Conditions

Sub Area Number	Total Area (Acres)	Total Area (mi2)	% Natural	% HD Res	% LD Res	% Commercial	20-yr (cfs/acre)	100-yr (cfs/acre)	Area Runoff 20-yr (cfs)	Total Runoff 20-yr (cfs)	Area Runoff 100-yr (cfs)	Total Runoff 100-yr (cfs)	Total Contributing Area (acres)	Sub-area Area Adjustment	Cumlative Area Adjustment	Adjusted Area Runoff 20-yr (cfs)	Adjusted Total Runoff 20-yr (cfs)	Adjusted Area Runoff 100-yr (cfs)	Adjusted Total Runoff 100-yr (cfs)
2.1	443	0.69	100	0	0	0	0.08	0.15	36	492	68	912	3473	0.77	0.55	28	352	52	667
2.2.1	33	0.05	15	0	0	85	1.07	1.71	35	121	56	202	117	1.00	0.88	35	106	56	178
2.2.2	42	0.07	0	40	45	15	0.93	1.63	39	39	69	69	42	1.00	1.00	39	39	69	69
2.2.3	42	0.07	0	75	10	15	1.10	1.84	46	46	77	77	42	1.00	1.00	46	46	77	77
2.2	117								121	121	202	202	117	0.88	0.88	106	106	178	178
2.3.1	393	0.61	65	10	22	3	0.09	0.16	35	224	65	434	1751	0.77	0.63	27	222	50	439
2.3.2	622	0.97	95	0	5	0	0.07	0.12	41	158	77	310	1042	0.69	0.63	29	180	53	361
2.3.3	316	0.49	100	0	0	0	0.10	0.19	32	32	59	59	316	0.77	0.77	24	24	46	46
2.3.4	420	0.66	100	0	0	0	0.08	0.16	35	35	66	66	420	0.77	0.77	27	27	51	51
2.3	1751								143	224	268	434	1751	0.63	0.63	90	141	169	273
2.4	871	1.36	97	3	0	0	0.05	0.10	47	111	88	208	1162	0.69	0.63	33	70	61	131
2.5.1	171	0.27	75	0	25	0	0.15	0.27	25	63	46	120	291	0.88	0.77	22	49	41	92
2.5.2	22	0.03	10	0	90	0	0.61	1.21	13	39	27	73	120	1.00	0.88	13	34	27	64
2.5.3	98	0.15	97	3	0	0	0.26	0.47	25	25	46	46	98	0.97	0.97	24	24	45	45
2.5	291								63	63	120	120	291	0.77	0.77	49	49	92	92
3.1	359	0.56	100	0	0	0	0.09	0.17	33	1178	62	2070	4531	0.77	0.55	26	648	48	1138
3.2	111	0.17	25	0	0	75	0.97	1.56	108	108	173	173	111	0.88	0.88	95	95	152	152
3.3.1	58	0.09	0	75	0	25	1.16	1.91	67	207	111	338	177	1.00	0.88	67	182	111	298
3.3.2	28	0.04	0	100	0	0	1.14	1.90	32	78	53	129	68	1.00	1.00	32	78	53	129
3.3.3	51	0.08	0	0	0	100	1.22	1.93	62	62	98	98	51	1.00	1.00	62	62	98	98
3.3.4	40	0.06	0	100	0	0	1.14	1.90	46	46	76	76	40	1.00	1.00	46	46	76	76
3.3	177								207	207	338	338	177	0.88	0.88	182	182	298	298
3.4	770	1.20	70	15	5	10	0.06	0.11	45	830	84	1497	3884	0.69	0.55	31	457	58	823
3.5.1	45	0.07	0	40	0	60	1.19	1.92	53	100	86	163	85	1.00	0.97	53	97	86	158
3.5.2	40	0.06	0	75	0	25	1.16	1.91	46	46	76	76	40	1.00	1.00	46	46	76	76
3.5	85								100	100	163	163	85	0.97	0.97	97	97	158	158
3.6.1	99	0.15	15	80	0	5	1.01	1.68	100	334	166	603	713	0.97	0.69	97	230	161	416
3.6.2	55	0.09	30	70	0	0	0.87	1.46	48	134	80	251	244	1.00	0.77	48	103	80	193
3.6.3	47	0.07	100	0	0	0	0.23	0.43	11	11	20	20	47	1.00	1.00	11	11	20	20
3.6.4	45	0.07	100	0	0	0	0.23	0.43	10	65	19	119	247	1.00	0.77	10	50	19	92
3.6.5	76	0.12	80	0	20	0	0.31	0.60	24	24	46	46	76	1.00	1.00	24	24	46	46
3.6.6	55	0.09	100	0	0	0	0.23	0.43	13	87	24	171	189	1.00	0.88	13	76	24	150
3.6.7	40	0.06	20	40	40	0	0.76	1.37	30	55	55	100	202	1.00	0.77	30	42	55	77
3.6.8	52	0.08	60	0	40	0	0.40	0.78	21	21	40	40	52	1.00	1.00	21	21	40	40
3.6.9	82	0.13	0	0	100	0	0.65	1.30	53	53	107	107	82	0.97	0.97	52	52	103	103
3.6.10	162	0.25	80	10	10	0	0.15	0.28	24	24	45	45	162	0.88	0.88	21	21	40	40
3.6	713								310	334	557	603	713	0.69	0.69	214	230	385	416
3.7.1	40	0.06	0	0	80	20	0.76	1.43	31	351	57	647	2316	1.00	0.55	31	193	57	356
3.7.2	79	0.12	0	50	50	0	0.90	1.60	71	301	126	552	2176	1.00	0.55	71	165	126	304
3.7.3	29	0.05	0	35	65	0	0.82	1.51	24	177	44	326	922	1.00	0.69	24	122	44	225
3.7.4	81	0.13	2	38	60	0	0.83	1.51	67	153	122	282	893	0.97	0.69	65	105	119	195
3.7.5	176	0.28	100	0	0	0	0.14	0.27	25	25	47	47	176	0.88	0.88	22	22	41	41
3.7.6	505	0.79	98	0	2	0	0.08	0.14	38	38	71	71	505	0.69	0.69	26	26	49	49
3.7.7	131	0.20	85	0	15	0	0.17	0.32	22	61	42	113	636	0.88	0.69	20	42	37	78
3.7	1041								278	351	510	647	2316	0.63	0.55	175	193	321	356
3.8	1175	1.84	95	0	3	2	0.05	0.08	53	53	100	100	1175	0.63	0.63	34	34	63	63
3.9	100	0.16	90	0	10	0	0.20	0.38	20	20	38	38	100	0.97	0.97	19	19	36	36
L.M.									81	81	166	166							

APPENDIX D

Hydrologic Tables:
Future Conditions with Detention Basin A

Hydrologic Table - Future Conditions with Detention Basin A

Sub Area Number	Total Area (Acres)	Total Area (mi2)	% Natural	% HD Res	% LD Res	% Commercial	20-yr (cfs/acre)	100-yr (cfs/acre)	Area Runoff 20-yr (cfs)	Total Runoff 20-yr (cfs)	Area Runoff 100-yr (cfs)	Total Runoff 100-yr (cfs)	Total Contributing Area (acres)	Sub-area Area Adjustment	Cumlative Area Adjustment	Adjusted Area Runoff 20-yr (cfs)	Adjusted Total Runoff 20-yr (cfs)	Adjusted Area Runoff 100-yr (cfs)	Adjusted Total Runoff 100-yr (cfs)
2.1	443	0.69	100	0	0	0	0.08	0.15	36	492	68	912	3473	0.77	0.55	28	352	52	667
2.2.1	33	0.05	15	0	0	85	1.07	1.71	35	121	56	202	117	1.00	0.88	35	106	56	178
2.2.2	42	0.07	0	40	45	15	0.93	1.63	39	39	69	69	42	1.00	1.00	39	39	69	69
2.2.3	42	0.07	0	75	10	15	1.10	1.84	46	46	77	77	42	1.00	1.00	46	46	77	77
2.2	117								121	121	202	202	117	0.88	0.88	106	106	178	178
2.3.1	393	0.61	65	10	22	3	0.09	0.16	35	224	65	434	1751	0.77	0.63	27	222	50	439
2.3.2	622	0.97	95	0	5	0	0.07	0.12	41	158	77	310	1042	0.69	0.63	29	180	53	361
2.3.3	316	0.49	100	0	0	0	0.10	0.19	32	32	59	59	316	0.77	0.77	24	24	46	46
2.3.4	420	0.66	100	0	0	0	0.08	0.16	35	35	66	66	420	0.77	0.77	27	27	51	51
2.3	1751								143	224	268	434	1751	0.63	0.63	90	141	169	273
2.4	871	1.36	97	3	0	0	0.05	0.10	47	111	88	208	1162	0.69	0.63	33	70	61	131
2.5.1	171	0.27	75	0	25	0	0.15	0.27	25	63	46	120	291	0.88	0.77	22	49	41	92
2.5.2	22	0.03	10	0	90	0	0.61	1.21	13	39	27	73	120	1.00	0.88	13	34	27	64
2.5.3	98	0.15	97	3	0	0	0.26	0.47	25	25	46	46	98	0.97	0.97	24	24	45	45
2.5	291								63	63	120	120	291	0.77	0.77	49	49	92	92
3.1	359	0.56	100	0	0	0	0.09	0.17	33	1115	62	2015	4531	0.77	0.55	26	613	48	1108
3.2	111	0.17	25	0	0	75	0.97	1.56	108	108	173	173	111	0.88	0.88	95	95	152	152
3.3.1	58	0.09	0	75	0	25	1.16	1.91	67	207	111	338	177	1.00	0.88	67	182	111	298
3.3.2	28	0.04	0	100	0	0	1.14	1.90	32	78	53	129	68	1.00	1.00	32	78	53	129
3.3.3	51	0.08	0	0	0	100	1.22	1.93	62	62	98	98	51	1.00	1.00	62	62	98	98
3.3.4	40	0.06	0	100	0	0	1.14	1.90	46	46	76	76	40	1.00	1.00	46	46	76	76
3.3	177								207	207	338	338	177	0.88	0.88	182	182	298	298
3.4	770	1.20	70	15	5	10	0.06	0.11	45	767	84	1442	3884	0.69	0.55	31	422	58	793
3.5.1	45	0.07	0	40	0	60	1.19	1.92	53	100	86	163	85	1.00	0.97	53	97	86	158
3.5.2	40	0.06	0	75	0	25	1.16	1.91	46	46	76	76	40	1.00	1.00	46	46	76	76
3.5	85								100	100	163	163	85	0.97	0.97	97	97	158	158
3.6.1	99	0.15	15	80	0	5	1.01	1.68	100	334	166	603	713	0.97	0.69	97	230	161	416
3.6.2	55	0.09	30	70	0	0	0.87	1.46	48	134	80	251	244	1.00	0.77	48	103	80	193
3.6.3	47	0.07	100	0	0	0	0.23	0.43	11	11	20	20	47	1.00	1.00	11	11	20	20
3.6.4	45	0.07	100	0	0	0	0.23	0.43	10	65	19	119	247	1.00	0.77	10	50	19	92
3.6.5	76	0.12	80	0	20	0	0.31	0.60	24	24	46	46	76	1.00	1.00	24	24	46	46
3.6.6	55	0.09	100	0	0	0	0.23	0.43	13	87	24	171	189	1.00	0.88	13	76	24	150
3.6.7	40	0.06	20	40	40	0	0.76	1.37	30	55	55	100	202	1.00	0.77	30	42	55	77
3.6.8	52	0.08	60	0	40	0	0.40	0.78	21	21	40	40	52	1.00	1.00	21	21	40	40
3.6.9	82	0.13	0	0	100	0	0.65	1.30	53	53	107	107	82	0.97	0.97	52	52	103	103
3.6.10	162	0.25	80	10	10	0	0.15	0.28	24	24	45	45	162	0.88	0.88	21	21	40	40
3.6	713								310	334	557	603	713	0.69	0.69	214	230	385	416
3.7.1	40	0.06	0	0	80	20	0.76	1.43	31	288	57	592	2316	1.00	0.55	31	158	57	326
3.7.2	79	0.12	0	50	50	0	0.90	1.60	71	237	126	497	2176	1.00	0.55	71	130	126	273
3.7.3	29	0.05	0	35	65	0	0.82	1.51	24	113	44	271	922	1.00	0.69	24	78	44	187
3.7.4	81	0.13	2	38	60	0	0.83	1.51	67	89	122	227	893	0.97	0.69	65	62	119	157
3.7.5	176	0.28	100	0	0	0	0.14	0.27	0	0	25	25	176	0.88	0.88	0	0	22	22
3.7.6	505	0.79	98	0	2	0	0.08	0.14	0	0	38	38	505	0.69	0.69	0	0	26	26
3.7.7	131	0.20	85	0	15	0	0.17	0.32	22	22	42	80	636	0.88	0.69	20	15	37	55
3.7	1041								215	288	455	592	2316	0.63	0.55	135	158	286	326
3.8	1175	1.84	95	0	3	2	0.05	0.08	53	53	100	100	1175	0.63	0.63	34	34	63	63
3.9	100	0.16	90	0	10	0	0.20	0.38	20	20	38	38	100	0.97	0.97	19	19	36	36
L.M.									81	81	166	166							

**** - Improved condition icludes Detention Basin A which completely retains the 20-Yr runoff and reduces the 100-Yr Runoff such that it equals the non-detained (unimproved) 20-Yr value. This applies to Sub-Area 3.7.5 and 3.7.6**

APPENDIX E

Analysis of Pipe Capacities:
Existing Conditions, 20-Year Event

Analysis of Pipe Capacities: Existing Conditions, 20-Year Event

Basin	Pipe ID	Length (ft)	Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Meets Required Capacity
2.3.1	2100100	108	60	364	27	2%	1					0	1	Yes
2.4	2100400	104	36	63	33	40%	13					0	13	Yes
2.5.1	2101500	480	24	28	22	70%	15					0	8	Yes
2.4	2102300	83	18	12	33	3%	1					0	1	Yes
2.4	2102400	57	30	58	33	3%	1					0	1	Yes
2.4	2102500	68	12	5	33	3%	1					0	1	Yes
2.4	2102800	92	18	25	33	3%	1					0	1	Yes
2.4	2102900	78	18	22	33	3%	1					0	1	Yes
2.5.1	2103200	94	24	15	22	25%	5					0	3	Yes
2.5.1	2103300	95	24	15	22	25%	5					0	3	Yes
2.5.1	2103401	106	30	82	22	15%	3					0	3	Yes
2.5.1	2103403	33	18	25	22	15%	3					0	3	Yes
2.5.1	2103405	66	30	62	22	15%	3					0	3	Yes
2.5.1	2103407	27	24	37	22	30%	7					0	7	Yes
2.5.1	2103409	40	24	23	22	30%	7					0	7	Yes
2.5.1	2103410	5	24	11	22	15%	3					0	3	Yes
2.5.1	2103411	165	18	11	22	15%	3					0	3	Yes
2.5.1	2103413	201	18	13	22	15%	3					0	3	Yes
2.5.1	2103415	49	18	16	22	10%	2					0	2	Yes
2.5.1	2103416	41	18	18	22	10%	2					0	2	Yes
2.5.1	2103418	142	18	6	22	5%	1					0	1	Yes
2.5.1	2103420	42	18	12	22	5%	1					0	1	Yes
2.5.1	2103422	72	12	3	22	10%	2					0	2	Yes
2.5.1	2103424	54	12	3	22	10%	2					0	2	Yes
2.5.1	2103426	60	12	2	22	5%	1					0	1	Yes
2.5.1	2103428	197	18	16	22	10%	2					0	2	Yes
2.5.1	2103430	68	18	14	22	10%	2					0	2	Yes
2.5.1	2103500	260	24	16	22	15%	3					0	3	Yes
2.5.1	2103502	307	24	27	22	5%	1					0	1	Yes
2.5.1	2103504	109	24	16	22	5%	1					0	1	Yes
2.5.1	2103506	25	18	11	22	5%	1					0	1	Yes
2.5.1	2103508	88	18	9	22	5%	1					0	1	Yes
2.5.1	2103511	106	12	8	22	5%	1					0	1	Yes
2.5.1	2103513	85	18	9	22	5%	1					0	1	Yes
2.5.1	2103515	76	12	4	22	10%	2					0	2	Yes
2.5.1	2103517	92	12	4	22	10%	2					0	2	Yes
2.5.1	2103519	26	12	4	22	10%	2					0	2	Yes
2.5.1	2103600	116	12	5	22	5%	1					0	1	Yes
2.5.1	2103602	24	12	5	22	2%	0					0	0	Yes
2.5.1	2103605	41	18	35	22	5%	1					0	1	Yes
2.4	2103701	21	18	17	33	10%	3					0	3	Yes
2.4	2103703	108	18	9	33	10%	3					0	3	Yes
2.4	2103705	103	18	12	33	10%	3					0	3	Yes
2.4	2103707	129	18	12	33	10%	3					0	3	Yes
2.4	2103709	64	18	4	33	9%	3					0	3	Yes
2.4	2103711	77	18	11	33	9%	3					0	3	Yes
2.4	2103713	95	18	14	33	9%	3					0	3	Yes
2.4	2103715	98	18	23	33	9%	3					0	3	Yes
2.4	2103717	82	18	24	33	8%	3					0	3	Yes
2.4	2103719	96	18	23	33	8%	3					0	3	Yes
2.4	2103721	106	18	24	33	7%	2					0	2	Yes
2.4	2103723	109	18	23	33	6%	2					0	2	Yes
2.4	2103725	109	18	24	33	5%	2					0	2	Yes
2.4	2103727	101	18	19	33	4%	1					0	1	Yes
2.4	2103729	81	18	18	33	3%	1					0	1	Yes
2.4	2103731	89	18	9	33	2%	1					0	1	Yes
2.4	2103733	59	18	21	33	1%	0					0	0	Yes
2.4	2103735	67	18	15	33	1%	0					0	0	Yes
2.4	2103737	57	18	20	33	1%	0					0	0	Yes
2.5.1	2103800	40	18	24	22	5%	1					0	1	Yes
2.5.3	2109354	48	18	12	24	1%	0					0	0	Yes
2.5.3	2109356	140	18	10	24	1%	0					0	0	Yes
2.2.1	2200202	320	36	69	35	90%	32	2.2.3				46	78	No
2.2.1	2200203	232	36	94	35	70%	25	2.2.3				46	71	Yes
2.2.1	2200204	232	36	67	35	50%	18	2.2.3				46	64	Yes
2.2.1	2200205	385	36	82	35	20%	7	2.2.3				46	53	Yes
2.2.1	2200300	735	36	25	35	40%	14	2.2.3				46	60	No

Analysis of Pipe Capacities: Existing Conditions, 20-Year Event

Basin	Pipe ID	Length (ft)	Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Meets Required Capacity
2.2.1	2200500	5	36	101	35	40%	14	2.2.3				46	60	Yes
2.2.1	2200700	57	36	95	35	40%	14	2.2.3				46	60	Yes
2.2.3	2200900	138	18	17	46	100%	46					0	46	No
2.2.1	2201100	251	18	12	35	40%	14					0	14	No
2.2.1	2201300	185	18	17	35	10%	4					0	4	Yes
2.2.1	2201500	72	18	13	35	5%	2					0	2	Yes
2.2.1	2201700	240	18	13	35	20%	7					0	7	Yes
2.2.1	2201900	212	18	8	35	10%	4					0	4	Yes
2.2.1	2202000	44	18	42	35	5%	2					0	2	Yes
2.3.1	2202400	98	36	89	27	25%	7	2.3.3				24	16	Yes
2.3.1	2202500	97	72	686	27	75%	20	2.3.2	2.3.3			205	112	Yes
2.3.1	2202900	97	96	1268	27	90%	24	2.3.2	2.3.3			205	229	Yes
2.3.1	2203400	129	24	21	27	8%	2					0	2	Yes
2.3.1	2203500	39	24	39	27	8%	2					0	2	Yes
2.3.1	2205300	80	24	38	27	8%	2					0	2	Yes
2.3.1	2205500	70	24	45	27	8%	2					0	2	Yes
2.3.1	2205700	43	24	74	27	8%	2					0	2	Yes
2.2.1	2205900	41	18	18	35	10%	4					0	4	Yes
2.2.1	2206000	86	18	13	35	100%	35					0	35	No
2.2.2	2206200	66	36	88	39	5%	2					0	2	Yes
2.2.3	2206300	124	24	35	46	50%	23					0	23	Yes
2.3.1	2300300	33	36	125	27	25%	7					0	7	Yes
2.3.1	2300500	40	36	113	27	20%	5					0	5	Yes
2.3.1	2300701	51	24	48	27	5%	1					0	0	Yes
2.3.1	2300702	51	24	48	27	5%	1					0	0	Yes
2.3.1	2300703	51	24	48	27	5%	1					0	0	Yes
2.3.1	2300704	51	24	48	27	5%	1					0	0	Yes
2.3.1	2301100	33	24	30	27	15%	4					0	4	Yes
2.3.1	2301200	48	18	12	27	15%	4					0	4	Yes
2.3.1	2301400	38	18	13	27	4%	1					0	1	Yes
2.3.1	2301500	55	18	11	27	4%	1					0	1	Yes
2.3.1	2301552	100	18	11	27	4%	1					0	1	Yes
2.3.1	2301554	60	18	15	27	4%	1					0	1	Yes
2.3.1	2301600	65	18	7	27	4%	1					0	1	Yes
2.3.1	2301700	72	18	7	27	4%	1					0	1	Yes
2.5.2	2301800	52	18	16	13	30%	4					0	4	Yes
2.5.2	2301900	20	18	14	13	30%	4					0	4	Yes
2.3.1	2302000	68	36	60	27	30%	8					0	8	Yes
2.3.1	2302200	35	36	149	27	30%	8					0	8	Yes
2.3.1	2302400	66	36	125	27	30%	8					0	8	Yes
2.3.1	2302600	62	36	129	27	30%	8					0	8	Yes
2.3.1	2302800	58	24	101	27	35%	9					0	9	Yes
2.3.1	2303000	24	24	25	27	35%	9					0	9	Yes
2.3.1	2303200	40	24	27	27	35%	9					0	9	Yes
2.5.3	2303400	66	18	14	24	16%	4					0	4	Yes
2.5.3	2303500	62	18	14	24	16%	4					0	4	Yes
2.5.3	2303600	71	18	13	24	16%	4					0	4	Yes
2.5.3	2303700	66	18	14	24	16%	4					0	4	Yes
2.5.3	2303800	71	18	13	24	16%	4					0	4	Yes
2.5.3	2303900	60	18	10	24	8%	2					0	2	Yes
2.5.3	2304100	45	18	12	24	8%	2					0	2	Yes
2.5.3	2304200	84	18	9	24	8%	2					0	2	Yes
2.5.3	2304400	26	18	22	24	8%	2					0	2	Yes
2.3.1	2304500	36	42	165	27	2%	1	2.3.2	2.3.3			205	68	Yes
2.3.1	2304600	33	30	84	27	2%	1	2.3.2	2.3.3			205	68	Yes
2.3.1	2304700	34	30	91	27	2%	1	2.3.2	2.3.3			205	68	Yes
2.3.1	2304900	32	24	43	27	1%	0					0	0	Yes
2.3.1	2305000	31	60	418	27	2%	1					0	0	Yes
2.3.1	2305100	39	24	60	27	2%	1					0	0	Yes
2.3.1	2305300	85	24	26	27	2%	1					0	1	Yes
2.3.1	2305400	31	18	14	27	1%	0					0	0	Yes
2.3.1	2305600	63	24	31	27	1%	0	2.3.3				24	25	Yes
2.3.1	2305800	58	24	72	27	0%	0	2.3.3				24	24	Yes
2.3.3	2305900	70	18	3624	24	1%	0					0	0	Yes
2.3.3	2306200	122	30	129	24	65%	16					0	16	Yes
2.3.3	2306400	86	30	69	24	65%	16					0	16	Yes
2.3.3	2306600	211	30	98	24	65%	16					0	16	Yes

Basin	Pipe ID	Length (ft)	Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Meets Required Capacity
2.3.3	2306800	124	30	146	24	65%	16					0	16	Yes
2.3.3	2307100	77	30	123	24	35%	9					0	9	Yes
2.3.3	2307200	14	30	83	24	35%	9					0	9	Yes
2.3.3	2307300	100	24	50	24	35%	9					0	9	Yes
2.3.3	2307500	436	24	51	24	35%	9					0	9	Yes
2.3.3	2307800	8	24	122	24	10%	2					0	2	Yes
2.3.3	2308000	57	24	32	24	10%	2					0	2	Yes
2.3.3	2308200	121	24	307	24	10%	2					0	2	Yes
2.3.3	2308400	69	24	29	24	10%	2					0	2	Yes
2.3.3	2308700	56	24	103	24	1%	0					0	0	Yes
2.3.3	2308900	27	24	148	24	1%	0					0	0	Yes
2.3.3	2309100	38	24	28	24	1%	0					0	0	Yes
2.3.3	2309302	41	18	39	24	1%	0					0	0	Yes
2.5.3	2309303	632	36	178	24	1%	0					0	0	Yes
2.5.3	2309305	71	18	9	24	5%	1					0	1	Yes
2.5.3	2309307	55	18	11	24	2%	0					0	0	Yes
2.5.3	2309309	19	18	18	24	5%	1					0	1	Yes
2.5.3	2309402	83	18	58	24	10%	2					0	2	Yes
2.5.3	2309404	99	18	16	24	10%	2					0	2	Yes
2.5.3	2309406	474	36	57	24	10%	2					0	2	Yes
2.5.3	2309408	17	18	47	24	10%	2					0	2	Yes
2.5.3	2309410	16	18	49	24	10%	2					0	2	Yes
2.5.3	2309502	23	18	41	24	3%	1					0	1	Yes
3.1	3200201	221	36	68	26	45%	12					0	6	Yes
3.1	3200202	221	36	68	26	45%	12					0	6	Yes
3.3.1	3200401	142	36	52	42	100%	42	3.3.3	3.3.2			86	64	No
3.3.1	3200402	143	36	52	42	100%	42	3.3.3	3.3.2			86	64	No
3.3.1	3200600	82	24	92	42	99%	41					0	41	Yes
3.3.1	3200800	261	36	148	42	98%	41	3.3.2				74	115	Yes
3.3.1	3201000	384	36	162	42	98%	41	3.3.2				74	115	Yes
3.3.1	3201200	546	30	80	42	98%	41	3.3.2				74	115	No
3.3.1	3201250	108	30	95	42	40%	17					0	17	Yes
3.3.2	3201400	43	18	12	33	15%	5					0	5	Yes
3.3.2	3201600	384	30	53	33	70%	23	3.3.4				41	64	No
3.3.2	3201800	335	30	66	33	60%	20	3.3.4				41	61	Yes
3.3.2	3202000	602	30	58	33	30%	10	3.3.4				41	51	Yes
3.3.2	3202200	259	30	129	33	20%	7	3.3.4				41	47	Yes
3.3.2	3202400	128	30	82	33	15%	5					0	5	Yes
3.3.1	3202700	43	24	59	42	20%	8					0	8	Yes
3.3.4	3203001	119	30	36	41	100%	41					0	20	Yes
3.3.4	3203002	119	30	36	41	100%	41					0	20	Yes
3.3.4	3203201	91	24	18	41	95%	39					0	19	No
3.3.4	3203202	94	24	21	41	95%	39					0	19	Yes
3.3.4	3203501	51	24	26	41	90%	37					0	18	Yes
3.3.4	3203502	51	24	26	41	90%	37					0	18	Yes
3.3.4	3203700	20	24	54	41	40%	16					0	16	Yes
3.3.3	3203900	86	24	49	12	80%	9					0	9	Yes
3.3.3	3204100	106	24	24	12	80%	9					0	9	Yes
3.3.3	3204400	70	18	53	12	80%	9					0	9	Yes
3.3.4	3204600	62	18	11	41	90%	37					0	37	No
3.3.4	3204800	46	18	13	41	90%	37					0	37	No
3.3.4	3205200	37	24	27	41	30%	12					0	12	Yes
3.3.1	3205400	48	24	35	42	60%	25	3.3.3				12	37	No
3.3.1	3205600	81	24	54	42	40%	17	3.3.3				12	28	Yes
3.3.1	3206100	44	30	141	42	15%	6					0	6	Yes
3.3.1	3206200	107	24	24	42	35%	15	3.3.3				12	26	No
3.3.1	3206600	83	24	19	42	25%	10	3.3.3				12	22	No
3.3.1	3206900	62	24	41	42	15%	6	3.3.3				12	18	Yes
3.3.1	3207200	12	18	45	42	15%	6	3.3.3				12	18	Yes
3.3.3	3207500	90	12	4	12	10%	1					0	1	Yes
3.3.3	3207700	36	12	4	12	10%	1					0	1	Yes
3.4	3300100	115	18	11	31	1%	0					0	0	Yes
3.4	3300300	145	24	67	31	15%	5					0	5	Yes
3.4	3300400	87	24	74	31	15%	5					0	5	Yes
3.4	3300600	39	24	39	31	15%	5					0	5	Yes
3.4	3300800	28	18	48	31	5%	2					0	2	Yes
3.4	3301000	121	48	183	31	15%	5	3.5.1				97	51	Yes

Analysis of Pipe Capacities: Existing Conditions, 20-Year Event

Basin	Pipe ID	Length (ft)	Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Meets Required Capacity
3.4	3301100	121	48	183	31	15%	5	3.5.1				97	51	Yes
3.4	3301200	53	18	16	31	5%	2					0	2	Yes
3.5.1	3301400	44	18	17	53	15%	8					0	8	Yes
3.5.1	3301650	50	54	299	53	85%	45	3.5.2				46	92	Yes
3.5.1	3301652	276	48	294	53	80%	43	3.5.2				46	89	Yes
3.5.1	3301654	148	48	254	53	80%	43	3.5.2				46	89	Yes
3.5.1	3301656	203	48	217	53	80%	43	3.5.2				46	89	Yes
3.5.1	3301658	70	48	320	53	70%	37	3.5.2				46	84	Yes
3.5.1	3301660	21	36	248	53	40%	21					0	21	Yes
3.5.1	3301663	234	24	30	53	40%	21					0	21	Yes
3.5.1	3303000	334	24	48	53	40%	21					0	21	Yes
3.5.1	3303400	331	36	74	53	15%	8	3.5.2				46	54	Yes
3.5.1	3303600	319	36	57	53	10%	5	3.5.2				46	52	Yes
3.5.1	3303750	747	42	119	53	40%	21					0	21	Yes
3.5.2	3303800	104	36	70	46	98%	45	3.5.2				46	92	No
3.5.1	3303850	80	18	18	53	4%	2					0	2	Yes
3.4	3400100	68	42	125	31	100%	31					0	31	Yes
3.4	3400500	56	42	176	31	5%	2					0	2	Yes
3.4	3400701	43	30	67	31	5%	2					0	1	Yes
3.4	3400702	42	30	68	31	5%	2					0	1	Yes
3.4	3400703	41	30	69	31	5%	2					0	1	Yes
3.4	3400900	373	72	626	31	98%	30	3.5.1	3.6.1			327	358	Yes
3.4	3401100	615	72	586	31	98%	30	3.5.1	3.6.1			327	358	Yes
3.4	3401300	558	72	603	31	90%	28	3.5.1	3.6.1			327	355	Yes
3.4	3401500	435	72	464	31	90%	28	3.5.1	3.6.1			327	355	Yes
3.4	3401700	441	72	732	31	80%	25	3.6.1				230	255	Yes
3.4	3401900	478	66	517	31	80%	25	3.6.1				230	255	Yes
3.4	3402100	6	24	310	31	80%	25					0	25	Yes
3.4	3402300	82	66	498	31	85%	26					0	26	Yes
3.4	3402500	93	18	41	31	5%	2					0	2	Yes
3.4	3402700	153	18	9	31	5%	2					0	2	Yes
3.4	3402800	59	18	15	31	5%	2					0	2	Yes
3.4	3402900	594	66	549	31	85%	26					0	26	Yes
3.7.1	3403100	681	60	527	31	10%	3	3.9	3.7.2			185	188	Yes
3.7.1	3403300	712	60	509	31	10%	3	3.9	3.7.2			185	188	Yes
3.7.1	3403500	701	54	469	31	8%	2	3.9	3.7.2			185	187	Yes
3.7.1	3403700	330	60	723	31	10%	3	3.9	3.7.2			185	188	Yes
3.4	3403901	42	24	38	31	10%	3					0	2	Yes
3.4	3403902	42	18	14	31	2%	1					0	0	Yes
3.6.1	3500100	60	72	625	97	97%	94	3.6.2	3.6.3	3.6.4	3.6.5	188	282	Yes
3.6.1	3500300	55	72	456	97	90%	87	3.6.2	3.6.3	3.6.4	3.6.5	188	275	Yes
3.6.1	3500500	46	72	435	97	97%	94	3.6.2	3.6.3	3.6.4	3.6.5	188	282	Yes
3.6.1	3500800	157	72	536	97	60%	58	3.6.3	3.6.4	3.6.5		85	143	Yes
3.6.1	3501000	158	72	1025	97	20%	19	3.6.3	3.6.4	3.6.5		85	104	Yes
3.6.1	3501200	190	18	12	97	3%	3					0	3	Yes
3.6.1	3501300	15	24	140	97	3%	3	3.6.2	3.6.3	3.6.4	3.6.5	188	191	No
3.6.2	3501400	248	48	121	48	95%	45	3.6.6				76	122	No
3.6.1	3501600	105	12	4	97	20%	1					0	1	Yes
3.6.2	3501800	274	48	129	48	50%	24	3.6.6				76	50	Yes
3.6.2	3502000	276	48	208	48	50%	24	3.6.6				76	50	Yes
3.6.2	3502200	61	48	156	48	50%	24	3.6.6				76	50	Yes
3.6.2	3502400	3	18	92	48	45%	21	3.6.6				76	49	Yes
3.6.2	3502600	285	42	190	48	45%	21	3.6.6				76	49	Yes
3.6.2	3502800	3	24	140	48	45%	21	3.6.6				76	49	Yes
3.6.2	3503000	88	24	37	48	30%	14	3.6.6				76	45	No
3.6.2	3503100	230	42	50	48	20%	10	3.6.6				76	43	Yes
3.6.2	3503300	276	42	164	48	25%	12	3.6.6				76	44	Yes
3.6.2	3503500	59	36	127	48	30%	14	3.6.6				76	91	Yes
3.6.6	3503700	19	36	222	13	100%	13	3.6.8				21	33	Yes
3.6.6	3503900	62	24	51	13	90%	11	3.6.8				21	32	Yes
3.6.6	3504000	47	24	58	13	90%	11	3.6.8				21	32	Yes
3.6.6	3504200	104	24	48	13	90%	11	3.6.8				21	32	Yes
3.6.6	3504400	37	24	61	13	90%	11	3.6.8				21	32	Yes
3.6.6	3504600	102	24	49	13	90%	11	3.6.8				21	32	Yes
3.6.6	3504800	26	24	45	13	80%	10	3.6.8				21	31	Yes
3.6.6	3505000	73	24	35	13	80%	10	3.6.8				21	31	Yes
3.6.6	3505200	32	24	51	13	80%	10	3.6.8				21	31	Yes

Analysis of Pipe Capacities: Existing Conditions, 20-Year Event

Basin	Pipe ID	Length (ft)	Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Meets Required Capacity
3.6.6	3505500	21	24	53	13	70%	9	3.6.8				21	30	Yes
3.6.8	3506400	23	24	51	21	100%	21					0	21	Yes
3.6.8	3506500	235	24	57	21	98%	20					0	20	Yes
3.6.8	3506601	154	24	55	21	10%	2					0	2	Yes
3.6.8	3506700	46	24	36	21	98%	20					0	20	Yes
3.6.8	3506900	170	24	26	21	95%	20					0	20	Yes
3.6.8	3507100	164	24	42	21	90%	19					0	19	Yes
3.6.8	3507300	173	24	37	21	90%	19					0	19	Yes
3.6.8	3507700	93	18	27	21	50%	10					0	10	Yes
3.6.8	3507800	79	18	32	21	90%	19					0	19	Yes
3.6.8	3507900	54	18	15	21	10%	2					0	2	Yes
3.6.8	3508100	25	18	32	21	10%	2					0	2	Yes
3.6.1	3508400	54	24	47	97	40%	39	3.6.4	3.6.3			61	100	No
3.6.1	3508600	76	24	48	97	30%	29	3.6.4	3.6.3			61	90	No
3.6.1	3508800	67	24	30	97	20%	19	3.6.4	3.6.3			61	80	No
3.6.1	3509000	47	24	35	97	10%	10	3.6.4	3.6.3			61	71	No
3.6.1	3509201	22	24	37	97	5%	5	3.6.4	3.6.3			61	66	No
3.6.1	3509202	22	24	37	97	5%	5	3.6.4	3.6.3			61	66	No
3.6.1	3509401	47	36	105	97	0%	0	3.6.4	3.6.3			61	20	Yes
3.6.1	3509402	47	36	105	97	0%	0	3.6.4	3.6.3			61	20	Yes
3.6.1	3509403	47	36	105	97	0%	0	3.6.4	3.6.3			61	20	Yes
3.6.2	3509600	185	24	22	48	40%	19	3.6.6				76	95	No
3.6.2	3509900	127	24	26	48	65%	31	3.6.6				76	54	No
3.6.2	3510100	56	24	23	48	45%	21					0	21	Yes
3.6.2	3510400	77	24	31	48	10%	5	3.6.6				76	81	No
3.6.2	3510600	53	24	36	48	15%	7	3.6.6				76	83	No
3.6.2	3510800	73	24	28	48	15%	7	3.6.6				76	83	No
3.6.6	3511101	124	24	53	13	10%	1					0	1	Yes
3.6.6	3511102	123	24	58	13	10%	1					0	1	Yes
3.6.9	3511300	243	18	22	52	100%	52					0	52	No
3.6.9	3511500	24	18	18	52	95%	49					0	49	No
3.6.9	3511700	68	18	19	52	90%	47					0	47	No
3.6.8	3511900	122	24	38	21	15%	3					0	3	Yes
3.6.8	3512100	58	24	32	21	25%	5					0	5	Yes
3.6.1	3512300	52	24	48	97	50%	48					0	48	No
3.6.1	3512500	66	24	42	97	40%	39					0	39	Yes
3.6.1	3512700	48	24	35	97	35%	34					0	34	Yes
3.6.1	3512900	50	24	34	97	30%	29					0	29	Yes
3.6.1	3513100	23	24	51	97	2%	2					0	2	Yes
3.6.4	3513300	152	36	82	10	65%	7	3.6.7				42	16	Yes
3.6.4	3513301	151	36	117	10	65%	7	3.6.7				42	16	Yes
3.6.4	3513302	151	36	117	10	65%	7	3.6.7				42	16	Yes
3.6.4	3513501	103	24	39	10	55%	6	3.6.7				42	24	Yes
3.6.4	3513502	102	24	38	10	55%	6	3.6.7				42	24	Yes
3.6.4	3513900	18	24	57	10	5%	1	3.6.7				42	43	Yes
3.6.7	3514200	50	24	46	30	50%	15	3.6.10				21	37	Yes
3.6.7	3514300	186	24	73	30	100%	30	3.6.10				21	52	Yes
3.6.7	3514500	122	24	73	30	95%	29	3.6.10				21	50	Yes
3.6.7	3514700	7	18	49	30	5%	2					0	2	Yes
3.6.7	3514800	122	24	72	30	90%	27	3.6.10				21	49	Yes
3.6.7	3515000	7	18	23	30	5%	2					0	2	Yes
3.6.7	3515100	122	24	74	30	85%	26	3.6.10				21	47	Yes
3.6.7	3515300	7	18	11	30	5%	2					0	2	Yes
3.6.7	3515401	723	24	67	30	15%	5	3.6.10				21	26	Yes
3.6.7	3515500	97	24	124	30	15%	5	3.6.10				21	26	Yes
3.6.7	3515700	189	24	121	30	10%	3	3.6.10				21	24	Yes
3.6.7	3515900	46	24	17	30	5%	2					0	2	Yes
3.6.7	3516100	86	24	17	30	5%	2					0	2	Yes
3.6.7	3516300	371	24	56	30	5%	2	3.6.10				21	23	Yes
3.6.7	3516500	38	24	73	30	5%	2					0	2	Yes
3.6.7	3516600	272	24	59	30	0%	0	3.6.10				21	21	Yes
3.6.10	3516800	56	24	20	21	2%	0					0	0	Yes
3.6.10	3517000	321	24	50	21	98%	21					0	21	Yes
3.6.10	3517200	43	24	55	21	3%	1					0	1	Yes
3.6.10	3517400	335	24	53	21	95%	20					0	20	Yes
3.6.10	3517600	226	24	52	21	95%	20					0	20	Yes
3.6.10	3517800	39	36	141	21	3%	1					0	1	Yes

Analysis of Pipe Capacities: Existing Conditions, 20-Year Event

Basin	Pipe ID	Length (ft)	Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Meets Required Capacity
3.6.10	3518000	20	36	227	21	3%	1					0	1	Yes
3.6.10	3518100	540	24	55	21	92%	20					0	20	Yes
3.6.10	3518300	38	36	116	21	20%	4					0	4	Yes
3.6.5	3518500	84	24	56	24	25%	6					0	6	Yes
3.6.5	3518501	60	24	12	24	20%	5					0	5	Yes
3.6.5	3518700	96	24	75	24	25%	6					0	6	Yes
3.6.5	3518900	39	24	128	24	10%	2					0	2	Yes
3.6.5	3519000	123	24	75	24	20%	5					0	5	Yes
3.6.5	3519200	225	24	92	24	15%	4					0	4	Yes
3.6.5	3519400	83	24	160	24	10%	2					0	2	Yes
3.6.5	3519600	44	24	119	24	10%	2					0	2	Yes
3.6.3	3520600	65	24	78	11	55%	6					0	6	Yes
3.6.3	3520800	71	24	89	11	30%	3					0	3	Yes
3.6.4	3521300	73	24	49	10	5%	1					0	1	Yes
3.6.7	3521500	55	24	57	30	15%	5					0	5	Yes
3.6.9	3521600	122	24	22	52	50%	26					0	26	No
2.3.1	3521700	38	24	28	27	5%	1					0	1	Yes
2.3.1	3521800	72	18	13	27	5%	1					0	1	Yes
3.6.6	3522000	21	30	96	13	10%	1					0	1	Yes
3.6.6	3522200	63	30	56	13	20%	3					0	3	Yes
3.6.6	3522400	22	30	93	13	20%	3					0	3	Yes
3.6.6	3522500	78	12	5	13	10%	1					0	1	Yes
3.6.6	3522501	47	12	6	13	10%	1					0	1	Yes
3.6.6	3522600	55	18	8	13	10%	1					0	1	Yes
3.6.6	3522800	276	18	14	13	20%	3					0	3	Yes
3.6.6	3523000	158	18	24	13	20%	3					0	3	Yes
3.6.6	3523200	166	18	26	13	20%	3					0	3	Yes
3.6.6	3523400	53	18	18	13	20%	3					0	3	Yes
3.6.6	3523600	119	18	21	13	20%	3					0	3	Yes
3.6.4	3524101	173	36	164	10	33%	3	3.6.7				42	46	Yes
3.6.4	3524102	173	36	164	10	33%	3	3.6.7				42	46	Yes
3.6.4	3524103	173	36	164	10	33%	3	3.6.7				42	46	Yes
3.6.4	3524301	199	36	144	10	90%	9	3.6.7				42	17	Yes
3.6.4	3524302	199	36	144	10	90%	9	3.6.7				42	17	Yes
3.6.4	3524303	199	36	144	10	90%	9	3.6.7				42	17	Yes
3.6.4	3524400	90	36	6753	10	40%	4	3.6.7				42	46	Yes
3.6.4	3524600	63	24	60	10	40%	4	3.6.7				42	46	Yes
3.6.4	3524900	188	24	59	10	5%	1					0	1	Yes
3.6.5	3525500	183	18	24	24	60%	14					0	14	Yes
3.6.5	3525700	86	36	145	24	60%	14					0	14	Yes
3.6.5	3526300	174	24	64	24	50%	12					0	12	Yes
3.6.5	3526500	5	24	109	24	50%	12					0	12	Yes
3.6.5	3526800	37	24	57	24	50%	12					0	12	Yes
3.6.5	3527000	133	24	42	24	40%	10					0	10	Yes
3.6.5	3527200	318	24	49	24	10%	2					0	2	Yes
3.6.5	3527400	73	24	46	24	30%	7					0	7	Yes
3.6.5	3527600	41	24	65	24	30%	7					0	7	Yes
3.8	3527800	88	36	132	34	40%	13					0	13	Yes
3.8	3528000	39	24	39	34	40%	13					0	13	Yes
3.8	3528200	202	18	29	34	5%	2					0	2	Yes
3.8	3528400	51	18	32	34	5%	2					0	2	Yes
3.6.8	3540100	70	24	96	21	5%	1					0	1	Yes
3.6.8	3540200	231	24	66	21	5%	1					0	1	Yes
3.6.8	3540300	225	24	86	21	5%	1					0	1	Yes
3.6.8	3540400	108	18	69	21	2%	0					0	0	Yes
3.6.8	3540500	183	18	65	21	2%	0					0	0	Yes
3.7.1	3600100	144	30	384	31	10%	3	3.9				19	23	Yes
3.7.1	3600300	166	30	59	31	8%	2	3.9				19	22	Yes
3.9	3600400	84	36	235	19	100%	19					0	19	Yes
3.9	3600600	73	24	40	19	98%	19					0	19	Yes
3.9	3600800	162	36	218	19	98%	19					0	19	Yes
3.9	3601000	89	36	108	19	95%	19					0	19	Yes
3.9	3601200	77	18	16	19	40%	8					0	8	Yes
3.9	3601300	65	24	67	19	15%	3					0	3	Yes
3.9	3601500	58	24	32	19	10%	2					0	2	Yes
3.9	3601600	44	18	17	19	5%	1					0	1	Yes
3.7.1	3700100	156	60	2374	31	10%	3	3.7.2				165	168	Yes

Analysis of Pipe Capacities: Existing Conditions, 20-Year Event

Basin	Pipe ID	Length (ft)	Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Meets Required Capacity
3.7.1	3700300	638	54	954	31	90%	28	3.7.2				165	193	Yes
3.7.1	3700500	612	54	557	31	70%	21	3.7.2				165	187	Yes
3.7.1	3700700	573	54	320	31	30%	9	3.7.2				165	174	Yes
3.7.1	3700900	106	72	577	31	30%	9	3.7.2				165	174	Yes
3.7.1	3701000	25	54	378	31	30%	9					0	9	Yes
3.7.1	3701100	41	72	900	31	30%	9	3.7.2				165	174	Yes
3.7.1	3701300	179	72	791	31	30%	9	3.7.2				165	174	Yes
3.7.1	3701500	396	72	702	31	10%	3	3.7.2				165	168	Yes
3.7.2	3701601	9	18	38	71	5%	4					0	4	Yes
3.7.2	3701700	20	72	322	71	99%	70	3.7.3				122	192	Yes
3.7.2	3701801	29	24	45	71	5%	4					0	4	Yes
3.7.2	3701803	3	24	99	71	2%	1					0	1	Yes
3.7.2	3701806	92	18	20	71	2%	1					0	1	Yes
3.7.2	3701901	21	72	358	71	99%	70	3.7.3				122	192	Yes
3.7.2	3702000	206	72	749	71	98%	69	3.7.3				122	191	Yes
3.7.2	3702200	55	72	614	71	98%	69	3.7.3				122	191	Yes
3.7.2	3702400	25	72	911	71	98%	69	3.7.3				122	191	Yes
3.7.2	3702600	94	72	665	71	98%	69	3.7.3				122	191	Yes
3.7.2	3702800	194	72	801	71	98%	69	3.7.3				122	191	Yes
3.7.2	3703000	147	72	376	71	98%	69	3.7.3				122	191	Yes
3.7.2	3703200	17	72	1563	71	98%	69	3.7.3				122	191	Yes
3.7.2	3703400	45	72	1358	71	75%	53	3.7.3				122	175	Yes
3.7.2	3703600	15	72	1176	71	50%	35	3.7.3				122	157	Yes
3.7.2	3703800	40	72	1441	71	50%	35	3.7.3				122	157	Yes
3.7.2	3704000	21	72	2109	71	45%	32	3.7.3				122	154	Yes
3.7.2	3704200	24	72	1315	71	45%	32	3.7.3				122	154	Yes
3.7.2	3704400	43	48	553	71	45%	32	3.7.3				122	154	Yes
3.7.2	3704500	294	42	264	71	40%	28	3.7.3				122	150	Yes
3.7.3	3704700	119	36	164	24	98%	23	3.7.4				105	129	Yes
3.7.3	3704900	286	36	159	24	90%	21	3.7.4				105	127	Yes
3.7.4	3705100	248	30	103	65	30%	20	3.7.4				105	125	No
3.7.6	3705500	84	24	38	26	98%	26					0	26	Yes
3.7.6	3705700	56	24	65	26	95%	25					0	25	Yes
3.7.6	3705900	430	24	49	26	85%	22					0	22	Yes
3.7.6	3706100	195	24	44	26	80%	21					0	21	Yes
3.7.6	3706300	83	24	27	26	75%	20					0	20	Yes
3.7.6	3706500	329	24	81	26	85%	22	3.7.3				122	144	No
3.7.1	3706600	112	30	66	31	10%	3					0	3	Yes
3.7.2	3706700	33	24	42	71	10%	7					0	7	Yes
3.7.2	3706900	37	24	49	71	5%	4					0	4	Yes
3.7.4	3707100	35	24	41	65	5%	3					0	3	Yes
3.7.2	3707300	11	24	52	71	3%	2					0	2	Yes
3.7.2	3707500	38	24	56	71	15%	11					0	11	Yes
3.7.2	3707700	15	24	89	71	5%	4					0	4	Yes
3.7.2	3707900	40	24	67	71	15%	11					0	11	Yes
3.7.2	3708000	41	24	66	71	15%	11					0	11	Yes
3.7.2	3708100	23	24	62	71	15%	11					0	11	Yes
3.7.2	3708300	30	24	54	71	15%	11					0	11	Yes
3.7.2	3708500	10	24	131	71	45%	32	3.7.3				122	154	No
3.7.2	3708700	24	24	50	71	25%	18					0	18	Yes
3.7.2	3708900	14	24	65	71	25%	18					0	18	Yes
3.7.5	3709400	149	18	23	22	98%	22					0	22	Yes
3.7.5	3709600	106	18	9	22	60%	13					0	13	No
3.7.5	3709800	137	18	10	22	60%	13					0	13	No
3.7.4	3710100	61	24	27	65	30%	20	3.7.5				22	42	No
3.7.4	3710300	46	18	17	65	30%	20	3.7.5				22	42	No
3.7.7	3710500	196	24	135	20	95%	19					0	19	Yes
3.7.7	3710700	64	24	61	20	90%	18					0	18	Yes
2.1	4000300	75	36	203	28	1%	0					0	0	Yes

APPENDIX F

Analysis of Pipe Capacities:
Existing Conditions, 100-Year Event

Analysis of Pipe Capacities: Existing Conditions, 100-Year Event

Basin	Pipe ID	Length (ft)	Section Size (in)	Calc. Pipe Capacity	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Street Capacity (cft/s)	Total Capacity	Pipe Meets Required Capacity
3.3.1	3201200	546	30	80	69	98%	68	3.3.2				122	189	101.5	182	No
3.5.2	3303800	104	24	24	76	98%	75	3.5.2				76	151	94.8	119	No
3.4	3401500	435	72	464	58	90%	52	3.5.1	3.6.1			574	626	85.6	549	No
3.4	3401900	478	66	517	58	80%	47	3.6.1				416	463	85.6	603	Yes
3.7.1	3403500	701	54	469	57	8%	5	3.9	3.7.2			340	345	112.7	582	Yes
3.6.7	3514200	50	24	46	55	100%	55	3.6.1				416	471	177.8	224	No
3.7.1	3700700	573	54	320	57	30%	17	3.7.2				304	321	112.3	432	Yes
3.7.1	3701000	25	54	378	57	30%	17	3.7.2				304	321	112.3	491	Yes
3.7.2	3703200	17	72	0	126	98%	124	3.7.3				225	349	139.8	140	No
3.7.2	3704200	24	72	0	126	45%	57	3.7.3				225	282	139.8	140	No
3.7.3	3704700	119	36	164	44	98%	43	3.7.4				195	238	139.8	304	Yes
3.7.3	3704900	286	36	159	44	90%	39	3.7.4				195	234	139.8	299	Yes
3.7.4	3705100	248	30	103	119	30%	36	3.7.4				195	231	139.8	243	Yes
2.3.1	2306200	122	30	129	50	65%	32					0	32	162.9	291	Yes
2.3.1	2306400	86	30	69	50	65%	32					0	32	162.9	232	Yes
2.3.1	2306600	211	30	98	50	65%	32					0	32	162.9	260	Yes
2.3.1	2306800	124	30	146	50	35%	17					0	17	162.9	309	Yes
2.3.1	2307100	77	30	123	50	35%	17					0	17	162.9	286	Yes
2.3.1	2307200	14	30	83	50	35%	17					0	17	162.9	246	Yes
2.3.1	2307300	100	24	50	50	35%	17					0	17	162.9	213	Yes
2.3.1	2307500	436	24	51	50	35%	17					0	17	162.9	214	Yes
2.3.1	2309302	41	18	0	50	1%	0					0	0	155.9	156	Yes
2.5.3	2309303	632	36	178	45	0%	0					0	0	155.9	334	Yes
3.1	3200800	261	36	148	48	98%	47	3.3.2				122	169	114.7	263	Yes
3.3.1	3201000	384	36	162	69	98%	68	3.3.2				122	189	114.7	277	Yes
3.3.2	3201600	384	30	53	53	70%	37	3.3.4				68	106	101.5	154	Yes
3.3.2	3201800	335	30	66	53	60%	32	3.3.4				68	100	101.5	168	Yes
3.3.2	3202000	602	30	58	53	30%	16	3.3.4				68	84	101.5	159	Yes
3.5.1	3301600	260	36	161	86	85%	73	3.5.2				76	150	94.8	256	Yes
3.5.1	3301800	210	36	131	86	80%	69	3.5.2				76	145	94.8	226	Yes
3.5.1	3302000	34	36	123	86	80%	69	3.5.2				76	145	94.8	218	Yes
3.5.1	3302200	244	36	92	86	80%	69	3.5.2				76	145	94.8	187	Yes
3.5.1	3302400	39	36	115	86	70%	60	3.5.2				76	137	94.8	210	Yes
3.5.1	3302600	156	36	70	86	40%	35					0	35	94.8	165	Yes
3.5.1	3302800	70	36	121	86	40%	35					0	35	94.8	216	Yes
3.5.1	3303000	66	36	125	86	40%	35					0	35	94.8	220	Yes
3.5.1	3303200	120	24	22	86	40%	35					0	35	94.8	117	Yes
3.5.1	3303400	331	24	25	86	15%	13	3.5.2				76	89	94.8	120	Yes
3.5.1	3303600	319	24	19	86	10%	9	3.5.2				76	85	94.8	114	Yes
3.4	3401700	441	72	732	58	80%	47	3.6.1				416	463	85.6	818	Yes
3.4	3402300	82	66	498	58	85%	49					0	49	85.6	584	Yes
3.4	3402900	594	66	549	58	85%	49					0	49	85.6	635	Yes
3.7.1	3403100	681	60	527	57	10%	6	3.9	3.7.2			340	346	112.7	640	Yes
3.7.1	3403300	712	60	509	57	10%	6	3.9	3.7.2			340	346	112.7	622	Yes
3.7.1	3403700	330	60	723	57	10%	6	3.9	3.7.2			340	346	112.7	836	Yes
3.6.2	3502200	61	48	156	80	50%	40	3.6.6				150	95	67.6	223	Yes
3.6.2	3502600	285	42	190	80	45%	36	3.6.6				150	93	67.6	257	Yes
3.6.2	3503100	230	42	50	80	20%	16	3.6.6				150	83	67.6	118	Yes
3.6.2	3503300	276	42	164	80	25%	20	3.6.6				150	85	67.6	231	Yes
3.6.9	3511300	243	18	22	103	100%	103					0	103	115.4	137	Yes
3.6.9	3511500	24	18	18	103	95%	98					0	98	115.4	133	Yes
3.6.9	3511700	68	18	19	103	90%	93					0	93	115.4	135	Yes
3.6.7	3514300	186	24	73	55	100%	55	3.6.10				40	95	177.8	251	Yes
3.6.7	3514500	122	24	73	55	95%	52	3.6.10				40	92	177.8	251	Yes
3.6.7	3514800	122	24	72	55	95%	52	3.6.10				40	92	177.8	250	Yes
3.6.7	3515100	122	24	74	55	95%	52	3.6.10				40	92	177.8	252	Yes
3.6.7	3515401	723	24	67	55	15%	8	3.6.10				40	48	177.8	245	Yes
3.6.7	3516300	371	24	56	55	5%	3	3.6.10				40	43	123.3	180	Yes
3.6.7	3516600	272	24	59	55	0%	0	3.6.10				40	40	123.3	183	Yes
3.6.10	3517000	321	24	50	40	98%	39					0	39	123.3	173	Yes
3.6.10	3517400	335	24	53	40	95%	38					0	38	123.3	176	Yes
3.6.10	3517600	226	24	52	40	95%	38					0	38	123.3	175	Yes
3.6.10	3518100	540	24	55	40	92%	37					0	37	123.3	179	Yes
3.7.1	3700300	638	54	954	57	90%	51	3.7.2				304	355	118.2	1,072	Yes
3.7.1	3700500	612	54	557	57	70%	40	3.7.2				304	344	183	740	Yes
3.7.1	3700900	106	72	577	57	30%	17	3.7.2				304	321	112.3	689	Yes
3.7.2	3702200	55	72	614	126	98%	124	3.7.3				225	349	139.8	754	Yes

Analysis of Pipe Capacities: Existing Conditions, 100-Year Event

Basin	Pipe ID	Length (ft)	Section Size (in)	Calc. Pipe Capacity	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Street Capacity (cft/s)	Total Capacity	Pipe Meets Required Capacity
3.7.2	3702400	25	72	911	126	98%	124	3.7.3				225	349	139.8	1,051	Yes
3.7.2	3702600	94	72	665	126	98%	124	3.7.3				225	349	139.8	804	Yes
3.7.2	3702800	194	72	801	126	98%	124	3.7.3				225	349	139.8	941	Yes
3.7.2	3703000	147	72	376	126	98%	124	3.7.3				225	349	139.8	516	Yes
3.7.2	3703400	45	72	1,358	126	75%	95	3.7.3				225	320	139.8	1,498	Yes
3.7.2	3703600	15	72	1,176	126	50%	63	3.7.3				225	288	139.8	1,316	Yes
3.7.2	3703800	40	72	1,441	126	50%	63	3.7.3				225	288	139.8	1,580	Yes
3.7.2	3704000	21	72	2,109	126	45%	57	3.7.3				225	282	139.8	2,249	Yes
3.7.2	3704400	43	48	553	126	45%	57	3.7.3				225	282	139.8	692	Yes
3.7.2	3704500	294	42	264	126	40%	51	3.7.3				225	276	139.8	404	Yes
3.7.6	3705500	84	24	38	49	98%	48					0	48	117.8	155	Yes
3.7.6	3705700	56	24	65	49	95%	47					0	47	117.8	183	Yes
3.7.6	3705900	430	24	49	49	85%	42					0	42	117.8	167	Yes
3.7.6	3706100	195	24	44	49	80%	39					0	39	117.8	162	Yes
2.3.1	3706300	83	24	27	50	75%	37					0	37	117.8	145	Yes

APPENDIX G

Analysis of Pipe Capacities:
Future Conditions, 20-Year Event, w/o Detention Basins

Pipeline Improvements Required: 20-Year Event, without Detention Basins

Basin	Pipe ID	Length (ft)	Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Meets Required Capacity	Replacement Size	New Capacity	20-Yr Parallel Size	Replacement Pipe Cost	Parallel Pipe Cost
2.2.1	2200202	320	36	69	35	90%	32	2.2.3				46	78	No	42	105	18	$ 81,920.00	$ 48,960.00
2.2.1	2200300	735	36	25	35	40%	14	2.2.3				46	60	No	54	74	42	$ 337,365.00	$ 188,160.00
2.2.3	2200900	138	18	17	46	100%	46					0	46	No	30	66	24	$ 26,772.00	$ 23,598.00
2.2.1	2201100	251	18	12	35	40%	14					0	14	No	24	27	18	$ 42,921.00	$ 38,403.00
2.2.1	2206000	86	18	13	35	100%	35					0	35	No	30	52	24	$ 16,684.00	$ 14,706.00
3.3.1	3200401	142	36	52	67	100%	67	3.3.3	3.3.2			140	104	No	48	112	42	$ 54,102.00	$ 36,352.00
3.3.1	3200402	143	36	52	67	100%	67	3.3.3	3.3.2			140	104	No	48	111	42	$ 54,483.00	$ 36,608.00
3.3.1	3201200	546	30	80	67	98%	66	3.3.2				78	143	No	42	197	30	$ 139,776.00	$ 105,924.00
3.3.2	3201600	384	30	53	32	70%	22	3.3.4				46	68	No	36	86	24	$ 86,784.00	$ 65,664.00
3.3.4	3203201	91	24	18	46	95%	43					0	22	No	30	33	18	$ 17,654.00	$ 13,923.00
3.3.4	3203202	94	24	21	46	95%	43					0	22	No	30	38	18	$ 18,236.00	$ 14,382.00
3.3.3	3203900	86	24	49	62	80%	50					0	50	No	30	89	18	$ 16,684.00	$ 13,158.00
3.3.3	3204100	106	24	24	62	80%	50					0	50	No	36	71	30	$ 23,956.00	$ 20,564.00
3.3.4	3204600	62	18	11	46	90%	41					0	41	No	30	44	30	$ 12,028.00	$ 12,028.00
3.3.4	3204800	46	18	13	46	90%	41					0	41	No	36	82	24	$ 10,396.00	$ 7,866.00
3.3.1	3205400	48	24	35	67	60%	40	3.3.3				62	103	No	36	104	36	$ 10,848.00	$ 10,848.00
3.3.1	3205600	81	24	54	67	40%	27	3.3.3				62	89	No	30	98	24	$ 15,714.00	$ 13,851.00
3.3.1	3206200	107	24	24	67	35%	24	3.3.3				62	86	No	42	105	36	$ 27,392.00	$ 24,182.00
3.3.1	3206600	83	24	19	67	25%	17	3.3.3				62	79	No	42	84	42	$ 21,248.00	$ 21,248.00
3.3.1	3206900	62	24	41	67	15%	10	3.3.3				62	72	No	30	75	24	$ 12,028.00	$ 10,602.00
3.3.1	3207200	12	18	45	67	15%	10	3.3.3				62	72	No	24	97	18	$ 2,052.00	$ 1,836.00
3.3.3	3207500	90	12	4	62	10%	6					0	6	No	18	11	18	$ 13,770.00	$ 13,770.00
3.3.3	3207700	36	12	4	62	10%	6					0	6	No	18	12	18	$ 5,508.00	$ 5,508.00
3.5.1	3303400	331	24	25	53	15%	8	3.5.2				46	54	No	36	74	30	$ 74,806.00	$ 64,214.00
3.5.1	3303600	319	24	19	53	10%	5	3.5.2				46	52	No	36	57	30	$ 72,094.00	$ 61,886.00
3.5.2	3303800	104	24	24	46	98%	45	3.5.2				46	92	No	42	106	36	$ 26,624.00	$ 23,504.00
3.4	3400100	68	42	125	31	0%	0	3.4				457	457	No	72	524	60	$ 40,732.00	$ 33,932.00
3.6.1	3501300	15	24	140	97	3%	3	3.6.2	3.6.3	3.6.4	3.6.5	188	191	No	36	414	24	$ 3,390.00	$ 2,565.00
3.6.2	3501400	248	48	121	48	95%	45	3.6.6				76	122	No	54	165	24	$ 113,832.00	$ 42,408.00
3.6.2	3503000	88	24	37	48	30%	14	3.6.6				76	45	No	30	67	18	$ 17,072.00	$ 13,464.00
3.6.1	3508400	54	24	47	97	40%	39	3.6.4	3.6.3			61	100	No	36	138	30	$ 12,204.00	$ 10,476.00
3.6.1	3508600	76	24	48	97	30%	29	3.6.4	3.6.3			61	90	No	36	143	30	$ 17,176.00	$ 14,744.00
3.6.1	3508800	67	24	30	97	20%	19	3.6.4	3.6.3			61	80	No	36	88	30	$ 15,142.00	$ 12,998.00
3.6.1	3509000	47	24	35	97	10%	10	3.6.4	3.6.3			61	71	No	36	105	30	$ 10,622.00	$ 9,118.00
3.6.1	3509201	22	24	37	97	5%	5	3.6.4	3.6.3			61	66	No	30	67	30	$ 4,268.00	$ 4,268.00
3.6.1	3509202	22	24	37	97	5%	5	3.6.4	3.6.3			61	66	No	30	67	24	$ 4,268.00	$ 3,762.00
3.6.2	3509600	185	24	22	48	40%	19	3.6.6				76	95	No	42	97	36	$ 47,360.00	$ 41,810.00
3.6.2	3509900	127	24	26	48	65%	31	3.6.6				76	54	No	36	78	30	$ 28,702.00	$ 24,638.00
3.6.2	3510400	77	24	31	48	10%	5	3.6.6				76	81	No	36	90	30	$ 17,402.00	$ 14,938.00
3.6.2	3510600	53	24	36	48	15%	7	3.6.6				76	83	No	36	107	30	$ 11,978.00	$ 10,282.00
3.6.2	3510800	73	24	28	48	15%	7	3.6.6				76	83	No	36	84	30	$ 16,498.00	$ 14,162.00
3.6.9	3511300	243	18	22	52	100%	52					0	52	No	30	85	24	$ 47,142.00	$ 41,553.00
3.6.9	3511500	24	18	18	52	95%	49					0	49	No	30	70	24	$ 4,656.00	$ 4,104.00

Pipeline Improvements Required: 20-Year Event, without Detention Basins

Basin	Pipe ID	Length (ft)	Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Meets Required Capacity	Replacement Size	New Capacity	20-Yr Parallel Size	Replacement Pipe Cost	Parallel Pipe Cost
3.6.9	3511700	68	18	19	52	90%	47					0	47	No	30	75	24	$ 13,192.00	$ 11,628.00
3.6.1	3512300	52	24	48	97	50%	48					0	48	No	30	87	18	$ 10,088.00	$ 7,956.00
3.6.9	3521600	122	24	22	52	50%	26					0	26	No	30	40	18	$ 23,668.00	$ 18,666.00
3.7.4	3705100	248	30	103	65	30%	20	3.7.4				105	125	No	36	167	18	$ 56,048.00	$ 37,944.00
3.7.6	3706500	329	24	81	26	85%	22	3.7.3				122	144	No	30	148	24	$ 63,826.00	$ 56,259.00
3.7.2	3708500	10	24	131	71	45%	32	3.7.3				122	154	No	30	238	24	$ 1,940.00	$ 1,710.00
3.7.5	3709600	106	18	9	22	60%	13					0	13	No	24	19	18	$ 18,126.00	$ 16,218.00
3.7.5	3709800	137	18	10	22	60%	13					0	13	No	24	22	18	$ 23,427.00	$ 20,961.00
3.7.4	3710100	61	24	27	65	30%	20	3.7.5				22	42	No	30	48	24	$ 11,834.00	$ 10,431.00
3.7.4	3710300	46	18	17	65	30%	20	3.7.5				22	42	No	30	65	30	$ 8,924.00	$ 8,924.00
																	Total	$ 1,865,362.00	$ 1,381,664.00

APPENDIX H

Analysis of Pipe Capacities:
Future Conditions, 100-Year Event, w/o Detention Basins

Pipeline Improvements Required: 100-Year Event, without Detention Basins

Basin	Pipe ID	Length (ft)	Section Size (in)	Calc. Pipe Capacity	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Street Capacity (cft/s)	Total Capacity	Pipe Meets Required Capacity	Replacement Size	Parallel Size	Replacement Pipe Cost	Parallel Pipe Cost
3.3.1	3201200	546	30	80	111	98%	108	3.3.2				129	238	101.5	182	No	42	30	$ 139,776.00	$ 105,924.00
3.5.2	3303800	104	24	24	76	98%	75	3.5.2				76	151	94.8	119	No	36	30	$ 23,504.00	$ 20,176.00
3.4	3401500	435	72	464	58	90%	52	3.5.1	3.6.1			574	626	85.6	549	No	84	60	$ 313,635.00	$ 217,065.00
																		Total	$ 476,915.00	$ 343,165.00

APPENDIX I

Pipeline Improvements Required:
20-Year Event, with Detention Basin A

Pipeline Improvements Required: 20-Year Event, with Detention Basin A

Basin	Pipe ID	Length (ft)	Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Meets Required Capacity	Replacement Size	Parallel Size	New Capacity	Replacement Pipe Cost	Parallel Pipe Cost
2.2.1	2200300	735	36	25	35	40%	14	2.2.3				46	60	No	54	42	38	$ 337,365.00	$ 188,160.00
2.2.3	2200900	138	18	17	46	100%	46					0	46	No	30	24	36	$ 26,772.00	$ 23,598.00
2.2.1	2201100	251	18	12	35	40%	14					0	14	No	24	18	12	$ 42,921.00	$ 38,403.00
2.2.1	2206000	86	18	13	35	100%	35					0	35	No	30	24	29	$ 16,684.00	$ 14,706.00
3.3.1	3200401	142	36	52	67	100%	67	3.3.3	3.3.2			140	104	No	48	36	52	$ 54,102.00	$ 32,092.00
3.3.1	3200402	143	36	52	67	100%	67	3.3.3	3.3.2			140	104	No	48	36	52	$ 54,483.00	$ 32,318.00
3.3.1	3201200	546	30	80	67	98%	66	3.3.2				78	143	No	42	30	80	$ 139,776.00	$ 105,924.00
3.3.2	3201600	384	30	53	32	70%	22	3.3.4				46	68	No	36	24	29	$ 86,784.00	$ 65,664.00
3.3.4	3203201	91	24	18	46	95%	43					0	22	No	30	18	8	$ 17,654.00	$ 13,923.00
3.3.4	3203202	94	24	21	46	95%	43					0	22	No	30	18	10	$ 18,236.00	$ 14,382.00
3.3.3	3203900	86	24	49	62	80%	50					0	50	No	30	18	23	$ 16,684.00	$ 13,158.00
3.3.3	3204100	106	24	24	62	80%	50					0	50	No	36	30	44	$ 23,956.00	$ 20,564.00
3.3.4	3204600	62	18	11	46	90%	41					0	41	No	30	30	44	$ 12,028.00	$ 12,028.00
3.3.4	3204800	46	18	13	46	90%	41					0	41	No	30	24	28	$ 8,924.00	$ 7,866.00
3.3.1	3205400	48	24	35	67	60%	40	3.3.3				62	103	No	36	36	104	$ 10,848.00	$ 10,848.00
3.3.1	3205600	81	24	54	67	40%	27	3.3.3				62	89	No	30	24	54	$ 15,714.00	$ 13,851.00
3.3.1	3206200	107	24	24	67	35%	24	3.3.3				62	86	No	42	36	69	$ 27,392.00	$ 24,182.00
3.3.1	3206600	83	24	19	67	25%	17	3.3.3				62	79	No	42	42	84	$ 21,248.00	$ 21,248.00
3.3.1	3206900	62	24	41	67	15%	10	3.3.3				62	72	No	30	24	41	$ 12,028.00	$ 10,602.00
3.3.1	3207200	12	18	45	67	15%	10	3.3.3				62	72	No	24	18	45	$ 2,052.00	$ 1,836.00
3.3.3	3207500	90	12	4	62	10%	6					0	6	No	18	18	11	$ 13,770.00	$ 13,770.00
3.3.3	3207700	36	12	4	62	10%	6					0	6	No	18	18	12	$ 5,508.00	$ 5,508.00
3.5.1	3303400	331	24	25	53	15%	8	3.5.2				46	54	No	36	30	45	$ 74,806.00	$ 64,214.00
3.5.1	3303600	319	24	19	53	10%	5	3.5.2				46	52	No	36	30	35	$ 72,094.00	$ 61,886.00
3.5.2	3303800	104	24	24	46	98%	45	3.5.2				46	92	No	42	36	70	$ 26,624.00	$ 23,504.00
3.6.1	3501300	15	24	140	97	3%	3	3.6.2	3.6.3	3.6.4	3.6.5	188	191	No	30	24	140	$ 2,910.00	$ 2,565.00
3.6.2	3501400	248	48	121	48	95%	45	3.6.6				76	122	No	54	24	19	$ 113,832.00	$ 42,408.00
3.6.2	3503000	88	24	37	48	30%	14	3.6.6				76	45	No	30	18	17	$ 17,072.00	$ 13,464.00
3.6.1	3508400	54	24	47	97	40%	39	3.6.4	3.6.3			61	100	No	36	30	85	$ 12,204.00	$ 10,476.00
3.6.1	3508600	76	24	48	97	30%	29	3.6.4	3.6.3			61	90	No	36	30	88	$ 17,176.00	$ 14,744.00
3.6.1	3508800	67	24	30	97	20%	19	3.6.4	3.6.3			61	80	No	36	30	54	$ 15,142.00	$ 12,998.00
3.6.1	3509000	47	24	35	97	10%	10	3.6.4	3.6.3			61	71	No	36	30	64	$ 10,622.00	$ 9,118.00
3.6.1	3509201	22	24	37	97	5%	5	3.6.4	3.6.3			61	66	No	30	24	37	$ 4,268.00	$ 3,762.00
3.6.1	3509202	22	24	37	97	5%	5	3.6.4	3.6.3			61	66	No	30	24	37	$ 4,268.00	$ 3,762.00
3.6.2	3509600	185	24	22	48	40%	19	3.6.6				76	95	No	42	42	97	$ 47,360.00	$ 47,360.00
3.6.2	3509900	127	24	26	48	65%	31	3.6.6				76	54	No	36	30	48	$ 28,702.00	$ 24,638.00
3.6.2	3510400	77	24	31	48	10%	5	3.6.6				76	81	No	36	30	56	$ 17,402.00	$ 14,938.00
3.6.2	3510600	53	24	36	48	15%	7	3.6.6				76	83	No	36	30	66	$ 11,978.00	$ 10,282.00
3.6.2	3510800	73	24	28	48	15%	7	3.6.6				76	83	No	36	30	52	$ 16,498.00	$ 14,162.00
3.6.9	3511300	243	18	22	52	100%	52					0	52	No	30	24	47	$ 47,142.00	$ 41,553.00
3.6.9	3511500	24	18	18	52	95%	49					0	49	No	30	24	38	$ 4,656.00	$ 4,104.00

Pipeline Improvements Required: 20-Year Event, with Detention Basin A

Basin	Pipe ID	Length (ft)	Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Meets Required Capacity	Replacement Size	Parallel Size	New Capacity	Replacement Pipe Cost	Parallel Pipe Cost
3.6.9	3511700	68	18	19	52	90%	47					0	47	No	30	24	41	$ 13,192.00	$ 11,628.00
3.6.1	3512300	52	24	48	97	50%	48					0	48	No	30	18	22	$ 10,088.00	$ 7,956.00
3.6.9	3521600	122	24	22	52	50%	26					0	26	No	30	18	10	$ 23,668.00	$ 18,666.00
3.7.4	3710300	46	18	17	65	30%	20	3.7.5				0	20	No	24	18	17	$ 7,866.00	$ 7,038.00
																	Total	$ 1,564,499.00	$ 1,149,857.00

APPENDIX J

Pipeline Improvements Required:
100-Year Event, with Detention Basin A

Pipeline Improvements Required: 100-Year Event, with Detention Basin A

Basin	Pipe ID	Length (ft)	Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Street Capacity (cft/s)	Total Capacity	Pipe Meets Required Capacity	Replacement Size	Parallel Size	New Capacity	Replacement Pipe Cost	Parallel Pipe Cost
3.3.1	3201200	546	30	80	111	98%	108	3.3.2				129	238	101.5	182	No	42	30	80	$ 139,776.00	$ 105,924.00
3.5.2	3303800	104	24	24	76	98%	75	3.5.2				76	151	94.8	119	No	36	30	43	$ 23,504.00	$ 20,176.00
3.4	3401500	435	72	464	58	90%	52	3.5.1	3.6.1			574	626	85.6	549	No	84	60	285	$ 313,635.00	$ 217,065.00
																			Total	$ 476,915.00	$ 343,165.00

APPENDIX K

Pipeline Improvements Required:
20-Year Event, without Detention Basins

Pipeline Improvements Required: 20-Year Event, without Detention Basins

Basin	Pipe ID	Length (ft)	20-YR Section Size (in)	100-YR Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Cost
3.9	1	245	18	18	24	20	30%	6					0	6	$ 37,485.00
3.9	2	385	18	18	24	20	45%	9					0	9	$ 58,905.00
3.9	3	105	18	18	22	20	60%	12					0	12	$ 16,065.00
3.9	4	105	18	18	22	20	60%	12					0	12	$ 16,065.00
3.9	5	980	18	18	14	20	65%	13					0	13	$ 149,940.00
3.9	6	840	18	18	31	20	98%	20					0	20	$ 128,520.00
3.7.1	7	245	24	0	96	31	10%	3	3.8				53	56	$ 41,895.00
3.7.1	8	140	30	0	91	31	10%	3	3.8				53	56	$ 27,160.00
3.7.1	9	280	30	0	91	31	15%	5	3.8				53	58	$ 54,320.00
3.7.7	10	330	24	18	70	22	98%	22	3.7.6				38	60	$ 56,430.00
3.7.4	11	735	24	18	53	67	10%	7	3.7.6				38	45	$ 125,685.00
3.7.4	12	140	24	18	82	67	10%	7	3.7.7				61	67	$ 23,940.00
3.7.4	13	140	30	18	105	67	15%	10	3.7.7				61	71	$ 27,160.00
3.7.4	14	455	30	18	109	67	15%	10	3.7.7				61	71	$ 88,270.00
3.7.4	15	210	42	36	183	67	98%	66	3.7.7				61	126	$ 53,760.00
3.7.4	16	280	36	30	149	67	100%	67	3.7.7				61	128	$ 63,280.00
3.7.6	17	700	24	0	52	38	0%	0	3.7.5				25	25	$ 119,700.00
3.7.2	18	1855	18	18	32	71	10%	7					0	7	$ 283,815.00
3.7.2	19	385	18	18	25	71	15%	11					0	11	$ 58,905.00
3.7.2	20	210	18	0	37	71	20%	14					0	14	$ 32,130.00
3.5.1	21	315	36	30	140	53	0%	0	3.6.6				87	87	$ 71,190.00
3.5.1	22	4200	36	42	110	53	40%	21	3.6.6				87	108	100-Yr Pipe
3.5.1	23	665	36	42	129	53	60%	32	3.6.6				87	119	100-Yr Pipe
3.4	24	1400	18	18	28	45	40%	18					0	18	$ 214,200.00
3.4	25	140	18	18	19	45	40%	18					0	18	$ 21,420.00
3.4	26	930	24	18	42	45	60%	27					0	27	$ 159,030.00
3.4	27	280	24	18	63	45	80%	36					0	36	$ 47,880.00
3.4	28	108	24	18	47	45	80%	36					0	36	$ 18,468.00
3.4	29	140	30	18	65	45	85%	38					0	38	$ 27,160.00
3.4	30	420	24	18	41	45	85%	38					0	38	$ 71,820.00
3.7.2	31	440	18	18	25	71	10%	7					0	7	$ 67,320.00
3.8	32	775	36	36	115	53	100%	53					0	53	$ 175,150.00
3.6.10	33	1540	24	24											$ 263,340.00
3.6.10	34	1235	18	18											$ 188,955.00
3.6.10	35	840	18	18											$ 128,520.00
3.6.10	36	1410	18	18											$ 215,730.00
														Total	$ 3,133,613.00

APPENDIX L

Pipeline Improvements Required:
100-Year Event, without Detention Basins

Pipeline Improvements Required: 100-Year Event, without Detention Basins

Basin	Pipe ID	Length (ft)	20-YR Section Size (in)	100-YR Section Size (in)	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Street Capacity (cft/s)	Total Capacity	Pipe Cost
3.9	1	245	18	18	24	38	30%	11					0	11	104	128	20-Yr Pipe
3.9	2	385	18	18	24	38	45%	17					0	17	104	128	20-Yr Pipe
3.9	3	105	18	18	22	38	60%	23					0	23	104	126	20-Yr Pipe
3.9	4	105	18	18	22	38	60%	23					0	23	104	126	20-Yr Pipe
3.9	5	980	18	18	14	38	65%	24					0	24	104	117	20-Yr Pipe
3.9	6	840	18	18	31	38	98%	37					0	37	159	190	20-Yr Pipe
3.7.7	10	330	24	18	32	42	98%	41	3.7.6				71	112	147	179	20-Yr Pipe
3.7.4	11	735	24	18	25	122	10%	12	3.7.6				71	84	147	172	20-Yr Pipe
3.7.4	12	140	24	18	38	122	10%	12	3.7.7				113	125	147	185	20-Yr Pipe
3.7.4	13	140	30	18	27	122	15%	18	3.7.7				113	131	147	174	20-Yr Pipe
3.7.4	14	455	30	18	28	122	15%	18	3.7.7				113	131	147	175	20-Yr Pipe
3.7.4	15	210	42	36	121	122	98%	120	3.7.7				113	233	147	268	20-Yr Pipe
3.7.4	16	280	36	30	91	122	100%	122	3.7.7				113	235	147	238	20-Yr Pipe
3.7.2	18	1855	18	18	32	126	10%	13					0	13	167	199	20-Yr Pipe
3.7.2	19	385	18	18	25	126	15%	19					0	19	167	192	20-Yr Pipe
3.5.1	21	315	36	30	86	86	0%	0	3.6.6				171	171	90	176	20-Yr Pipe
3.5.1	22	4200	36	42	165	86	40%	35	3.6.6				171	205	90	255	$ 1,075,200.00
3.5.1	23	665	36	42	195	86	60%	52	3.6.6				171	222	90	284	$ 170,240.00
3.4	24	1400	18	18	28	84	40%	34					0	34	143	172	20-Yr Pipe
3.4	25	140	18	18	19	84	40%	34					0	34	134	153	20-Yr Pipe
3.4	26	930	24	18	20	84	60%	51					0	51	134	154	20-Yr Pipe
3.4	27	280	24	18	29	84	80%	67					0	67	134	163	20-Yr Pipe
3.4	28	108	24	18	22	84	80%	67					0	67	134	156	20-Yr Pipe
3.4	29	140	30	18	17	84	85%	72					0	72	134	151	20-Yr Pipe
3.4	30	420	24	18	19	84	85%	72					0	72	134	153	20-Yr Pipe
3.7.2	31	440	18	18	25	126	10%	13					0	13	167	192	20-Yr Pipe
3.8	32	775	36	36	115	100	100%	100					0	100	90	205	20-Yr Pipe
3.6.10	33	1540	24	24													20-Yr Pipe
3.6.10	34	1235	18	18													20-Yr Pipe
3.6.10	35	840	18	18													20-Yr Pipe
3.6.10	36	1410	18	18													20-Yr Pipe
																Total	$ 1,245,440.00

APPENDIX M

Opinions of Cost:

- Unit Costs for Pipelines
- Unit Costs for Curb and Gutter
- Detention Basin A

Planning Level unit costs for Mammoth Lakes Storm Drain Improvements

Last update 1/11/2004

* Assume 1,000 foot long project
* Assume 3 feet of bury
* Assume shoring if over 5 feet deep in depth
* Assume manholes every 300 feet - prorated factor
* Assume two catch basins every 300 feet - prorated factor
* Assume 2005 Construction

Planning Level Unit Costs

Pipe Size	Surface	
	Gravel	Pavement
18 HDPE	$134	$153
24 HDPE	$150	$171
30 HDPE	$171	$194
36 HDPE	$201	$226
42 HDPE	$229	$256
48 HDPE	$336	$381
54 RCP	$412	$459
60 RCP	$450	$499
72 RCP	$546	$599
84 RCP	$664	$721
96 RCP	$872	$933

Factors

	Material	Ex & Bf	Voids-haul	Pavement	Shoring	Manholes	Catch Basins
		$50	$20	$4	$20	$8K,12K,16K,20K	2 x $6000
	lf	cy	cy	sf +$5	lf	@300' & 400'	@300' & 400'
Size							
18	12.07	32.41	2.59	19.00	20.00	26.67	40.00
24	19.63	40.74	3.26	21.00	20.00	26.67	40.00
30	30.01	50.00	4.00	23.00	20.00	26.67	40.00
36	36.80	60.19	3.85	25.00	20.00	40.00	40.00
42	51.70	71.30	5.70	27.00	20.00	40.00	40.00
48	72.50	138.89	11.11	45.00	20.00	53.33	40.00
54	130.23	155.56	12.44	47.00	20.00	53.33	40.00
60	149.86	173.15	13.85	49.00	20.00	53.33	40.00
72	208.40	211.11	16.89	53.00	30.00	50.00	30.00
84	280.87	252.78	20.22	57.00	30.00	50.00	30.00
96	439.99	298.15	23.85	61.00	30.00	50.00	30.00

Unit Cost for Curb and Gutter

	$/LF	Remarks
Concrete Curb and Gutter (2@ $20)	$ 40	bid tabs from $16/lf to $49/lf - two used
4' Asphalt each side (8'@$5)	$ 40	same unit price as pipe estimates
Total per liner foot of Street	**$ 80**	

Detention Basin A Probable Costs for Construction

1/12/05

subarea	area acres	Area sf	Volume cf @2cf/sf	Volume cf @4cf/sf	Paving @$5/sf	HDPE pipe system @$7/cf	StormTech Pipe Arch system @$4/cf	Rain Store system @$7/cf
1	3	131000	262000	524000		$1,834,000	$1,048,000	$3,668,000
2	2	87000	174000	348000		$1,218,000	$696,000	$2,436,000
3	4	174000	348000	696000	$870,000	$3,306,000	$2,262,000	$5,742,000
4	0.5	22000	44000	88000		$308,000	$176,000	$616,000
5	0.3	13000	26000	52000		$182,000	$104,000	$364,000
Totals	9.8	427000	854000	1708000		$6,848,000	$4,286,000	$12,826,000
	total storage in acre feet					19.6	19.6	39.2
	cost prorated to 15 acre feet					$5,241,000	$3,280,000	$4,908,000
	45% design, environmental, contingency					$2,358,000	$1,476,000	$2,209,000
	Total project					$7,599,000	$4,756,000	$7,117,000
	Project Budget					Call $5M to $8M		

Rain store bottoms up estimate based on quantities generated by their online calculator.

	Quantity	Unit cost	Cost		
Geotextile SY	44678	1	44678		
Geogrid SY	66805	1	66805		
Excavation CY	48706	3	146118		
Sand Backfill CY	15822	10	158220		
Porous Cover CY	6748	10	67480		
Labor hours	3996	30	119880		
			603181	$0.91	call 1
	Material				5
	shipping and tax				1
	Total unit cost				7

APPENDIX N

Cost Summary 20-Year and 100-Year Events

Cost Summary: Future Conditions, Existing Pipe Improvements

		Future without Detention A						Future with Detention A					
Basin	Pipe ID	20-Yr Pipe Improvements Replacement	20-Yr Pipe Improvements Parallel	100-Yr Pipe Improvements Replacement	100-Yr Pipe Improvements Parallel	Replacement Pipe Cost	Parallel Pipe Cost	20-Yr Pipe Improvements Replacement	20-Yr Pipe Improvements Parallel	100-Yr Pipe Improvements Replacement	100-Yr Pipe Improvements Parallel	Replacement Pipe Cost	Parallel Pipe Cost
2.2.1	2200300	54	42			$ 337,365.00	$ 188,160.00	54	42			$ 337,365.00	$ 188,160.00
2.2.3	2200900	30	24			$ 26,772.00	$ 23,598.00	30	24			$ 26,772.00	$ 23,598.00
2.2.1	2201100	24	18			$ 42,921.00	$ 38,403.00	24	18			$ 42,921.00	$ 38,403.00
2.2.1	2206000	30	24			$ 16,684.00	$ 14,706.00	30	24			$ 16,684.00	$ 14,706.00
3.3.1	3200401	48	42			$ 54,102.00	$ 36,352.00	48	36			$ 54,102.00	$ 32,092.00
3.3.1	3200402	48	42			$ 54,483.00	$ 36,608.00	48	36			$ 54,483.00	$ 32,318.00
3.3.1	3201200	42	30	42	30	$ 139,776.00	$ 105,924.00	42	30	42	30	$ 139,776.00	$ 105,924.00
3.3.2	3201600	36	24			$ 86,784.00	$ 65,664.00	36	24			$ 86,784.00	$ 65,664.00
3.3.4	3203201	30	18			$ 17,654.00	$ 13,923.00	30	18			$ 17,654.00	$ 13,923.00
3.3.4	3203202	30	18			$ 18,236.00	$ 14,382.00	30	18			$ 18,236.00	$ 14,382.00
3.3.3	3203900	30	18			$ 16,684.00	$ 13,158.00	30	18			$ 16,684.00	$ 13,158.00
3.3.3	3204100	36	30			$ 23,956.00	$ 20,564.00	36	30			$ 23,956.00	$ 20,564.00
3.3.4	3204600	30	30			$ 12,028.00	$ 12,028.00	30	30			$ 12,028.00	$ 12,028.00
3.3.4	3204800	36	24			$ 10,396.00	$ 7,866.00	30	24			$ 8,924.00	$ 7,866.00
3.3.1	3205400	36	36			$ 10,848.00	$ 10,848.00	36	36			$ 10,848.00	$ 10,848.00
3.3.1	3205600	30	24			$ 15,714.00	$ 13,851.00	30	24			$ 15,714.00	$ 13,851.00
3.3.1	3206200	42	36			$ 27,392.00	$ 24,182.00	42	36			$ 27,392.00	$ 24,182.00
3.3.1	3206600	42	42			$ 21,248.00	$ 21,248.00	42	42			$ 21,248.00	$ 21,248.00
3.3.1	3206900	30	24			$ 12,028.00	$ 10,602.00	30	24			$ 12,028.00	$ 10,602.00
3.3.1	3207200	24	18			$ 2,052.00	$ 1,836.00	24	18			$ 2,052.00	$ 1,836.00
3.3.3	3207500	18	18			$ 13,770.00	$ 13,770.00	18	18			$ 13,770.00	$ 13,770.00
3.3.3	3207700	18	18			$ 5,508.00	$ 5,508.00	18	18			$ 5,508.00	$ 5,508.00
3.5.1	3303400	36	30			$ 74,806.00	$ 64,214.00	36	30			$ 74,806.00	$ 64,214.00
3.5.1	3303600	36	30			$ 72,094.00	$ 61,886.00	36	30			$ 72,094.00	$ 61,886.00
3.5.2	3303800	42	36	36	30	$ 26,624.00	$ 23,504.00	42	36	36	30	$ 26,624.00	$ 23,504.00
3.4	3400100	72	60			$ 40,732.00	$ 33,932.00	0	0			-	-
3.4	3401500	0	0	84	60	$ 313,635.00	$ 217,065.00	0	0	84	60	$ 313,635.00	$ 217,065.00
3.6.1	3501300	36	24			$ 3,390.00	$ 2,565.00	30	24			$ 2,910.00	$ 2,565.00
3.6.2	3501400	54	24			$ 113,832.00	$ 42,408.00	54	24			$ 113,832.00	$ 42,408.00
3.6.2	3503000	30	18			$ 17,072.00	$ 13,464.00	30	18			$ 17,072.00	$ 13,464.00
3.6.1	3508400	36	30			$ 12,204.00	$ 10,476.00	36	30			$ 12,204.00	$ 10,476.00
3.6.1	3508600	36	30			$ 17,176.00	$ 14,744.00	36	30			$ 17,176.00	$ 14,744.00
3.6.1	3508800	36	30			$ 15,142.00	$ 12,998.00	36	30			$ 15,142.00	$ 12,998.00
3.6.1	3509000	36	30			$ 10,622.00	$ 9,118.00	36	30			$ 10,622.00	$ 9,118.00
3.6.1	3509201	30	30			$ 4,268.00	$ 4,268.00	30	24			$ 4,268.00	$ 3,762.00
3.6.1	3509202	30	24			$ 4,268.00	$ 3,762.00	30	24			$ 4,268.00	$ 3,762.00
3.6.2	3509600	42	36			$ 47,360.00	$ 41,810.00	42	42			$ 47,360.00	$ 47,360.00
3.6.2	3509900	36	30			$ 28,702.00	$ 24,638.00	36	30			$ 28,702.00	$ 24,638.00
3.6.2	3510400	36	30			$ 17,402.00	$ 14,938.00	36	30			$ 17,402.00	$ 14,938.00
3.6.2	3510600	36	30			$ 11,978.00	$ 10,282.00	36	30			$ 11,978.00	$ 10,282.00
3.6.2	3510800	36	30			$ 16,498.00	$ 14,162.00	36	30			$ 16,498.00	$ 14,162.00
3.6.9	3511300	30	24			$ 47,142.00	$ 41,553.00	30	24			$ 47,142.00	$ 41,553.00
3.6.9	3511500	30	24			$ 4,656.00	$ 4,104.00	30	24			$ 4,656.00	$ 4,104.00
3.6.9	3511700	30	24			$ 13,192.00	$ 11,628.00	30	24			$ 13,192.00	$ 11,628.00
3.6.1	3512300	30	18			$ 10,088.00	$ 7,956.00	30	18			$ 10,088.00	$ 7,956.00
3.6.9	3521600	30	18			$ 23,668.00	$ 18,666.00	30	18			$ 23,668.00	$ 18,666.00
3.7.4	3705100	36	18			$ 56,048.00	$ 37,944.00	0	0			-	-
3.7.6	3706500	30	24			$ 63,826.00	$ 56,259.00	0	0			-	-
3.7.2	3708500	30	24			$ 1,940.00	$ 1,710.00	0	0			-	-
3.7.5	3709600	24	18			$ 18,126.00	$ 16,218.00	0	0			-	-
3.7.5	3709800	24	18			$ 23,427.00	$ 20,961.00	0	0			-	-
3.7.4	3710100	30	24			$ 11,834.00	$ 10,431.00	0	0			-	-
3.7.4	3710300	30	30			$ 8,924.00	$ 8,924.00	24	18			$ 7,866.00	$ 7,038.00
					Total =	**$ 2,097,077.00**	**$ 1,549,769.00**				**Total =**	**$ 1,878,134.00**	**$ 1,366,922.00**

APPENDIX O

Analysis of CMP’s Replaced with Equivalent Size Smooth Pipe

Existing CMP's Replaced by Equivalent Dia. Smooth Pipe

Basin	Pipe ID	Material	Length (ft)	Section Size (in)	Mannings n	Calculated Capacity 94% full	Total Basin Q	% of Basin	Basin Q at Pipe	Contibuting Basins				Contributing Q	Required Capacity	Pipe Meets Required Capacity	Replacement Cost
2.5.1	2101500	CMP	480	24	0.024	15	22	70%	15					0	8	Yes	$ 82,080.00
2.4	2102300	CMP	83	18	0.024	7	33	3%	1					0	1	Yes	$ 12,699.00
2.4	2103715	CMP	98	18	0.024	12	33	9%	3					0	3	Yes	$ 14,994.00
2.4	2103717	CMP	82	18	0.024	13	33	8%	3					0	3	Yes	$ 12,546.00
2.4	2103719	CMP	96	18	0.024	13	33	8%	3					0	3	Yes	$ 14,688.00
2.4	2103721	CMP	106	18	0.024	13	33	7%	2					0	2	Yes	$ 16,218.00
2.4	2103723	CMP	109	18	0.024	12	33	6%	2					0	2	Yes	$ 16,677.00
2.3	2202500	CMP	97	72	0.024	372	90	98%	88	L.M.				81	85	Yes	$ 58,103.00
2.3	2202900	CMP	97	96	0.024	687	90	95%	86	L.M.				81	167	Yes	$ 90,501.00
2.3	2203400	CMP	129	24	0.024	12	90	2%	2					0	2	Yes	$ 22,059.00
2.3	2301100	CMP	33	24	0.024	16	90	4%	4					0	4	Yes	$ 5,643.00
2.3	2301400	CMP	38	18	0.024	7	90	1%	1					0	1	Yes	$ 5,814.00
2.3	2301500	CMP	55	18	0.024	6	90	1%	1					0	1	Yes	$ 8,415.00
2.3	2302400	CMP	66	36	0.024	68	90	10%	9					0	9	Yes	$ 14,916.00
2.3	2302600	CMP	62	36	0.024	70	90	10%	9					0	9	Yes	$ 14,012.00
2.3	2302800	CMP	58	24	0.024	55	90	12%	11					0	11	Yes	$ 9,918.00
2.3	2304600	CMP	33	30	0.024	45	90	20%	18					0	6	Yes	$ 6,402.00
2.3	2304700	CMP	34	30	0.024	49	90	20%	18					0	6	Yes	$ 6,596.00
3.4	3300300	CMP	145	24	0.024	36	31	15%	5					0	5	Yes	$ 24,795.00
3.4	3300400	CMP	87	24	0.024	40	31	15%	5					0	5	Yes	$ 14,877.00
3.4	3402100	CMP	6	24	0.024	168	31	80%	25					0	25	Yes	$ 1,026.00
3.6.4	3513300	CMP	152	36	0.024	45	10	65%	7	3.6.7				55	21	Yes	$ 34,352.00
2.3	3521800	CMP	72	18	0.024	7	90	1%	1					0	1	Yes	$ 11,016.00
3.8	3527800	CMP	88	36	0.024	72	34	40%	13					0	13	Yes	$ 19,888.00
3.7.1	3600100	CMP	144	30	0.024	208	31	10%	3	3.8				53	56	Yes	$ 27,936.00
3.9	3600600	CMP	73	24	0.024	22	19	98%	19					0	19	Yes	$ 12,483.00
3.9	3601200	CMP	77	18	0.024	9	19	40%	8					0	8	Yes	$ 11,781.00
3.7.7	3710700	CMP	64	24	0.024	33	20	90%	18					0	18	Yes	$ 10,944.00
																Total	**$ 581,379.00**

APPENDIX P

Analysis of CMP Condition Assessment

Basin	Pipe ID	Material	Length (ft)	Section Size (in)	Replacement Pipe Cost
2.3.1	2100100	CMP	108	60	$ 53,892.00
2.4	2100400	CMP	104	36	$ 23,504.00
2.5.1	2101500	CMP	480	24	$ 82,080.00
2.4	2102300	CMP	83	18	$ 12,699.00
2.4	2102400	CMP	57	30	$ 11,058.00
2.4	2102500	CMP	68	18	$ 10,404.00
2.4	2102800	CMP	92	18	$ 14,076.00
2.4	2102900	CMP	78	18	$ 11,934.00
2.5.1	2103416	CMP	41	18	$ 6,273.00
2.5.1	2103420	CMP	42	18	$ 6,426.00
2.5.1	2103605	CMP	41	18	$ 6,273.00
2.4	2103701	CMP	21	18	$ 3,213.00
2.4	2103703	CMP	108	18	$ 16,524.00
2.4	2103705	CMP	103	18	$ 15,759.00
2.4	2103707	CMP	129	18	$ 19,737.00
2.4	2103711	CMP	77	18	$ 11,781.00
2.4	2103713	CMP	95	18	$ 14,535.00
2.4	2103715	CMP	98	18	$ 14,994.00
2.4	2103717	CMP	82	18	$ 12,546.00
2.4	2103719	CMP	96	18	$ 14,688.00
2.4	2103721	CMP	106	18	$ 16,218.00
2.4	2103723	CMP	109	18	$ 16,677.00
2.4	2103725	CMP	109	18	$ 16,677.00
2.4	2103727	CMP	101	18	$ 15,453.00
2.4	2103729	CMP	81	18	$ 12,393.00
2.4	2103731	CMP	89	18	$ 13,617.00
2.4	2103733	CMP	59	18	$ 9,027.00
2.4	2103735	CMP	67	18	$ 10,251.00
2.4	2103737	CMP	57	18	$ 8,721.00
2.5.1	2103800	CMP	40	18	$ 6,120.00
2.2.1	2200500	CMP	5	36	$ 1,130.00
2.2.1	2200700	CMP	57	36	$ 12,882.00
2.2.1	2201300	CMP	185	18	$ 28,305.00
2.2.1	2201500	CMP	72	18	$ 11,016.00
2.2.1	2201700	CMP	240	18	$ 36,720.00
2.2.1	2201900	CMP	212	18	$ 32,436.00
2.2.1	2202000	CMP	44	18	$ 6,732.00
2.3.1	2202400	CMP	98	36	$ 22,148.00
2.3.1	2202500	CMP	97	72	$ 58,103.00
2.3.1	2202900	CMP	97	96	$ 90,501.00
2.3.1	2203400	CMP	129	24	$ 22,059.00
2.3.1	2203500	CMP	39	24	$ 6,669.00
2.3.1	2205300	CMP	80	24	$ 13,680.00
2.3.1	2205500	CMP	70	24	$ 11,970.00
2.3.1	2205700	CMP	43	24	$ 7,353.00
2.2.1	2205900	CMP	41	18	$ 6,273.00
2.2.2	2206200	CMP	66	36	$ 14,916.00
2.2.3	2206300	CMP	124	24	$ 21,204.00
2.3.1	2300300	CMP	33	36	$ 7,458.00
2.3.1	2300500	CMP	40	36	$ 9,040.00
2.3.1	2300701	CMP	51	24	$ 8,721.00
2.3.1	2300702	CMP	51	24	$ 8,721.00
2.3.1	2300703	CMP	51	24	$ 8,721.00
2.3.1	2300704	CMP	51	24	$ 8,721.00
2.3.1	2301100	CMP	33	24	$ 5,643.00
2.3.1	2301200	CMP	48	18	$ 7,344.00
2.3.1	2301400	CMP	38	18	$ 5,814.00
2.3.1	2301500	CMP	55	18	$ 8,415.00
2.3.1	2301600	CMP	65	18	$ 9,945.00
2.3.1	2301700	CMP	72	18	$ 11,016.00
2.5.2	2301800	CMP	52	18	$ 7,956.00
2.5.2	2301900	CMP	20	18	$ 3,060.00
2.3.1	2302000	CMP	68	36	$ 15,368.00
2.3.1	2302200	CMP	35	36	$ 7,910.00
2.3.1	2302400	CMP	66	36	$ 14,916.00
2.3.1	2302600	CMP	62	36	$ 14,012.00
2.3.1	2302800	CMP	58	24	$ 9,918.00

CMP Condition Replacement

Basin	Pipe ID	Material	Length (ft)	Section Size (in)	Replacement Pipe Cost
2.3.1	2303000	CMP	24	24	$ 4,104.00
2.3.1	2303200	CMP	40	24	$ 6,840.00
2.5.3	2303400	CMP	66	18	$ 10,098.00
2.5.3	2303500	CMP	62	18	$ 9,486.00
2.5.3	2303600	CMP	71	18	$ 10,863.00
2.5.3	2303700	CMP	66	18	$ 10,098.00
2.5.3	2303800	CMP	71	18	$ 10,863.00
2.5.3	2303900	CMP	60	18	$ 9,180.00
2.5.3	2304100	CMP	45	18	$ 6,885.00
2.5.3	2304200	CMP	84	18	$ 12,852.00
2.5.3	2304400	CMP	26	18	$ 3,978.00
2.3.1	2304500	CMP	36	42	$ 9,216.00
2.3.1	2304600	CMP	33	30	$ 6,402.00
2.3.1	2304700	CMP	34	30	$ 6,596.00
2.3.1	2304900	CMP	32	24	$ 5,472.00
2.3.1	2305000	CMP	31	60	$ 15,469.00
2.3.1	2305100	CMP	39	24	$ 6,669.00
2.3.1	2305300	CMP	85	24	$ 14,535.00
2.3.1	2305400	CMP	31	18	$ 4,743.00
2.3.1	2305800	CMP	58	24	$ 9,918.00
2.3.3	2305900	CMP	70	18	$ 10,710.00
2.3.3	2307300	CMP	100	24	$ 17,100.00
2.3.3	2307500	CMP	436	24	$ 74,556.00
3.1	3200201	CMP	221	36	$ 49,946.00
3.1	3200202	CMP	221	36	$ 49,946.00
3.3.1	3200600	CMP	82	24	$ 14,022.00
3.3.1	3200800	CMP	261	36	$ 58,986.00
3.3.1	3201000	CMP	384	36	$ 86,784.00
3.3.2	3201400	CMP	43	18	$ 6,579.00
3.3.2	3201800	CMP	335	30	$ 64,990.00
3.3.2	3202000	CMP	602	30	$ 116,788.00
3.3.2	3202200	CMP	259	30	$ 50,246.00
3.3.2	3202400	CMP	128	30	$ 24,832.00
3.3.1	3202700	CMP	43	24	$ 7,353.00
3.3.4	3203501	CMP	51	24	$ 8,721.00
3.3.4	3203502	CMP	51	24	$ 8,721.00
3.3.4	3203700	CMP	20	24	$ 3,420.00
3.3.3	3204400	CMP	70	18	$ 10,710.00
3.4	3300100	CMP	115	18	$ 17,595.00
3.4	3300300	CMP	145	24	$ 24,795.00
3.4	3300400	CMP	87	24	$ 14,877.00
3.4	3300600	CMP	39	24	$ 6,669.00
3.4	3300800	CMP	28	18	$ 4,284.00
3.4	3301000	CMP	121	48	$ 46,101.00
3.4	3301100	CMP	121	48	$ 46,101.00
3.4	3301200	CMP	53	18	$ 8,109.00
3.5.1	3301400	CMP	44	18	$ 6,732.00
3.5.1	3301600	CMP	260	36	$ 58,760.00
3.5.1	3301800	CMP	210	36	$ 47,460.00
3.5.1	3302800	CMP	70	36	$ 15,820.00
3.5.1	3303000	CMP	66	36	$ 14,916.00
3.5.1	3303200	CMP	120	24	$ 20,520.00
3.4	3400100	CMP	68	42	$ 17,408.00
3.4	3400500	CMP	56	42	$ 14,336.00
3.4	3400701	CMP	43	30	$ 8,342.00
3.4	3400702	CMP	42	30	$ 8,148.00
3.4	3400703	CMP	41	30	$ 7,954.00
3.4	3402100	CMP	6	24	$ 1,026.00
3.4	3402500	CMP	93	18	$ 14,229.00
3.4	3402700	CMP	153	18	$ 23,409.00
3.4	3402800	CMP	59	18	$ 9,027.00
3.4	3403901	CMP	42	24	$ 7,182.00
3.4	3403902	CMP	42	18	$ 6,426.00
3.6.2	3502400	CMP	3	18	$ 459.00
3.6.2	3503500	CMP	59	36	$ 13,334.00
3.6.6	3503900	CMP	62	24	$ 10,602.00
3.6.6	3504000	CMP	47	24	$ 8,037.00

Basin	Pipe ID	Material	Length (ft)	Section Size (in)	Replacement Pipe Cost
3.6.6	3504200	CMP	104	24	$ 17,784.00
3.6.6	3504400	CMP	37	24	$ 6,327.00
3.6.6	3504600	CMP	102	24	$ 17,442.00
3.6.6	3504800	CMP	26	24	$ 4,446.00
3.6.6	3505000	CMP	73	24	$ 12,483.00
3.6.6	3505200	CMP	32	24	$ 5,472.00
3.6.6	3505500	CMP	21	24	$ 3,591.00
3.6.8	3506500	CMP	235	24	$ 40,185.00
3.6.8	3506601	CMP	154	24	$ 26,334.00
3.6.8	3506700	CMP	46	24	$ 7,866.00
3.6.8	3506900	CMP	170	24	$ 29,070.00
3.6.8	3507100	CMP	164	24	$ 28,044.00
3.6.8	3507300	CMP	173	24	$ 29,583.00
3.6.8	3507700	CMP	93	18	$ 14,229.00
3.6.8	3507800	CMP	79	18	$ 12,087.00
3.6.8	3507900	CMP	54	18	$ 8,262.00
3.6.8	3508100	CMP	25	18	$ 3,825.00
3.6.2	3510100	CMP	56	24	$ 9,576.00
3.6.6	3511101	CMP	124	24	$ 21,204.00
3.6.6	3511102	CMP	123	24	$ 21,033.00
3.6.8	3511900	CMP	122	24	$ 20,862.00
3.6.8	3512100	CMP	58	24	$ 9,918.00
3.6.1	3512500	CMP	66	24	$ 11,286.00
3.6.1	3512700	CMP	48	24	$ 8,208.00
3.6.1	3512900	CMP	50	24	$ 8,550.00
3.6.4	3513300	CMP	152	36	$ 34,352.00
3.6.4	3513501	CMP	103	24	$ 17,613.00
3.6.4	3513502	CMP	102	24	$ 17,442.00
3.6.4	3513900	CMP	18	24	$ 3,078.00
3.6.7	3515401	CMP	723	24	$ 123,633.00
3.6.7	3515500	CMP	97	24	$ 16,587.00
3.6.7	3515700	CMP	189	24	$ 32,319.00
3.6.7	3516500	CMP	38	24	$ 6,498.00
3.6.10	3517200	CMP	43	24	$ 7,353.00
3.6.10	3517800	CMP	39	36	$ 8,814.00
3.6.10	3518000	CMP	20	36	$ 4,520.00
3.6.10	3518300	CMP	38	36	$ 8,588.00
3.6.3	3520600	CMP	65	24	$ 11,115.00
3.6.3	3520800	CMP	71	24	$ 12,141.00
3.6.4	3521300	CMP	73	24	$ 12,483.00
3.6.7	3521500	CMP	55	24	$ 9,405.00
2.3.1	3521700	CMP	38	24	$ 6,498.00
2.3.1	3521800	CMP	72	18	$ 11,016.00
3.6.6	3522000	CMP	21	30	$ 4,074.00
3.6.6	3522200	CMP	63	30	$ 12,222.00
3.6.6	3522400	CMP	22	30	$ 4,268.00
3.6.4	3524400	CMP	90	36	$ 20,340.00
3.6.4	3524600	CMP	63	24	$ 10,773.00
3.6.5	3525700	CMP	86	36	$ 19,436.00
3.6.5	3526300	CMP	174	24	$ 29,754.00
3.6.5	3526500	CMP	5	24	$ 855.00
3.6.5	3526800	CMP	37	24	$ 6,327.00
3.6.5	3527000	CMP	133	24	$ 22,743.00
3.8	3527800	CMP	88	36	$ 19,888.00
3.8	3528000	CMP	39	24	$ 6,669.00
3.8	3528200	CMP	202	18	$ 30,906.00
3.8	3528400	CMP	51	18	$ 7,803.00
3.7.1	3600100	CMP	144	30	$ 27,936.00
3.7.1	3600300	CMP	166	30	$ 32,204.00
3.9	3600400	CMP	84	18	$ 12,852.00
3.9	3600600	CMP	73	60	$ 36,427.00
3.9	3600800	CMP	162	42	$ 41,472.00
3.9	3601000	CMP	89	60	$ 44,411.00
3.9	3601200	CMP	77	42	$ 19,712.00
3.9	3601300	CMP	58	24	$ 9,918.00
3.9	3601500	CMP	58	24	$ 9,918.00
3.9	3601600	CMP	58	18	$ 8,874.00

CMP Condition Replacement

Basin	Pipe ID	Material	Length (ft)	Section Size (in)	Replacement Pipe Cost
3.7.6	3705500	CMP	84	24	$ 14,364.00
3.7.6	3705700	CMP	56	24	$ 9,576.00
3.7.6	3705900	CMP	430	24	$ 73,530.00
3.7.6	3706100	CMP	195	24	$ 33,345.00
3.7.2	3708100	CMP	23	24	$ 3,933.00
3.7.2	3708300	CMP	30	24	$ 5,130.00
3.7.2	3708700	CMP	24	24	$ 4,104.00
3.7.2	3708900	CMP	14	24	$ 2,394.00
3.7.7	3710500	CMP	196	24	$ 33,516.00
3.7.7	3710700	CMP	64	24	$ 10,944.00
2.1	4000300	CMP	75	36	$ 16,950.00
				Total Cost to Replace CMP's =	$ 3,754,371.00
				Replace 30% over next 15 years =	$ 1,126,311.30
				15% Contingency =	$ 168,946.70
				20% Engineering and Admin. =	$ 225,262.26
				Total Cost =	$ 1,521,000.00

APPENDIX Q

Memorandum of Understanding Between Lahontan Regional Water Quality Control Board and the Town of Mammoth Lakes

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION

RESOLUTION NO. 6-91-926

Directing the Executive Officer to Enter into a Memorandum of Understanding with the Town of Mammoth Lakes, Regarding Implementation of Erosion Control Requirements, Mono County

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The California Regional Water Quality Control Board, Lahontan Region (Board) finds:

1. The South Lahontan Basin Water Quality Control Plan (Plan) recognizes the adverse affect discharge of silt due to land development and natural erosion has on surface water within the South Lahontan Region mountainous watershed areas;

2. The Plan prohibits the discharge of waste earthen materials to surface waters within the Mammoth Creek Watershed above the elevation 7,650 feet, including the community of Mammoth Lakes;

3. The Plan contains guidelines for erosion control (see copy attached) to be observed in land development projects;

4. The Town of Mammoth Lakes' (Town) sphere of influence lies within the area described in Finding No. 2;

5. The Town regulates the construction of projects within their sphere of influence. This regulation includes the review of erosion control plans for proposed construction projects;

6. The Town issues building and grading permits that contain provisions pertaining to erosion control measures for proposed construction projects. Provisions pertaining to erosion control used by the Town incorporate the Regional Board's "Guidelines for Erosion Control in the Mammoth Lakes Area" as adopted by the Board on May 8, 1975, and which was added as an amendment to the Water Quality Control South Lahontan Basin Plan on June 9, 1983;

7. The Town has an approved Ordinance No. 91-02 regarding encroachment and grading regulations in which the Town established drainage and erosion design standards that are in addition to the Board requirements;

8. The Town has an approved 1984 Storm Drainage Master Plan for the Town of Mammoth Lakes, which was reviewed and updated in September 1990, places a high priority on the protection of water quality in Mammoth and Hot Creeks from degradation due to sediment discharges;

9. The Town facilities and staff are located in close proximity to construction projects in the area and routinely conduct compliance inspections at various stages of construction;

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10. Projects under five acres in size are not likely to significantly impact water quality when properly regulated by the Town;

11. The Board desires to minimize the levels of regulatory review and the staff time required to perform duplicate regulatory reviews;

12. The Board and the Town propose to enter into a Memorandum of Understanding (MOU) which describes procedures to be followed by both entities to implement the Board's erosion control guidelines;

13. This MOU has been circulated to interested parties and has been the subject of a Town Council Meeting where it was approved by the Town Council on May 1, 1991 and signed by the Town Manager on August 7, 1991.

THEREFORE BE IT RESOLVED; that the Board authorizes the Executive Officer to enter into the MOU between the Regional Board and the Town of Mammoth Lakes.

I, Harold J. Singer, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of a resolution adopted by the California Regional Water Quality Control Board, Lahontan Region, on September 12, 1991.

Harold J. Singer

HAROLD J. SINGER
EXECUTIVE OFFICER

Attachment 2

EROSION AND SEDIMENT CONTROL GUIDELINES

Memorandum of Understanding
between the
California Regional Water Quality Control Board
Lahontan Region
and the
Town of Mammoth Lakes
Mono County

This Memorandum of Understanding is entered into by and between the California Regional Water Quality Control Board, Lahontan Region, hereinafter referred to as "Board", and the Town of Mammoth Lakes, hereinafter referred to as "Town". Its purpose is to expedite the overall review process for certain proposed developments and to provide a clear operating policy between the Board and the Town on the implementation of the Board's guidelines for erosion and sediment controls for land developments.

On June 9, 1983, the Regional Board adopted Resolution No. 83-5. The Resolution is an amendment to the Water Quality Control Plan for the South Lahontan Basin (Basin Plan). The Basin Plan contains general erosion control guidelines for the South Lahontan Basin. The Resolution established specific erosion and sediment control guidelines for land developments within the Mammoth Creek Watershed above elevation 7000 feet. Such standards are necessary to provide developers with a uniform approach for the design and installation of adequate systems to control erosion. The guidelines were designed to mitigate urban drainage impacts from the Town in an effort to prevent the degradation of waters of Mammoth and Hot Creeks.

Section 13260 of the California Water Code requires any person discharging waste or proposing to discharge waste within any region that could affect the quality of the waters of the State, other than into a community sewer system, to file a report of waste discharge with the regional board of that region. Implementation of Section 13260 includes regulation of any waste earthen materials being discharged wherever warranted.

Pursuant to Section 13269, the requirements of Section 13260 may be waived by a regional board as to a specific discharge or a specific type of discharge where such waiver is not against the public interest. Such waiver shall be conditional and may be terminated at any time by the board.

On January 14, 1988, the Board adopted Resolution No. 88-18. The Resolution describes that a conditional waiver of waste discharge requirements for erosion from construction would not be against the public interest when the discharge is effectively regulated by other public agencies.

In the interest of water quality and to promote a realistic and effective erosion control management program, the Board recognizes that the Town has:

1. Immediate proximity to the Mammoth Creek Watershed, to conduct on-going site inspections of construction projects; and

2. A departmental mechanism more readily available to the Town population, to expedite construction permits for projects encompassing less than five (5) acres, while effectively administering erosion control measures through plan reviews and site inspections.

Therefore, it is agreed that:

1. The Town will incorporate into its review criteria for proposed developments, Section III. GUIDELINES, of the Board's "Guidelines for Erosion Control in the Mammoth Lakes Area".

2. The Town will issue construction permits for projects encompassing less than five (5) acres without the Board's prior review provided the project complies with the "Guidelines for Erosion Control in the Mammoth Lakes Area".

3. The Town will not issue a construction permit for a project encompassing five (5) acres or more unless the Board has adopted waste discharge requirements for the project or unless the Board's Executive Officer has issued a written waiver for the project.

4. The Town at its discretion may defer consideration of those projects involving water quality issues to the Board regardless of the project's compliance with this Memorandum of Understanding.

5. The Town will maintain a record of all documents submitted and reviewed, number of permits issued, inspections performed, and compliance record and any followup actions under this Memorandum of Understanding. This record will be submitted to the Board on an annual basis, if so requested.

6. The Board after reviewing the annual record submitted by the Town, reserves the right to require the submittal of reports of waste discharge by a Town permittee for review and action (if necessary) by the Board.

7. This Memorandum of Understanding may be amended as mutually agreed in writing by the Town and the Board.

8. This Memorandum of Understanding shall be effective immediately upon execution of this agreement by both parties. It may be terminated for any reason by either party. Termination will occur upon receipt of written notice by the non-terminating party.

9. All notices and communications under this Memorandum of Understanding shall be addressed to the following person(s):

Town Representative
Town of Mammoth Lakes
Department
Address
Mammoth Lakes, CA 93546

Harold J. Singer, Executive Officer
California Regional Water Quality Control Board, Lahontan Region
15428 Civic Drive, Suite 100
Victorville, CA 92392-2494

This Memorandum of Understanding is executed on the date of the most recent signature below, by the following authorized representatives of the parties:

Town Representative	Harold J. Singer
Title Town Manager	Executive Officer
Date 8-7-91	Date 9/12/91

GUIDELINES FOR EROSION CONTROL

IN THE MAMMOTH LAKES AREA

osion control guidelines have been adopted by the Regional Board to establish andards for the control of erosion and drainage from developments in the Mammoth eek Watershed, above elevation 7,000 feet. Such standards are necessary to provide velopers with a uniform approach for the design and installation of an adequate stem to control erosion and storm runoff. The guidelines are designed to prevent e degradation of Mammoth and Hot Creeks by minimizing the impacts on the creeks of e drainage from the community of Mammoth Lakes.

GENERAL POLICY

The Regional Board will request a report of waste discharge from the developers of a proposed project and will establish waste discharge requirements to ensure that proper control measures for the protection of water quality are taken during all phases of a proposed development. The report of waste discharge and the adopted waste discharge requirements will be in conformance with the erosion control guidelines which are listed below:

I. WASTE DISCHARGE REPORTS

A. The submittal of a report of waste discharge shall be required according to the following criteria:

1. A new development involving either (a) six or more dwelling units, or (b) commercial developments that involve soil disturbance on ½ acre or more shall file a complete report of waste discharge not less than 90 days before the intended commencement of construction activities.

2. Existing developments and new developments involving five or less dwelling units shall file a report of waste discharge only at the request of the Regional Board. Such filing shall be no more than 60 days from the date of request, or sooner, if so stated in the initial request.

B. Reports of waste discharge for projects in the Mammoth Creek Watershed that involve the disturbance of soil shall contain the following elements:

1. A description of the interim erosion control measures to be applied during the period in which the project is under construction.

2. Details of the short-term and long-term erosion and drainage control measures to be employed following the completion of the construction phase of the project.

3. A time schedule delineating the sequence by which the above erosion and drainage control measures will be applied and are expected to become effective.

Details of all erosion control measures shall be shown on suitable-scale engineering drawings. The report shall also include engineering criteria and design calculations for erosion control facilities.

III. GUIDELINES

The following guidelines are necessary for the protection of water quality within the Mammoth Lakes area.

1. Drainage collection, retention, and infiltration facilities shall be constructed and maintained to prevent transport of the runoff from a 20-year, 1-hour design storm from the project site.a/
2. Surplus or waste material shall not be placed in drainage ways or within the 100-year flood plain of surface waters.
3. All loose piles of soil, silt, clay, sand, debris, or earthen materials shall be protected in a reasonable manner to prevent any discharge to waters of the State.
4. Dewatering shall be done in a manner so as to prevent the discharge of earthen material from the site.
5. All disturbed areas shall be stabilized by appropriate soil stabilization measures by October 15th of each year.
6. All work performed between October 15th and May 1st of each year shall be conducted in such a manner that the project can be winterized within 48 hours.
7. Where possible, existing drainage patterns shall not be significantly modified.
8. After completion of a construction project, all surplus or waste earthen material shall be removed from the site and deposited at a legal point of disposal.
9. Drainage swales disturbed by construction activities shall be stabilized by the addition of crushed rock or riprap as necessary or other appropriate stabilization methods.
10. All nonconstruction areas shall be protected by fencing or other means to prevent unnecessary disturbance.

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a/ The 20-year, 1-hour design storm for the Mammoth Lakes area is equal to 1.0 inch (2.5 cm).

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11. During construction, temporary erosion control facilities (e.g. impermeable dikes, filter fences, hay bales, etc.) shall be used as necessary to prevent discharge of earthen materials from the site during periods of precipitation or runoff.

12. Revegetated areas shall be continually maintained in order to assure adequate growth and root development. Physical erosion control facilities shall be placed on a routine maintenance and inspection program to provide continued erosion control integrity.

13. Where construction activities involve the crossing and/or alteration of a stream channel, such activities shall be timed to occur during the period in which streamflow is expected to be lowest for the year.

.7. IMPLEMENTATION

1. The responsibility for the timely submittal of information necessary for the Regional Board to determine compliance with these guidelines rests with persons submitting proposals for development. The Porter-Cologne Water Quality Control Act provides that no person shall initiate any new discharge of wastes prior to filing a complete report of waste discharge and prior to issuance of waste discharge requirements, the expiration of 120 days after submittal of a complete report of waste discharge, or the waiver of waste discharge requirements.

2. The Regional Board may pursue enforcement action should these erosion control guidelines not be adhered to.

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Plates