HYDROLOGY ANALYSIS

of the

DOUBLE DIAMOND RANCH

WASHOE COUNTY, NEVADA

Prepared for

DOUBLE DIAMOND RANCH --

SOUTHMARK CORPORATION

Prepared by

SUMMIT ENGINEERING CORPORATION
248 Winter Street, Suite 1
Reno, Nevada 89503

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Introduction

The following report presents the results of the hydrologic analysis of the Double Diamond Ranch. Double Diamond Ranch is currently located in Washoe County, Nevada, just south of the City of Reno corporate boundary, but is in the process of being annexed to the City of Reno. Double Diamond Ranch is east of U.S. Highway 395 between Huffaker Hills and Zolezzi Lane and contains 2,188± acres, encompassing part of Sections 4, 5, 8, 9, 16, 17, Township 18 North, Range 20 East, and Section 33, Township 19 North, Range 20 East, M.D.B.&M. (Reference Figure 1). The proposed development of the ranch will contain the following land uses:

Residential	-	1377 acres
Schools	-	76 acres
Public Facilities	-	12 acres
Commercial	-	200 acres
Business Development	-	80 acres
Open Space	-	293 acres

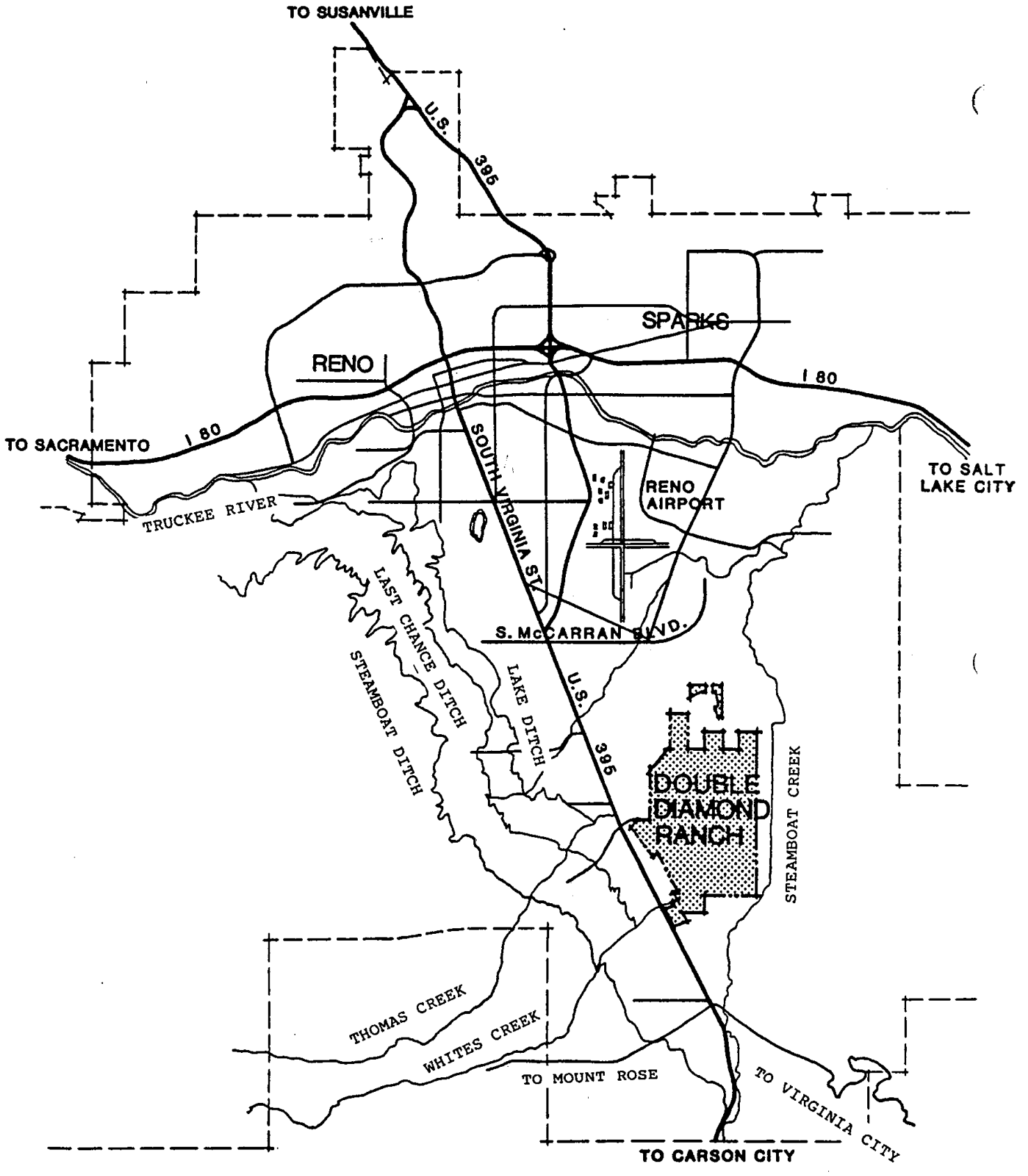
The purpose of the analysis was to prepare hydrologic calculations for the existing upstream condition to determine the peak storm water runoff flows that intersect the Double Diamond Ranch and to prepare recommendations for onsite storm drainage improvements and onsite water right routes.

The report details the methodology, the results of the calculated peak discharges values, and the recommendations.

Hydrology

The analysis of Double Diamond Ranch had four different interconnecting parts: 1) The calibration of the hydrologic model with the most recent Army Corps of Engineers Hydrology Report on the Thomas and Whites Creek drainage basins, dated February 1980, 2) The hydrology analysis of Thomas and Whites Creek (upstream) drainage basins, 3) The hydrology analysis of the onsite storm drainage system of ponds and channels, 4) The interpolation and hydraulic calculations of the existing surface water right claims and flows.

The upstream drainage basins were analyzed using the HEC-1 computer program while the onsite drainage basins and ponds were analyzed using a computer program similar to the Soil Conservation Service (SCS) program outlined in TR-20. In addition, two routing methods were used within the two programs. The Modified Puls Method for routing through reservoirs and the Muskingum Method for channel routing. Both program models are used to simulate the surface runoff response of a basin to precipitation by representing the basin as an interconnected system of hydrologic and hydraulic components. Representation of the components requires a set of parameters which specify the particular characteristics of the components and the



DOUBLE DIAMOND RANCH
LOCATION MAP
FIGURE 1

mathematical relationships which describe the physical processes.

The results of the computer modeling process is the computation of stream flow hydrographs at desired locations within the basin. The major components of the computer programs are the drainage areas, precipitation, interception/infiltration loss rate, and unit hydrograph.

The watershed drainage basin areas were calculated by outlining the tributary basin on U.S.G.S. quad maps of scale one inch to 2000 feet and the Double Diamond Ranch topographic map of scale one inch to 300 feet. The quad maps have topographic contour interval of 20 or 40 feet while the Double Diamond Ranch topographic map has a contour interval of 2 feet.

The precipitation values were established using the NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume VII - Nevada and the Army Corps of Engineers Standard Project Storm (SPS) Data in the Truckee River Hydrology Report, February, 1980. No areal reduction factors were used to the precipitation values for drainage areas less than one square mile. The precipitation values calculated from the NOAA maps were selected at the approximate centroid of the watershed.

The interception/infiltration loss rate was either calculated using SCS curve number or transferring the initial and uniform loss rate data calculated by the Army Corps of Engineers.

To calculate the SCS curve number, there are four considerations to follow:

1. Soil Type - Soils are classified according to their hydrologic behavior. The four classes in the SCS analysis are A, B, C, and D with A being the most pervious and D being the least. The soil types were determined from the SCS Soil Survey of Washoe County, Nevada, south part.

2. Vegetative Type - Vegetation type affects runoff rates and the SCS has grouped this variable by adjective description, such as "sage grass," "forests," etc.

3. Land Cover - The curve number is influenced by the extent of protective cover on the watershed. Cover is usually defined by the percent of surface area covered by vegetation. These percentages are related to adjectives, "good," "fair," "poor."

4. Soil Moisture - Soil moisture is expressed in antecedent precipitation (AMC). AMCII is taken as the reference status with AMCI and AMCIII are on either side of the reference. Basically, AMCI is for dryish soil and AMCIII is for saturated or frozen soil. As a matter of practical usage, most calculations for peak flows are done with AMCII.

All considerations must be considered together when making the selection for the curve number. Curve numbers vary from values of 0 (a completely pervious watershed with no possible runoff) to 100 (a completely impervious watershed with runoff equal to the rainfall).

The subarea lag time was calculated using the velocity method. The velocity method splits up the hydraulic length of the subarea into segments of slopes and land uses. Each segment has a velocity determined for its condition which is divided into the segment's length to find the time of concentrations. All the time of concentrations are added and divided by 5/3 to get the subarea lag time. The subarea lag time is used to estimate the delay in time from initial precipitation to actual runoff at some reference point in the watershed. It is important that the input lag variable correctly describes the field condition.

Calibration of Model

The calibration of the hydrologic model was with the most recent Army Corps of Engineers hydrology report on the Thomas and Whites Creek drainage basins. The hydrology report is entitled "Truckee River, California and Nevada, Hydrology Offsite Report, February, 1980."

In the report, peak flows were determined for Whites Creek at Steamboat Ditch, and Thomas Creek at Steamboat Ditch. The peak flows were determined for a standard project flood (SPF) during a summer cloud burst (3-hour) storm. The summer cloudburst storm was determined by the Corps to be the standard project storm (SPS) and will produce the highest peak flows even though the volume of the storm is less than a longer duration storm.

The calibration worked in two ways: 1) To develop the peak flow values of the Corps of Engineers, and 2) To interpolate the given 15-minute interval Unit Hydrograph into a five-minute interval unit hydrograph. Reference Appendix "A" for the HEC-1 computer data showing the two calibrations. Table 1 shows the correlations of the calibration.

Table 1 - Correlations of Calibration

	Army Corps of Engineers	15-Min. Interval	5-Min. Interval
Thomas Crk. at Steamboat Ditch	5600 $cfs_1(1730)_2$ 100%	5442 $cfs_1(1745)_2$ $97.2\%_3$	5422 $cfs_1(1745)_2$ $96.8\%_3$
Whites Crk. at Gage Sta.	No results given	4919 $cfs_1(1223)_2$	4911 $cfs_1(1272)_2$
Whites Crk. at Steamboat Ditch	8700 $cfs_1(2110)_2$ 100%	8364 $cfs_1(2120)_2$ $96.2\%_3$	8354 $cfs_1(2120)_2$ $96.0\%_3$

1. The values in cfs are the SPF values.
2. The values in (parenthesis) are the volume of the storm in ac-ft.
3. The values in percentages are the percent of flow from the original Corps of Engineers values.

The correlations show that the Interpolated Unit Hydrograph and the original Unit Hydrograph display less than .4 percent difference in the peak flows calculated. Also, the difference in peak flows from the Army Corps of Engineers given values and this report's computer model indicate a maximum difference of four percent.

Hydrology Analysis - Upstream

The hydrologic analysis of the Thomas and Whites Creek drainage basins upstream of the Double Diamond Ranch used much of the data developed by the Army Corps of Engineers in their hydrology report entitled "Truckee River, California and Nevada, Hydrology Offsite Report, February, 1980."

The Corps calculates all the peak flows for the drainage basins for the standard project flood (SPF) during a standard project storm (SPS). The SPF represents a 250-year flow and the SPS for Whites and Thomas Creeks is 35 percent of the probable maximum precipitation (PMP) which is a 500-year event. Also, included in the report is a table of ratios to determine different year flows (see Table 2).

Table 2 - SPF Runoff Ratios

Flood	Ratios of SPF
1000 yr.	4.31
500 yr.	2.06
SPF	1.00
200 yr.	0.84
100 yr.	0.45
50 yr.	0.24
20 yr.	0.11
10 yr.	0.06

The ratios are multiplied by the calculated SPF values to determine the wanted year flows.

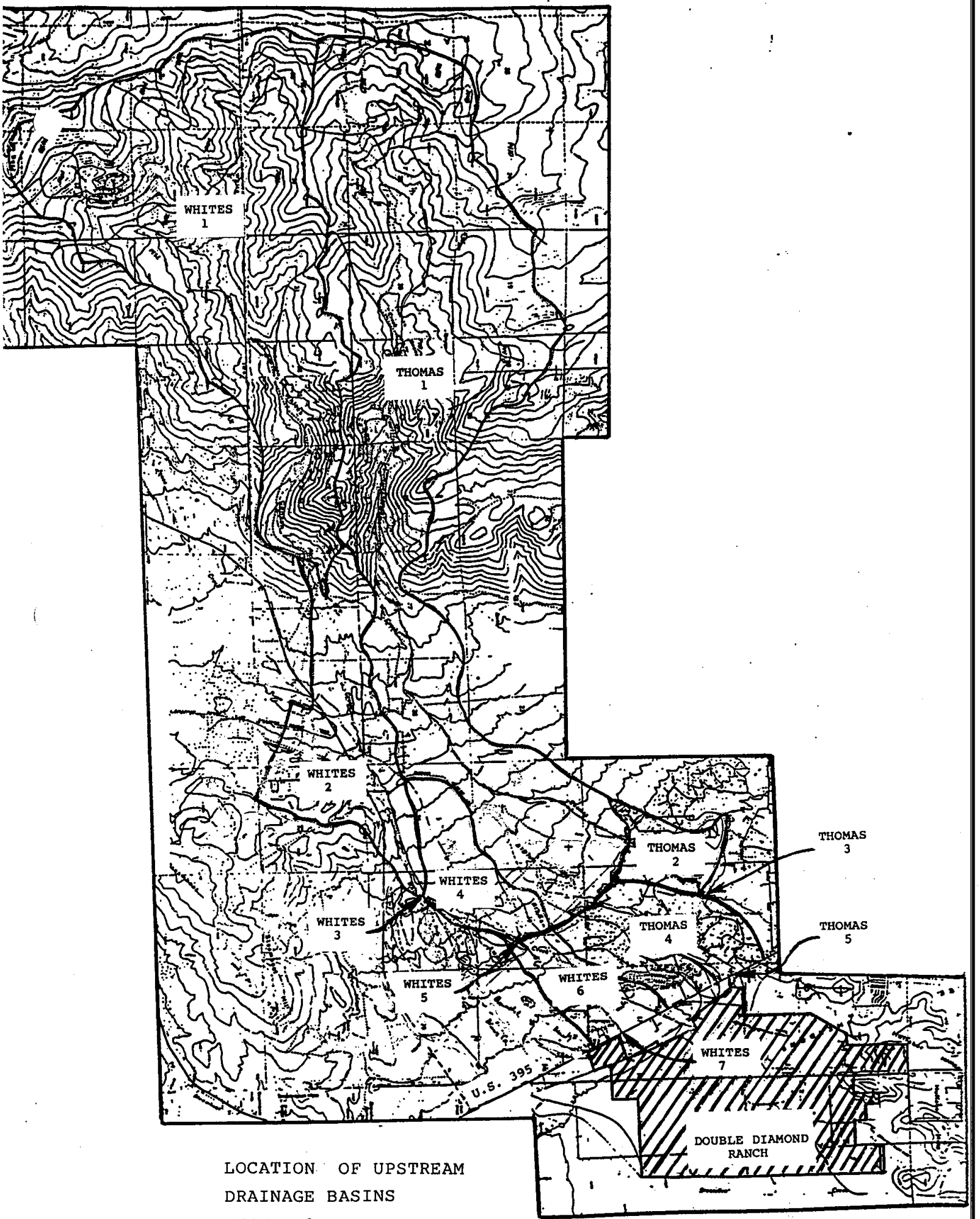
The computer model used two subareas developed by the Corps (#48 and #42), the Thomas Creek Basin above Steamboat Ditch, and the Whites Creek Basin above U.S.G.S. #3497 which is the mouth of the canyon. The Whites Creek basin, the Corps calculated, between Steamboat Ditch and the U.S.G.S. #3497 was not used because the area represented the entire Whites Creek watershed. The entire Whites Creek watershed does not flow into the Double Diamond Ranch. Only the North Fork of Whites Creek, which is called Howards Creek, flows into the Double Diamond Ranch. Below these calculated subareas, the remaining subareas were calculated to reflect the areas draining into the Double Diamond Ranch. Reference Figure 2 for the locations of drainage basins and Figure 3 for a flow chart of the drainage basins.

Both Whites Creek and Thomas Creek have diversion (split flow) structures which are proposed to split the flow by 50 percent, half to one side and half to the other side. The Whites Creek diversion structure is located approximately one mile above Steamboat Ditch whereas the Thomas Creek diversion structure is located just below Last Chance Ditch.

Whites Creek used to be divided into four channels at the diversion structure location, but only two remain: the north branch, Howards Creek, which flows into the Double Diamond Ranch, and the third from the north branch, Browns Creek. The second from the north branch, Browns Lateral, is plugged at the mouth with a large dike. The south branch, unknown name, is filled at the mouth with a large area fill. The Browns Lateral does have water flowing in it below Steamboat Ditch from water which is diverted from Browns Creek. Thomas Creek is divided into two channels at the diversion structure location, the north branch flows to Huffaker Hills area and the south branch flows to the Double Diamond Ranch.

By field observation, a major storm event will overload both the Whites and Thomas Creek diversion structures. When the Whites Creek diversion structure is overloaded, water will flow over the structure and be directed into the Browns lateral channel which flows south of the Double Diamond Ranch. When the Thomas Creek diversion structure is overloaded, water will flow toward the north channel due to the topography of the land, which is toward the City of Reno. The City of Reno is in the process of analyzing solutions to the flooding problems of the Huffaker Hills area. One alternative being discussed is diverting more runoff water into the south channel. The computer model does not involve any of these City of Reno alternatives.

A portion of Huffaker Hills also drains into the Double Diamond Ranch. This is the southeast corner of the Huffaker Hills range which totals 268 acres±. The peak flows calculated for Thomas Creek and Howards Creek at U.S. 395 or South Virginia Street and the Huffaker Hills area are shown in Table 3.



LOCATION OF UPSTREAM DRAINAGE BASINS

FIGURE 2

Table 3 - Peak Flows Upstream of the Double Diamond Ranch

Description	5-yr. Peak Flows (cfs)	100-yr. Peak Flows (cfs)	Time to Peak (hrs.)
Thomas Creek @ U.S. 395	106	1402	3.58
Howards Creek @ U.S. 395	107	1416	3.33
Huffaker Hills Area	20	67	12.75

The peak flow frequency chart for Thomas and Whites Creeks, developed by the Corps, had to extrapolated to determine the five-year peak flows because the chart ends at the 10-year interval. The extrapolation happened in four steps: First, the peak flow frequency lines, four of them, were extended; next, initial peak flow values were taken from the chart and divided into the SPF values to get the percentages; then, the percentages were averaged to get the SPF ratio value for the five-year peak flow. Last, the peak flows were checked against the initial values. Reference Table 4 for the extrapolation data.

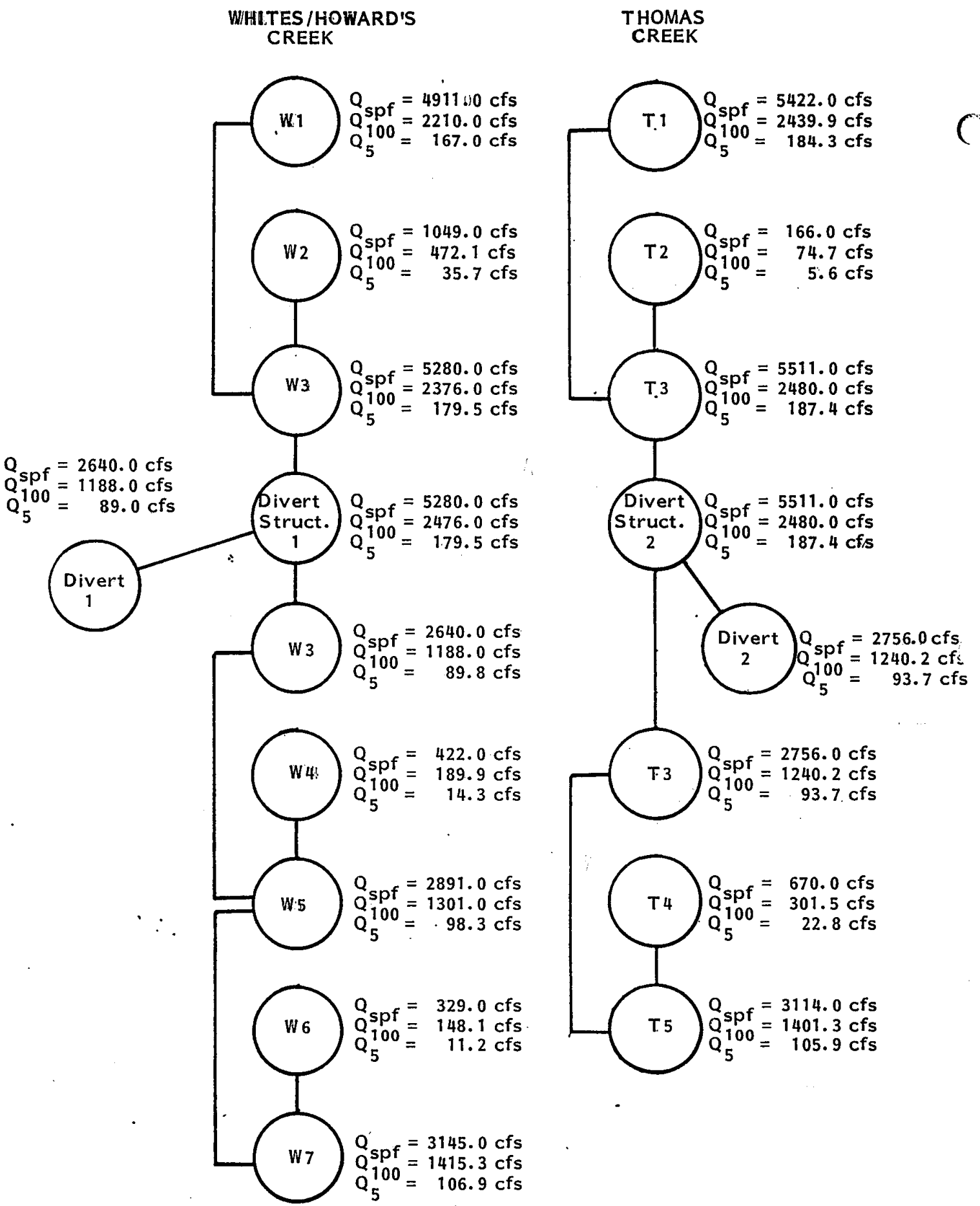
Table 4 - Extrapolation

Subarea #	Initial Peak Flow Value	SPF Value	Percentage	Ratio of SPF
66	165 cfs	4,900	3.33%	
48	190 cfs	5,600	3.39%	3.4% or 0.034
44	295 cfs	8,700	3.39%	
64	375 cfs	10,900	3.44%	

Reference Appendix "B" for the hydrographs and computer data.

Hydrology Analysis - Onsite

The hydrology analysis of the onsite Double Diamond Ranch included the area of the Double Diamond Ranch and the area between the Double Diamond Ranch and U.S. 395 which is partially developed as commercial. Due to the very preliminary nature of the development plan, the entire site area was lumped together to produce one total drainage area. The drainage area was calculated mainly to determine the volume increase of stormwater between the pre-development condition and the post-development condition. The post-development condition does produce a higher peak flow than the pre-development condition, but the higher



FLOW CHART
WHITES/HOWARD'S CREEK AND THOMAS CREEK
Figure 3

peak flow is misleading. The City of Reno ordinances state that the stormwater peak flow from a site (pre-developed) can not be increased from the site after development occurs (post-development). The additional flow will be detained within the onsite pond system to be able to attain the pre-developed peak flows. Reference Table 5 for the preliminary peak flows and volumes of the pre-development and post-development conditions.

Table 5 - Onsite Peak Flows and Volumes

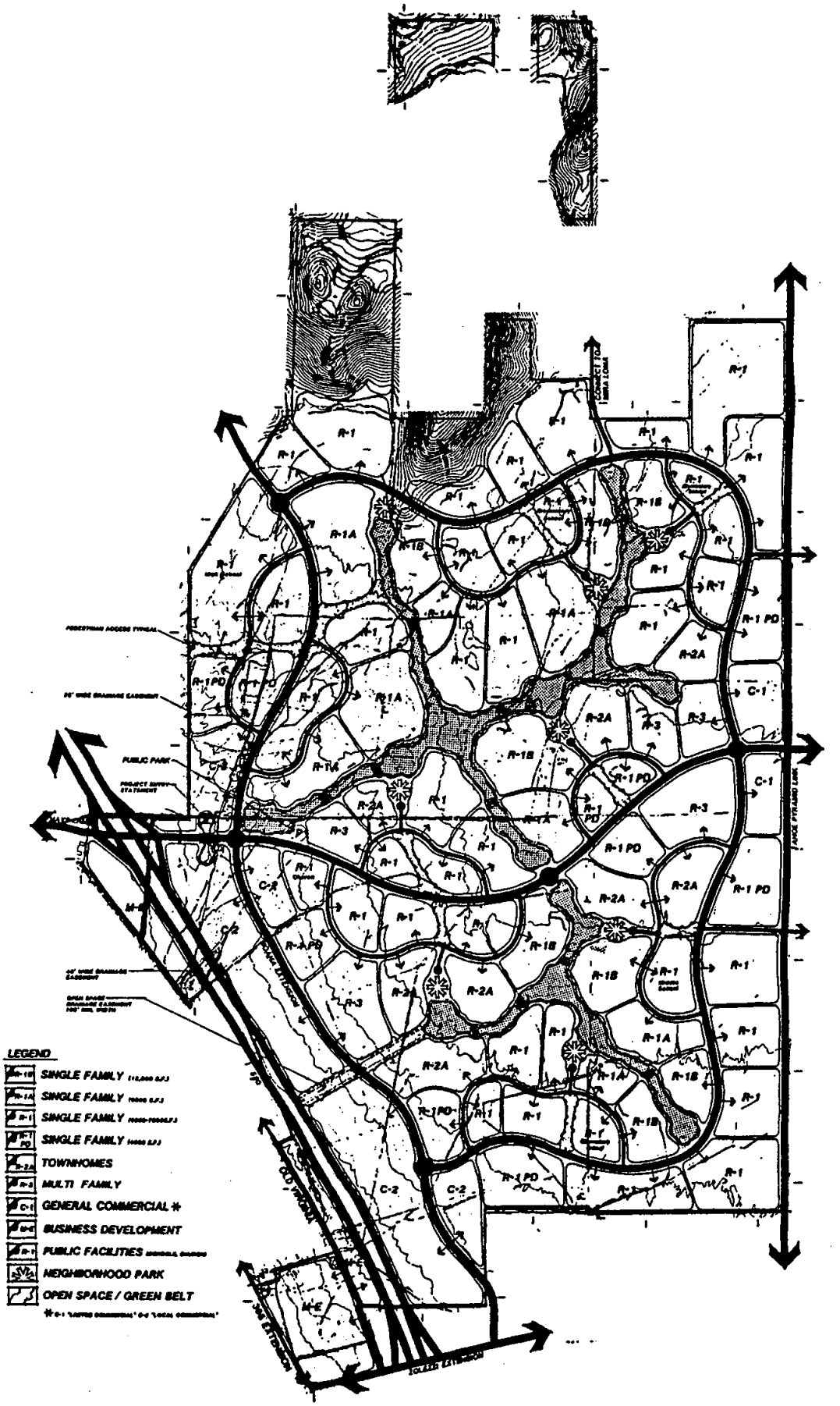
	5-Yr. Peak Flow (cfs)	5-Yr. Vol. (ac-ft)	100-Yr. Peak Flow (cfs)	100-Yr. Vol. (ac-ft)
Pre-Development	62	42	188	116
Post-Development	346	108	1346	241

The detention ponds/lakes cover approximately 90 acres of surface area. The cross-sections of the lakes will range from 100 to 300 feet across with a depth of approximately 8 feet at the center of the cross section and 0.5 feet deep at the sides of the cross section. The lakes will hold approximately 500 acre-feet of water plus have the ability to hold 180 acre-feet of storm water detention. This 180 acre-feet of detention storage is more than enough to hold the additional storm water runoff from the site for a 100-year, 24-hour storm event. Reference Appendix "C" for the hydrographs and computer data. Figure 4 shows the onsite land uses and lake conceptual layout.

The onsite channels will be constructed to carry the 100-year flows developed onsite and upstream. The channels will be excavated into the original ground and planted with erosion resistance grasses. The City of Reno requires that the channel be lining with a non-eroding material from the bottom to the level of 6 inches above the 5-year flow water level. The channels will be placed within the open space areas. The channels will also act to lower the existing high water table and concentrate the water into the lake area.

Portions of the Double Diamond Ranch are within the 100-year flood plain designated by the Federal Emergency Management Agency (FEMA). The 100-year flood plains are derived from Thomas Creek, Whites/Howard's Creek, and Steamboat Creek. Thomas Creek and Whites/Howard's Creek are responsible for the majority of the flood plain area (Zone A). Also, there are no areas within the Double Diamond Ranch designated as flood ways. The Steamboat Creek's floodway channel is more than 900 feet east of the Double Diamond Ranch easterly boundary.

The onsite storm drainage channels and the roadway fill for the future Interstate 580 will direct the storm water from Thomas and Whites/Howard's Creek into the designed channels. The



DOUBLE DIAMOND RANCH
ONSITE LAND USES
AND LAKE LAYOUT
FIGURE 4

roadway fill for the Tahoe-Pyramid Link will not allow overflow water from Steamboat Creek to cross onto the Double Diamond Ranch. The only other area where storm water crosses into the Double Diamond Ranch is the south boundary line. Some storm water flows here will be carried into the site by designed channels and dikes and some will be carried to the Steamboat Creek channel with a diversion dike. By the use of using the future planned roadways and highway systems and designed storm drainage channels, all the 100-year storm water flows will be controlled throughout the developed site area. Once this onsite system is placed, the 100-year flood plains can be amended by the process of the FEMA map revisions, to show that the 100-year flood plains are now contained in the channels. By amending the FEMA maps to show the current 100-year flood plains, the City of Reno flood ordinances of filling the existing developed land above the flood water elevation will not be required. Reference Figures 5, 6, 7, and 8 for the FEMA maps of the Double Diamond Ranch area.

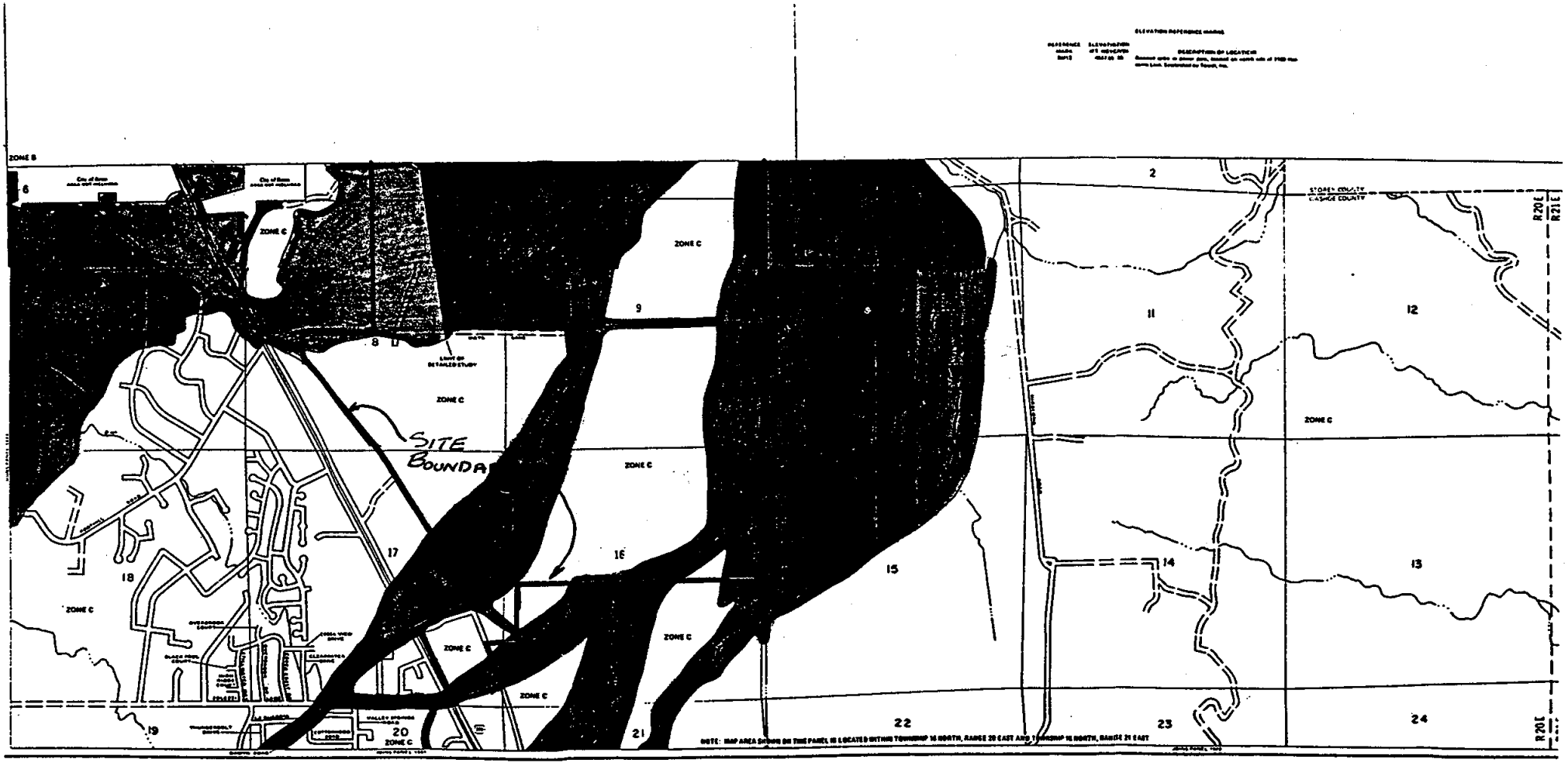
Double Diamond Surface Water Right Considerations

The development of the Double Diamond Ranch property will eliminate numerous irrigation ditches and tail water ditches. Fortunately, the Double Diamond property is located in an area where there are only a few immediate downstream surface water right owners that need to be taken into consideration. The following Orr Ditch decreed water rights receive surface water from ditches that pass through the Double Diamond property. New ditch systems will need to be constructed to by-pass or pass through the proposed development in order to provide surface water to these water righted acreages. All other surface water sources either terminate on the Double Diamond property or by-pass this development without being affected.

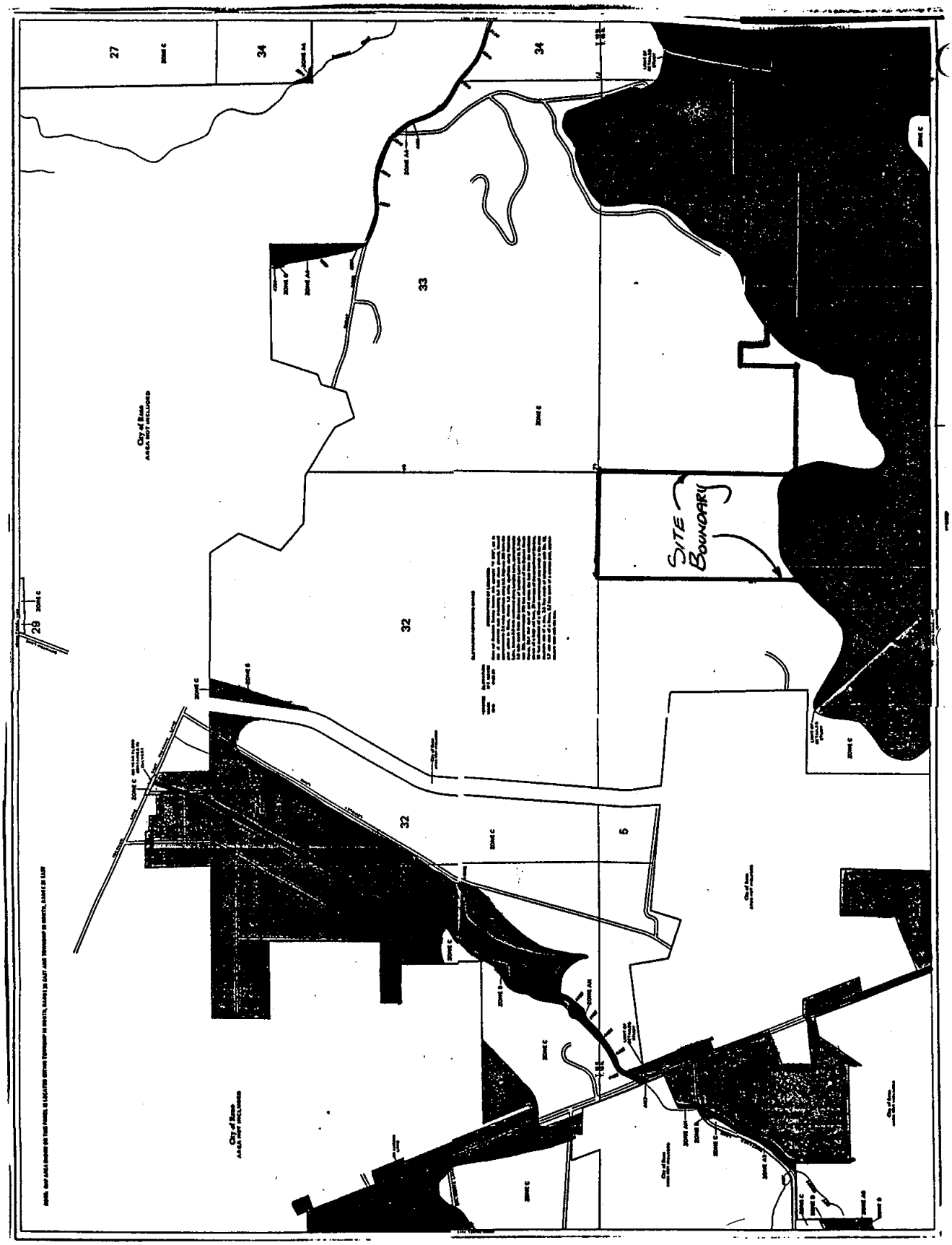
THOMAS CREEK

Alexander Lake under Orr Ditch Decree Claim No. 713 is "allowed to receive water from Thomas Creek and the south branch thereof and from wastewaters, a flow not exceeding 1000 inches (25 cubic feet per second) to the extent necessary to fill and keep filled the Candle Reservoir which is also known as Alexander Lake." The priority of this right is October 14, 1889 which is junior to all the other August 5, 1859 priority water rights on Thomas Creek. It will be necessary to insure that once the upstream senior rights are receiving their full allotment of water that the Alexander Lake right is also satisfied. This can be accomplished in the following manner.

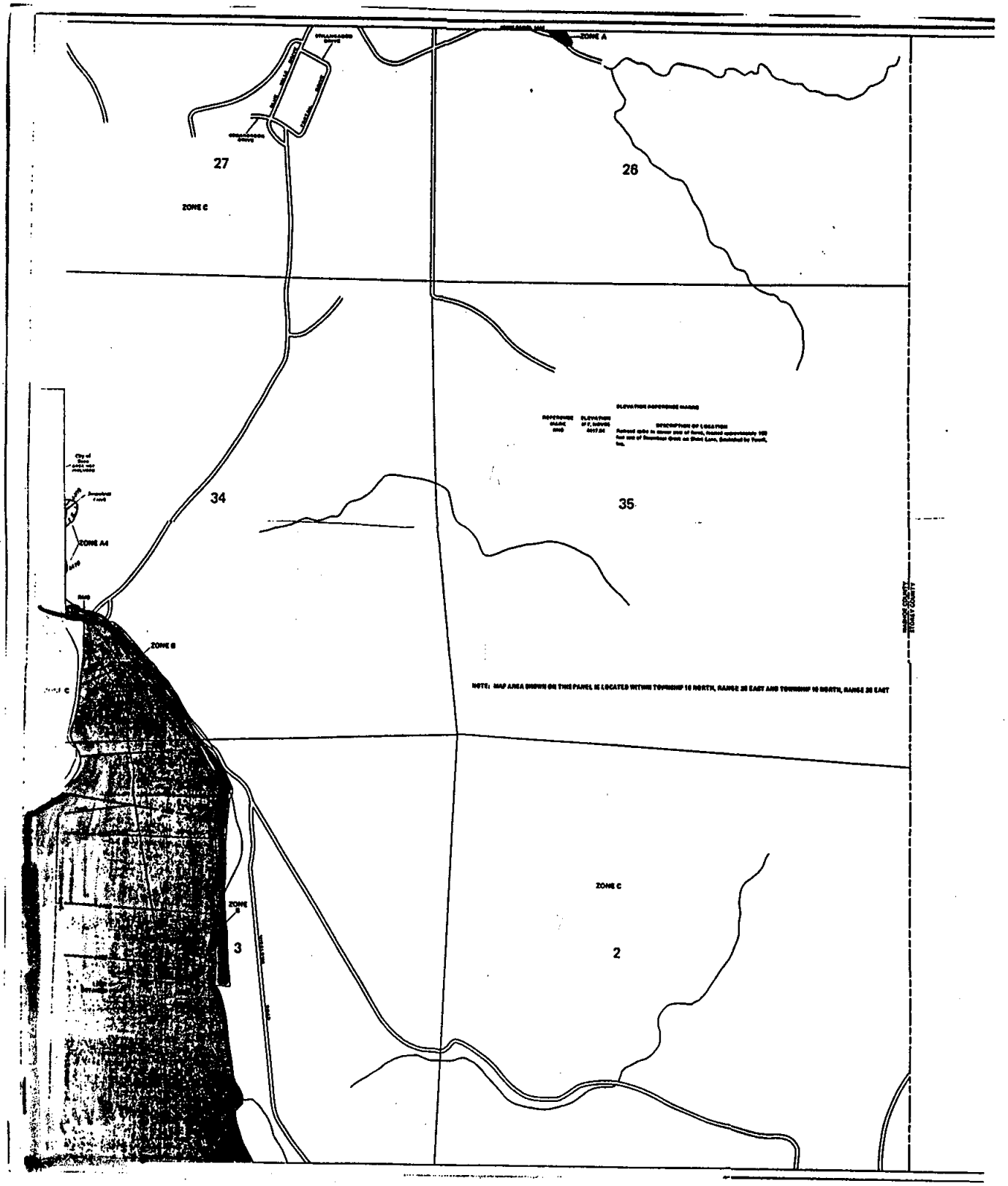
Water from Thomas Creek would need to be measured in appropriate locations to determine whether or not the proper amount of water is being delivered to Alexander Lake. Washoe County presently maintains and operates a measurement/recording station at the mouth of Thomas Creek Canyon. According to the Orr Ditch Decree, the earliest priorities on Thomas Creek are allowed to



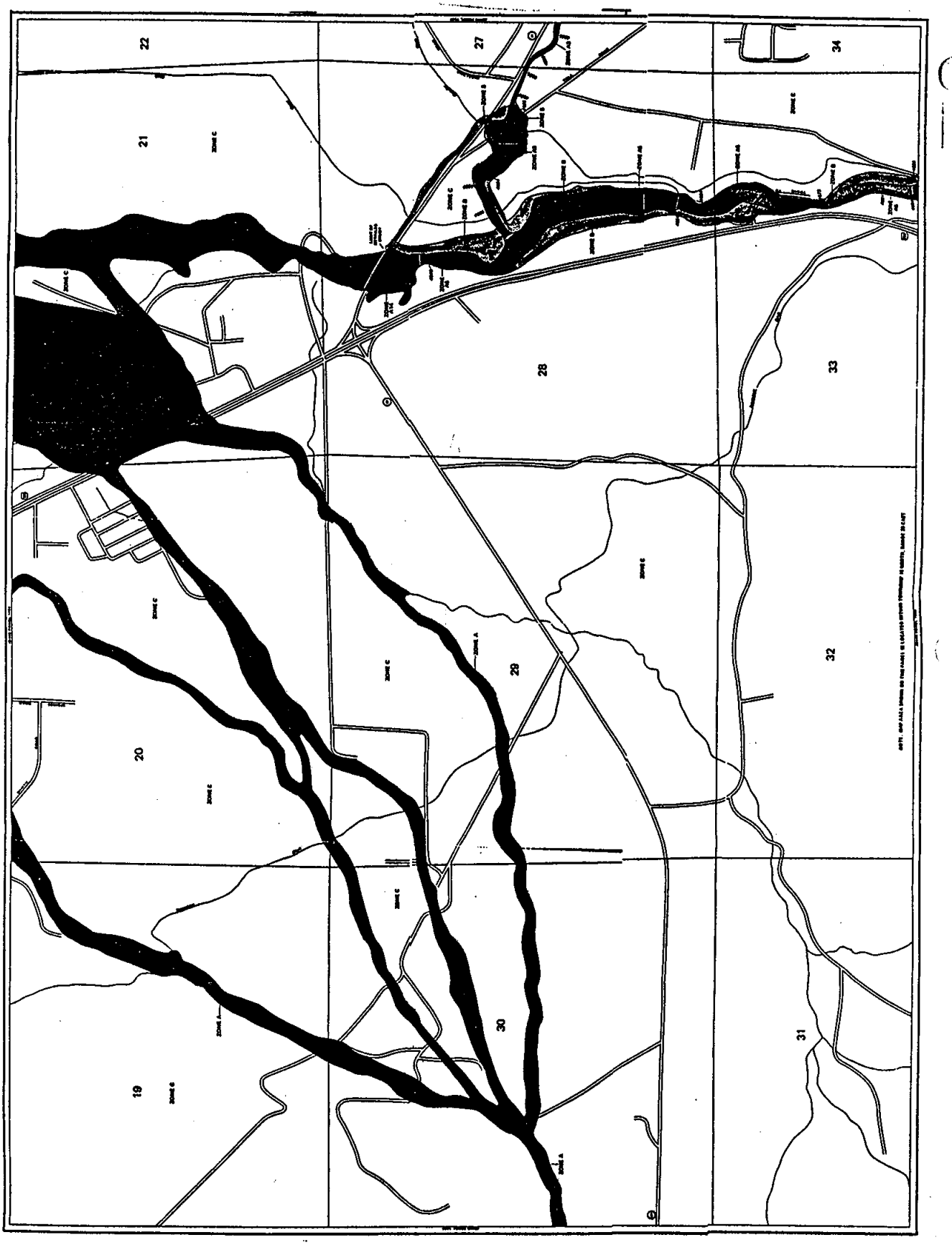
FEMA MAP
PANEL #1465
FIGURE 5



FEMA MAP
PANEL #1461
FIGURE 6



FEMA MAP
PANEL #1462
FIGURE 7



FEMA MAP
PANEL #1501
FIGURE 8

divert up to 15.5 cubic feet per second (cfs) or 7,000 gpm of "direct water" before Alexander Lake is entitled to receive water. Should the County measurement stations show that 25 cfs is flowing in Thomas Creek, Alexander Lake would be entitled to divert 9.5 cfs of "direct water." A means of transporting these waters to the ditch leading into Alexander Lake will need to be constructed.

Alexander Lake has rights to waste water with a priority of October 14, 1889. The Double Diamond properties have waste and flood water rights which have an earlier priority of 1875 and 1876. By taking the Double Diamond properties out of agricultural production there will be a large reduction in the amount of wastewater generated and therefore less available. The only wastewater foreseen is that from the irrigated lands above Highway 395 which would be by priority first available to Double Diamond and then to the Alexander Lake.

These "direct," waste and flood waters could pass through the proposed Recreational Lake so long as the proper amount can be delivered to Alexander Lake.

A measurement station and possibly a recording device may be required either at the intersection of Highway 395 where Thomas Creek and waste/flood waters enter the Double Diamond properties or as water enters the ditch into Alexander Lake. This station would be needed to verify that the decreed amount of "direct water" and waste/flood water is being allocated properly.

STEAMBOAT CREEK

The development of the Double Diamond properties will eliminate ditch systems that currently provide Steamboat Creek water to water right acreage located in the W 1/2 NW 1/4 of Section 10 and the W 1/2 W 1/2 of Section 3, T. 18 N., R. 20 E., M.D.M. These water righted acreages are stipulated under Steamboat Creek in the Orr Ditch Decree Claim Nos. 709, 710, 711, and 712. It is anticipated that a new diversion structure in Steamboat Creek and a ditch system will be required in order to provide water to these areas.

BROWNS CREEK AKA WHITES CREEK

Ditch systems carrying Brown Creek water through Double Diamond properties located in the SE 1/4 SE 1/4 Section 17, T. 18 N., R. 20 E., M.D.M. will need to be perpetuated or reconstructed in such a way to insure that decreed rights located under Claim Nos. 715 and 715a and appurtenant to portions of Sections 16, 17, 20, and 21 T. 18 N., R. 20 E., M.D.M. are satisfied.

RECREATIONAL LAKE

The proposed Recreational Lake will experience evaporation and seepage losses. It will be necessary to cover these losses with water rights in order to avoid effects on downstream water right owners. The Double Diamond properties contain decreed water rights under Orr Ditch Decree Claim No. 729 (priority 1875), Claim No. 730 (priority 1876) and Claim No. 731 (priority 1890) for waste and flood water which can be used for offsetting the expected evaporation and seepage losses. These decreed rights allow for the use of any flood and wastewater entering the Double Diamond property and for any onsite drainage and waste to be diverted into the Recreational Lake.

Conclusions

The development of the Double Diamond Ranch will have no storm drainage impact downstream of the site. The onsite channeling of the storm water will direct the water into the lakes. Once at the lakes, the storm water leaving the developed site will not increase the existing peak flows currently leaving the site under the same storm event. Also, all the water right claims have been considered and approaches made to direct the water right claims to each appropriated individual. All development will be done according to the City of Reno ordinances meaning the major storm drainage ways and lakes will be designed for the 100-year flows and the interior development sites will be designed to have an underground storm drainage system to carry the 5-year flows and an overland system to carry the 100-year flows.

After a tentative grading plan has been developed, a more comprehensive hydrology report of the onsite area will need to be completed to show how the individual development areas affect the lakes as a system and which lake will receive the excess storm water. Also, the major storm drainage channels can be located and designed with the more detailed grading.