



1.0 Project Background

1.0 PROJECT BACKGROUND

1.1 PURPOSE

The primary purposes of this Update to the Dry Creek Watershed Flood Control Plan (Plan Update) are to update the hydrologic analysis of the watershed, to identify possible means to mitigate development impacts on flooding and reduce flood damages, to provide new analytical tools to evaluate projects, and to present funding options. The 1992 Dry Creek Watershed Flood Control Plan (1992 Plan) recommended structural and non-structural measures to correct existing deficiencies and mitigate for impacts of future development. Some of the recommendations of the 1992 Plan have been implemented, though many have not been implemented due to environmental and/or economic constraints. This Plan Update evaluates the hydrology of the watershed and provides recommendations based on an overall watershed approach with the objective of identifying improvements that will be both feasible and effective.

1.2 WATERSHED DESCRIPTION

The Dry Creek watershed covers an area of 101.4 square miles in Placer and Sacramento Counties. The majority of the watershed (82 percent) is contained within the limits of Placer County. The Cities of Rocklin and Roseville, and the Town of Loomis are wholly or partially contained within the watershed. Other unincorporated communities in the watershed include Granite Bay, Penryn, Newcastle, Orangevale, and Rio Linda. A vicinity map of the watershed is provided on Plate 1 and a watershed overview is provided on Plate 2. Of the 101.4 square miles that cover the watershed, 88.4 square miles are within, or are tributary to, parts of Placer County. The remaining 13.0 square miles are within Sacramento County, along Dry Creek, downstream from the Sacramento County – Placer County line.

The headwaters of Dry Creek are located in the upper portions of the Loomis Basin, in the vicinity of Penryn and Newcastle, in unincorporated Placer County, in the Granite Bay area near Folsom Lake, and in Orangevale in Sacramento County. Antelope Creek and Clover Valley Creek form the northwest boundary of the watershed, and Secret Ravine and Miners Ravine comprise the northeast portion of the watershed. Antelope Creek and Miners Ravine, downstream from their confluences with Clover Valley Creek and Secret Ravine, respectively, combine near Interstate 80 and Atlantic Street in Roseville to form Dry Creek. Cirby Creek, made up of the combination of Cirby and Linda Creeks and Strap Ravine, joins Dry Creek just upstream from Riverside Avenue in Roseville. Downstream of Roseville, just downstream of Elverta Road, Dry Creek branches into North Dry Creek and Dry Creek and forms Cherry Island in the Rio Linda area.¹ (See Plate 2)

¹ James M. Montgomery, Dry Creek Watershed Flood Control Plan, 1992.



Watershed topography, soil types and ground cover, and land use (imperviousness and drainage systems) are the basic elements that determine the portion of rainfall that becomes runoff and the timing of the runoff flowing through the watershed. These elements are introduced in this section and are elaborated upon in a subsequent section of the Plan Update. Additional descriptive information about the watershed is available in the various sources referenced in the Plan Update.

1.2.1 Topography

The lower end of the Dry Creek watershed is on the Sacramento Valley floor and the headwaters are located in the Sierra Nevada foothills. The mouth of Dry Creek, at its confluence with the Natomas East Main Drainage Canal, is at an elevation of about 30 feet above mean sea level (msl). Antelope Creek, Secret Ravine, and Miners Ravine have headwaters in the vicinity of Newcastle and Penryn at elevations of 900 to 1,200 feet msl, in hilly topography typical of the foothills. Linda Creek, Cirby Creek, and Strap Ravine have headwaters in Orangevale in Sacramento County, and in the Granite Bay area at elevations of 300 to 500 feet msl, with less relief than is found in the other Dry Creek tributaries.²

The upper portions of the Dry Creek watershed are characterized by relatively steep slopes and moderate relief. The lower reaches of the Dry Creek watershed, especially downstream of Roseville, are characterized by very gentle slopes. The stream channels throughout the watershed are generally well defined, but are not especially wide or deep.³

1.2.2 Soils

Soils within the Dry Creek watershed are variable, depending upon landscape position and underlying geology. Most soils are formed from either granitic or volcanic parent material, and often include a clay pan, or other consolidated layer that impedes water permeability. Shallow soils and rock outcrops are fairly common at higher elevations.⁴ The United States Department of Agriculture Natural Resources Conservation Service (USDA NRCS) has given each soil type a hydrologic classification based on infiltration rates. Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four hydrologic soil groups (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. The hydrologic soil groups are defined as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel, and have high rates of water transmission, greater than 0.30 inches per hour (in/hr).

² James M. Montgomery, Dry Creek Watershed Flood Control Plan, 1992.

³ James M. Montgomery, Dry Creek Watershed Flood Control Plan, 1992.

⁴ ECORP Consulting, Inc., Dry Creek Watershed Coordinated Resource Management Plan, 2003.



Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have moderate rates of water transmission (0.15-0.36 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water, and soils with moderately fine to fine texture. These soils have low rates of water transmission (0.05-0.20 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have very low rates of water transmission (0-0.09 in/hr).⁵

Table 1 lists the hydrologic soil groups found within the Dry Creek watershed for Placer and Sacramento Counties.

Table 1. Dry Creek Watershed Hydrologic Soil Types

Watershed Name	Hydrologic Soil Type (acres)			
	A	B	C	D
Antelope Creek	0	3,278	529	3,501
Cirby Creek	42	8	172	1,506
Clover Valley	0	602	179	1,543
Dry Creek	796	1,057	1,799	12,221
Linda Creek	64	2,318	351	5,234
Miners Ravine	0	9,155	694	3,249
Secret Ravine	18	8,106	1,371	4,667
Strap Ravine	31	750	53	1,611
Total	951	25,273	5,148	33,532
Percentage	1.5%	38.9%	7.9%	51.7%

A map depicting the hydrologic soil group for the soils in the Dry Creek watershed is shown in Plate 3. For additional information, an extensive listing of the soil names and classifications for the soils located in the Dry Creek watershed can be found in the 2003 Dry Creek Watershed Coordinated Resource Management Plan (DCWCRMP).

1.2.3 Land Use and Development Projections

The types of land use that occur in a watershed are significant in determining the amount of runoff that results from a given amount of rainfall. Much of the difference in runoff from different land uses can be attributed to the difference in the percentage of the land that is impervious (paved or covered by buildings). Another important factor that is determined by the type of land use is the condition, or hydraulic efficiency, of the

⁵ USDA NRCS, Urban Hydrology for Small Watersheds, TR-55, 1986.

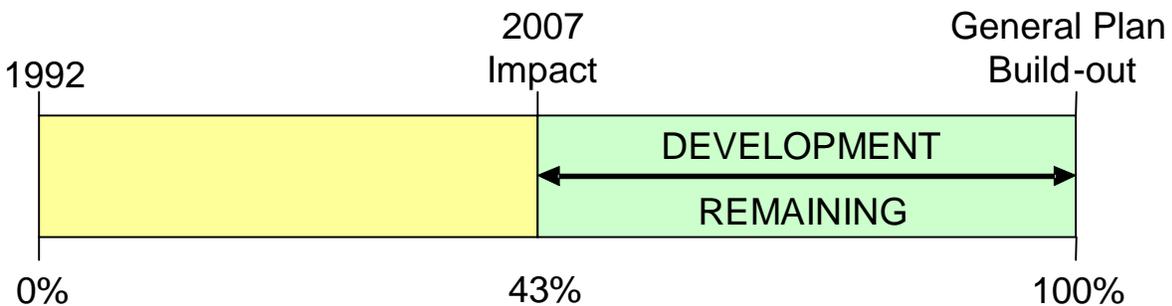


smaller tributaries and streams in the area and what portion of the flows are conveyed along streets and in storm drains. The land uses in the Dry Creek watershed vary widely, from mixed urban, suburban, rural, and open space land.

From the completion of the 1992 Plan through 1997, land development within the Dry Creek watershed was relatively slow due to an economic recession. Development activities began to accelerate in 1998, and by 2002, development was occurring at record levels. Another recession slowed land development down in late 2002 and early in 2003. From 2004 and continuing into 2007, land development activity was high again, but by late 2007 the pace of land development dropped dramatically due to a severe recession. Due to the slow pace of development since 2007, it was determined that the estimate of 2007 land use could be considered as new baseline from which to move forward for the purposes of this Plan Update. This Plan Update anticipates that development to the build-out conditions described in the various municipal General Plans will eventually occur.

It is estimated that approximately 43 percent of the projected total impacts (within the 88.4 square miles within and tributary to Placer County, based on impervious area estimates, prior to considering mitigation measures) of development on runoff expected to occur between 1992 and the General Plan build-out condition, occurred prior to 2007 (refer to Figure 1). These development status values are presented relative to the initiation of the mitigation impact fee program.

Figure 1: Development Scenario



Estimates of imperviousness were used to indicate the amount of development that has occurred. Plate 4 identifies the imperviousness for the watershed in the 1992 (baseline) conditions. Plate 5 identifies the imperviousness for the watershed in the 2007 conditions, and Plate 6 identifies the imperviousness for the watershed for the General Plan (build-out) conditions. Plate 7, Plate 8 and Plate 9 illustrate land use for the baseline, 2007 and build-out conditions, respectively. The upper portion of Table 2 lists the estimated impervious area within the Dry Creek watershed and its major sub-basins for the baseline 1992, 2007 and build-out conditions. The lower portion of Table 2 shows the results of calculations based on the listed impervious area values. These calculations show that 43 percent of the impervious area expected to be added between 1992 and build-out had already been constructed by 2007. $\{(17.63-14.35)/(21.96-14.35)=43.1\}$



Of the 88.4 square miles within and tributary to Placer County, approximately 6 percent is within Sacramento County, and this area, generally within Orangevale, accounts for approximately 1.9 percent of the expected increases in imperviousness within and tributary to Placer County. Specifically, 0.08 square miles of the expected increase of 3.79 square miles of imperviousness within the 88.4 square mile portion of the Dry Creek watershed upstream from the Placer County line is expected to occur within Sacramento County.

Table 2: Watershed Imperviousness

Watershed	Area (sq. mi)	Impervious Area (sq. mi)		
		1992	2007	Build-out
Antelope Creek	11.41	2.36	2.53	3.02
Cirby Creek	2.70	1.16	1.45	1.49
Clover Valley	3.63	0.24	0.33	0.88
Dry Creek	11.82	3.25	3.45	4.39
Linda Creek	12.45	1.29	2.29	2.56
Miners Ravine	20.47	1.92	2.56	3.09
Secret Ravine	22.13	3.45	3.93	5.29
Strap Ravine	3.82	0.68	1.09	1.24
Grand Total	88.43	14.35	17.63	21.96
Percent build-out from 1992 baseline		0.0%	43.0%	100.0%
Percent build-out in absolute terms		65.4%	80.3%	100.0%
Percent impervious		16.2%	19.9%	24.8%

1.3 1992 DRY CREEK WATERSHED FLOOD CONTROL PLAN

The purpose of 1992 Plan was to provide the District and other governmental agencies (in both Placer and Sacramento Counties) with the information and policies necessary to manage stormwater runoff within the Dry Creek watershed from a flood control perspective. The 1992 Plan was intended to provide an approach for meeting existing and future flood control needs in the watershed. In addition, the 1992 Plan recommended structural and non-structural measures to correct existing deficiencies and mitigate for impacts of future development within the watershed. The 1992 Plan was formally adopted by District Board in June 1995.

The 1992 Plan focused on the ability of on-channel regional detention basins to both correct existing flooding problems and mitigate for the increase in flood flows due to development. The 1992 Plan studied 25 potential detention basin sites throughout the Dry Creek watershed and identified 16 sites that might be feasible. The 16 sites were evaluated to determine both local and regional flood reduction capacity. Regional flood reduction capacity was measured based on flow rates at Vernon Street in Roseville. Seven sites were selected for inclusion in the 1992 Plan based on costs and flood flow reduction efficiency at Vernon Street. If implemented, these sites could have provided peak 100 year flood flow reduction of nearly 4,000 cubic feet per second (cfs) at Vernon Street. However, none of the on-channel regional detention basins included in the 1992



Plan have been, nor are currently expected to be, implemented.

In 1997-1998, the District studied the feasibility and began planning efforts for an on-channel regional structural flood control project on Miners Ravine upstream of Sunrise Avenue as recommended in the 1992 plan. However, that project was met with strong public opposition, and significant permitting and environmental constraints were identified. The District Board voted to abandon that project and evaluate other types of flood control projects more acceptable to the public, the environmental community and permitting agencies.

The 1992 Plan also included an extensive evaluation of bridge and culvert replacement needs, and an evaluation of three channel improvement projects. Furthermore, the 1992 Plan addressed non-structural alternatives and included sections on local stormwater detention, floodplain management and a flood warning system.

1.4 INFORMATION SOURCES

Numerous information sources were referenced in the preparation of this Plan Update, including the following hydrologic and environmental reports. Additional references can be found in Appendix A. Data sources used in the direct development of the computer models prepared as part of the Plan Update are described in Sections 1.5 and 1.7.

1.4.1 Hydrologic Reports

1.4.1.1 1988 Hydrology Office Report, Dry Creek Basin, Placer and Sacramento Counties (United States Army Corps of Engineers [USACE])

The 1988 Hydrology Office Report was an update of a 1984 study prepared by the Sacramento District of the USACE for use in the feasibility study for flood control projects with the Dry Creek watershed. The study provides flood history data, performed both general storm and cloudburst storm hydrology, and evaluated existing land use conditions and projected 2040 flood flows. Standard Project Flood (SPF), 100-year, 50-year, 25-year, and 10-year discharges were tabulated.

1.4.1.2 1992 Dry Creek Watershed Flood Control Plan (JMM)

The 1992 Dry Creek Watershed Flood Control Plan has been the basis of flood control planning in the Dry Creek watershed used by the District, Placer County, the City of Roseville, the City of Rocklin and other local communities. This Plan Update will supersede the 1992 Plan.

1.4.1.3 2000 Dry Creek Watershed Flood Detention and Stream Restoration Feasibility Study (Swanson & EDAW)

The Dry Creek Watershed Flood Detention and Stream Restoration Feasibility Study investigated 19 potential sites for regional flood detention projects based on project



feasibility, relative cost, and environmental issues. Two sites, Miners Ravine below Sierra College Boulevard and Secret Ravine above Sierra College Boulevard, were examined conceptually as example projects to produce preliminary cost estimates for multi-use regional flood detention projects.

1.4.1.4 2001 Flood Insurance Study (Federal Emergency Management Agency [FEMA])

The Placer County Flood Insurance Study (FIS) provided an update to the FEMA 100-year floodplain maps, and baseline FEMA hydrology. The FIS was largely based on the hydrology of the 1992 Plan; however, some updates were made for various areas of the watershed, where new studies with better calibrations had been made.

1.4.1.5 2001 Town of Loomis Drainage Master Plan (West Yost)

The Town of Loomis Drainage Master Plan describes the existing storm drain system for the Town of Loomis and provides recommendations for upgrades to the system to decrease localized flooding problems. The localized flooding issues are due primarily to inadequate storm drain infrastructure, and not necessarily flood flows from streams in the Dry Creek Watershed. It also lists several crossings of Antelope Creek, Sucker Ravine, and Secret Ravine that are inundated by flood flows. The crossings are presented in the Existing Flood Hazard section of this report.

1.4.1.6 2004 Alternative Regional Detention Sites (URS)

The Alternative Regional Detention Sites report documents analysis of four potential sites for regional detention basins: Strap Ravine immediately upstream of McLaren Drive next to Maidu Park in Roseville; Miners Ravine upstream of East Roseville Parkway; Linda Creek west of Rocky Ridge Drive and south of Meadowlark Way in Roseville; and Miners Ravine immediately downstream of Sierra College Boulevard. The report uses the hydrology information developed for the 1992 Plan and created an unsteady-state HEC-RAS hydraulic model from various existing hydraulic models. The report recommended the construction of the Miners Ravine detention basin immediately downstream of Sierra College Boulevard and reported that “although the other three sites did reduce peak discharges immediately downstream of their locations, their hydraulic benefits were localized and only minor positive impacts downstream near Riverside Ave. and Vernon St. Bridges (E-1).” The only regional detention basin that was recommended in this report, Miners Ravine Off-Channel Detention Basin, was completed in 2007.

1.4.1.7 2006 Central Rocklin Drainage Master Plan (West Yost)

The Central Rocklin Drainage Master Plan documents analysis of the urban drainage through storm drain systems and also includes sections on stream flooding. The District’s HEC-2 models used for the 1992 report and the 1998 FEMA Flood Insurance Studies (FIS) were converted to HEC-RAS and used to analyze flooding in the Dry Creek tributary streams in the City of Rocklin. Three locations along Antelope Creek and four locations along Sucker Ravine were identified where City of Rocklin roadways



would be expected to be overtopped during a 100-year storm event.

1.4.1.8 2007 Miners Ravine Off-Channel Detention Basin Hydrology and Hydraulic Design Report (RBF Consulting)

The Miners Ravine Off-Channel Detention Basin Hydrology and Hydraulic Design Report contains the methodology and calculations used to design the Miners Ravine Off-Channel Detention Basin for the District. The report outlines the baseline hydrology for key points in the Dry Creek Watershed. Hydraulic design methods and calculations are also documented, including spillway design, sediment transport, and failure scenarios.

1.4.2 Environmental Documents

1.4.2.1 1994 Dry Creek Watershed Flood Control Program Programmatic Environmental Impact Report (Jones & Stokes)

The Dry Creek Watershed Flood Control Program Programmatic Environmental Impact Report (PEIR) describes the potential environmental impacts of the proposals of the 1992 Plan and presents mitigation measures to be used while implementing the recommendations of the 1992 Plan.

1.4.2.2 2001 Secret Ravine Adaptive Management Plan (Dry Creek Conservancy)

The Secret Ravine Adaptive Management Plan describes remedial actions for increasing natural salmonid production and satisfying a wide range of stakeholder interests.

1.4.2.3 2002 Miners Ravine Restoration Project (EDAW)

The Miners Ravine Restoration Project report describes the plan for improvements of the Miners Ravine Nature Reserve near the intersection of Oak Glen Lane and Auburn-Folsom Road to enhance floodplain function and habitat value. The plan includes channel excavation to restore natural floodplain function, removal of debris, bank re-vegetation, and removal of barriers to fish passage.

1.4.2.4 2002 Miners Ravine Habitat Assessment (State of California, The Resources Agency, Department of Water Resources)

The Miners Ravine Habitat Assessment report describes the biological habitat survey of Miners Ravine with special attention given to salmon habitat.

1.4.2.5 2003 Dry Creek Watershed Coordinated Resources Management Plan (Dry Creek Conservancy, Harding Lawson Associates, Swanson Hydrology & Geomorphology, ECORP Consulting, Inc.)

The broad scope of the Dry Creek Watershed Coordinated Resources Management Plan offered a comprehensive review of the Dry Creek watershed covering hydrology,



biology and wildlife, population growth and development projections, and policy implementation plans.

1.5 COMPUTER MODELING

This Plan Update provides a new hydrologic modeling system that is a significant technological advance over the 1992 Plan. Though the 1992 Plan was state-of-the-art at the time it was prepared, the new modeling system is better able to evaluate flood flow timing and backwater impacts on flow routing that are significant to development impact and project analysis than the 1992 Plan model. Computer programs, including the USACE's "Flood Hydrograph Package" (HEC-1), "Hydrologic Modeling System" (HEC-HMS) and "River Analysis System" (HEC-RAS) software developed by the U.S. Army Corps of Engineers (USACE); GIS software; and other software, referred to as the Dry Creek Desktop software (DCDESKTOP) (see Appendix J) developed specifically for this Plan Update, were employed to develop a new basis for watershed runoff and flood flow evaluations. The new modeling system includes substantially more detail than the 1992 modeling system, thereby allowing it to be used on smaller tributaries which will facilitate its application on smaller projects. Furthermore, the new modeling system has been calibrated using precipitation and stream flow gage data from December 1995, January 2007 and December 2005 storm events to ensure the validity of the results.

This Plan Update uses more than seven times the number of sub-watersheds than included in the 1992 Plan HEC-1 model to facilitate evaluation of smaller features and the effects of routing along tributaries. Also, whereas the 1992 Plan developed some HEC-1 flow (Modified Puls) routing parameters using steady-state flood profiles calculated in HEC-2, the Plan Update HEC-1 and HEC-HMS models include far more detailed flow routing parameters developed using steady-state HEC-RAS models. Additionally, an unsteady-state hydraulic routing model that covers the streams in the lower (downstream) two-thirds of the watershed was prepared and used to perform critical routing analysis. The unsteady-state hydraulic model was used to calibrate the system model and to perform realistic evaluations of project impacts that would otherwise not be feasible. The watershed details, improved hydrologic routing, implementation of hydraulic (unsteady-state HEC-RAS) routing, and event calibrations form the basis of this Plan Update. This Plan Update uses HEC-HMS that is replacing HEC-1, to take advantage of its capabilities and to modernize the analysis procedure.

1.5.1 Application of HEC-1 and HEC-HMS

The District's procedures for using HEC-1 to perform hydrology studies are provided in the District's Stormwater Management Manual (SWMM) dated September 1, 1990 which were formally adopted in 1994. Historically, the District's methodology for using HEC-1 requires the use of the Placer County Design Precipitation Program (PDP) dated August 15, 1994. A key element of the District's hydrology procedures requires the use of multiple storm centerings to identify the appropriate design rainfall distribution for each unique condition.

The 1992 Plan was based on modeling of multiple storm center locations generally



consistent with, but not equivalent to, the subsequently adopted procedures. Various storm centering model runs established the peak flow rates at key locations throughout the watershed. Hydrology for local benefit analysis was performed for each of the projects included in the 1992 Plan was based on a storm center within each project's tributary watershed. Hydrology was also performed for each project based on the storm centering that generated the peak discharge along Dry Creek at Vernon Street to measure regional benefit. In the 1992 Plan, the storm used to measure regional benefit of projects was centered in the Miners Ravine watershed. Numerous subsequent studies relied on using this single storm centering.

In the process of applying the PDP for this Plan Update, it was determined that there was an error in the programming code that became significant under some circumstances. As a result, the District's PDP software was updated to Version 2.0 (PDP2) with this Plan Update, to correct a precipitation generation error and to provide a smoother precipitation intensity distribution based on interpolation of rainfall depths.

The DCDESKTOP software provides an improved means to prepare HEC-1 input files based on District approved methodologies, to perform multiple storm centering analyses, to convert HEC-1 files to HEC-HMS and to perform some other functions such as creating summary output tables. HEC-HMS offers more GIS mapping capabilities, input data error detection and other advantages over HEC-1. The DCDESKTOP software provides a much more efficient means to apply the PDP in HEC-HMS than is possible using HEC-1 input file conversion tools built into HEC-HMS. DCDESKTOP software may be downloaded from www.pcdrycreek.org.

1.5.2 Application of HEC-RAS

This Plan Update used HEC-RAS to calculate Modified Puls routing parameters used in the hydrology models and to perform hydraulic routing to account for varying backwater conditions that cannot be simulated using HEC-1 or HEC-HMS. Varying backwater infers that there is not a one-to-one correlation between stage and discharge, a condition that is typical at structures and in the vicinity of stream confluences. HEC-RAS has replaced the USACE's HEC-2 "Water Surface Profiles" and UNET "One-Dimensional Unsteady Flow through a Full Network of Open Channels" computer programs. The Modified Puls routing parameters were calculated using steady-state HEC-RAS and were included in the HEC-1 and HEC-HMS models which only allow a one-to-one stage vs. discharge relationship. Unsteady-state HEC-RAS was used for evaluations that are sensitive to backwater conditions.

Initially, the baseline project model was compiled in HEC-RAS version 4.0 for the lower two-thirds of the watershed. The model was built based on the assembly of existing hydraulic models for the various main tributaries of Dry Creek including: Miners Ravine, Secret Ravine, Sucker Ravine, Strap Ravine, Linda Creek, Cirby Creek, Antelope Creek, and Clover Valley. Modifications to the model were made as determined to be appropriate for the new system model to run in the unsteady-state mode. The model was also run in the steady-state mode to calculate Modified Puls routing parameters. However, HEC-RAS version 4.0 did not provide correct storage parameters for Modified



Puls, so version 4.0.1 beta was obtained from USACE and was used for the Modified Puls calculations and preliminary unsteady-state analyses. Additionally, simple (no structures) steady-state HEC-RAS models were created for some of the upstream reaches using the topographic data obtained for the Plan Update for the sole purpose of calculating Modified Puls routing parameters for Plan Update hydrology. Hydrographs from the HEC-HMS model output were input into the unsteady-state models using USACE's "Data Storage System" (HEC-DSS). Software tools within the DCDESKTOP were also developed specifically for this Plan Update to assist in the organization and retrieval of the results of the HEC-RAS and HEC-HMS hydrology analyses. Ultimately, multiple combinations of hydrology and hydraulics were evaluated to consider appropriate land use and project scenarios necessary for Plan Update development. Final unsteady-state HEC-RAS model runs were all made using HEC-RAS version 4.1.0.

1.5.3 Topographic Data

The primary source of topographic data used for watershed delineations in this Plan Update was interferometric synthetic aperture radar (IFSAR) data acquired from Intermap Technologies Inc. The Intermap data is proprietary and was licensed to the District. The Intermap data was provided in NAD83 horizontal datum and NAVD88 vertical datum, with measurement units in feet.

The Intermap data represents a higher point density of data than typically found in the USGS Digital Elevation Model (DEM), with a slightly better vertical resolution. The data set used in this Plan Update also included some artifact terrain areas near bridges and overpasses which did not correctly represent the ground surface. However, this data exceeds the accuracy requirements for determining watershed boundaries (with other supplemental data sources and limited field investigation) and watershed overland response factors, but is limited in its usefulness for detailed hydraulic studies or other purposes requiring higher resolution data. The topographic mapping and watershed delineations based on the Intermap data are provided in Appendix B.

Supplemental data sources used to define watershed boundaries included a digital terrain model (DTM) provided by the City of Roseville, previous detailed drainage studies and some field investigations. Though the City of Roseville's DTM was not well documented and may have absolute accuracy issues, it was developed as part of the City's 2007 aerial imagery ortho-rectification process and it included breaklines that were useful in defining grade breaks and flow directions in some locations where it was unclear from other sources. Also, sub-watersheds within the Cirby Creek watershed were based on a previous detailed delineation provided by the City of Roseville. Other supplemental data included Placer County Water Agency (PCWA) water distribution canal maps, municipal drainage master plans, and other storm drainage system layout information. Field investigations were performed to refine boundaries at a few locations.

The Plan Update used HEC-RAS unsteady-state hydraulic models to perform flow routing and project benefit analysis. These unsteady-state models were assembled for the Plan Update from various sources (see Section 3.5.2), though these are primarily



from FEMA models. Therefore, this Plan Update indirectly used other sources of topographic data, including topography developed for FEMA and some private development projects. The datum of existing models used in this Plan Update were not researched, but can reasonably be expected to be consistent with NGVD29 vertical datum, as was used for the original Flood Insurance Studies.

1.5.4 Land Use

For the purpose of this Plan Update, land use data mapping (GIS) was assembled for three conditions: 1992, 2007, and the General Plan build-out. The 1992 Plan included land use maps (AutoCAD) for the estimated 1989/1992 land use conditions. These maps were converted to GIS files to establish the 1992 baseline land use areas. The 1992 Baseline Land Use is shown in detail in Plate 7.

A high resolution aerial map taken in 2005 was used to compare each parcel to the General Plan build-out land use map. If the aerial showed a lower density land use than called for in the build-out condition, the land use type visible in the aerial image was applied. A color orthorectified radar image (CORI) obtained from Intermap, also from 2005, was also used to establish current conditions impervious area. Other information was used to have the impervious area estimate reflect what was built through 2007. Specifically, data from the City of Rocklin Master Plan dated February 2006 was used to update areas in Rocklin and information from the City of Roseville website provided "current uses" data. Field inspection of some properties was performed, and observed conditions were incorporated into the impervious area estimates. In many cases the known site land uses, and field inspected land uses conflicted with the land use identified in the applicable Master Plan. In these cases the known land use was used as a basis for "current condition" studies. The 2007 (current) Land Use is shown in Plate 8.

Updated General Plan build-out land use files were requested from various agencies in the Dry Creek watershed. Information was obtained and converted into a GIS file type (shape file). In many cases, the various agencies had overlapping information which conflicted with each other. To resolve these issues, information from the agency responsible for mapping that area or the current land use observed in the field was used, as determined to be appropriate. The General Plan Build-Out Land Use is shown in Plate 9.

1.6 HISTORIC FLOODING

Floods in the Dry Creek watershed generally occur from October through April. The floods are usually caused by a combination of prolonged rainfall leading to saturated soils, and a short period of one to six hours of intense precipitation associated with frontal convection or severe thunderstorms.

Dry Creek and its tributaries have an extensive record of flood conditions, especially in the Roseville area. Streamflow records are available for a gage in Roseville beginning



in 1950. Damaging floods occurred in December 1955, April 1958, October 1962, December 1964, March 1983 and February 1986. The floods of 1983 and 1986 were the largest and most damaging on record before 1992. Hydrologic studies have shown that the recurrence interval of the March 1983 flood was approximately 10 years and the recurrence interval of the February 1986 flood was from 50 to 100 years, depending on the specific location in the Dry Creek watershed.⁶ Flood events also occurred in 1995 and 2005, with the 1995 flood event causing extensive damage. Descriptions of flood events since 1983 are provided because information is available and the data from some of these events was used to calibrate the hydrology model.

Figure 2 is a photograph of Dry Creek flows inundating portions of downtown Roseville, including Royer Park, Douglas Boulevard, and Saugstad Park, during the 1995 flood event.

Figure 2: Portions of downtown Roseville during the 1995 flood event



1.6.1 March 1983

The March 1983 event was estimated to have an average exceedance recurrence interval of about 10 years and “damaged approximately 25 residences along Linda and Cirby Creeks in Roseville. Portions of Royer Park were under water as well as areas in the Sierra Lakes Mobile Home Park. Dry Creek overflowed the Darling Way and Riverside Avenue bridges, disrupting traffic and flooding six businesses along Riverside Avenue.”⁷

1.6.2 February 1986

The February 1986 event was classified as an approximately 70 year event, and Placer

⁶ James M. Montgomery, Dry Creek Watershed Flood Control Plan, 1992.

⁷ James M. Montgomery, Dry Creek Watershed Flood Control Plan, 1992.



County was designated as a Federal Disaster Area. Nearly all bridges and culverts were overtopped with 30 crossings sustaining embankment damage including Rocky Ridge Drive washing out. Two bridges over Dry Creek were damaged and street cave-ins occurred at a number of locations. Flooding caused the closure of many major streets in the watershed, including Riverside Avenue, Darling Way, Douglas Boulevard, Vernon Street, Sierra College Boulevard, and others. Around 100 homes in Roseville along Dry Creek, Linda Creek, and Cirby Creek were flooded with water levels up to five feet above floor levels.

Ten homes along Antelope Creek and Secret Ravine tributaries in Rocklin and about sixteen homes along Miners Ravine in Placer County, in the area of Joe Rodgers Road, were flooded. Roseville City Hall and libraries were temporarily closed when their basements flooded. Downstream of Roseville, several residences along Dry Creek in Placer County were flooded. Flooding occurred along most of Elkhorn Boulevard near Dry Creek in Sacramento County, including many residences, schools, and businesses. Available gaged flow rates and stream stages from the February 1986 storm event were used to calibrate the 1992 model. Total damages within Placer County were estimated at \$7.5 million. Based upon application for disaster assistance, 62 homes were damaged or destroyed within the watershed, although the actual number of damaged homes is thought to have been higher. Dozens of businesses in downtown Roseville were damaged or destroyed, and one fatality was associated with this flood event.

1.6.3 March 25, 1989

The March 1989 event was estimated to have an average exceedance recurrence interval of between 1 and 2 years. Available gaged flow rates and stream stages from the March 1989 storm event were used to calibrate the 1992 model.

1.6.4 January 1995

The January 1995 event had been classified as being approximately a 100 year event prior to this Plan Update. Further analysis of available data indicated that the January 1995 event was statistically closer to a 200-year storm event than a 100 year event at some key locations. (Identification of the 1995 storm event as potentially being significantly more severe than a 100-year storm event in no way limits municipality's ability to regulate to this maximum storm of record instead of a 100-year event.) The January 1995 storm resulted in the most severe recorded flooding to date occurring in the Dry Creek watershed, with Placer County being designated as a Federal Disaster Area.

The storm included two high precipitation storm events spaced about 12 hours apart. The first event delivered approximately a 10-year storm event. The second storm event delivered even higher intensities of precipitation. As with the 1986 flood, numerous bridges were overtopped. Total damages within Placer County were estimated at \$8.3 million, with 750 damaged or destroyed structures (\$4.2 million estimated damages for the Roseville area alone). Of the \$4.2 million in damages, one million was for road and bridge repairs, and two million was for utility repairs. Within the Roseville area, 385



homes, businesses, apartments, and mobile homes were damaged or destroyed. In addition, two sewage treatment plants were overtopped, and one landfill was damaged. No injuries or fatalities were associated with this flood event.

Figure 3 shows a photograph of flows from Miners Ravine overtopping Sierra College Boulevard during the January 1995 event.

Figure 3: Miners Ravine overtopping Sierra College Boulevard during the January 1995 storm event



1.6.5 January 1997

The flood events of 1997 were some of the most severe on record for the region. An isolated storm event typical for the Roseville area occurred on top of soils saturated from repetitive storm events causing a flash flood. This flooding resulted in 21 structures being inundated with floodwaters. The impact of this event was significantly reduced by a partially completed Cirby-Linda-Dry Creek Flood Control project. No injuries or fatalities were associated with this flood event.⁸

1.6.6 February 1998

A small flood event occurred on February 3, 1998, resulting in eight structures being inundated by floodwaters in the Dry Creek Basin. Once again, this event was caused by an isolated storm event centered over the watershed. No injuries or fatalities were associated with this flood event.⁹

⁸ City of Roseville, *Draft Flood Risk Assessment*, 2004.

⁹ City of Roseville, *Draft Flood Risk Assessment*, 2004.



1.6.7 December 2005

The December 2005 event was estimated to have an average exceedance recurrence interval of between 10 and 25 years. This event, often referred to as the “New Years Eve” event, occurred in the early morning hours of December 31, 2005. Most gages reported peak 6 hour precipitation between the 10-year and 25-year precipitation depths listed in the SWMM. Flooding was most noticeable in the lower watershed where the overtopping of Walerga Road made news as vehicles and drivers attempting to cross the bridge during overtopping flows required emergency assistance to have their stalled vehicles pulled to safety. One vehicle was pushed by the velocities in the overtopping flows onto the guardrail, and against a tree, requiring a helicopter rescue.

Roadways that were overtopped included Champion Oaks Drive on Linda Creek as shown on Figure 4 and Barton Road on Miners Ravine as shown on Figure 5.

Figure 4: Linda Creek overtopping Champion Oaks Drive in 2005



Figure 5: Miners Ravine overtopping Barton Road during the 2005 flood event



In addition to the events listed above, flooding has occurred in numerous other events for storms in 1950, 1952, 1963, 1969, 1970, and 1973. However insufficient historic data are available to precisely define the geographic extent of flooding and the impact of these events.¹⁰

1.7 GAGE DATA

The District, the City of Roseville, and Sacramento County own and maintain 23 precipitation gages and 20 stream gages distributed throughout the Dry Creek watershed. These gages, the location of which are shown on Plate 10, contain ALERT type transmitters and are used to record, forecast and predict flooding in critical flood hazard areas of Placer and Sacramento County. The real-time gage data is transmitted to base station servers in Auburn, Roseville and Sacramento where the data is recorded and stored for either real-time or historical use. Additionally, the base stations located in Auburn and Roseville act as redundant data storage servers since both systems receive a majority of the Western Placer County gage data. All data received by the Auburn and Roseville base stations is also uploaded to a server in Colorado maintained by OneRain, Inc. This data is available via the internet through the Conrail Web system. Plate 10 indicates whether the stream gage provides only stage values or if a rating curve based on flow measurements is available to provide a direct estimate of discharge.

¹⁰ City of Roseville, *Draft Flood Risk Assessment*, 2004.



Historical record event data was supplied for this Plan Update from data stored by the City of Roseville. Some of the gage records for the calibration events used in this plan were missing either because the data was corrupted or the gages were not installed or functioning properly. The application of the valid record gage data is explained in Appendix C for each record event of the calibration analysis.

1.8 RELATED FLOOD MANAGEMENT PROGRAMS

Floodplain management is the operation of a community program providing corrective and preventative measures for reducing flood damage. These measures take a variety of forms and generally include requirements for zoning, subdivision or building, and special-purpose floodplain ordinances. A community's agreement to adopt and enforce floodplain management ordinances, particularly with respect to new construction, is an important element to provide flood loss reduction building standards for new and existing development.

1.8.1 FEMA

FEMA plays a particularly prominent role in floodplain management. FEMA is charged with overseeing disaster assistance and mapping floodplains. One of FEMA's programs is the National Flood Insurance Program (NFIP). Nearly 20,000 communities across the United States and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities. Community participation in the NFIP is voluntary; however, Placer and Sacramento Counties, including the Cities of Lincoln, Rocklin and Roseville and the Town of Loomis, are participants in the Flood Insurance Program. In addition to providing flood insurance and reducing flood damages through floodplain management regulations, the NFIP identifies and maps the Nation's floodplains.

Mapping flood hazards creates broad-based awareness of the flood hazards and provides the data needed for floodplain management programs and to actuarially rate new construction for flood insurance.¹¹ These Flood Insurance Rate Maps (FIRMs) identify floodplains in the watershed that are used to assign risk and insurance rates for homeowners and businesses. FIRMs denote the location of the federal 100-year flood area, 500-year flood area, and the Base Flood Elevation. In a 100-year floodplain, there is a 1 percent chance of flooding in a given year, and in a 500-year floodplain, there is a 0.2 percent chance of flooding in a given year. If an area is within a 100-year floodplain, flood insurance is required by most mortgage companies. FEMA is also responsible for the accreditation of levee systems.

¹¹ FEMA Website. Available at: <http://www.fema.gov/hazard/flood/index.shtm>. Accessed: July 10, 2010.



1.8.2 Roseville¹²

The City of Roseville joined the NFIP on August 2, 1974. By implementing good floodplain management practices, Roseville became the first (and currently, only) community in the nation to receive the FEMA's Community Rating System (CRS) highest rating of Class #1. This rating allows Roseville property owners up to a 45 percent discount on their flood insurance premiums.¹³

Flood protection is a major concern in Roseville as well as the remainder of the Sacramento/South Placer region. Flooding in Roseville is associated with storm runoff exceeding creek and storm drainage capacities. As a result, flooding in the City is generally confined to limited areas of low elevation adjacent to the creek systems.

The City of Roseville is involved in several flood control projects and mitigation programs designed to protect residents and lessen the potential for flooding both within the City and within neighboring communities:

The City has initiated the Cirby-Linda-Dry Creek Flood Control Project to reduce storm water back up at constrictions and increase the overall capacity of the floodplain. Of the seven work packages described in the project study, five have been completed. As a result of those improvements, the number of structures in the floodplain has been reduced to about 90. Most of the structures remaining in the floodplain are near Cirby Creek in the Zien Court and Trimble Way area and along Dry Creek upstream of Folsom Road.

The City is currently collecting drainage mitigation fees within the Pleasant Grove and Dry Creek watersheds to be used to alleviate potential downstream drainage problems in these basins. Roseville is also involved, through the District, in the Auburn Ravine, Coon Creek, and Pleasant Grove Creeks Flood Mitigation Plan dated June 1993, as well as the Dry Creek Watershed Flood Control Plan.

The City presently has a flood alert system in place. After the '86 flood, the City installed an alert warning system with 18 rain gauges, 19 stream level gauges, and a computer monitoring system. During high stream flows, the City broadcasts stream levels on Roseville Cable TV Channel 14/73 and monitors Doppler radar and satellite imaging of incoming storms to assist in advance notification efforts in the event evacuation of flood-prone areas is deemed necessary. In summer 2001, we put real-time stream gauge data on the City's website.

After the '86 flood, the City entered into a Memorandum of Understanding with the State

¹² City of Roseville General Plan, 2025, adopted by the City Council on May 5, 2010. Available at: http://www.roseville.ca.us/planning/general_plan_n_development_guidelines.asp. Accessed: July 14, 2010.

¹³ City of Roseville Website. Available at: http://www.roseville.ca.us/pw/engineering/floodplain_management/flood_facts.asp. Accessed: May 8, 2011.



Department of Fish & Game to allow clearing creeks of fallen trees and debris which could otherwise float downstream and block culverts and bridges.

1.8.3 Rocklin¹⁴

The City of Rocklin joined the NFIP on July 19, 1974. The City currently has a CRS Class of 10 with an application pending to improve its CRS Class to 8.¹⁵ In addition, the City of Rocklin participates in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. City of Rocklin Municipal Code *Section 15.16 Flood Hazard Areas* addresses floodplain management. In exchange for this voluntary participation, the NFIP make federally-backed flood insurance available to homeowners, renters, and business owners in the City

On October 26, 2010 the City adopted Ordinance 967 Repealing and Reenacting Chapter 15.16 of the Rocklin Municipal Code Relating to Flood Hazard Areas within the City of Rocklin.

The City of Rocklin has a Floodplain Management Program established as part of a community effort of corrective and preventive measures for reducing flood damage. These measures include zoning, subdivision or building requirements, and special-purpose floodplain ordinances. Specifically, the City has a Recreation-Conservation (R-C) designation for all established floodplain areas, and restricts development which would have an adverse impact on flood control. The City also requires new development to detain drainage to maintain peak flow runoff at pre-development levels.

The City currently is identifying sites for storm water detention basins along Sucker Ravine between Dominguez Road and Rocklin Road. Completion of the project study report is anticipated in 2012.

1.8.4 Loomis¹⁶

The Town of Loomis joined the NFIP on December 29, 1986. The Town does not currently participate in the Community Rating System (CRS) but will probably join soon.¹⁷

The Town's Municipal Code Chapter 11.08, "Flood Damage Prevention" covers building guidelines in the floodplain and restricts development in the floodway. Chapter 12.04, "Grading, Erosion and Sediment Control" covers preventive measures of erosion and sediment into the creek systems. The Town currently follows the California Stormwater Quality Association (CASQA) Handbooks for Stormwater Best Management

¹⁴ City of Rocklin Flood Zone Information, 2010. Available at: http://www.rocklin.ca.us/government/development/engineering/tools_n_resources/flood_zone_information.asp. Accessed: July 14, 2010.

¹⁵ E-mail from Jee Choy, City of Rocklin, March 17, 2011.

¹⁶ Town of Loomis General Plan, Adopted July 31, 2001. Available at: <http://www.loomisca.gov/uploads/final%20general%20plan.pdf>. Accessed: July 14, 2010.

¹⁷ E-mail from Brian Fragiao, City of Loomis, March 10, 2011.



Practices.

The Town has a five year agreement with Fish & Game to keep the creek channels clear. The Public Works Department field inspects the channels twice a year during the dry season and after every rain storm during the winter. Resident call-ins are the most effective way of finding out about creek problems.

Creek channel maintenance to alleviate flooding potential has been an ongoing concern in Loomis. The majority of the properties that line the major creek systems in Loomis are privately owned, but the Town has made every effort to get site access from homeowners when vegetation, debris and/or downed trees have restricted rainfall flows. All future developments along the creek systems are required to include easements to the Town to facilitate maintenance.

1.8.5 Unincorporated Placer County

Placer County floodplain maps (FIRM) have been available since 1983. The County has been a part of the CRS since 1990 and a part of the National Flood Insurance Program (NFIP) since 1983. Placer County as of 2010 has a CRS Class of 5 and currently in good standing with both the CRS and NFIP. The County's floodplain management program is continuing to improve to better serve the community and lower the CRS rating for lower insurance premiums for residents and business owners.

The County has the following ordinances governing development and activity in the floodplain. They are:

1. Grading Ordinance, Placer County Code Article 15.48 Grading, Erosion and Sediment Control
2. Flood Damage Prevention Ordinance, Placer County Code Article 15.52 Flood Damage Prevention Regulations
3. Storm Water Quality Protection Ordinance, Placer County Code Article 8.28 Stormwater Quality

Through the Flood Control District, annual stream maintenance, which removes debris and trash to open the channel for flood flows, is completed on several stream reaches in the Western County area. Streams usually included are Dry Creek, Secret Ravine, and Miners Ravine.

1.8.6 Sacramento County¹⁸

Sacramento County has a Floodplain Management Ordinance which regulates floodplain management activities, such as setting construction standards in floodplain areas, and establishing permitting and floodplain mapping criteria as required for participation in the NFIP. The County is required to permit all activities within federally

¹⁸ Sacramento County General Plan. Available at: http://www.dera.saccounty.net/portals/0/docs/EnvDocs_Notices/200201051020100419083507.pdf. Accessed: July 14, 2010.



designated special flood hazard areas prior to any new construction. The Floodplain Management (FPM) Ordinance creates a Floodplain Management Permit for this purpose. In order to accomplish its purposes, the Ordinance includes methods and provisions to:

1. Restrict or prohibit development which is dangerous to health, safety, and property due to flood hazards, or which result in damaging increases in flood heights or velocities;
2. Require that development vulnerable to floods, including facilities which serve such development, be protected against flood damage at the time of initial construction;
3. Control the alteration of natural floodplains, stream channels, and natural protective barriers, which help accommodate or channel flood waters;
4. Control filling, grading, dredging, and other development which may increase flood damage; and
5. Prevent or regulate the construction of flood barriers which will unnaturally divert floodwater or which may increase flood hazards in other areas.¹⁹

¹⁹ Sacramento County Floodplain Management Ordinance. Available at: <http://www.msa.saccounty.net/waterresources/files/Drainage/FloodplainMgmtOrd-1993.pdf>. Accessed: July 14, 2010.

