4.0 Potential Improvement Projects and Mitigation Measures

4.0 POTENTIAL IMPROVEMENT PROJECTS AND MITIGATION MEASURES

4.1 PLANNED BRIDGE AND CULVERT IMPROVEMENTS

The 1992 Plan evaluated 208 crossings (bridges and culverts) on streams in the watershed and concluded that 130 would be overtopped during the 100-year flood event based on 1989 land use conditions. Each jurisdiction reviewed the list of inadequately sized bridges and culverts and prepared a list of the crossings with the highest priority for replacement. Several factors were included in this decision, including:

1. Potential for injury or loss of life
2. Potential for property damage or damage to the bridge or culvert
3. Emergency access to isolated areas
4. Inconvenience caused by road closure
5. Exclusion of privately owned structures

Since the 1992 Plan, several bridge and culvert crossings have been modified or replaced, or have been scheduled for replacement, and are listed in Table 19:

Table 19: Scheduled and Completed Bridge and Culvert Projects

Bridge Location	Replacement Status	Recommended for Replacement in 1992 Plan
Dry Creek at Walerga Road	Not Completed	Yes
Dry Creek at Cook Riolo Road	Not Completed	Yes
Dry Creek at Watt Avenue	Not Completed	No
Miners Ravine at Barton Road	Completed	Yes
Miners Ravine at Dick Cook Road	Completed; No As-Builts Received	Yes
Dry Creek at PFE/Atkinson Street	Completed	Yes
Dry Creek Railroad Crossing near PFE/Atkinson Street	Completed	No
Miners Ravine at Sierra College Boulevard	Completed	Yes
Secret Ravine at Sierra College Boulevard	Completed	No

4.2 BRIDGE AND CULVERT PROJECT RECOMMENDATIONS

Bridge and culvert improvement recommendations need to consider the risks associated with the existing condition, what risk reduction would likely be feasible, and the potential negative impacts of the recommended improvements. In some circumstances, removing a restriction at a bridge could reduce effective floodplain storage and increase downstream peak discharges. Detailed analyses of bridge and culvert modification projects using the modeling system developed for this Plan Update can quantify the potential impacts of proposed projects on regional flooding and can, if necessary, be used to evaluate mitigation measures to offset potential increases in discharge due to stream crossing modifications. This Plan Update recommends

pursuing roadway improvement projects to reduce roadway overtopping, with the caveat that special features be constructed so that bridge enlargements do not reduce the effectiveness of existing floodplain areas at reducing downstream discharges. Special features could include weirs upstream from the replacement to maintain the efffectiveness of existing floodplain storage.

Lists of structures that may be overtopped during a 100-year storm event are included in Appendix E.

The 1992 Plan recommended replacement of 42 structures, six of which have been replaced as listed previously in Table 19. Of the 36 structures that have not been replaced, 17 are not included in the Plan Update HEC-RAS model because the model does not include all of the smaller tributaries and corresponding structures that were addressed in the 1992 Plan. Table E.2 lists the 17 structures recommended for replacement in the 1992 Plan that are not included in the Plan Update HEC-RAS model, and this Plan Update does not revise the recommendations for these structures. The other 19 structures that were recommended for replacement in the 1992 Plan that have not been replaced are included in the Plan Update HEC-RAS model and recommendations are made based on the model results and potential project feasibility.

The Plan Update HEC-RAS model includes 67 public roadways that are overtopped by at least one of the seven critical 100-year storm centerings, including 14 of the 19 structures recommended for replacement in the 1992 Plan. The other five structures that were recommended for replacement in the 1992 plan that are not shown to be overtopped by any of the seven critical storm centerings in the Plan Update HEC-RAS model are: Linda Creek at Sunrise Avenue, Strap Ravine at Sierra College Boulevard, Dry Creek at Darling Way, Miners Ravine at Auburn Folsom Road, and Miners Ravine at King Road.

It is important to note that the seven critical centerings do not necessarily represent the 100-year storm event at each structure, which could be somewhat greater if the critical storm centering for each structure were to be evaluated. However, the differences are not expected to be significant.

This Plan Update recommends replacing a total of 23 of the 67 structures that are overtopped, including 12 structures that were previously recommended for replacement in the 1992 Plan. A complete listing of the overtopped structures and structures recommended for replacement can be found in Table E.1.

4.3 REGIONAL DETENTION BASIN PROJECT OPTIONS

As identified in the 1992 Plan, Regional detention basin projects have the potential to reduce peak flows at significant locations in the watershed. In the 1992 Plan, Vernon Street was used as the key location to compare the impact of potential projects and continues to be used for this purpose in the Plan Update. Two of the projects included

in this Plan Update are at selected regional detention basin sites identified in the 1992 Plan. The sites, on Antelope Creek upstream from Atlantic Street and on Secret Ravine upstream from Sierra College Boulevard still have potential for beneficial projects. Instead of traditional dams, the Plan Update recommends use of structures configured as slightly undersized bridge crossings that span the main stream channel with an arch and are designed to be overtopped during major storm events. Analysis for the Plan Update determined that it could be feasible to provide over 800 cfs of 100-year peak flow reduction at Vernon Street by constructing two similarly configured (but differently sized) structures in series on Antelope Creek upstream from Atlantic Street.

For the Plan Update, information from previous studies and suggestions made by the District, review of topographic data and aerial imagery, and limited field observations were used to identify potential project locations. Ten potential project sites were analyzed to determine peak flow reduction benefits. The storm centering that produces the peak 100-year flow at Vernon Street, SE40N at 0, was used as the design storm to analyze the potential benefits of each of these potential projects. The selection process considered the volume in the peak of the hydrograph and the potential to build a facility to detain a significant enough part of that peak to provide worthwhile benefit. All ten potential project sites, including those deemed infeasible, are described in detail in Appendix H. Of the ten potential projects, five have the potential to reduce peak flow rates at Vernon Street for the design storm centering. Plate H.1 shows the locations the ten potential project sites within the Dry Creek watershed. Table 20 lists the five potentially feasible regional detention basin projects and the calculated peak flow reduction at Vernon Street for each for the design storm. The net combined benefit does not equal the sum of the benefits of the individual projects due to the effect of the projects on the timing of flows.

It is possible that additional locations could be identified for local or regional flood control projects that were not evaluated as part of this Plan Update. For example, the City of Rocklin is currently investigating the feasibility of a flood damage reduction project along Sucker Ravine to reduce localized flooding. Such a project may have some regional benefit that could be considered by the District in the context of meeting Plan Update objectives.

Table 20: Potential Regional Detention Basin Projects

Project Location	Project Type	Peak Flow Reduction at Vernon Street (cfs)
Antelope Creek at Atlantic Street & Bike Trail	Weirs	825
Secret Ravine at Sierra College Boulevard	Weir	175
Linda Creek at Old Auburn Road	Off-channel	28
Linda Creek at Wedgewood Drive	Weir	13
Linda Creek at Auburn-Folsom Road	Off-channel	12
Net Combined Benefit of Five Listed Projects		1085

4.3.1 Antelope Creek at Atlantic Street

One potential project site is located adjacent to westbound Interstate 80, north of

Atlantic Street on Antelope Creek. The majority of the project site is owned by the City of Roseville. A capped landfill exists adjacent to the stream at the location of this potential project site. A flood easement may be negotiated with the City of Roseville for most of the areas impacted by the potential project. A few land owners would be slightly impacted.

The potential flood detention project that was evaluated consists of constructing two weirs or embankments spanning the main channel to allow passage of low flows while detaining higher flows. This concept was evaluated with one weir 200 feet upstream from the railroad bridge that runs adjacent to Atlantic Street and a second weir that would replace the bicycle path bridge downstream from Roseville Parkway. The calculations show that the project has the potential to reduce peak flows at Vernon Street by 825 cfs for the design storm. For the purposes of this planning level analysis and cost estimate the evaluated project consisted of two earthen embankments stabilized to withstand the overtopping flows that would span the main channel with arch structures. The details of the potential project would be addressed in a future design level evaluation.

4.3.2 Secret Ravine at Sierra College Boulevard

Another potential project site is located upstream (east) from Sierra College Boulevard on Secret Ravine. This potential project involves construction of an in-channel weir just upstream from Sierra College Boulevard that would allow the low flows to pass, but detain the high flows. This project was evaluated for construction in 2007 but could not be constructed at that time due to funding constraints. This potential project could reduce peak flow rates by 175 cfs at Vernon Street for the design storm by raising flood levels upstream from Sierra College Boulevard. Although this planning level analysis and cost estimate considered a wall with an opening that spans the main channel, a different project configuration may be evaluated as part of a future design level evaluation.

4.3.3 Linda Creek at Old Auburn Road

Just upstream (south) of Old Auburn Road on Linda Creek is a potential project site that was previously studied by the City of Roseville for possible future development. A portion of the site was found to be infeasible for development purposes due to the current extent of the floodplain. However, this portion of the site may be used for detention purposes by excavating approximately 5,000 cubic yards, and depositing it on the right bank, above the existing floodplain. This potential project would include a berm constructed along the left (west) bank to increase effective detention volume in the off-channel detention basin. This project has the potential of reducing peak flow at Vernon Street by 28 cfs.

4.3.4 Linda Creek at Wedgewood Drive

Just upstream (north) from Wedgewood Drive on Linda Creek is a steep, narrow ravine between residential developments that could potentially be used as a flood detention

project site. The surface area of the potential project site is approximately 2.5 acres that is covered by riparian vegetation and trees. The project concept would be to construct an in-channel weir, allowing low flow passage, but detaining the peak flows by increasing the water surface elevation. Based on the evaluated configuration, the potential project could decrease peak flows by 13 cfs at Vernon Street.

4.3.5 Linda Creek near Auburn-Folsom Road

Another potential project site is located on the upper portion of Linda Creek, upstream (east) from Auburn-Folsom Road, adjacent to Cavitt Junior High School. The project site is approximately 6.5 acres and is currently undeveloped open space with some tree coverage. The potential project site is within the preliminary FEMA floodplain.[32] The project concept would be to add a berm on the right bank of Linda Creek, creating an off-channel detention basin to divert and attenuate peak flows. The project has the potential of reducing peak flows at Vernon Street by 12 cfs.

Each of the potential regional projects could be implemented independently. The two weirs identified as a potential project on Antelope Creek could be considered two phases of a single project or could be considered as two separate projects.

4.4 CHANNEL IMPROVEMENT AND RESTORATION OPPORTUNITIES, AND POTENTIAL PROJECT CONSTRAINTS

Restoration Resources performed field investigations at each of the five potential regional detention basin sites described in this Plan Update to provide a preliminary review of environmental considerations without the benefit of formal environmental surveys. In each case, US Army Corp of Engineers (USACE) Clean Water Act (CWA), Section 404, California Department of Fish and Game (CDFG) Section 1600 Streambed Alteration Agreement and State Water Resources Control Board (SWRCB) Section 401 permit requirements would need to be met. Additionally, any project that involves placement of fill within the FEMA regulatory floodway must satisfy FEMA requirements. A brief summary of potential constraints and opportunities at each of the five sites is included below. The full report is included as 5.4Appendix K.

4.4.1 Antelope Creek at Atlantic Street

Locating a weir near the railroad overcrossing would need to address an underground gas and sewer line. A project along Antelope Creek upstream from Atlantic Street would need to avoid or mitigate for impacts to Oregon Ash and Valley Oak trees, some other woody and riparian habitat, and a few elderberry shrubs. Detailed analysis and coordination with the landfill managers will be required to ensure that the project would not negatively impact the landfill. This potential site provides opportunities for stream habitat enhancements by constructing an oxbow channel. Potential locations for oak

[32] Nolte and Associates, Preliminary Sacramento County Flood Insurance Study, 2006.

tree and oak woodland habitat mitigation also are present upstream from Atlantic Street.

The upstream weir location at the bicycle path overcrossing could impact well-developed stream zone waters of the U.S. and wetlands, along with riparian habitat which developed as a result of beaver damming activities. A sewer line is also present in the vicinity of the upstream weir location. Removal of the beaver dam and beaver control may enhance stream function. Increased flood storage may be achieved through modification of the bicycle path configuration to minimize potential impacts to upstream habitat. Though increased flood depths would be infrequent and for short duration, the impact of these changes would need to be evaluated and addressed.

4.4.2 Secret Ravine at Sierra College Boulevard

The potential project site upstream from Sierra College Boulevard contains some wetlands, elderberry shrubs and Northwestern Pond turtle habitat. Although there are some potential habitat impacts, there are significant opportunities for oak woodland, riparian, and grassland enhancements.

This site is privately owned and the project would cause the existing regulatory base flood elevation to increase by approximately three feet. Land acquisition is a significant constraint on this project. Though FEMA requirements for causing a rise in floodplain elevations would need to be addressed, obtaining rights to flood the areas of potential impacted should satisfy the most significant aspect of FEMA requirements.

Recent modifications to Sierra College Boulevard at Secret Ravine raised the elevation at which the roadway would be overtopped. The 2007 conditions evaluations considered the roadway to be in its 2007 configuration while the project evaluations are based on the modified configuration.

4.4.3 Linda Creek at Old Auburn Road

The site along Linda Creek upstream from Old Auburn Road has become completely occupied by oak tree mitigation and is maintained by the City of Roseville. Use of this site would be challenging because it would require offsetting the current mitigation uses.

4.4.4 Linda Creek at Wedgewood Drive

The site along Linda Creek upstream from Wedgewood Drive supports extensive mature riparian woodland and riparian wetland communities. The creek corridor is relatively narrow and confined by the steep local topography. The potential rise in water level could impact adjacent upland oak woodlands and would need to be addressed. Construction of the modifications would also need to address any impacts on surrounding private properties.

4.4.5 Linda Creek near Auburn-Folsom Road

Potential constraints on the identified potential project site on Linda Creek upstream

from Auburn-Folsom Road include existing oak trees, wetland habitat, riparian habitat, mitigation plantings, elderberry shrubs, and salmonid habitat in stream and juvenile entrapment issues. Existing water and sewer lines would need to be accommodated in site planning. Potential opportunities at this site include oak, wetland and riparian wetland, woodland, and elderberry mitigation.

4.5 NON-STRUCTURAL FLOOD HAZARD REDUCTION MEASURES

4.5.1 Local Storage and Detention Facilities

Historically, local detention basins were used in an attempt to mitigate for the increase in peak runoff from development. However, as this study has demonstrated, in some cases detaining the increase volume of runoff resulting from new development can cause higher peak flows than if no detention was used. As part of upcoming storm water quality requirements, development projects will be required to include LID features and some will be required to meet hydromodification management requirements, which are not yet defined. Hydromodification management features retain and detain site runoff to try to mimic pre-project hydrology to meet specific criteria. Inclusion of LID features and systems to meet hydromodification management objectives into site design limit the need for local detention with flood control objectives that are often not effective at meeting regional objectives, anyway. Therefore, one recommendation of the Plan Update is for future use of local detention to be limited to situations where it is designed to meet specific localized mitigation objectives. Some onsite (local) detention may be a necessary part of mitigation plan for a project, but the size and configuration of detention necessary to meet mitigation objectives depends on the location of the project in the watershed and the effectiveness of LID measures.

Some LID features and hydromodification management measure detain runoff long enough, or retain and infiltrate runoff, so that mitigation for potential impacts from development can be realized. Major projects should include LID features and hydromodification management measures and evaluate how the proposed system will perform in the event of major storm events.

4.5.2 Elevation and Buy-Out Projects

Elevation and buy-out projects would be a feasible means to relieve some of the remaining flood problems in the watershed.

Retrofitting existing structures through elevation projects can reduce the risk of flood damage. Communities may apply to FEMA's Hazard Mitigation Assistance (HMA) grant programs for funding for elevation projects. The HMA grant applications are submitted by State emergency management agencies on behalf of local sub-applicants for projects for individual properties.

Elevation above flood hazard levels may reduce the risk to the elevated property.

Project costs for elevation, as estimated by FEMA, are shown in Table 21.

Table 21. Approximate Square Foot Costs of Elevating a Home (2009 Dollars)[33]

Construction Type	Existing Foundation	Retrofit	Cost (per square foot of house footprint)
Frame (for frame house with brick veneer on wall, add 10 percent)	Basement or Crawlspace	Elevate **2** Feet on Continuous Foundation Walls or Open Foundation	$29
		Elevate **4** Feet on Continuous Foundation Walls or Open Foundation	$32
		Elevate **8** Feet on Continuous Foundation Walls or Open Foundation	$37
	Slab-on-Grade	Elevate **2** Feet on Continuous Foundation Walls or Open Foundation	$80
		Elevate **4** Feet on Continuous Foundation Walls or Open Foundation	$83
		Elevate **8** Feet on Continuous Foundation Walls or Open Foundation	$88
Masonry	Basement or Crawlspace	Elevate **2** Feet on Continuous Foundation Walls or Open Foundation	$60
		Elevate **4** Feet on Continuous Foundation Walls or Open Foundation	$63
		Elevate **8** Feet on Continuous Foundation Walls or Open Foundation	$68
	Slab-on-Grade	Elevate **2** Feet on Continuous Foundation Walls or Open Foundation	$88
		Elevate **4** Feet on Continuous Foundation Walls or Open Foundation	$91
		Elevate **8** Feet on Continuous Foundation Walls or Open Foundation	$96

Buyouts represent a final mitigation solution to remove existing structures from flood hazard areas and may be an effective mitigation strategy when flood reduction methods are more costly than the value of the property that is at risk.

FEMA provides funding to the State and local community buyout projects in flood hazard areas when money is available. The buyout process is entirely voluntary by the homeowner.[34]

4.5.3 ALERT Flood Warning Response System

Implementation of an ALERT flood warning response system has been successful in

[33] FEMA 347 Above the Flood: Elevating Your Flood Prone House and FEMA 312 Homeowner's Guide to Retrofitting: Six ways to Protect Your House from Flooding.
[34] FEMA 317: Property Acquisition Handbook for Local Communities.

providing flood warnings within the Dry Creek watershed. This Plan Update recommends that the current ALERT flood warning response system be maintained and that seven gages be added. It is also recommended that flood forecasting capabilities be added to the flood warning system. As technology continues to advance, it is expected that a system that links real time (or possibly even predicted rainfall data) to a hydrologic model, in order to predict flood conditions will become feasible. Such a system could provide more warning than is currently available. Benefits of additional flood warning include increased opportunities for sandbagging, evacuation, and quicker emergency response and road closures. Improving the ALERT system can provide mitigation for accelerating flows into the creeks which can reduce the time to peak flood stage.

4.5.4 Low Impact Development

An analysis was performed to evaluate the potential peak flow impacts to the watershed from the expected use of LID measures as a result of the State Water Resources Control Board's expected future updates to the Municipal Separate Storm Sewer Systems (MS4) Phase II permit standards.

The Plan Update considered the alternative LID measures identified in the Construction General Permit. It was found that some measures such as "Rain Barrels" are effective for the small, frequent events they are designed for, but would not be expected to add any benefits during flood events when they would be expected to full long before peak flow conditions. Other similarly functioning LID devices such as typical detention storage and some bio-swale configurations do not offer significant flood benefits for large events. However, it was determined that LID features, such as permeable pavement and bio-retention facilities which promote infiltration and provide substantial storage would have some potential to impact flood flows by effectively reducing the imperviousness of proposed developments.

For this evaluation, it was assumed LID mitigation measures would be effective at reducing the imperviousness of developments to half of what would have occurred with traditional development approaches. It was also assumed that the LID measures would not slow down runoff compared to non-LID projects because it is expected that the capacity of the LID features below overflow connections to the storm drain system would fill during the major storm events.

LID measures can be effective in areas of any hydrologic soil group. Though more than half of the Dry Creek watershed is underlain with Type D soils, the retention and runoff delay in undeveloped areas is highly significant in general, and more so during frequent storm events. LID measures that promote infiltration attempt to make the developed watershed mimic the undeveloped hydrologic conditions, to the extent practicable. Plate 9 shows that a significant amount of future development is expected to occur in the area shown to be hydrologic soil group B on Plate 3. Increased impervious area on soil group B areas can dramatically increase runoff and this increase can be mitigated using LID principles and other techniques. However, LID can be challenging in areas where there are shallow zones of hydrologic soil group B over less permeable material.

The permeability of the native material under LID features must be considered when assessing effectiveness at reducing runoff.

The results of the analysis of implementing LID on new developments found that the impacts of future development on peak discharge at Vernon Street could be reduced by 32 percent for a 2-year flood. For the 100-year event, the analysis demonstrated that impacts could be reduced through the use of LID by 28 percent at the Vernon Street crossing. Varying degrees of benefit were noted for various locations and recurrence intervals. (The unexpectedly high benefit indicated at study Point No. 92 was determined to be due to a flow timing issue where the model differences resulted in a double peak instead of superposed hydrographs.)

Watershed outflow hydrographs from HEC-HMS models that included general plan build-out with LID were linked to the 2010 Updated Baseline hydraulic routing model and run to generate Scenario 8. This model represents the expected build-out flows that would result if LID were implemented in a manner consistent with the assumptions made for this evaluation. The potential peak flow reduction benefits from LID features are presented in Table 22 which compares Scenario 8 to Scenario 7.

Watershed outflow hydrographs from HEC-HMS models that included general plan build-out with LID were linked to the hydraulic routing model with all identified projects and run to generate Scenario 9. This model represents the potential benefit that could be realized from implementation of all five potentially feasible projects that were identified. The potential total peak flow reduction benefits from five identified projects are presented in Table 23 which compares Scenario 9 to Scenario 8.

The potential net peak flow impacts from 2010 to build-out with all identified projects are presented in Table 24 which compares Scenario 9 to Scenario 6. The potential net peak flow impacts from 1992 to build-out with all identified projects are presented in Table 25 which compares Scenario 9 to Scenario 1.

Table 22: Potential Peak Flow (cfs) Reduction Benefits from LID Features

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Recurrence Interval: / Model Hydrology: / Description / Model Geometry:	100-year Build-out with LID 2010 Baseline (SCB@Secret)	100-year Unmitigated Build-out 2010 Baseline (SCB@Secret)	Difference cfs
Miners Ravine			Scenario:	8	7	
UR15K2	MR15	207	Dick Cook Road	1779	1791	-12
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	1977	1984	-7
YMR29I	MR29R	202	Cottonwood Lake	2554	2562	-8
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2451	2456	-5
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7244	7322	-78
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4804	4856	-52
YSE51K	SE51R	232	Sierra College Blvd.	4972	5011	-39
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4691	4697	-6
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5441	5497	-56
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1103	1135	-32
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2912	2914	-2
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	3017	3026	-9
UC41E4	AC41R	126	Antelope Creek Road - Downstream of SR-65 (Gage 1583)	4035	4095	-60
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3883	3918	-35
Cirby Creek						
YCC40C	CC40R	51	Coloma Way (Gage 1635)	942	943	-1
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3347	3376	-29
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek @ McClaren (Gage 1611)	1227	1250	-23
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	397	595	-198
UC45J2	LC45R	82	@ Sacramento County/Placer County Line	2441	2503	-62
ULC80I	LC80R	76	Champion Oaks/Sanoma Way (Gage 1626/1628)	2213	2245	-32
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2749	2755	-6
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3276	3303	-27
Dry Creek						
UDC5B	DC5R	26	Royer Park	10746	10880	-134
YDCCC	RYCOMB	23	Confluence with Linda Creek/Cirby Creek	8740	8811	-71
YDC10D	VERNON	21	Vernon Street Crossing	13361	13535	-174
YDC71B	DCC11	9	Sacramento County/Placer County Line	12865	13079	-214

Flow comparison impacted by bypass, in channel discharge listed.

Table 23: Potential Peak Flow (cfs) Reduction Benefits from Identified Projects

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Recurrence Interval: / Model Hydrology: / Description / Model Geometry:	100-year Build-out with LID All Identified Projects	100-year Build-out with LID 2010 Baseline (SCB@Secret)	Difference cfs
Miners Ravine			Scenario:	9	8	
UR15K2	MR15	207	Dick Cook Road	1780	1779	1
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	1978	1977	1
YMR29I	MR29R	202	Cottonwood Lake	2562	2554	8
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2452	2451	1
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7203	7244	-41
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4803	4804	-1
YSE51K	SE51R	232	Sierra College Blvd.	4916	4972	-56
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4682	4691	-9
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5401	5441	-40
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1103	1103	0
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2912	2912	0
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	3017	3017	0
UC41E4	AC41R	126	Antelope Creek Road - Downstream of SR-65 (Gage 1583)	4035	4035	0
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3557	3883	-326
Cirby Creek						
YCC40C	CC40R	51	Coloma Way (Gage 1635)	941	942	-1
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3274	3347	-73
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek @ McClaren (Gage 1611)	1227	1227	0
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	331	397	-66
UC45J2	LC45R	82	@ Sacramento County/Placer County Line	2377	2441	-64
ULC80I	LC80R	76	Champion Oaks/Sanoma Way (Gage 1626/1628)	2191	2213	-22
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2731	2749	-18
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3256	3276	-20
Dry Creek						
UDC5B	DC5R	26	Royer Park	10058	10746	-688
YDCCC	RYCOMB	23	Confluence with Linda Creek/Cirby Creek	8648	8740	-92
YDC10D	VERNON	21	Vernon Street Crossing	12276	13361	-1085
YDC71B	DCC11	9	Sacramento County/Placer County Line	12237	12865	-628

Flow comparison impacted by bypass, in channel discharge listed.

Table 24: Potential Net Peak Flow (cfs) Impacts from 2010 to Build-out with All Identified Projects and LID Measures

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Recurrence Interval: / Model Hydrology: / Description / Model Geometry:	100-year Build-out with LID All Identified Projects	100-year 2007 Locally Detained Inflows 2010 Baseline (SCB@Secret)	Difference cfs
Miners Ravine			Scenario:	9	6	
UR15K2	MR15	207	Dick Cook Road	1780	1728	52
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	1978	1913	65
YMR29I	MR29R	202	Cottonwood Lake	2562	2366	196
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2452	2275	177
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7203	7152	51
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4803	4286	517
YSE51K	SE51R	232	Sierra College Blvd.	4916	4617	299
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4682	4598	84
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5401	5377	24
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1103	958	145
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2912	2829	83
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	3017	2985	32
UC41E4	AC41R	126	Antelope Creek Road - Downstream of SR-65 (Gage 1583)	4035	3624	411
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3557	3593	-36
Cirby Creek						
YCC40C	CC40R	51	Coloma Way (Gage 1635)	941	932	9
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3274	3258	16
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek @ McClaren (Gage 1611)	1227	1191	36
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	331	559	-228
UC45J2	LC45R	82	@ Sacramento County/Placer County Line	2377	2330	47
ULC80I	LC80R	76	Champion Oaks/Sanoma Way (Gage 1626/1628)	2191	2229	-38
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2731	2728	3
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3256	3229	27
Dry Creek						
UDC5B	DC5R	26	Royer Park	10058	10314	-256
YDCCC	RYCOMB	23	Confluence with Linda Creek/Cirby Creek	8648	8738	-90
YDC10D	VERNON	21	Vernon Street Crossing	12276	12908	-632
YDC71B	DCC11	9	Sacramento County/Placer County Line	12237	12595	-358

Flow comparison impacted by bypass, in channel discharge listed.

Table 25: Potential Net Peak Flow (cfs) Impacts from 1992 to Build-out with All Identified Projects and LID Measures

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Recurrence Interval: / Model Hydrology: / Description / Model Geometry:	100-year Build-out with LID All Identified Projects	100-year 1992 Baseline Inflows 1992 Baseline System	Difference cfs
Miners Ravine			Scenario:	9	1	
UR15K2	MR15	207	Dick Cook Road	1780	1714	66
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	1978	1899	79
YMR29I	MR29R	202	Cottonwood Lake	2562	2402	160
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2452	2268	184
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7203	7427	-224
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4803	4219	584
YSE51K	SE51R	232	Sierra College Blvd.	4916	4681	235
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4682	4679	3
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5401	5447	-46
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1103	987	116
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2912	2819	93
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	3017	2982	35
UC41E4	AC41R	126	Antelope Creek Road - Downstream of SR-65 (Gage 1583)	4035	3630	405
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3557	3605	-48
Cirby Creek						
YCC40C	CC40R	51	Coloma Way (Gage 1635)	941	758	183
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3274	3096	178
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek @ McClaren (Gage 1611)	1227	919	308
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	331	545	-214
UC45J2	LC45R	82	@ Sacramento County/Placer County Line	2377	2044	333
ULC80I	LC80R	76	Champion Oaks/Sanoma Way (Gage 1626/1628)	2191	2158	33
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2731	2682	49
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3256	3024	232
Dry Creek						
UDC5B	DC5R	26	Royer Park	10058	10663	-605
YDCCC	RYCOMB	23	Confluence with Linda Creek/Cirby Creek	8648	8582	66
YDC10D	VERNON	21	Vernon Street Crossing	12276	12635	-359
YDC71B	DCC11	9	Sacramento County/Placer County Line	12237	12571	-334

Flow comparison impacted by bypass, in channel discharge listed.

4.6 COST ESTIMATES

Planning level costs estimates (in 2010 dollars, Engineering New Record 20-City Construction Cost Index is 8865) for the five flood control project sites within the Dry Creek watershed (discussed in Section 4.3) that have the potential to reduce peak flow rates at Vernon Street for the design storm centering are listed below in Table 26. (Peak flow reduction for the combination of the five projects does not equal the sum of the flow reduction values for the five individual projects due to timing of runoff.)

Table 26: Project cost estimates and peak flow reduction summary for regional mitigation projects.

Description	Cost	Flow Reduction (cfs)	Cost/Benefit (cfs flow reduction)
Antelope Creek at Atlantic Street	$ 3,367,000	825	$4,000/cfs
Secret Ravine at Sierra College Boulevard	$ 3,234,000	175	$18,000/cfs
Linda Creek at Old Auburn Road	$ 932,000	28	$33,000/cfs
Linda Creek at Wedgewood Drive	$ 1,019,000	13	$78,000/cfs
Linda Creek near Auburn-Folsom Road	$ 1,008,000	12	$84,000/cfs
Total Cost and Net Flow Reduction @ Vernon	**$ 9,560,000**	**1085**	

It is estimated that upgrading the ALERT system will cost approximately $234,000, for seven additional gages plus some rainfall gage or prediction based flood forecast capabilities, bringing the total cost of the identified projects to $9,794,000. Inclusion of just the Atlantic Street project and ALERT system upgrades would bring the project cost to $3,601,000.

In addition to funding the capital costs associated with the mitigation projects and ALERT system improvements, funding for on-going maintenance and life cycle replacement costs (present value of cost to replace those portions of the projects that should be considered to have a 50-year service life) should also be considered. Table 27 lists estimates for on-going maintenance and replacement costs.

Table 27: Estimated Maintenance and Replacement Costs

Project	Annual Maintenance Cost	Present Value of Replacement Cost	Annualized value of replacement for i=6%, 50-year
Miners Ravine Off-Channel Detention Basin	$ 32,000	$ 500,000	$ 32,000
Antelope Creek at Atlantic Street	$ 21,000	$ 684,000	$ 43,000
Secret Ravine at Sierra College Boulevard	$ 13,000	$ 437,000	$ 28,000
Linda Creek at Old Auburn Road	$ 4,000	$ 130,000	$ 8,000
Linda Creek at Wedgewood Drive	$ 5,000	$ 172,000	$ 11,000
Linda Creek near Auburn-Folsom Road	$ 4,000	$ 123,000	$ 8,000
Alert System (including upgrades)	$ 44,000	-	-
Total	$ 123,000		$ 130,000

4.7 PROJECT RECOMMENDATIONS

To manage the risks and reduce potential hazards associated with existing local and regional flooding deficiencies, the following recommendations are provided:

1. Implement the two phases of the Antelope Creek at Atlantic Street project and ALERT system upgrades to mitigate for development impacts as funding becomes available.
2. Pursue other regional flood flow reduction projects with consideration for additional multi-objective components along with stream corridor if and when opportunities for funding develop.
3. Implement bridge and culvert improvements in a manner that does not exacerbate flooding at other locations in the watershed. Stream crossing modifications may provide opportunities for additional projects that could improve the flood control benefit of the existing floodplain.
4. Support building elevation and floodplain property buy-outs as these programs are expected to be the most effective means available to reduce future flood damage to existing structures.
5. Require onsite (local) detention where mitigation is necessary due to local flood impact considerations.
6. Incorporate LID measures into future development design that promotes infiltration.

Five development impact flood flow mitigation projects were identified as part of the Plan Update. The two most significant of these projects, those on Antelope Creek and Secret Ravine, include weirs that span the stream channels without impacting frequent flows to limit the impacts of the proposed projects on the streams while enhancing floodplain storage and modifying flood flow timing to reduce peak downstream discharges at key locations. As listed in Table 20, two of the three smaller projects use on off-channel configurations. The Plan Update recommends pursuing implementation of the Antelope Creek project. The other four projects are included as options because opportunities and future needs may make it necessary or beneficial to do more than the one project on Antelope Creek.

The District and City of Roseville have a flood warning ALERT System that monitors numerous precipitation and stream gages and provides a good source of flood warning information. Enhancing the flood warning system with flood forecasting based on rainfall predictions and the modeling system developed for this Plan Update would be worthwhile. The Plan Update recommends $234,000 in upgrades to the ALERT system including new gages and enhanced predictive capabilities.

Depending on what assumptions that the District decides to make regarding pursuit of flood flow mitigation projects, the District has options of selecting a funding plan based on a plan to implement: 1) only the Antelope Creek project, 2) the Antelope Creek and Secret Ravine projects, or 3) all five identified potential projects.

The cost of the Antelope Creek project plus the ALERT system upgrades are expected to be $3,601,000. The District may select this option if the assumed benefits of anticipated LID requirements are considered as part of the overall mitigation of development impacts.

The cost of the Antelope Creek and Secret Ravine projects plus the ALERT system upgrades are expected to be $6,835,000. The District may select this option if the assumed benefits of anticipated LID requirements are not considered as part of the overall mitigation of development impacts due to uncertainty in the implementation criteria and long term effectiveness because of maintenance considerations.

The cost of all five projects plus the ALERT system upgrades are expected to be $9,794,000. The District may select this option based on various combinations of considerations related to: 1) uncertainty in the anticipated LID requirements and LID effectiveness, 2) appropriateness to consider mitigation for impacts at locations other than Vernon Street, and 3) uncertainty in the ability to achieve the amount of peak flow mitigation from the Antelope Creek and Secret Ravine projects indicated as being potentially feasible in the planning level evaluation performed for the Plan Update.

4.8 POLICY RECOMMENDATIONS

The Plan Update identified that local on-site detention basins typically do not provide regional mitigation for increases in runoff and can actually exacerbate regional flood flows by delaying the increased runoff from the development to coincide with the surrounding natural flows. As a result of superposition, the detained and natural flows can be higher than had the increased development flows been released earlier. However, removal of local detention requirements can only be permitted if it is confirmed that there would not be any localized unacceptable increase in discharge rate. This Plan Update recommends application of Low Impact Design (LID) principles that promote infiltration as a primary means of on-site mitigation, and the system modeling tools developed for this Plan Update provide a means to assess the impacts of major developments on the regional system to determine if credits are justified based on impacts differing from that assumed in the mitigation element of this Plan Update. Local on-site detention basins may be necessary in some circumstances to mitigate for local impacts that are not addressed through the application of LID measures. The impact of any proposed significant local detention on the regional system should be considered in the project planning process.