4.0 LIKELY FUTURE CONDITIONS

This chapter examines the likely future condition of the watershed at the time of build-out. Build-out is defined for this study to be the time at which all development has occurred that is allowed by the various plans adopted by the jurisdictions within the watershed. These include the general plans for Placer County, Sutter County, the City of Rocklin, and the City of Roseville; specific plans for West Roseville, Regional University and Community (formerly De La Salle), Placer Ranch, and Placer Vineyards; and the Curry Creek Community Plan. During the development of this ERP, the City of Rocklin annexed the Sunset Ranchos development and the City of Lincoln expanded its boundaries to meet Rocklin's northern boundary.

Section 4.1 discusses the methodology used in assessing the impacts due to development. The land use pattern, infrastructure and population at build-out are presented in Section 4.2 through 4.4. Section 4.5 and 4.6 present the impacts to watershed hydrology and habitat.

4.1 METHODOLOGY

This section details the methodology used to assess potential development impacts and population growth in the Pleasant Grove/Curry Creek watershed. The budget and scope of this project did not allow development of detailed hydrologic models for the streams or detailed mapping of habitat for each species of concern. Rather, more generalized models were used to provide overall assessments of the impacts of changes in land use on various species and the quantity and quality of water that may be carried by the major streams.

Modeling of population growth to predict watershed population at build-out was based upon projected land use patterns at build-out, current population densities for low, medium and high density residential land use types, and future persons-per-household estimates by Placer County.

Hydrologic modeling was performed using the Soil Water and Assessment Tool (SWAT) developed by the USDA Agricultural Research Service (ARS). This model creates projections for water quantities and nutrient and sediment loading given a defined land use condition. The data provided allowed us to make some inferences on the potential effects of watershed development on local stream channels, particularly with respect to conveyance of water volumes and changes in flood regime. The SWAT model does not directly tell us what effects mitigation strategies such as

the use of on-site detention or retention might have on reduction in overall storm water runoff quantities or peak volumes. On-site detention may be expected to mitigate peak runoff, and retention basins to mitigate increases in stormwater volume runoff. In order to accurately analyze effects of stormwater detention storage, hydrologic models such as HEC-1 or HEC-HMS should be used.

SWAT is designed to predict the total quantity of water draining from a watershed or sub-basin. Total water quantity does not significantly change with on-site detention, since the water that is detained is eventually released back into the system. The extent to which retention strategies reduce total water draining from a watershed depends on the duration of retention and holding capacity of the retention structures. For purposes of this plan, no assumptions about size and location of specific detention and/or retention facilities were made. The SWAT analyses, however, offer some inferences about the amount of additional detention and/or retention needed to mitigate for the increased runoff based upon the numbers provided by the model. We can also qualitatively discuss the potential effects of on-site detention/retention for large development projects required by the City of Roseville and Placer County.

Habitat modeling was based upon patch statistics for selected sensitive species including changes to total habitat acreages, average patch sizes and the average complexity of patch shapes.

4.1.1 Impact Assessment

Impacts due to development within the watershed were examined in four major areas:

- Land cover
- Infrastructure
- Flood flow
- Drainage conditions

Land cover impacts result from direct conversion of land cover from one form to another, such as development of low density single family residential units in a former grassland or agricultural area. Impacts from changes in land use include direct displacement of species through conversion of breeding, foraging or nesting habitat and indirect impacts such as increased noise or closer proximity of humans. Due to the complexity of modeling indirect impacts, this report is primarily focused on direct impacts from land cover conversion.

Infrastructure impacts result from development of roads, power lines, sewer lines and other infrastructure elements. Many utilities are now being included in road right-of-ways; therefore, the primary infrastructure elements examined in this report are roads. Impacts from roads include displacement of terrestrial habitat, creation of barriers to migration that often result in increased animal mortality, reduced water quality from road runoff, increased barriers to aquatic species at bridges and/or culverts and increased noise and air pollution.

Flood flow impacts result from the increase in impervious surfacing associated with land development. Land uses such as open space and parks and recreation may have a low to moderate increase in impervious surfacing while commercial and industrial land uses often involve expansive structures with extended parking lots. Impervious surfacing in residential developments is somewhere between these two extremes. Impacts to flood flow include an increase in the total volume of runoff, decrease in retention time of storm water in the landscape, higher and earlier peak storm water flows, and changes in seasonal flows. Changes in seasonal flow are often the result of one or more of several causes:

- Improper or excessive use of water. This can originate from landscape irrigation around homes, commercial areas, streetscapes, parks, golf courses and other areas, or may arise from waste water from car washing and other home and office water usage.
- Discharges from wastewater treatment facilities.
- Decrease in groundwater and soil moisture levels due to reduced infiltration and water retention. This decrease may arise through soil compaction, structures, or direct armoring or paving of the surface.

Impacts to drainage conditions result from the direct and indirect impacts of land use and infrastructure. Some of these potential impacts include the following:

- Decrease in water quality due to introduction of oil, grease and automobile byproducts; household chemicals such as phosphates; landscape chemicals such as Diazinon, Malathion, herbicides and fertilizers; and industrial byproducts.
- Realignment, reengineering or straightening of creek channels, often done for flood control or to increase available land for agriculture or development.
- Armoring of stream banks to reduce erosion, which often occurs as a result of increased storm water flow, straightening of a creek

channel, or reducing the channel roughness through aggressive vegetation management.

- Placement of streams in culverts to increase available land for agriculture or development.
- Channel incision resulting from increased storm water flow, straightening of a creek channel, or reducing the channel roughness through aggressive vegetation management.

Of the impacts of development on watershed hydrology, the direct impacts, such as channel realignment and culvert installation, are more likely to occur on ephemeral drainages than on higher order creeks. Both the City of Roseville and Placer County have requirements for setbacks on development adjacent to intermittent and perennial streams; however, since much of the Pleasant Grove and Curry Creek watersheds consist of small drainages that might be classified as ephemeral creeks, the cumulative impacts to these minor drainages could result in significant effects on the larger stream hydrology.

4.1.2 Defining the Build-out Condition

One key to identifying potential impacts of future development within the watershed is to identify the land use at the build-out condition. For this study, build-out was defined by Placer County to be specified by the following plans:

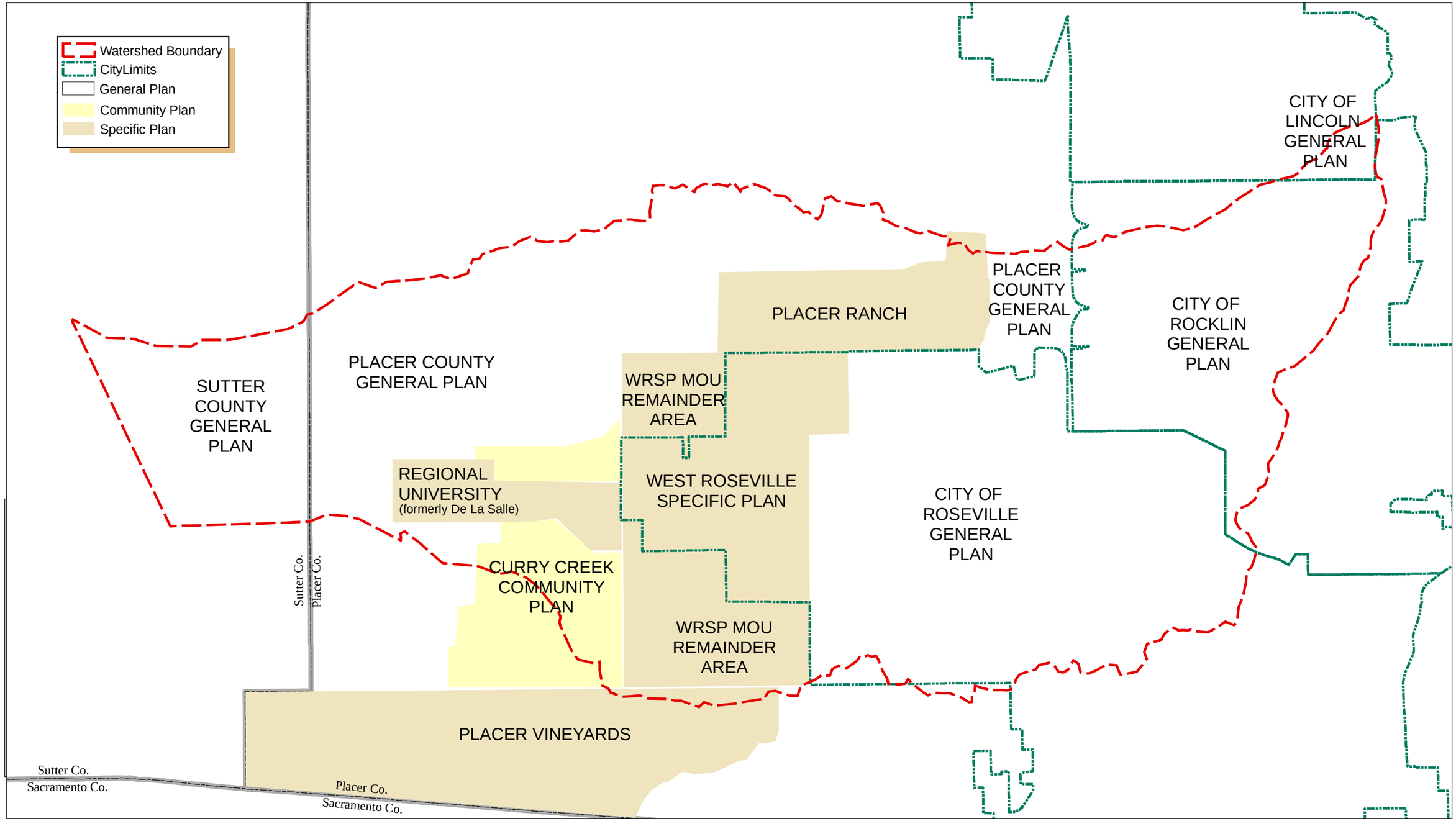
- The Placer County General Plan,
- The City of Roseville General Plan,
- The City of Rocklin General Plan,
- The City of Roseville West Roseville Specific Plan, including both Specific Plan and Remainder areas,
- The Curry Creek Community Plan, including the Regional University and Community Specific Plan,
- The Placer Vineyards Specific Plan,
- The Placer Ranch Specific Plan, and
- The proposed Placer Parkway.

Draft and/or final plans have been developed for all of these components except for the West Roseville Specific Plan Remainder Area and the Curry Creek Community Plan. The West Roseville Specific Plan Remainder consists of 2,365 acres located north and south of the West Roseville

Specific Plan area (see Figure 4-1). The Curry Creek Community Plan covers 2,828 acres west of the West Roseville Specific Plan.

In order to define the build-out condition for these two areas, conceptual diagrams were developed to identify potential land use and major road networks. For the West Roseville Specific Plan Remainder area, roads are specified in the West Roseville Specific Plan Draft EIR. The potential land use pattern was defined by locating more intensive land uses such as light industrial, business professional and commercial uses close to major roads and community nodes (community commercial and higher density residential) near intersections of primary arterials. The total acreages of the various land uses were also taken from the West Roseville Specific Plan.

For the Curry Creek Community Plan, primary roads were identified as extensions of existing routes with additional arterials defined to provide access to the interior of the community planning area. Land uses were located in the same manner as for the Remainder area, with land use acreages extrapolated from the total area within the plan using overall percentages from the West Roseville Specific Plan. The assumption made in this process was that the development patterns in the Curry Creek Community Plan will be similar to the West Roseville Specific Plan area. It must be stressed that the patterns used in modeling the Curry Creek Community Plan and the West Roseville Specific Plan Remainder Area are diagrammatic only and not meant to suggest overall land use patterns for these regions.



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COMPONENTS OF THE BUILD-OUT SCENARIO

PLEASANT GROVE/CURRY CREEK ECOSYSTEM RESTORATION PLAN

N

0 2,250 4,500
SCALE IN FEET

FIGURE 4-1

Springfield:\Pleasant_Grove_and_Curry_Creek\GIS_Projects\WDGT_Report_Figures\Fig-4-1_buildout_components.mxd

4.1.3 Modeling

Land Cover/Habitat Impacts

Modeling for the land cover/habitat impacts from build-out of the watershed was accomplished by identifying species of concern that have the potential to be impacted by development, mapping habitat for those species, and assessing potential impacts to that habitat from the anticipated build-out conditions.

The modeling steps performed to assess overall development impacts to sensitive species habitat are detailed below.

Step 1 – Correlate sensitive species to land cover types

Wildlife biologists and natural resource planners identified habitat requirements of selected species, then correlated those habitat requirements to land use/land cover types taken from the Placer County Habitat Conservation Plan (HCP) database, the land use codes from Placer County assessor's data, and land use types from Sutter County's General Plan.

Step 2 – Create existing conditions land use/land cover (LULC) maps

The land cover GIS database from the Placer County HCP project was aggregated with City of Roseville, Placer County and Sutter County land use data. This step was performed because the land cover data from the HCP Project has finer spatial resolution and greater specificity in rural areas than the land use data, but the land use data contains better land use type specificity in urban areas. The result of this step was an existing conditions LULC GIS map.

Step 3 – Create build-out land use/land cover map.

The existing conditions LULC map was combined with the Placer County and Roseville General Plans, proposed plans for the West Roseville Specific Plan, Placer Vineyards, Placer Ranch and Del La Salle developments, extrapolated land use for the West Roseville Specific Plan and Curry Creek Community Plan, and riparian and wetland areas that were deemed likely to be preserved from future development. The latter areas were identified as lands within the 100-year floodplain, vernal pools, and wetlands identified in the Placer County HCP project, and selected wetlands from the National Wetlands Inventory (NWI) database. The development plans and urban (developed) portions of the Placer County

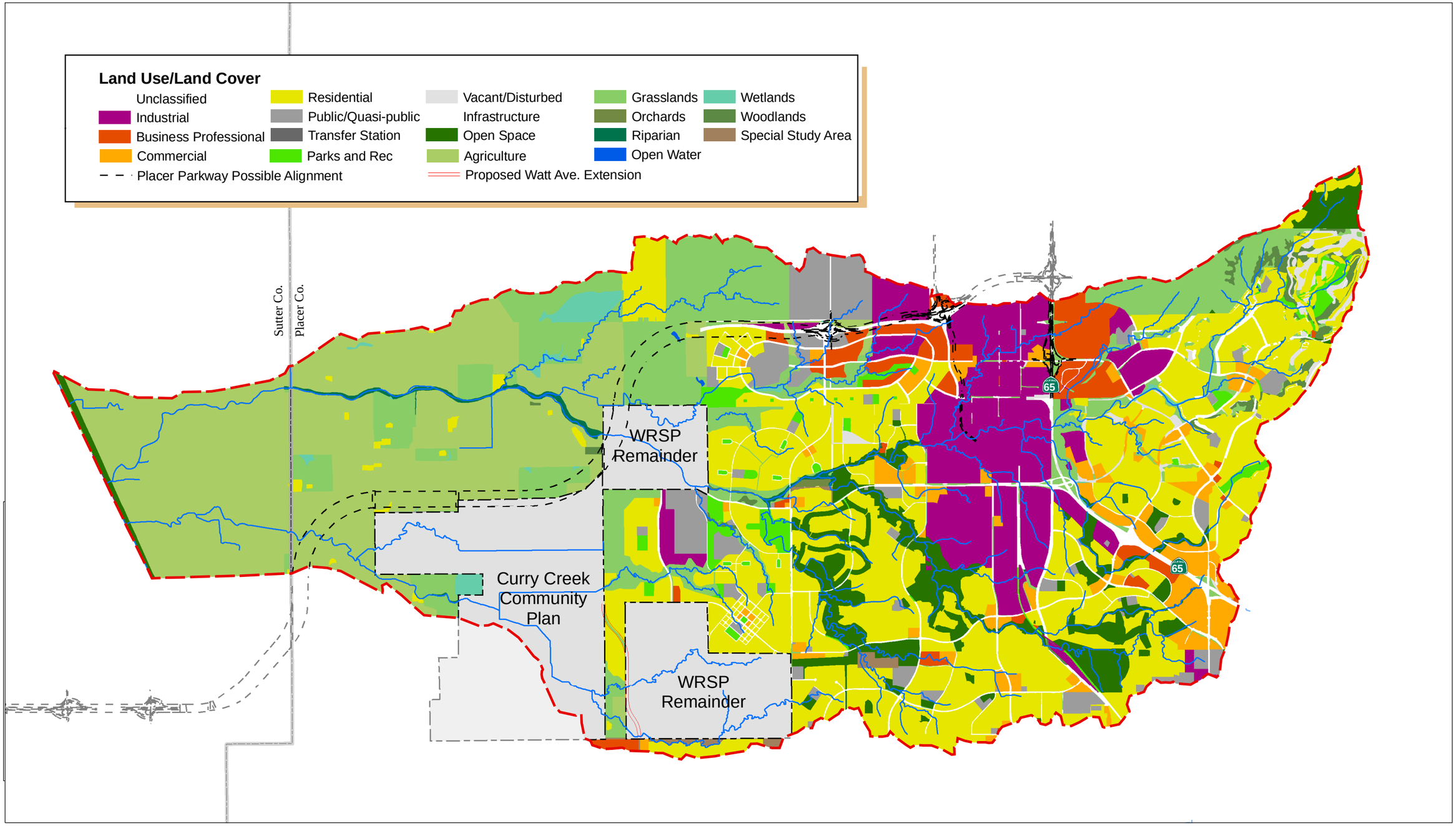
and Roseville General Plans were overlaid upon the existing conditions LULC map to preserve the more detailed land cover data in the rural/undeveloped areas. This step resulted in the build-out LULC map (Figure 4-2).

Step 4 – Assess potential habitat statistics for existing and build-out conditions

Habitat statistics were generated for selected species of concern for existing and build-out conditions using GIS functions. Statistics were generated based upon landscape ecology principles and included total potential habitat acreage, minimum patch size, maximum patch size, average patch size, and perimeter complexity. Perimeter complexity was selected to provide an assessment of the irregularity of the patch and was generated by dividing the average patch perimeter by the perimeter of a circle of equal area. Highly irregular patches can be beneficial or constraining depending upon whether a species requires interior habitat or thrives in edge conditions.

Step 5 – Assess potential habitat impacts based upon impact statistics

Impacts were summarized based upon the landscape patch assessment and project biologist assessments of the impact of habitat changes on the selected species.



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BUILD-OUT LAND USE/LAND COVER

PLEASANT GROVE/CURRY CREEK ECOSYSTEM RESTORATION PLAN

N

0 2,500 5,000
SCALE IN FEET

FIGURE 4-2

Springfield:\Pleasant_Grove_and_Curry_Creek\GIS_Projects\Scenarios\buildout_diagram.mxd

Infrastructure Impacts

Infrastructure impacts to habitat were examined based upon growth of the major road network and increase in the number of stream crossings. This study examined only major rural and urban routes, including arterials and primary collectors and did not include local streets in the growth areas, since the layout of the local streets is not known until specific developments are proposed. Data from the 2003 census Tiger files was used in mapping and modeling roads. This data did not appear to be fully updated to match the conditions in the Roseville-Rocklin area in 2004/2005; however, it was out of the scope of this project to modify or correct the census data, and since we were examining the likely increase in the major road network from current conditions to build-out, discrepancies were not expected to result in large errors. Classification of roads as major or minor routes was based upon the professional knowledge of the project team. While the census data does include a classification of the road network by CFCC number, this number did not prove sufficient to discriminate between major and minor roads in the watershed.

Hydrology Impacts

Storm water flow impacts due to development are primarily attributable to increases in impervious surfacing that accompanies development. This results in both higher peak flows and decreased retention time, and thus decreased time to peak flow in the watershed. Accurate predictions of the impacts of development on hydrologic flow require detailed hydrographic models that are beyond the scope of this study, but are currently being used on this watershed in a project for the Placer County Flood Control and Water Conservation District. However, an order of magnitude assessment can be made using the USDA's Soil and Water Analysis Tool (SWAT).

The SWAT model was designed to "predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long periods of time"[67]. The model calculates values on a daily time step making it ideal for long term cumulative impact analysis. SWAT is not intended for use on simulating event based flows such as in flood or hydraulic studies.

The model inputs were set up using the U.S. Environmental Agency's (USEPA) Better Assessment Science Integrating point and Nonpoint

[67] SWAT Users Manual, 2001

Sources (BASINS) program which is an application built upon ERSI's ArcView GIS software. There is a general lack of real world data to properly calibrate the model. However, by keeping all of the variables constant and only changing the land use, we can identify trends and changes that will likely occur due to land use policy decisions.

Modeling Methodology

The following steps outline the basic methodology used to conduct the analysis.

Step 1 – Delineate Watershed and Stream Network

Using BASINS' automatic watershed delineation tool, a 30 m^2 grid size Digital Elevation Model (DEM), and a USGS National Hydrologic Data (NHD) stream data layer, the watershed boundary was determined and subbasins within the watershed defined. The watershed and surrounding areas were analyzed for flow direction, creating subbasins throughout the region. Delineating subbasins outside of the watershed help in identifying a more accurate watershed boundary than opposed to analyzing an area just larger than the watershed. To select just the PGCC watershed, only those subbasins that drained to the end of the Pleasant Grove Canal were selected.

Step 2 – Land Use and Soil Theme Overlays

With the watershed delineation complete and a boundary file saved, the next step was to identify both land use and soils. The land use shape file compiled for the Land Cover/Habitat Impacts modeling was used as the starting point. The original land covers designations had to be converted to a four digit alpha-numeric land use code stored within the SWAT Crop or Urban database. Additional land uses can be added to the databases, but require detailed knowledge of the land use in order to provide all of the parameters needed by the model (35 parameters for crops and 14 parameters for urban land uses). Because of the limited scope of work, instead of defining new land use codes, the land covers were mapped to an equivalent land use already defined within the SWAT database. This mapping from land cover to SWAT land use was done though the use of a lookup table specially developed for this project. These lookup tables are presented in Appendix B and C. The new land use shape file was then rasterized using the newly mapped land use codes and added through the Land Use and Soils Definition utility.

Soils in the States Soils Geographic database (STATSGO) format were then required as input to the Land Use and Soils Definition utility. The

shape file provided by BASINS was used, and converted automatically by the utility to a grid file. Then the statsgol.dbf file was designated as the appropriate look up table to fill in the correct soil ID.

Once both land use and soils themes have been rasterized and added to the utility, they are overlayed to identify areas of unique soils and land uses which are used in creating HRUs in Step 3.

Step 3 – Create Hydrologic Response Units (HRUs)

The HRU Distribution utility is used to identify Hydrologic Response Units (HRUs) within the watershed. HRUs are areas with a unique land use and soil combination, which allow the model to more accurately reflect differences in the hydrologic conditions.

The multiple HRUs option was selected for this project, where each subbasin is further divided into multiple HRUs based upon a minimum threshold. A 15% threshold was selected for both the land use and soils.

Step 4 – Weather Data Simulations

The simulation option for the Weather Data Definition inputs were selected for rain, temperature, solar radiation, wind speed, and relative humidity data. The US database for simulated weather data was also selected.

Step 5 – Write Configuration and Data Files

Configuration and data files were written using SWAT. The Mannings "n" value used in both the Subbasins General Input file (.sub) and the Main Channel Input file (.rte) needed to be changed to 0.025[68] in order to reflect the actual stream roughness. Rainfall depths for each month also needed to be changed to meet the average 24 inches of annual precipitation experienced within the watershed (Personal Comm. w/ Brian Keating). Based upon monthly percentages of total annual rainfall, monthly rainfall depths were calculated (Table 4-1) and updated in the input files.

[68] Personal Comm. Mike Garello, HDR Inc.

Table 4-1 Corrected precipitation (PCP) values based upon regional percentages

MONTH	% ANNUAL PCP	CORR. PCP (INCHES)	CORR. PCP (MM)
January	21.88%	5.25	133.38
February	16.47%	3.95	100.39
March	14.53%	3.49	88.59
April	6.55%	1.57	39.96
May	1.63%	0.39	9.95
June	0.47%	0.11	2.84
July	0.28%	0.07	1.71
August	0.33%	0.08	1.99
September	1.59%	0.38	9.67
October	4.74%	1.14	28.87
November	13.34%	3.20	81.34
December	18.19%	4.37	110.91
Total	**100.00%**	**24.00**	**609.60**

Step 6 – Set Up and Run SWAT Model Simulation

The following input options and ranges were selected for all SWAT simulation runs performed for this project.

Period of Simulation:

Starting Date: January 1, 2000

Ending Date: December 31, 2099

Rationale: Provides 100 years of simulation data to average.

Rainfall/Runoff/Routing:

Daily Rain/CN/Daily

Rationale: The project's goals did not require hourly or sub-hourly results.

Rainfall Distribution:

Skewed Normal

Rationale: Due to a limited budget, we do not know what an appropriate exponent would be for the watershed to use in the Mixed Exponent option.

Potential ET Method:

Hargreaves method

Rationale: The Hargreaves method requires fewer input parameters and results in a more accurate calculation of potential ET when error exists within the data.

Crack Flow:

Not Active

Rationale: This is a more advanced feature of the model that is outside the scope of the project and will not necessarily change the outcome of the study.

Channel Water Routing Method:

Variable Storage

Rationale: Does not require additional parameters as is needed by the Muskingum method.

Channel Degradation:

Not Active

Rationale: This is a more advanced feature of the model that is outside the scope of the project and will not necessarily change the outcome of the study. Channel degradation is better simulated by other models.

Stream Water Quality Processes:

Not Active

Rationale: This is a more advanced feature of the model that is outside the scope of the project and will not necessarily change the outcome of the study. This models transformation of in-stream nutrients, and the project is only concerned with total nutrient loading.

Lake Water Quality Processes:

Not Active

Rationale: No lakes present within the watershed.

Printout Frequency:

Monthly

Rationale: Allows for analysis of data on a monthly or seasonal time step in addition to annually.

Routing Pesticide:

{none}

Rationale: Pesticide transport is not covered in the scope of the project.

Step 7 – Model Output Analysis

The SWAT model output is imported into a Microsoft Access database which is used to calculate monthly averages for: 1) water volume, 2) nitrogen loading, 3) phosphorous loading, 4) sediment loading, and 5) dissolved oxygen loading.

Step 8 – Comparison Analysis

Steps 1 through 7 were then repeated using a predicted or likely future build-out land use theme. Monthly averages calculated in Step 7 were then used in the final analysis to identify possible changes that may be occurring within the watershed as a result of future land use conditions.

In order to perform this future build-out analysis, output obtained from the SWAT model with the existing conditions land use is used as a starting point for change. For each of the parameters of interest (flow, total nitrogen, total phosphorous, sediment, carbonaceous biological oxygen demand and dissolved oxygen), a percent change was first calculated on an annual basis using Equation 4-1. The Percent Change as defined for this project is the build-out condition value minus existing condition value, all divided by the existing condition value multiplied by 100, or:

Equation 4-1 Percent change of a parameter from modeled existing conditions to modeled build-out conditions

$$\%\Delta_A = \frac{B_A - E_A}{E_A} \times 100$$

Where $\%\Delta_A$ is the percent annual change, B_A is the annual build-out value and E_A is the annual existing value.

For the water quality parameters, a second analysis was performed to identify which months contributed to the observed annual change. A percentage of each month's average contribution to the annual change was calculated using Equation 4-2. The Monthly Percentage of Annual Change is defined as the monthly change divided by the annual change, multiplied by 100, or:

Equation 4-2 Monthly Percentage of Annual Change

$$\%\Delta^1_A = \frac{B_M - E_M}{B_A - E_A} \times 100$$

Where $\%\Delta^1_A$ is the percentage of the annual change, B_M is the monthly build-out value and E_M is the monthly existing value, B_A is the annual build-out value and E_A is the annual existing value. Equation 4-2 normalizes the monthly percentages based upon the total annual change. This alleviates instances where a high monthly percent change is calculated when a small loading change occurs during a low loading month. For example, the annual nitrogen of the watershed is in the tens of thousands of kilograms, but during the summer months it may only be 1 kg per month. A very small increase of 0.25 kg during the summer will cause a large 25% change for the month even though it contributes very little to the overall annual change.

Population Growth

The population projection for the likely build-out condition was developed using acreages of residential land use types, densities for residential land use types (in dwellings per acre) and Placer County projections for persons-per-household in 2050. Minimums, maximums and averages were examined for dwellings per acre as provided in Placer County and City of Roseville General Plan codes to create approximate population projection ranges for the build-out condition. Population projections were made for the individual elements of the build-out condition and for the overall build-out condition itself. The estimates resulting from the sum of the individual elements resulted in slightly different figures than for the full build-out because some of the elements, such as the Placer County and Roseville General Plans, contained greater resolution of housing types that were not contained within the full build-out condition.

4.2 LAND USE AT BUILD-OUT

Figure 4-2 depicts the likely land use condition at watershed build-out and Table 4-2 shows the acreages used by each land use type. The most obvious observation that arising when comparing the existing land use patterns to Figure 4-2 is that much land that was formerly in agriculture and grasslands has been converted to urban land uses. The predominant build-out land use type is residential (approximately 12,500 acres), an increase of approximately 8,050 acres from the existing condition. Approximately thirty percent of the total watershed is in residential land

use at build-out. The majority of this residential use (approximately 7,800 acres) is low-density, amounting to 1.1 to 5.0 dwelling units per acre.

The next largest land use type is agriculture, with approximately 8,300 acres remaining in production, mostly in the western watershed. The largest net loss is to grasslands, which decrease from 15,400 acres of available grasslands in 2004 to less than 5,500 acres at build-out, a loss of 65 percent. This will have an impact on species such as raptors that utilize grasslands for foraging, as well as reduce potential flood-plains along creeks and groundwater recharge areas. Since grasslands are better at slowing the flow of storm water runoff into local creeks than are urbanized land cover types, we can expect increases in runoff volumes and peak flows unless careful planning is done to mitigate potential increases.

Industrial land use has increased sharply, from 900 acres in the existing condition to 3,600 acres at build-out, with the majority of this expansion occurring in the corridor west of Highway 65 along Industrial Boulevard. Increases in industrial land use have the potential to lead to lower water quality in local waterways due to large areas of impervious surfacing, industrial waste and other byproducts, outdoor storage of heavy equipment needed in industrial processes, and other factors related to industrial operations. Careful management of industrial operations can reduce these effects.

Total urban land use is up approximately 11,600 acres from existing to build-out or just about double the urbanized area of the watershed in 2004.

Table 4-2 Build-out Land Use Acreages

LAND USE / LAND COVER CLASSIFICATION	ACRES	CHANGE FROM EXISTING
Agriculture	8,336	-2,638
Business Professional	1,204	+1,161
Commercial	1,464	+734
Grassland	5,449	-9,984
Industrial	3,578	+2,669
Infrastructure	1,286	+269
Orchards/vineyards	22	-21
Open space	2,125	+1,934
Public/Quasi-public	2,171	+1,945
Parks and Recreation	1,115	-364
Residential	12,476	+7,774
Riparian	179	-248
Special Study Area	115	+115
Transfer Station	0	-7
Unclassified	104	-308
Vacant	404	-1,355
Water	23	-41
Wetlands	395	-532
Woodlands	320	-715

The likely build-out scenario preserves a significant amount of land in open space, which increases from 190 acres to over 2,100 acres[69]. This preserved open space occurs mostly along the major waterways of Pleasant Grove and Curry Creeks in the middle watershed in the WRSP, Placer Ranch, and Curry Creek Community Plan areas. Even though significant amounts of open space are preserved, over 500 acres of wetland and over 700 acres of woodland are lost in conversion of land from rural to urban uses. Some of these values do not reflect accurate projections because of the coarseness of the general plan data. This discrepancy will occur primarily in the urban land uses, e.g. the losses in parks and recreation and transfer stations are likely related to this difference in data resolution.

[69] The relatively low amount of open space in the existing land use scenario may not accurately reflect existing conditions due to the fact that some of the open space polygons in the GIS data were made transparent with respect to the underlying land cover classification for urban areas, since the land cover data was a higher resolution. The open space polygons were therefore recorded as different land cover types, such as riparian, woodland, or grassland.

4.3 INFRASTRUCTURE AT BUILD-OUT

Infrastructure expansion in the likely build-out condition will result in an approximately 41 percent increase in the major road network, from approximately 58 miles to approximately 82 miles. If an average four lane arterial is 78 feet, including four 12-foot travel lanes with two 10-foot shoulders for emergency pull-off and a 10-foot median or center turn lane, this results in an additional 227 acres of land converted to transportation. Additionally, since the width of the road right-of-way is often much greater than the space occupied by the actual road, additional land is consumed by the right-of-way. Sometimes this additional buffer is left in a natural state, but often it is used for storm water conveyance, bicycle or pedestrian paths, or left in a degraded state. The right-of-way width for a typical non-expressway principal arterial is 120-feet (Harris and Dines, 1988), with the result being a total of 350 acres of existing land cover converted to infrastructure in the build-out condition.

Other than direct conversion of land from its existing state to infrastructure, additional impacts from road network expansion arise from creek crossings. Some potential impact of bridges and culverts are listed in Table 4-3. The likely build-out of the watershed will result in approximately five arterial road crossings of major streams, eight primary collector road crossings of major streams, 13 arterial road crossings of minor streams, and 21 primary collector road crossings of minor streams. In this case, major streams have been defined as the main channels of the named streams: Pleasant Grove, Kaseberg, South Branch Pleasant Grove and Curry Creek. Minor streams are all of the remaining tributaries and drainages. It is likely that new road crossings of major streams will be bridges, while crossings of minor streams often take the form of culverts.

Table 4-3 Potential Impacts of Bridges on Stream Systems

Habitat	– Danger to wildlife crossing roads from vehicular traffic – Degraded fish habitat due to impacts to water quality of road runoff – Disruption of migratory corridor – Potential fishing access point where fish are more easily caught (due to decreased visibility of the angler) – Sediment accumulation – Prevention of natural meandering

Water Quality	– Degraded water quality due to road runoff – Potential access point for trash dumping into stream system – Increased chance of homeless camps which often results in increased contamination due to feces and cleaning supplies
Flood Conveyance	– Potential barrier to floodwaters causing greater chance of upstream flooding

Bridges have less impact on wildlife and aquatic species than culverts; however, some culverts have been created that reduce the environmentally detriments of traditional culverts. These culverts are wider to improve wildlife migration and have natural bottoms.

4.4 POPULATION PROJECTIONS

Table 4-4 lists the projected population for the likely build-out scenario. Compared to the existing watershed population of approximately 60,000 people, this is a phenomenal increase of 286 percent. In other words, the population of the watershed will almost triple at time of build-out. This figure is even more staggering when increases in dwelling units are examined. Because the number of people per household is expected to drop over the next fifty years, from 2.7 persons-per-household to 2.21 persons-per-household[70], the number of dwelling units increases more than the population. The existing 20,000 dwelling units will expand to approximately 77,800 dwelling units, and increase of almost four times the current number. These estimates assume build-out occurs at average densities for the residential land use types. If developers construct at the maximum densities allowable under ordinance, build-out could result in an additional 27,200 dwelling units for a total of approximately 105,000 units at build-out.

Table 4-4 Population Projections at Build-out

JURISDICTION (PORTION WITHIN WATERSHED)	MAXIMUM POPULATION	AVERAGE POPULATION
Roseville, Rocklin & Placer County General Plans	120,300	101,200
Placer Vineyards	5,400	3,300
WRSP & Remainder areas	58,600	34,900
Curry Creek Community Plan (including Regional University)	33,000	21,100

[70] Placer County projections, 2005

Placer Ranch	14,800	11,400
Total	**232,100**	**171,900**

If following state and national averages for 1996 and 1997, these 77,800 additional homes would annually consume 9 trillion BTU of energy[71], 11.6 billion gallons of water[72], 87 million pounds of meat, fresh fruits and vegetables and an additional 102 million pounds of processed food a year[73].

4.5 IMPACTS TO WATERSHED HYDROLOGY

4.5.1 Modeling Results

Hydrologic results from the SWAT model output analysis are presented in Table 4-5. Because SWAT performs its calculations using a daily time step, the hydrologic algorithms calculate a daily average discharge in cubic meters per second (m^3/s) which is used by various other algorithms in the model requiring discharge or flow rate inputs. The data analysis shows an average monthly discharge increase of 0.3%, while the maximum average monthly discharge showed a 2.3% decrease. This apparent anomaly is discussed in section 4.5.2 below. Additionally, the average estimated water volume exiting the watershed on an annual basis through the Pleasant Grove Canal increased by 0.3%. This amount of increase is attributed to land use changes in the approximately 20% of the watershed where development is anticipated within the foreseen future.

[71] Residential Energy Consumption and Expenditures per Household member and per Building, eia.doe.gov.

[72] 1996 American Water Works Association Survey of Western States.

[73] Putnam and Allshouse, 1999.

Table 4-5 Discharge Percent Change Estimates for the Pleasant Grove & Curry Creeks Watershed under Build-out

	AVERAGE MONTHLY DISCHARGE	MAX MONTHLY AVERAGE DISCHARGE	AVERAGE ANNUAL VOLUME
CHANGE	0.3%	-2.3%	0.3%

Water quality analysis results are presented in Table 4-6. Total nitrogen (TN) shows a 35% increase over existing conditions, with 90% of the increase occurring December through March. Total phosphorous (TP) shows a similar 39% increase, with 89% of that increase occurring during the wettest part of the season (December through March). A 57% increase in sediment loading with 90% of that increase occurring during the same four months as the TN and TP increases. Carbonaceous Biological Oxygen Demand (CBOD) also showed an increase of 67%, with 89% of the increase during the same four months as the other parameters. Dissolved Oxygen (DO), however, showed an annual 6% decrease, with the majority of the decrease occurring during November through January, but with slight increases (represented by negative monthly percentages in Table 4-6) during March, April, May and September.

Table 4-6 Water Quality Percent Change Estimates for the Pleasant Grove & Curry Creeks Watershed under Build-out

		TOTAL NITROGEN	TOTAL PHOSPHOROUS	SEDIMENT	CBOD	DO
ANNUAL CHANGE		**35%**	**39%**	**57%**	**67%**	**-6%**
Percentage of Annual Change	October	1%	1%	1%	1%	2%
	November	5%	5%	4%	5%	20%
	December	20%	19%	20%	20%	44%
	January	33%	33%	34%	31%	34%
	February	25%	25%	26%	25%	7%
	March	12%	12%	11%	13%	-4%
	April	5%	5%	4%	5%	-2%
	May	0%	0%	0%	0%	-1%
	June	0%	0%	0%	0%	0%
	July	0%	0%	0%	0%	0%
	August	0%	0%	0%	0%	0%
	September	0%	0%	0%	0%	-1%

4.5.2 Discussion

The hydrology output did not show the expected results typically observed in an increasingly urbanized watershed. It has been well documented that watershed urbanization and associated increased impervious surface area cause changes in a watershed's hydrologic pathways that lead to increased peak storm flows, decreased time of concentrations, and a shorter length of time for the rising and falling limbs of the stream hydrograph (Figure 4-3). In essence, rainwater moves faster though the watershed via low friction surfaces such as roads, parking lots, gutters and storm drain systems. In contrast, a non altered watershed requires that the rainwater move over rough soil surfaces often with vegetation, resulting in longer, slower moving flow paths leading to surface drainages. Soil infiltration also slows the movement of water to the channels by providing temporary storage, allowing water in the soil to move both laterally towards the stream (slower movement than surface runoff) and vertically towards the groundwater. The lateral flow provides a water source for a longer period of time, often resulting in a more extended falling limb or tail of the hydrograph, as well as base flow.

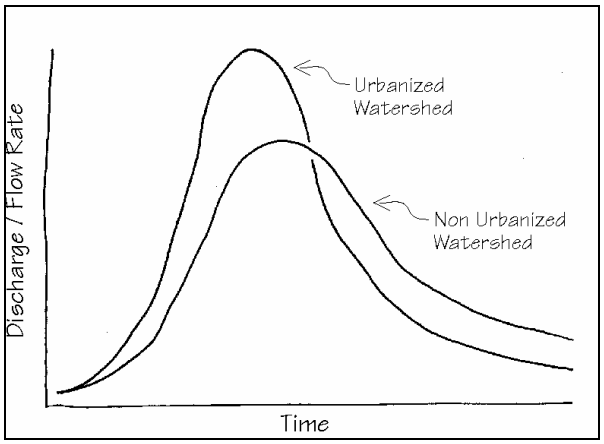

Figure 4-3 Hydrograph comparison between non-urbanized and urbanized watersheds

The SWAT model is not designed to assess event based impacts such as changes that occur in a hydrograph due to urbanization. This is evident in the fact that the model uses a daily time step to compute outputs. Other models are more efficient at this task such as the HEC-HMS and the HSPS models, which can work on hourly or sub-hourly time steps. Even with its larger time step, the increased hydrograph peaks should be represented to some extent in the SWAT output. This, however, was not observed in the model output, which was a 2.3% decrease in the maximum monthly average discharge. Peak storm flow information was likely lost due to

averaging because monthly outputs were obtained directly from the model instead of daily outputs in an attempt to optimize output file sizes and improve data manageability. Maximum monthly average discharge likely decreased in the model output because, even though maximum storm flows may have increased in the build-out scenario, they also moved through the entire watershed faster.

The 0.3% increase in total volume of water flowing out of the watershed on an annual basis indicates that there may be a slight decrease in storage capacity and groundwater recharge of the watershed as a result of the impervious surfaces being added during build-out. The build-out conditions used in this analysis did not incorporate either the City of Roseville's Reason Farms regional storm water retention facility, or the retention/detention facilities planned for the Sunset Industrial complex area located in the upper watershed. These major retention/detention facilities were purposefully excluded because: 1) detention basins are designed to hold water for up to 24 hours which falls within the model time step negating their affects, 2) the retention facilities typically hold water for up to a few day which doesn't affect the overall outcome of this project's analysis on a monthly or annual basis, 3) the objective of this modeling exercise is to identify impacts to hydrology and water quality caused by land use practices, and while retention/detention basins are designed to mitigate for impacts downstream, they don't change upstream impacts and, 4) there are other models which are more effective at assessing the impacts that detention basins have on watershed hydrology.

Other modeling efforts are more apt to accurately represent the impacts of urbanization to the watershed flow. The most promising study is the flood insurance study currently under way by FEMA for the Placer County Flood Control and Water Conservation District. When the results of the study are made public, changes to creek flows and flooding caused by various storm based flood events will be provided to a much greater detail than is intended by this ERP.

Total nitrogen (TN) and total phosphorous (TP) act as indicators representing changes in the stream's nutrient loading. The modeling results show a 35% and 37% increase respectively for TN and TP. This illustrates a trend shown in other watersheds that as more development takes place, nutrient inputs to our creeks and surface waterways also increases. This is primarily attributed to an increase in improperly applied fertilizers for both residential and commercial landscapes. Even though the saying "If a little is good, then more must be better" is not correct when it comes to fertilizers, it is often times the reasoning used by

residential homeowners and professional maintenance crews who want healthy looking vegetation but have not been properly informed or educated. Soils have a certain holding capacity for the nutrients provided in fertilizers. Excess fertilizer often times either leach past the rooting zone into the groundwater or dissolve on the surface and then wash away via sheet flow to sidewalks or other impervious surfaces that connect to local storm drain systems.

An increase in sediment is also associated with increased urbanization within a watershed. The results show a 57% increase in sediment loading leaving the watershed under the predicted build-out conditions. There are several reasons why urbanization leads to an increase in sediment loading, including:

- Increased bank erosion caused by elevated flow rates as a result of increased impervious surfaces (see previous discussion about changes in watershed hydrologic pathways)
- Sands from weathered blacktop
- Erosion from exposed soils during active construction
- Destruction of grassland around the streams that act as natural filters to help settle out and remove sediment before it enters the stream
- Improperly maintained landscaped areas with poorly stabilized soils
- Concentrated flow from rain gutters not being properly dispersed

Individually, on a per parcel basis, these causes contribute little to increased sediment loading. However, when concentrated in an urbanized area, these small individual sources will combine, overwhelming the systems natural sediment control mechanism, and result in substantial increases in sedimentation.

Carbonaceous Biological Oxygen Demand (CBOD), which measures the amount of oxygen required to decompose the organic material (OM) in the water column, showed a 67% increase. Increases in CBOD represent increases in the OM of the waterbody, which is primarily attributed to algae growth in stream systems. Algae growth is usually nutrient limited, typically by phosphorous, and is often associated with high levels of nutrients within the water, a relationship that our results show. Sediment also plays a major factor in the CBOD values of a stream. The sediment acts as a transport mechanism for nutrients and soil organic carbon, a second contributor to the OM content in the water.

The combination of nutrients, sediment, and CBOD in the water ultimately cause changes in the DO concentration. DO is the amount of oxygen in the water that is available for uptake by aquatic life, such as fish and benthic organisms, and is then used for respiration. A slight decrease in dissolved oxygen (DO) has been modeled, with a 6% drop in the total amount of dissolved oxygen within the watershed.

Oxygen dissolves and enters the water column through diffusion, with the maximum concentration being controlled by an equilibrium that is temperature sensitive. Because oxygen is a gas at standard atmospheric conditions, colder water is able to dissolve more oxygen. Mixing of surface waters, such as is done within a stream riffle, increases the oxygen to water contact area, allowing the diffusion to occur faster and increase the total amount dissolved. Oxygen is also made available for diffusion into the water as a byproduct of photosynthesis that occurs in photosynthetic algae. While live algae may contribute to increasing DO, once it dies the decomposition process consumes DO. The problem arises when large amounts of algae die and start to decompose. The bacteria decomposing the dead algae can consume the available DO within the water creating a condition called eutrophication. The depleted DO causes other organisms to die such as fish, resulting in an unfavorable condition of poor water quality.

Pleasant Grove and Curry Creeks have several disadvantages when it comes to maintaining higher levels of DO. Water temperatures tend to be higher within the watershed than in neighboring systems because of little or no groundwater contribution (which are typically colder than the surface water) and a general loss of riparian shade caused by urbanization and some agricultural practices. Also, because they are low gradient streams, there is a general absence of riffles within the creek systems, especially throughout the lower and mid watershed. Since riffles help with maintaining levels of DO in a stream, the lack of effective riffles within these creeks contributes to a system with lower oxygen content.

4.5.3 Summary

A general degradation to the watershed's water quality will likely occur as a result of the future build-out scenario. The model results indicate a substantial increase in nutrients (TN – 35%, TP – 37%), sediment (57%), and organic material (CBOD – 67%) within the creeks. Additionally, a likely decrease (6%) in dissolved oxygen may also be seen as a result of the current build-out plans. These changes will be evident primarily during the rainy season, a condition expected in an ephemeral drainage.

The final analysis for flows indicates that total flow volumes will increase (.3%), but the model does not provide information on hydrograph peak flow and duration. As explained earlier, the SWAT model is not intended to be used as a tool for flood management and design of flood control structures per se. Its utility is primarily for evaluating relative changes in storm water discharge as a function of changes in land use. The SWAT results showing increased flow related to urbanization are consistent with other more detailed studies (CH2M Hill 1993, 1994) that focus primarily on watershed flow as it relates to flood control.

In general, there is a void of both current flow and water quality data for the watershed. The water quality monitoring performed as part of the preparation of this ERP will be useful in establishing a baseline against which future water quality impacts may be evaluated. Flow data are available for the neighboring Dry Creek and Auburn Ravine watersheds but the hydrologic and geomorphic characteristics of these two watersheds are significantly different from the Pleasant Grove/Curry Creek system. The current base models for the Pleasant Grove/Curry Creek area were developed over 10 years ago and will be replaced once FEMA's mapping of the Pleasant Grove Creek main stem is completed.

4.6 IMPACTS TO HABITAT AND KEY RESOURCES

Table 4-7 shows the acres of potential habitat for selected species under the likely build-out conditions and Table 4-8 shows the changes in potential habitat from existing to build-out. For example, in the likely build-out scenario potential habitat for valley elderberry longhorn beetle is 442 acres, which is 693 acres less than existing potential habitat (Table 3-30). Minimum patch sizes are not shown in these tables because all minimums were close to a value of 0.0 as a result of the GIS modeling process, which tends to create small fragment polygons as data is aggregated. Therefore, the minimum values were not considered representative of real-world occurrences.

Table 4-7 Patch Statistics for Select Species – Likely Build-out

		POTENTIAL HABITAT	MAXIMUM PATCH SIZE	AVERAGE PATCH SIZE	NUMBER OF PATCHES	AVERAGE PERIMETER (FT)	PERIMETER COMPLEXITY
Species	Bogg's Lake Hedge-hyssop	354	147	11.4	31	3,018	1.21
	Vernal pool fairy shrimp	354	147	11.4	31	3,018	1.21
	Vernal pool tadpole shrimp	354	147	11.4	31	3,018	1.21
	Swainson's hawk	13,808	2,961	46.3	298	5,889	1.17
	California burrowing owl	10,256	2,961	40.2	255	5,168	1.10
	Dwarf downingia	368	147	9.9	37	2,786	1.19
	Legenere	369	147	8.8	42	2,531	1.15
	Red Bluff dwarf rush	373	147	9.1	41	2,636	1.18
	California linderiella	354	147	11.4	31	3,018	1.21
	Loggerhead shrike	8,596	2,961	44.8	192	5,593	1.13
	Tiger salamander	5,732	1,619	30.8	186	5,244	1.28
	Elderberry longhorn beetle	442	133	11.3	39	5,851	2.35
	Calif. red-legged frog	220	133	5.8	38	3,354	1.88
	Western spadefoot toad	525	147	9.9	53	3,698	1.59
	Giant garter snake	3,481	671	68.2	51	8,046	1.32
	Yellow-breasted chat	199	133	8.3	24	4,579	2.15

Note: all sizes are in acres, unless otherwise noted.

Table 4-8 Difference in Patch Statistics from Existing to Likely Build-out

		POTENTIAL HABITAT	MAXIMUM PATCH SIZE	AVERAGE PATCH SIZE	NUMBER OF PATCHES	AVERAGE PERIMETER (FT)	PERIMETER COMPLEXITY
Species	Bogg's Lake Hedge-hyssop	-506	-105	-2	-35	346	0.21
	Vernal pool fairy shrimp	-506	-105	-2	-35	346	0.21
	Vernal pool tadpole shrimp	-506	-105	-2	-35	346	0.21
	Swainson's hawk	-13,441	-6,500	-59	39	-3,468	-0.06
	California burrowing owl	-12,285	-6,500	-55	18	-3,233	-0.06
	Dwarf downingia	-519	-105	-2	-36	139	0.17
	Legenere	-528	-105	-1	-46	188	0.16
	Red Bluff dwarf rush	-527	-105	-3	-35	18	0.15
	California linderiella	-506	-105	-2	-35	346	0.21
	Loggerhead shrike	-10,297	-6,500	-71	29	-3,660	-0.03
	Tiger salamander	-10,391	-7,842	-61	10	-2,552	0.18
	Elderberry longhorn beetle	-693	-64	-14	-5	-3,993	-0.27
	Calif. red-legged frog	-283	-64	-4	-12	-1,559	-0.21
	Western spadefoot toad	-897	-105	-4	-51	108	0.28
	Giant garter snake	-1,691	-1,637	-61	11	-3,713	-0.08
	Yellow-breasted chat	-261	-64	-5	-11	-1,694	-0.19

Note: all sizes are in acres, unless otherwise noted.

As expected from the loss of grasslands, the largest impacts are to those species utilizing grasslands and open fields: Swainson's hawk, California burrowing owl, loggerhead shrike, and tiger salamander. Not only has potential habitat been reduced by approximately 10,000 acres, but maximum patch size has dropped by six to seven thousand acres, reflecting greater fragmentation of habitat. Average patch size has decreased by 55 to 71 acres. The number of patches for species utilizing

the grasslands has also increased, reflective of the fragmentation that is happening in this habitat type. Perimeter complexity has decreased six to seven percent, indicating simpler patches with less edge. Simplification of patch edges may have a negative effect on species that utilize edge conditions. Some raptors, for instance, will perch in tree tops between woodlands and grasslands watching for prey. More complex edges between these types of land cover patches create more opportunity for feeding.

Species using vernal pools or other wetlands as habitat (Bogg's Lake Hedge-hyssop, vernal pool fairy shrimp, vernal pool tadpole shrimp, dwarf downingia, legenere, Red Bluff dwarf rush and California linderiella) have seen a reduction in habitat of approximately 500 acres, reflecting the impacts to wetlands noted earlier. Maximum patch size is down 42 percent, average patch size is down 17 percent, resulting from the loss of 35 wetlands. Perimeter complexity is up, however, which can be beneficial in vernal pools and wetlands due to increased microclimate conditions within a specific pool.

Valley Elderberry Longhorn Beetle (VELB) habitat is down 61 percent to 443 acres. VELB are found on elderberry shrubs in woodlands and riparian areas, and reduction in VELB habitat reflects reductions in these land cover types. Patch statistics are not all that meaningful for VELB because they are often found on isolated plants.

California red-legged frog habitat is down 283 acres to just 43 percent of its original size. Maximum patch size, average patch size and perimeter complexity are all lower in the likely build-out scenario. California red-legged frogs are often found in riparian and open water or marshy areas, and loss of these habitats through urbanization could lead to the decline of this species in the watershed.

Western spadefoot toad habitat is also considerably reduced, from 1,422 to just 525 acres. These numbers could be somewhat misleading, because Western spadefoot toads live in grasslands and woodlands adjacent to vernal pools, which is a subtlety that was not build into the computer model. However, we do know that wetlands and vernal pools will be reduced significantly (by some 500 acres) in the build-out condition, which will have an impact on available toad habitat.

Another species of concern is yellow-breasted chat, a woodland warbler that breeds in brushy tangles and thorny thickets, along streams and shrubby hillsides and may be found in the Pleasant Grove watershed. There are currently 460 acres of mapped riparian lands in the watershed

(riparian and urban riparian classification). This will decrease to 199 acres of riparian habitat at build-out or 43 percent of current levels. While it is not currently known whether yellow-breasted chat live within the watershed, maintaining as much riparian woodland as possible will be important in providing habitat for this species.

Giant garter snakes generally live in upland areas adjacent to streams or wetlands. If present at all, they are most likely to be found in the lower Pleasant Grove and Curry Creek watersheds. While the conversion of grasslands and rice fields to urban land uses could impact these snakes, the majority of this is occurring in the middle watershed. Since the lower watershed should remain relatively intact in agricultural land uses, impacts to giant garter snakes due to build-out may be somewhat less than indicated by the model.

Clearly the likely build-out scenario has the potential to significantly impact potential habitat for key sensitive species, primarily through impacts to riparian and other woodlands, grasslands and wetlands. Impacts are the result of loss of overall habitat acreage as well as degradation in the quality of remaining habitat due to fragmentation, as seen in the reduced maximum and average patch size for all species, and a reduction in the number of patches for most species. Chapter 6 will introduce strategies for reducing these impacts and protecting these species.