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Middle Subbasin

Figure 1. Middle Subbasin. View of Eel River and the communities of Fortuna and Rohnerville.

The Middle Subbasin includes the area east of the Eel River from the confluence of Finch Creek (RM 7.8) to upstream of the confluence with Strongs Creek (RM 10.1) as well as a narrow parallel strip west of the Eel River (Figure 1). Stream elevations range from approximately 40 feet at the confluence of the Eel River with Finch Creek to approximately 1,700 feet in the headwaters of the tributaries. The subbasin encompasses 24 square miles, occupying 14% of the total assessment basin area. Lower elevations areas are mostly held in private parcels less than 40 acres in size while much of the higher elevation areas are owned by large timber companies and are managed for timber production. This subbasin contains the largest human population in the basin within the town of Fortuna. Fish surveys of the streams in this basin have identified the presence of coho, steelhead, and coastal cutthroat.

Hydrology

The Middle Subbasin is made up of sections of three CalWater Units (Figure 1). There are seven named tributaries (Table 1) and 20.5 permanent stream miles in this subbasin. Strongs Creek and North Fork Strongs Creek are second order streams using the Strahler (1964) classification. The other tributaries are first order streams. Drainage areas range from less than one to 16 square miles.

Table 1. Major streams in the Middle Subbasin.

Stream	Tributary to	River Mile	Drainage Area (square miles)	Stream Order	Permanent (miles)	Intermittent (miles)
Unnamed tributary	Eel River	6.7	0.43	Int	0.0	1.3
Finch Creek	Eel River	7.0	0.64	Int	0.0	2.3
Palmer Creek	Eel River	8.1	2.19	2	1.8	1.3
Little Palmer Creek	Eel River	0.5	0.50	1	0.6	1.1
Strongs Creek	Eel River	10.1	16.43	2	5.6	1.4
Rohner Creek	Strongs Creek	0.2	3.77	1	4.0	0.7
Unnamed tributary (Mill Creek)	Strongs Creek	1.3	2.04	1	2.0	0.8
Jameson Creek	Strongs Creek	1.8	1.60	1	2.2	0.6
North Fork Strongs Creek	Strongs Creek	3.7	3.26	2	2.5	0.4

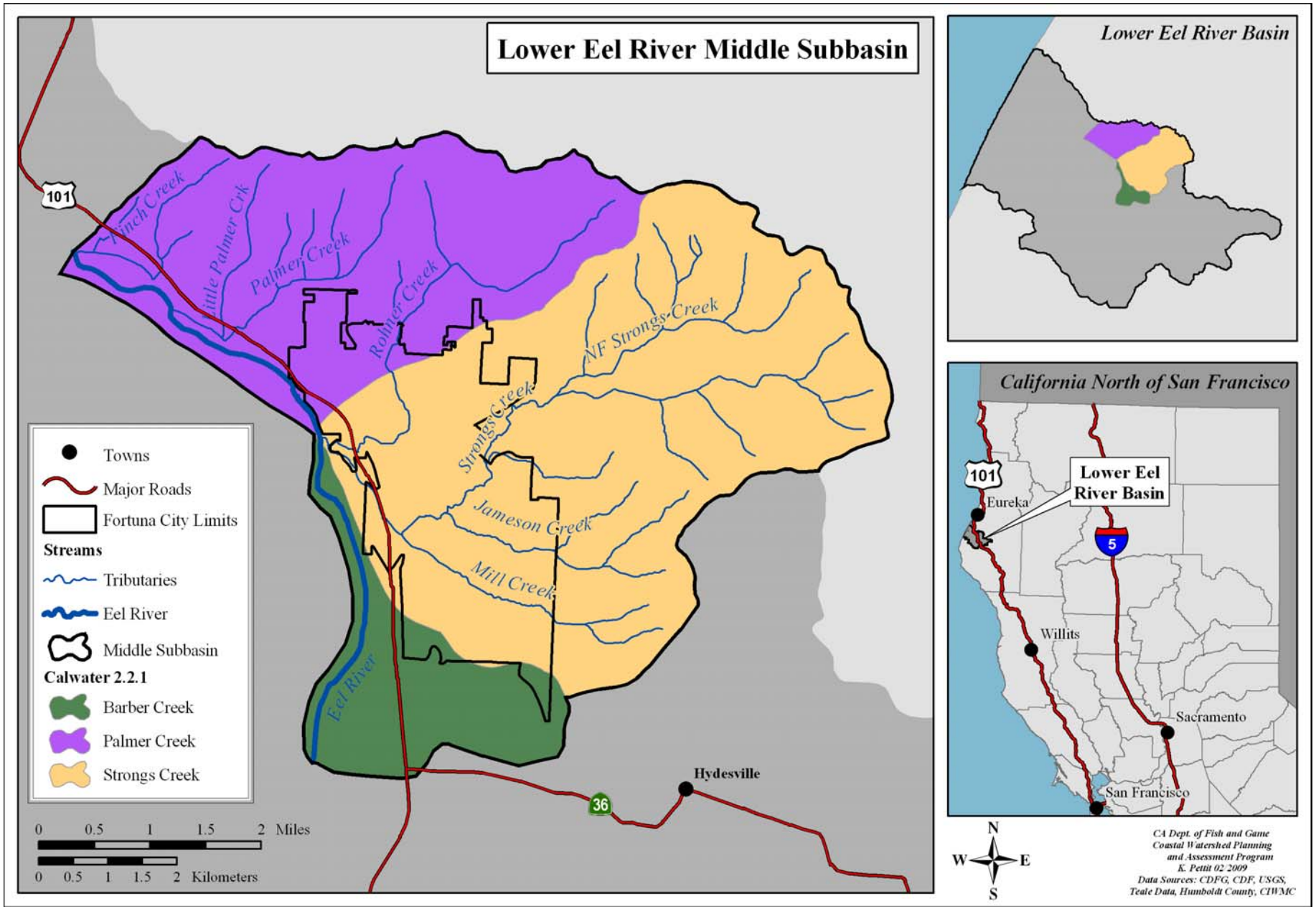

Figure 2. Middle Subbasin locator map and CalWater Units.

Strongs, Rohner, Mill, Jameson, and North Fork Strongs Creeks all flow through the city of Fortuna for part of their length. The Eel River forms the western margin of much of the city as well. Some development has occurred on all of these stream's floodplains (Figure 2).

Sections flowing through town have often been modified to accommodate development. Modifications include bank armoring, construction of stream crossings such as culverts and bridges, and channelization. Often, these modifications decrease or eliminate natural stream floodplains. This has increased the volume and velocity of flows during the rainy season, as is evidenced by Fortuna's flooding and drainage issues (Table 2).

Another factor contributing to flooding issues is the increase in impervious cover as the city of Fortuna has grown. Newly created impervious areas increase runoff to streams and aggravate flooding problems (FEMA 1981 as cited in Mintier and Associates 2006).

In addition, many of the storm drains and culverts within the city are considered inadequate (undersized for the 25 year design flow) (Winzler and Kelly 2005). A 2005 Storm Drain Master Plan update found that approximately one third of the improvements recommended in the 1982 Storm Drain Master Plan have been partially or fully completed (City of Fortuna 2005).

Fortuna's 2005 Storm Drain Master Plan combined drainage structure deficiencies and recommended 55 improvement projects. These included two culvert replacements on Mill Creek, one creek widening project and one creek re-routing project on Rohner Creek, and one stream bank protection project on Strongs Creek (Table 3, Figure 3). These types of flood control projects have the potential to impact salmonid upstream and downstream migration as well as juvenile rearing habitat.

Table 2. Drainage problems in Fortuna

Drainage Area	Noted Problems
North Fortuna	Drainage facilities generally acceptable; however, there are several areas subject to frequent flooding during relatively minor storm events and there is potential for significant flood problems.
Rohner Creek	Has more potential than any other creek in the city to cause serious flooding damage. Lower reaches flowing through city subject to bank erosion and heavy growth of vegetation, which contribute to a serious reduction in channel capacity.
Hillside Creek	Majority of drainage facilities considered undersized for a 25-year storm event.
Strongs Creek	Development is recommended to be conducted with setbacks corresponding to 100-year floodplain. So far this is occurring. During extreme floods, the Eel River causes flooding in the lower reaches.
Jameson Creek	Only floods at the confluence with Strongs Creek.
Mill Creek	Along with recent development, there has been a significant increase in the amount of runoff entering the drainage causing flooding in the lower reaches.

(2005 Storm Drain Master Plan, City of Fortuna 2005, Mintier and Associates 2006)

Table 3. Recommended storm drainage improvement projects on creeks in the Fortuna Storm Drain Master Plan (2005)

Project Type	Name	Priority
Culvert replacement	Mill Street Project - Mill Creek	Medium
	School Street Project No.2 - Mill Creek	Low
Creek Widening	Rohner Creek Widening Project (City Project No. 9600)	High
Creek Rerouting	Rohner Creek Bypass Project (City Project No. 9601 & City Project No. 9704)	High
Stream Bank Protection	Maxwell Lane Slope Stabilization Project - Strongs Creek	High

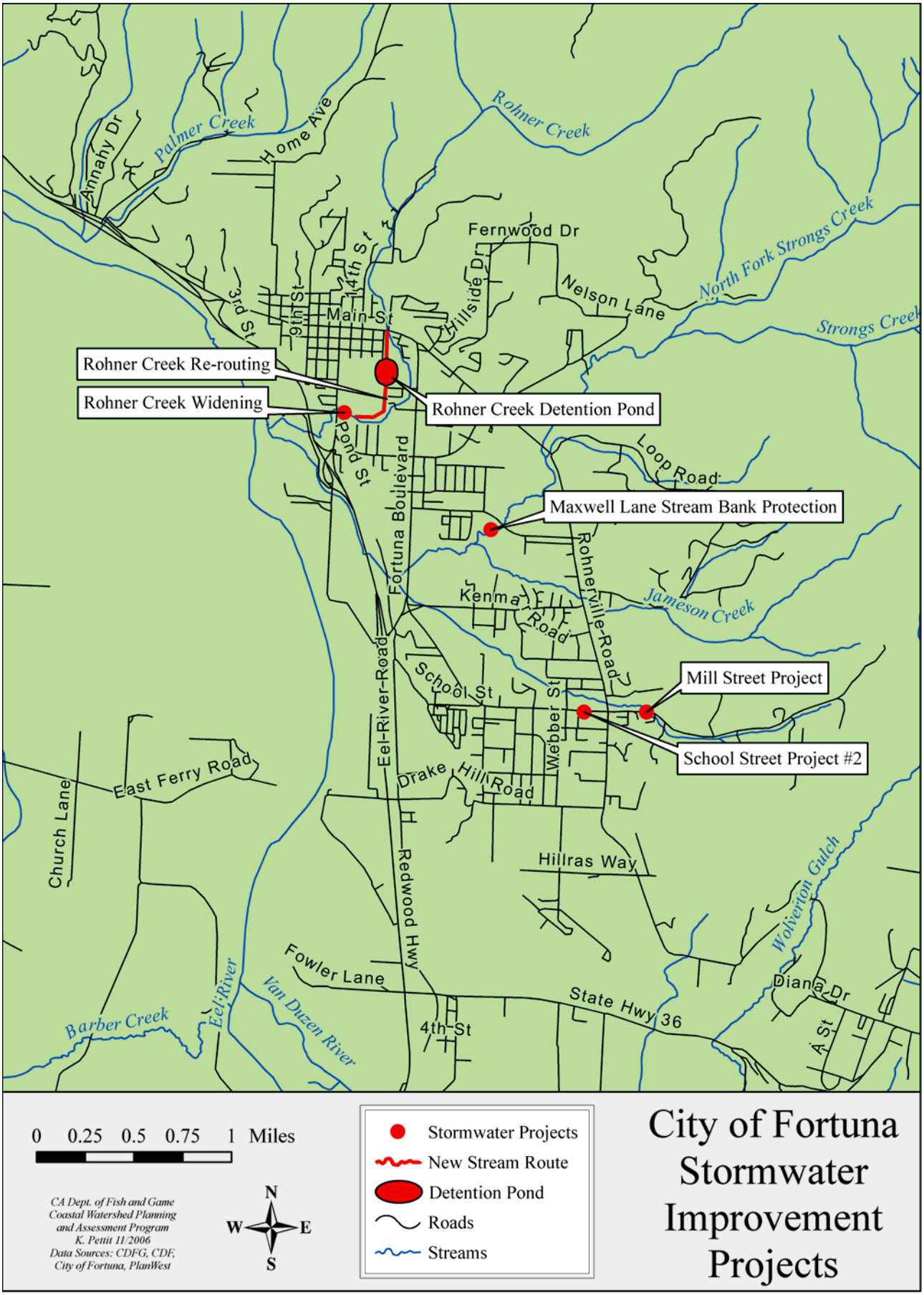

Figure 3. Proposed City of Fortuna stormwater improvement projects on creeks (City of Fortuna 2005).

Geology

Compositional Overview

River terrace deposits make up a large amount of the Middle Subbasin (Table 4 & Figure 4). The towns of Fortuna and Rohnerville are built on the remnants of an ancient, uplifted, unconsolidated floodplain deposit of Eel and Van Duzen River sediments termed the Rohnerville Formation. Above this gently sloping surface are earlier terrace deposits of the Hookton formation, which consist of poorly consolidated marine and river sediments. The Hookton Formation makes up a good portion of the hills above Fortuna and Rohnerville.

To the northeast of the Hookton and Rohnerville formations is the sedimentary bedrock of the Wildcat group. A series of terraces (including the Hookton and Rohnerville formations) have been uplifted from just above the current floodplain to hundreds of feet above the current floodplain and corresponding incision by the streams has occurred. These steeply incised canyons have exposed conglomerate and sandstone of the underlying Carlotta formation. To the northwest of the terrace deposits have been juxtaposed against Wildcat Group sediments by the Little Salmon Fault, Wildcat Group

The Wildcat Group is a sequence of five geologic formations that consist of Miocene to Pleistocene marine sediments grading to non-marine sediments in the uppermost formation (Ogle 1953). The majority of the Wildcat Group formed as sediments washed into and filled a forearc basin (the Eel River syncline) from about 13 to 1.48 million years ago (Ogle 1953). The sedimentary sequence of this infilling inlet reached a thickness of over ten thousand feet. As uplift of the western edge of Northern California occurred these sedimentary beds were lifted and tilted to their present position.

Table 4. Rock types of the Middle Subbasin.

Rock Type	% of Subbasin	Description
Alluvium	15.2	Unconsolidated river sediments within the active influence of streams.
Terrace deposits	43.4	Unconsolidated, poorly sorted river sediments that have been uplifted above the active stream influence.
Wildcat Group	41.5	A series of 5 formations; 4 consisting of poorly cemented, fine-grained, shallow marine sediments and one consisting of courser, poorly consolidated, predominately nonmarine sediment.

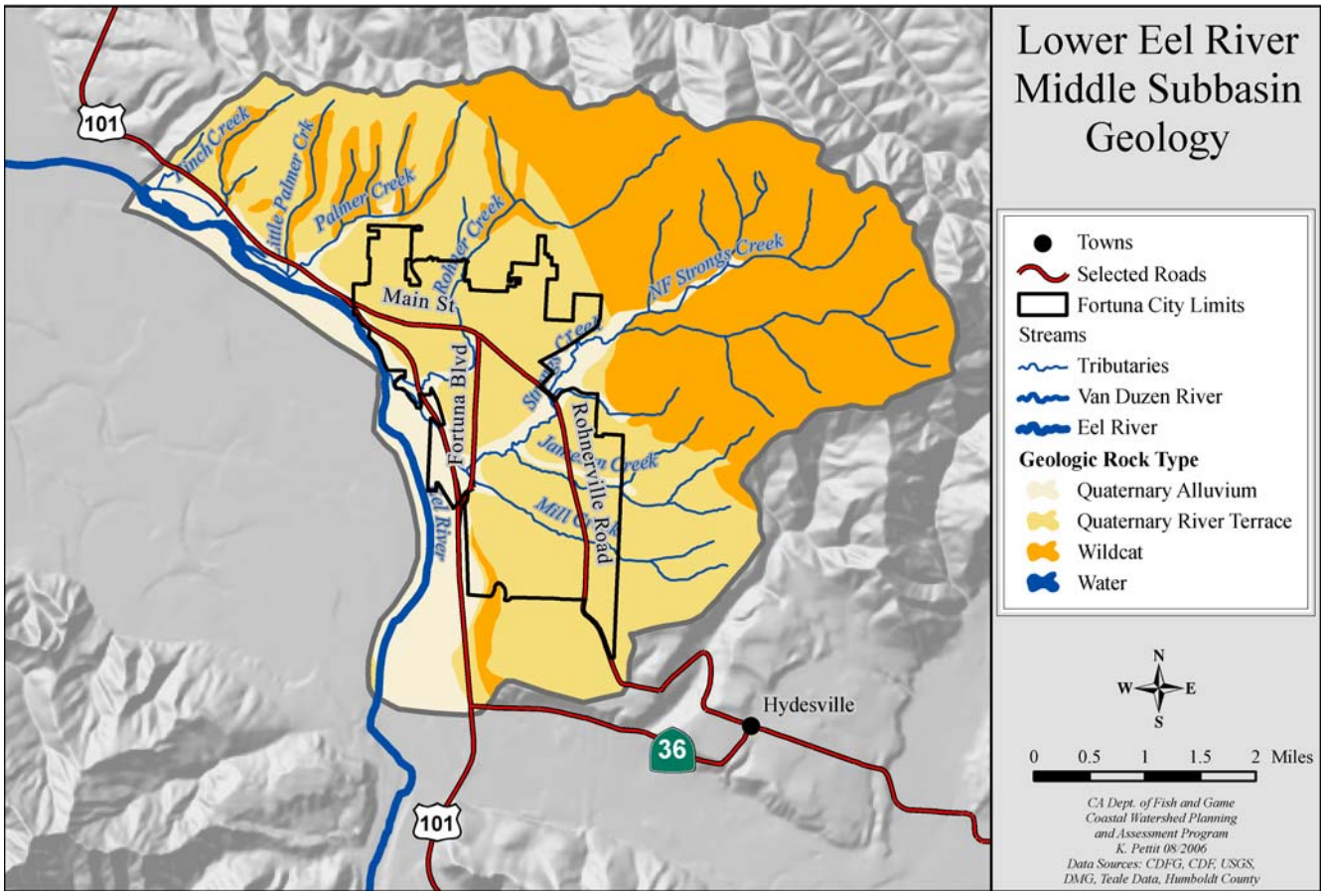

Figure 4. Geology of the Middle Subbasin.

Soils

A series of loamy soils has developed upon a flight of ancient, unconsolidated Eel River terrace deposits as well as portions of the current floodplain and on the steeper slopes of soft sedimentary bedrock of the Wildcat group in this subbasin (Table 5). Although all of these soils are sensitive to erosion they are especially so upon steep slopes or in areas denuded of vegetation.

Streams within this subbasin tend to incise steep banks into the soil/bedrock. Dry ravel, shallow landslides, and slumping are common along these steep banks.

Table 5. Soil types in the Middle Subbasin.

Soil Type	% of Middle Subbasin	Composition
Tramway-Irmulco-Empire	43	Loam
Timmons-Rohnerville-Hookton-Carlotta-Arcata	30	loam/silty clay loam/fine sandy loam
Riverwash-Loleta-Ferndale-Bayside	20	Loam/silt loam/silty clay loam
Fluvents-Riverwash complex	7	Loam

Earthquakes and Faults

The Little Salmon Fault cuts across this subbasin. The Little Salmon Fault is a relatively active fault that is capable of sizeable earthquakes that can trigger landsliding, liquefaction and modify the landscape. Past movement of this fault has disrupted bedrock leaving sheared zones that are somewhat more susceptible to erosion than their non-sheared bedrock counterparts. The Little Salmon Fault runs to the north of this subbasin and is capable of producing earthquakes that are large enough to trigger significant landsliding and/or liquefaction of the land within it. The Cascadia Megathrust and the San Andreas Fault have historically caused earthquakes large enough to alter the morphology of this subbasin.

Landslides

Quaternary river terraces, due to their unconsolidated nature, are subject to debris sliding especially when saturated by heavy rain. The Hookton formation is subject to gully erosion, debris slides, and earthflows (Kilbourne 1985). The Wildcat Group as a whole is made up of soft, poorly cemented fine sediments. Rapid rates of uplift and the "soft" nature of these rock types have allowed the stream channels to incise steep canyons. As well as uplift these formations have been steeply tilted and folded. Furthermore, these rock types have a relatively high porosity allowing them to absorb water during winter storms. When they become saturated they tend to fail along their steeply dipping bedding plains. Of the Wildcat Group the Rio Dell formation is one of the most susceptible to landsliding. Landsliding is most common in zones between mudstone and sandstone beds during super saturation. Landslides are historically common in this area - the original name of Fortuna was "Slide."

Fluvial Geomorphology

The upstream boundary of the Middle Subbasin is delineated near the confluence of the Eel and Van Duzen River. At this point the Eel River enters a broad alluvial valley with very low gradient known as the Eel River Delta. The valley itself was formed by the down-warping of the Eel River syncline which subsequently filled in with a sequence of marine sediments and finally fluvial sediments. Middle Subbasin the main stem of the Eel River enters a classic depositional regime. The slope of the channel drops to 1-2% and the flow slows.

Since this valley filled in with sediments the area has gone through tectonic uplift creating a series of terrace deposits. At the junction of Yager Creek and the Van Duzen River (~80 feet elevation) a flight of 8 terraces rising in excess of 200 feet is preserved. These terraces have been correlated with high stands of sea level during the last 83 thousand years. This correlation yields an approximate uplift rate of between .8 to 1.2 millimeters per year (O'Dea 1992). Currently the upstream end of this subbasin is 40 feet above sea level and the downstream end is at an elevation of less than 10 feet.

Historically the estuarine/tidal influence was reported to reach as far upstream as the confluence with the Van Duzen River and is considered to be the beginning of the Eel River Delta. The earthquake of April 1906 reportedly raised the bed of the river channel by a couple feet and caused the estuarine/tidal influence to shift farther downstream

(Trinity Associates 1996). It is not specified if the channel change was due to uplift or aggradation. Most likely it was a combination of each. The beginning of estuarine/tidal influence is currently delineated at Fernbridge.

A levee exists on the right bank of the mainstem within this subbasin from the confluence of the Van Duzen through the city of Fortuna. The presence of this levee alters the naturally occurring fluvial processes along this stretch as well as downstream. Levees tend to keep low gradient streams from naturally migrating and meandering over time. If a river has a levee on only one side it tends to cause flooding to increase on the opposite side. This can lead to greater sediment deposition on the opposite side and entrenchment of the channel. Levees can also straighten the channel and allow faster flows causing local scour and deposition of sediment further downstream. This can further entrench the channel locally.

Tributaries in this subbasin are relatively steep and moderately incised. To the south of the main stem they drain the poorly cemented, fine-grained sedimentary rock of the Wildcat Group. To the north they drain uplifted, poorly consolidated terrace deposits. Both of these terrain types can contribute an abundance of fine grained sediments to the streams.

The morphology of individual streams within a system when taken in a fluvial geomorphologic context can be used to help understand the current and as past fluvial regime/sediment changes. Some basic morphologic stream patterns have been defined by D.L. Rosgen, Rosgen channel types (Figure 5).

Tributary surveys of three reaches in the Middle Subbasin found that all were different types of Rosgen B channels (Table 6). Note that the surveyed reach of Strongs Creek began at the confluence with the North Fork of Strongs Creek. Type B channels are wide, shallow, and single thread. They are moderately entrenched, moderate to steep gradient reaches, which are riffle-dominated with step/pool sequences.

Table 6. Channel types in surveyed streams of the Middle Subbasin.

Stream	Reach	Length (feet)	Channel Type
Mill Creek	1	942	B4
North Fork Strongs Creek	1	6,091	B5
Strongs Creek	1	3,372	B3

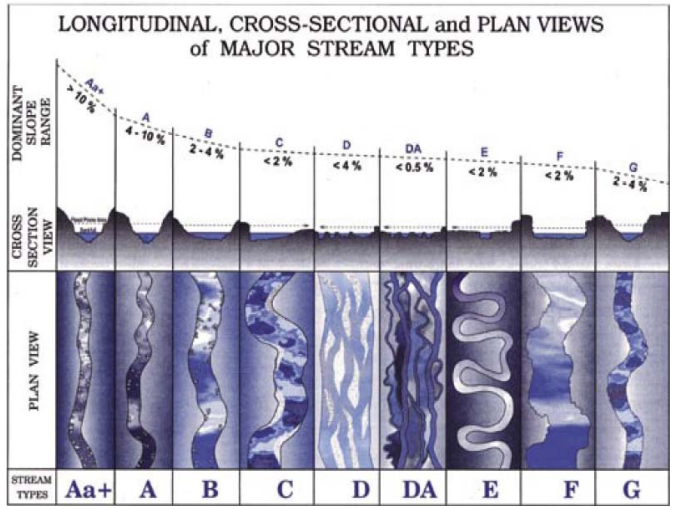

Figure 5. Illustration of how channel types A-G are delineated based on entrenchment, sinuosity, and slope (Rosgen 1996).

Vegetation

The vegetation description is based on USFS CALVEG data (2000). Forty-five percent of the vegetation in the Middle Subbasin is classified as conifer. Of this, 67% is composed of vegetation of the Redwood Alliance, followed by the Redwood – Douglas-fir Alliance (29%). Nearly all conifer cover in the Middle Subbasin lies in the headwaters of Rohner and Strongs Creeks. Redwoods in this subbasin are confined to the east side of the Eel River. The vegetation cover type designated "mixed" describes forest stands where conifers are the primary tree type; hardwoods are secondary. When this classification is combined with conifer, coniferous forest stands constitute over half of the Middle Subbasin at 52%. Under this CALVEG classification scheme, crown diameters of conifers are ordered into groups based on average visible diameter (Table 7).

Herbaceous vegetation composes 16% of the area. As it is difficult to remotely differentiate between grasslands used for agricultural purposes or otherwise, this in combination with land described as agriculture makes up 23% of the total, and more than likely describe the cattle grazing that occurs in the Middle Subbasin. Agricultural areas in the Middle Subbasin lie primarily to the east and west of the mainstem Eel River between Fortuna and the mouth of the Van Duzen River, with sections extending into the lower portions of Rohner and Strongs Creeks. The annual grasses occupy additional low-lying areas of the subbasin. The Middle Subbasin has the largest amount of land described as urban (10%) when compared to the other subbasins. The principal community and

population center of the Lower Eel Basin is Fortuna, which is located in the Middle Subbasin.

Table 7. Crown diameter of vegetation classified as primarily conifer forest in the Middle Subbasin.

Conifer Alliance	Size Range	Most abundant by area
Redwood	Sapling to Large	Medium
Redwood - Douglas-Fir	Sapling to Large	Small
Sitka Spruce	Sapling to Medium	Small
Sitka Spruce - Redwood	Sapling to Medium	Medium
Sitka Spruce - Grand Fir	Pole to Medium	Small

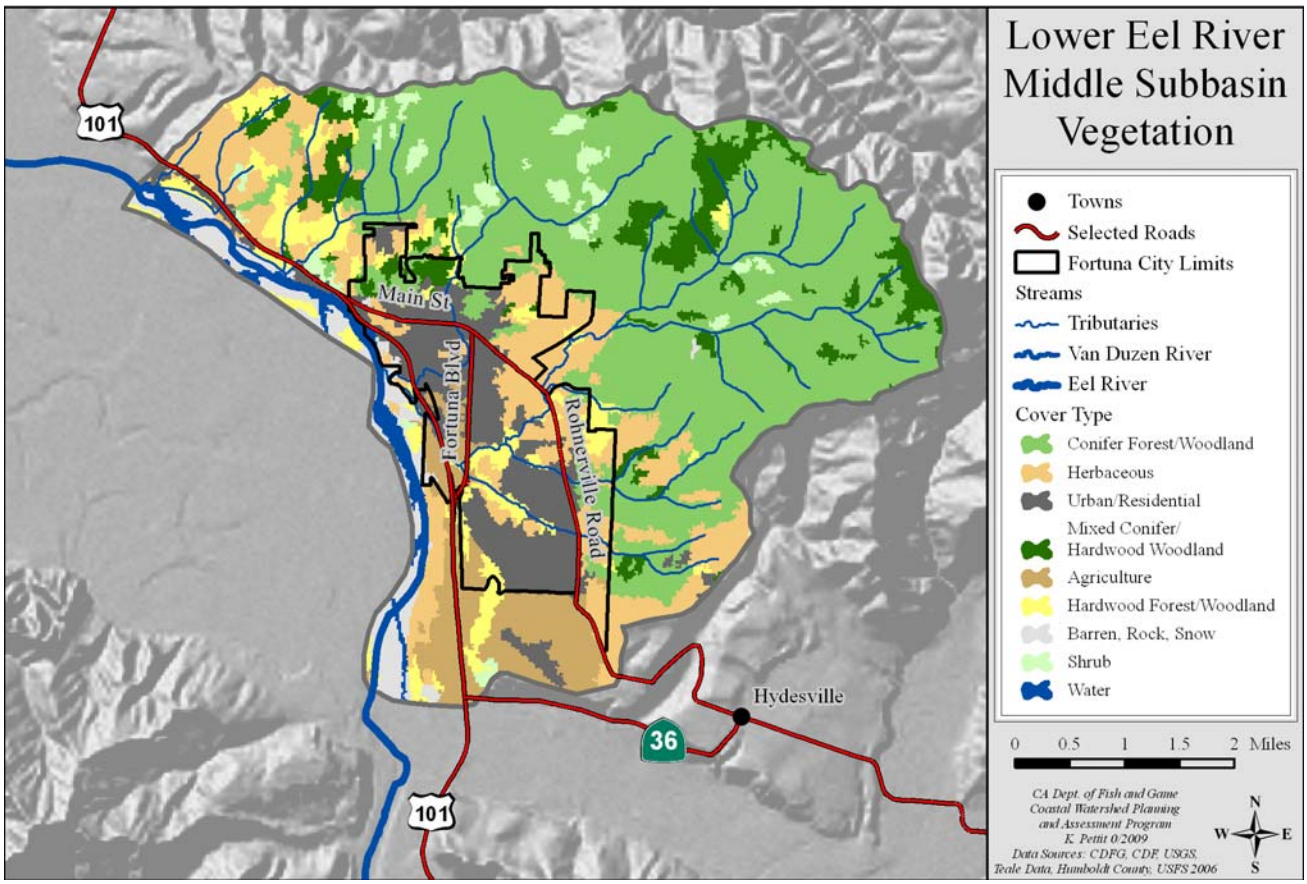

Figure 6. Vegetation of the Middle Subbasin.

Land and Resource Use

Historic Land Use

Henry Rohner, a former gold prospector, first settled the area of Rohnerville in 1850. Although he had purchased land to cultivate, he also opened a store that served as a supply center for miners traveling to the Trinity, Klamath, and Salmon Rivers. Rohnerville soon began to flourish, as it was located along the major transportation route to Humboldt Bay. The area also possessed fertile alluvial soils. For the purpose of claiming land for agriculture, trees were soon felled and processed into rough timber. With these profitable industries, by 1871 the town of Rohnerville was one of the largest in Humboldt County, with a population totaling 350 (Genzoli 1972). The town prospered, and supported several stores, a hotel, fairgrounds, a race track, as well as Mt. St. Joseph's College, a moderately sized school whose education was a draw to students from as far south as Santa Barbara, CA (Genzoli 1972).

Timber production quickly became an important industry. Rohnerville constructed a mill that processed timber in the summer and grain in the winter (www.sunnyfortuna.com/history/fortuna). In 1884, a mill was established in Newburg, which developed into the small town to the northeast of Fortuna. At this

time, the Newburg mill was the largest mill in the Eel River valley. It produced 40,000 board feet/day, which is an indication of how prosperous all of the timber mills in the Middle Subbasin were. By 1924, this one mill had fully harvested timber from the Strongs Creek basin (1891), North Fork Strongs Creek basin (1896), South Fork Strongs Creek basin (1901), Jameson Creek, Wolverton Gulch, Yager Creek, and Howe Creek basins (by 1924). Along with the harvesting of these areas came the laying down of railroad track, and the construction of roads. The mill was very successful, and output increased to 65,000 board feet/day, and employed 250 people (Spinney c. 1976).

Some of the timber processed at the mill in Rohnerville was used to build a walkway into the town of Slide, crossing over Jameson and Strongs Creeks along the way. Slide was so named because of the large landslide in the area which often presented travelers with difficulty on journeys to Humboldt Bay. Slide was later renamed to Springville, which was the name of the mill that was constructed in 1874 at the foot of 2nd Street. Lumber mills were a major regulator of growth to the communities in the Middle Subbasin. People began to move into mill towns for the prospect of steady jobs and to settle with their families. Within four years of the Springville Mill's founding, the town was flourishing, and provided many services including a market, post office, two schools, a saloon, and grist mill (McCormick 1999). As transportation routes improved, timber production in the Eel River Valley mills increased.

Springville was renamed Fortuna and lived up to its prosperous name. The fertile Eel River delta soils provided for successful crops, and the quantity of timber available for production seemed endless. The town was also fortunate in another important way. In 1885, the Northwestern Pacific Railroad laid track through the town of Fortuna, as opposed to Rohnerville. The railroad greatly improved the area's transportation. Businesses that had been established in Rohnerville began to move to Fortuna (Genzoli 1972). By 1914, Fortuna was considered a major railroad stop between San Francisco and Eureka.

In addition, roads were built that connected Fortuna with other surrounding towns, like Ferndale, which gave it standing as a center of business. The bridge at Fernbridge was built in 1911, replacing the ferry crossings at the present day Fortuna River Lodge and Singley Ferry by the end of Drake Hill Road. Fortuna grew to such an extent, that people traveling to northern California often opted to take the train into Fortuna, rather than a ship into Humboldt Bay (www.sunnyfortuna.com/history/fortuna).

Since Fortuna was incorporated in 1906, it has grown by annexation of surrounding areas (Table 8). The largest addition to the city was the annexation of the Campton Heights-Rohnerville area between 1975 and 1980 (Mintier and Associates 2006). This represents a change in urban area from 4% to 19.5% of the Middle Subbasin.

Table 8. Fortuna annexation history.

Year	City Land Area (square miles)	Population
1950	1.0	1,763
1960	1.4	3,523
1965	1.4	ND
1970	2.0	4,314
1975	3.0	ND
1980	5.3*	7,591

(Mintier and Associates 2006)

* The current General Plan found the area of the city to be 4.68 square miles.

Land and Resource Use

Urbanization

Fortuna has continued to grow in importance. Even with Eureka's rise in political and economic standing because of Humboldt Bay, Fortuna had established itself as a major town in Humboldt County. The major land use issues facing the Middle Subbasin today are urban development and land subdivision, which are a direct result of Fortuna's economic and spatial growth.

The 2004 Census estimated the population of Fortuna to be 10,995. The California Department of Finance estimated the population of Fortuna to be 11,250 in 2005. The average annual; growth rate from 1980 to 2005 was 1.6% (Mintier and Associates 2006).

The number of housing units in Fortuna has increased from 3,711 in 1990 to 4,729 in 2005. It is estimated that by 2030, Fortuna will require 2,298 new housing units if current growth rates continue. In addition, it is projected that additional space will be needed in the city for commercial, retail, and manufacturing activities (Table 9) (Mintier and Associates 2006).

Table 9. Projected additional floor space needed in the City of Fortuna in 2030.

Type	Projected additional floor space needed in 2030 (square feet)
Commercial	322,411
Retail	423,455
Manufacturing	107,000

(Mintier and Associates 2006)

Land use within Fortuna's city limits is predominantly single family residential (Table 10 & Table 11). The 1993 Fortuna General Plan laid out future growth plans for 3,070 acres of build out in the city. This included 1,980 acres of residential, 615 acres of public, 150 acres of industrial, 195 acres of commercial, and 130 acres of agricultural lands (Figure 7 & Figure 8). Within the city limits, the majority of land was designated for Residential Single Family.

Fortuna currently occupies 3,114 acres or 4.68 square miles in size. Its sphere of influence (SOI) is 7,129.5 acres or 11.1 square miles in size. A SOI is a boundary surrounding cities and special service districts that is intended to represent the ultimate area into which the city or district may expand and extend public services. Additionally, there is a Fortuna Area Community Plan (1985), which encompasses an area of 8 square miles and is the long range statement of public policy for unincorporated public land and private lands around the city of Fortuna.

Fortuna's municipal water source originates from groundwater wells near the Eel River. The city operates five wells at the Corrosion Control facility located at 1575 Eel River Drive (Mintier & Associates 2006). Fortuna operates a wastewater treatment plant on 180 Dinsmore Drive, just west of Highway 101. This plant was constructed during the 1970s, though an earlier plant was constructed in the 1950s. Wastewater during average flows is treated to secondary treatment standards using an activated sludge process. Effluent is discharged into the Eel River at the confluence with Strongs Creek.

Table 10. Existing land uses in Fortuna (Mintier and Associates 2006).

Existing Landuse	City Limits		Sphere of Influence		Planning Area	
	Acres	%	Acres	%	Acres	%
Agriculture	6	0.2	934	13.6	1,557	20.0
Rural Residential	203	6.5	1,445	21.0	1,502	19.3
Single Family	1,651	52.5	1,805	26.3	1,822	23.4
Multifamily	71	2.3	85	1.2	87	1.1
Commercial	123	3.9	150	2.2	172	2.2
Industrial	144	4.6	171	2.5	175	2.2
Public	110	3.5	344	5.0	344	4.4
Open Space	220	7.0	571	8.3	725	9.3
Timber	0	0.0	220	3.2	220	2.8
Vacant	614	19.5	1,151	16.7	1,171	15.1
Total	3,142	100	6,877	100	7,775	100

Total only includes parcels provided with an existing land use.

Table 11. Fortuna 1993 General Plan landuse designations.

Land use Designation	Acres	Percent	Developable Acres 1*	Percent Available
Residential Estates	699	22.4	173	24.7
Residential Single Family	1,252	40.2	239	19.1
Residential Multifamily	148	4.8	35	23.7
Neighborhood Commercial	7	0.2	2	34.1
Retail Commercial	27	0.9	2	5.9
Commercial Thoroughfare	148	4.8	28	18.8
Freeway Commercial	56	1.8	24	43.7
Light Industrial	99	3.2	18	18.0
Heavy Industrial	75	2.4	7	9.8
Public Facilities	196	6.3	81	41.3
Agricultural Exclusive	88	2.8	14	15.5
Subtotal	2,796	89.8	623	22.3
Other/Unknown (Rights of Ways) 2*	318	10.2	5	1.4
Total (City Limits only) 3*	3,114	100	628	20.2

1* Developable lands include vacant, open space, and agricultural lands

2* Other/Unknown includes undesignated areas such as rights-of-ways for roads

3 *The total area covered by the 1993 General Plan is contained within the city limits

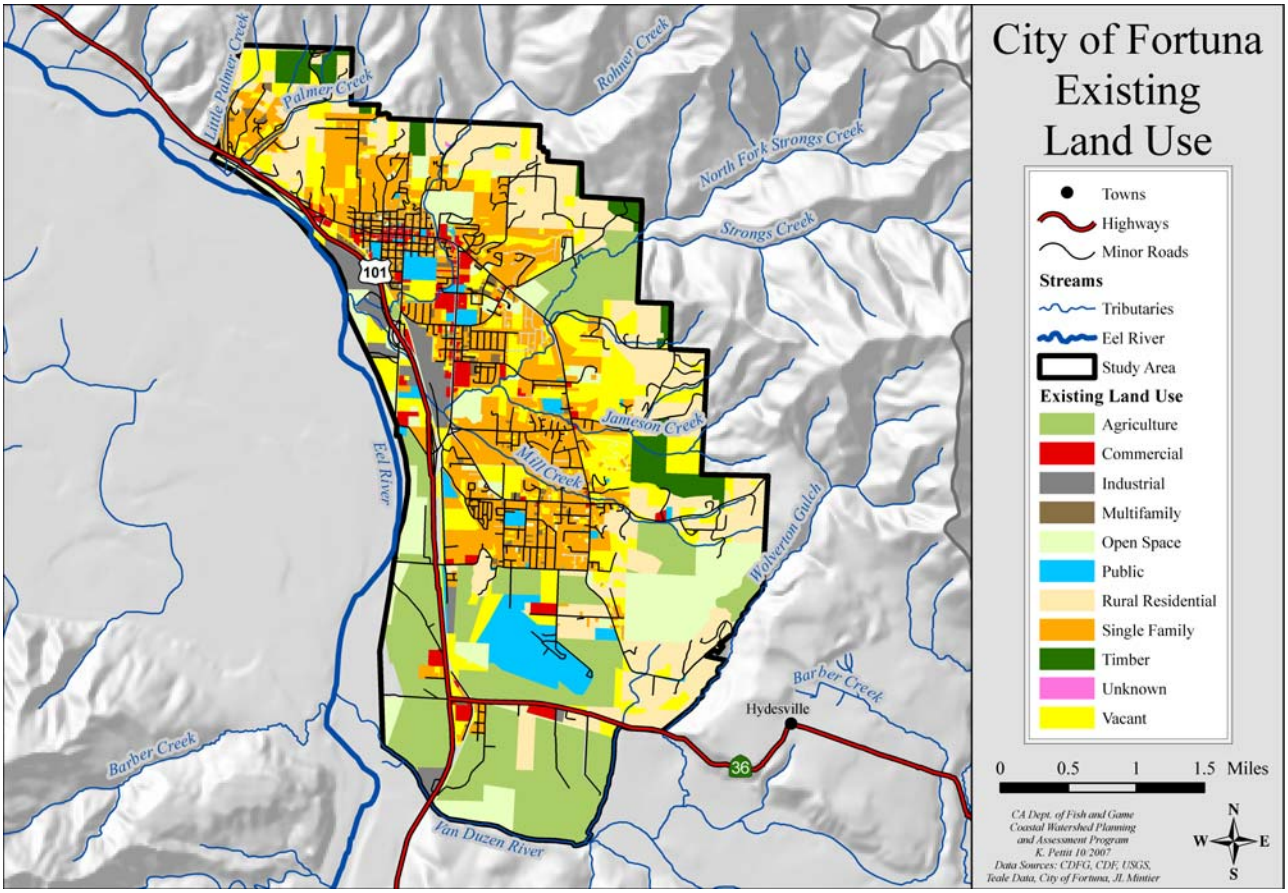

Figure 7. Existing land uses in Fortuna (Mintier and Associates 2006).

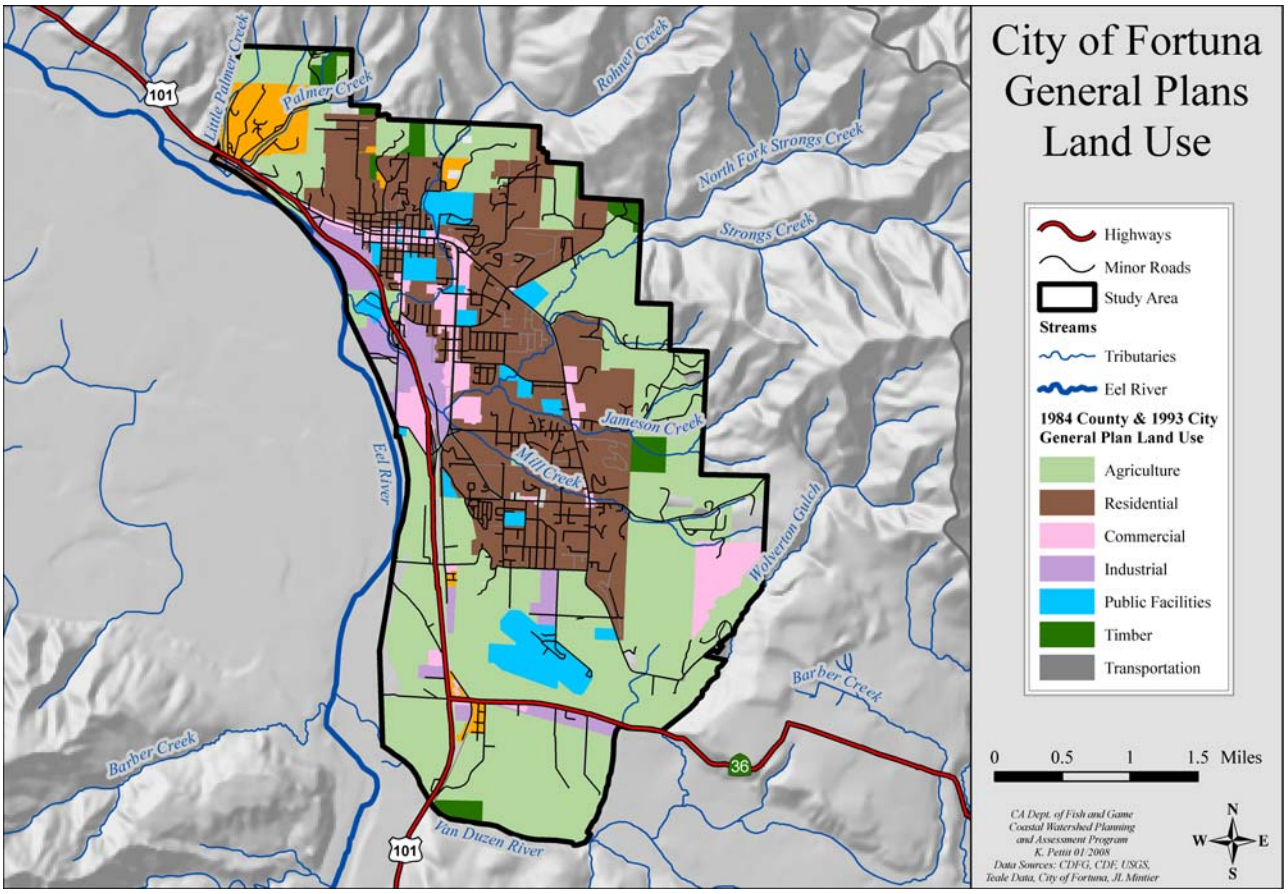

Figure 8. Fortuna 1993 General Plan land use designations.

In order to increase capacity during wet weather, the plant stores excess inflow in adjacent storage ponds. These ponds only had a one to two day capacity during wet weather and needed approximately one week of dry weather to recover (Mintier and Associates 2006). An upgrade to increase capacity was completed in March 2007.

When the Eel River reaches full capacity, river water floods the percolation ponds of the treatment plant. Managers attempt to forecast large rain events and stop discharging to the percolation ponds before saturation occurs. Treated Wastewater is discharged into Strongs Creek instead of the percolation ponds during these events. Water Board regulations also require the plant to discharge into Strongs Creek from September 15th through May 15th of the year; discharge is into the percolation ponds the remainder of the year (Cole 2003).

All of the fish producing streams in the Middle Subbasin flow directly through the city. The increase in hard surfaces, as well as the removal of riparian vegetation has significantly affected the watersheds abilities to respond to precipitation. Many of the streams have been extensively channelized, which has changed the direction and velocity of flow. Flooding has become a seasonal and persistent problem as described in the Hydrology section (page 3)

Forest Management

Timber harvest, while less of an issue than in the past, still occurred in the headwaters of all of the creeks in this subbasin from 1991 to 2006. Harvest in the headwaters of North Fork Strongs Creek was primarily second entry and occurs on Wildcat formation geology. Each year since 1991, an average of 2.2% of the Middle Subbasin has been included in a Timber Harvest Plan encompassing a variety of silviculture and yarding methods.

Gravel Mining

The County of Humboldt Extraction Review Team (CHERT) actively monitors six sites that remove over 5,000 cubic yards per year (cy/yr) of aggregate in the Middle Subbasin. Listed in the Final Program Environmental Impact Report (Humboldt County 1992) are 11 sites in this subbasin, including two that are downstream of Fernbridge by one mile. As mentioned in the basin section, there are also many smaller (less than 5,000 cy extracted per year) gravel mining sites on file with CDFG. Cumulative volumes taken out of this subbasin have significantly decreased since thorough scientific monitoring and management began in 1996 (Table 12). Before this time average volumes ranged from 500,000 cy/yr to 700,000 cy/yr. Currently, an average of 228,829 cy is extracted annually from this reach.

Since 1956, the general morphology of the river bed from the mouth of the Van Duzen River to Fernbridge has changed, based on the County of Humboldt's analysis of aerial photos (Humboldt County 1992). The annual removal of over 500,000 cy of aggregate from 1987 to 1992 alone "flattened the bed and caused the main low flow channel to split into two or three channels just below the mouth of the Van Duzen River" (Humboldt County 1992). It is also likely that the December 1955 flood set the stage for this consequence by filling pools and weakening banks.

Analyses of historic cross-sections have come up with disputed conclusions regarding the aggradation or degradation of the channel bed in the Eel River as well as the Van Duzen River (Kelsey 1977, USACOE 1999, and Humboldt County 1992). The most immediate channel morphology concern in this assessment area is in the reconfiguration of the low flow channel by its widening and shallowing. To this end, trench, alcove, or wetland pit mining are recommended over bar skimming between Fernbridge and the mouth of the Van Duzen River (USACOE 2003). A special concern with wetland pit mines has been fish stranding. Adults and juvenile salmonids have been documented in these river bar ponds along the Eel River by CDFG (1979). Currently, fish stranding is not a problem due to revised and improved gravel mining techniques.

As monitored, extraction amounts for the entire Lower Eel Basin have decreased from what they were in the last five or six decades. Without this decrease, impacts to salmonids would likely be significant and would include loss of deep holding pools during adult migration, and loss of cover, suitable temperature, and complex habitat for juvenile salmonids. Monitoring of these locations in particular is also important in regards to the hydraulic effects instream mining can have on the piers of bridge structures, in this case the historic Fernbridge and the bridges spanning the lower Van Duzen River.

Table 12. Lower Eel River Annual Extraction (1997-2005) (CHERT 2006).

Year	Recommended Volume (cy)	Extracted Volume (cy)	Percent of recommended volume extracted
1997	561,700	326,500	58%
1998	399,100	273,000	68%
1999	471,400	290,500	62%
2000	291,300	208,600	72%
2001	389,900	119,300	31%
2002	387,300	220,000	57%
2003	318,300	163,900	51%
2004	188,840	120,305	64%
2005	199,370	166,280	83%
Totals	3,207,210	1,601,800	50%
Averages	356,357	228,829	64%

Agriculture

Agriculture production occupies large areas of the Middle Subbasin. Approximately 23% of the subbasin is utilized for livestock grazing operations. The streams in the Middle Subbasin are affected by these agriculture productions. In parts of Strongs Creek, for example, livestock are allowed unrestricted access to the creek. Although no specific tests of nutrients and/or coliform bacteria have been conducted in these creeks, levels of these constituents often exceed water quality standards in areas with extensive livestock use. Not only does this pose a threat to chemical water quality, it increases the amount of sediment introduced into the watershed through bank erosion and as well as reducing or eliminating riparian vegetation.

The Humboldt Creamery operates a facility on the Eel River just downstream from Fernbridge. Dairy products are processed and the creamery has a wastewater discharge permit for discharge into the Eel River.

Fish Habitat Relationship

Fishery Resources

Other than anecdotal accounts, fish presence has been documented in the Middle Subbasin by observations made during stream surveys since 1938. However, stream survey efforts were neither specific nor standardized until 1990 when the *California Salmonid Stream Habitat Restoration Manual (*Flosi et al. 1998) was published. Most observations in stream surveys are not quantitative and have limited use.

Historically, coho salmon were found in Palmer and Strongs creeks and potentially Rohner Creek; however, in recent years they have only been detected (1995) in Strongs Creek. Steelhead trout were historically found in Palmer, Rohner, Strongs, and North Fork Strongs Creeks. In recent years, steelhead and coastal cutthroat trout observations have been limited to Strongs and North Fork Strongs Creeks. The Strongs Creek coastal cutthroat trout population is believed to represent the southernmost extent of the species (Gerstung 1996).

In addition to salmonid species other native freshwater fish species have been observed in the Middle Subbasin including pacific lamprey, threespine stickleback and coastrange and prickly sculpin. The invasive Sacramento pikeminnow has been detected in Rohner and Strongs creeks. Table 13 displays the documented fish presence from surveys in the streams of the Middle Subbasin from 1951 to 2006.

Table 13. Documented fish presence in surveys from 1951 to 2006 in the Middle Subbasin.
(NCCSI= North Coast California Coho Salmon Investigation - Bill Jong personal comm.)

Stream	Date Surveyed	Source	Survey Method	Fish Observations				Fish Comments
				Coho	Steelhead	Coastal Cutthroat	Salmonids	
Palmer Creek	05-07/1951	Hallock et al (1952)	Seine	X				
	1979	Geppert (2004)	Unknown		X			Steelhead observed by CDFG in 1979
	01/04/1982	CDFG 1982	Streamside observation					
	Summer 1997	HCRCD 1997	Streamside observation (assumed)		X			Stickleback also observed
	10/12/2000	CDFG 2000	Electrofishing					Lamprey spp. observed
	06/14 and 21/2001	CDFG NCCCSI 2005	Electrofishing					No salmonids observed. Lamprey spp. observed
	07/23/2002	CDFG NCCCSI 2005	Electrofishing					No salmonids observed. Lamprey spp. observed
	06/26 and 08/06/2003	CDFG NCCCSI 2005	Direct observation/ Electrofishing				X	Trout observed. Lamprey spp. observed
Rohner Creek	01/16/1952	CDFG 1952	Streamside observation					High water limited fish observation.
	04/19 and 22/1964	Lewis 1964, Day 1964	Streamside observation		X			Fish kill after copper iron spill from reservoir. Coho were found dead in the Eel below Rohner Creek confluence pool. Other observed fish mortalities: sticklebacks, lamprey ammocetes, sculpin, suckers.
	05/18/1972	CDFG 1972	Streamside observation					No fish observed.
	01/06 and 07/1982	CDFG 1982	Streamside observation					No fish observed during 1982 observation. However, author adds anecdotal comment that coho spawning was observed by wastewater treatment plant employee in 1980-81.
	09/07/2001	CDFG NCCCSI 2005	Electrofishing				X	California roach, Sacramento pikeminnow, lamprey spp., threespine stickleback, Cottid spp. observed
	07/24 and 25/2002	CDFG NCCCSI 2005	Electrofishing				X	Sacramento pikeminnow, lamprey spp., threespine stickleback, Cottid spp., observed
	07/02 and 08/06/2003	CDFG NCCCSI 2005	Electrofishing				X	California roach, lamprey spp., threespine stickleback, Cottid spp. observed
Strongs Creek	04/02/1951	CDFG 1951	Streamside observation				X	Dead trout and sculpins observed near pump intake due to electrical shock
	04/22/1968	CDFG 1968	Streamside observation					

Strongs Creek	04/29/1969	CDFG 1969	Streamside observation					"water was muddy"
	01/08/1982	CDFG 1982	Streamside observation					
	7/15/1993	CDFG Stream Inventory	Electrofishing		X	X		Steelhead ranged in size from 78 to 94 mm FL. Coastal Cutthroat ranged in size from 152 to 190 mm FL
	11/15/1995	CDFG 1995	Electrofishing	X			X	Coastal cutthroat trout, 1+ coho, prickly sculpin, brook lamprey, threespine stickleback, sculpin spp., unidentified salmonid observed. Comment that fishing was difficult due to habitat conditions
	07/24/2002	CDFG NCCCSI 2005	Electrofishing				X	Sacramento pikeminnow, threespine stickleback, Cottid spp., lamprey spp. observed
North Fork Strongs Creek	07/03/1984	Franklin and Mitchell (1984)	Electrofishing		X	X		Coastal cutthroat trout observed. Fish capture efficiency was poor due to poor water clarity and large amounts of woody debris.
	7/7 and 15/1993	CDFG Stream Inventory	Electrofishing		X	X		Steelhead ranged in size from 31 to 104 mm FL. Coastal Cutthroat ranged in size from 35 to 150 mm FL
Mill Creek	11/8/1997	CDFG 2004	Streamside observation				X	Juvenile salmonids observed approximately 600 feet downstream of Rohnerville road culvert
	04/1998		Streamside observation					Redd observed approximately 1800 feet from mouth (concluded to be steelhead based on time of spawning, size and shape of redd).
	03/1998		Streamside observation				x	An attempted fish rescue of juvenile salmonids, which were observed approximately 2000 feet from mouth and had been stranded in a pasture due to flooding.
	07/23/1999		Streamside observation				x	Juvenile salmonids observed approximately 1200 feet upstream of Rohnerville Road culvert (unknown whether resident or anadromous)
Unnamed Tributary (to Strongs Creek)	02/25/1980	CDFG 1980	Electrofishing					
	06/29/2005	CDFG 2005	Electrofishing					Threespine stickleback observed

Habitat Overview

Historic Conditions

Stream surveys were conducted by CDFG as early 1952; however, stream survey efforts were neither specific nor standardized until 1990 when the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998) was published. Most observations in the historic stream surveys are not quantitative and have limited use in comparative analysis with current habitat inventories. However, data from these stream surveys provide a snapshot of conditions, including barriers limiting fish passage at the time of survey (Table 14).

Past habitat surveys indicate fish passage problems in Palmer Creek caused by the culvert under Highway 101 since 1979. This culvert was most likely a barrier since the construction of the highway in the 1960s. Spawning habitat is described as poor in Rohner Creek in 1952 and 1972, but small sections of good spawning were noted in 1982. Surveys in 1972 and 1982 also indicate that stream banks were stabilized with rocks and old car bodies. Early surveys of Strongs Creek note that the Highway 101 culvert did not block fish passage, though a barrier was noted on an unnamed tributary to Strongs Creek in 2005.

Table 14. Habitat observations made in the Middle Subbasin from 1952-2005.

Stream	Date Surveyed	Source	Habitat Comments	Barrier Comments
Palmer Creek	1979	Geppert (2004)		Culvert at HWY 101 is barrier to fish migration (2004)
	01/04/1982	CDFG 1982		Fish cannot access creek above "storm drain" in first 500 feet
	Summer 1997	HCRCD 1997	Approximately 1 mile of good anadromous habitat above culvert	Culvert should be modified to allow fish passage
	10/12/2000	CDFG 2000	Maximum depth of pools was 2.5 ft. Cover was good and consisted of undercut banks and woody debris	No salmonids observed in this survey conducted upstream of HWY 101 culvert
Rohner Creek	01/16/1952	CDFG 1952	Bottom composed of mud, silt, organic debris. Few spawning areas, numerous pools, excellent shelter, numerous log jams	
	05/18/1972	CDFG 1972	Average stream depth was 6 inches. Steep banks, water clarity very muddy, bottom composition: fine sand, silt, rubble and boulders. No spawning substrate available. Rocks and automobiles used for bank stabilization.	Obstructions listed as logs, debris and automobiles.
	01/06 and 07/1982	CDFG 1982	Bottom composed of 100% sand and silt, water is silty. Gravel was described as good in small sections, ranging from "pea size to baseball size," and frequently compacted and covered with silt. Streambanks have been stabilized with rock rubble and crushed car bodies.	Four obstructions noted on stream: two considered possible barriers, 1 a probable barrier.
Strongs Creek	04/22/1968	CDFG 1968		Surveyors determined that HWY 101 culvert did not pose fish passage problem
	04/29/1969	CDFG 1969		HWY 101 culvert did not pose fish passage problem
	01/08/1982	CDFG 1982	Creek is 2 ft. wide and 6/8" deep, heavily silted, with little to no spawning gravel.	
	11/15/1995	CDFG 1995	Low-gradient riffle and trench pools, tannin-stained water. Submerged debris, terrestrial vegetation encroachment	
North Fork Strongs Creek	07/03/1984	Franklin and Mitchell (1984)	Second-growth redwood form 60% of canopy, bottom composed of mostly fine sediments, abundant log jams, no aquatic vegetation.	
Mill Creek	11/8/1997	Downie and Halstead	Urban garbage collected in creek included motorcycle and five gallon bucket of drain oil	
Unnamed Tributary (to Strongs Creek)	02/25/1980	CDFG 1980	Stream is heavily damaged from livestock, and may not flow during summer months	
	06/29/2005	CDFG 2005	Generally composed of pools less than 1 ft deep (max pool = 3 ft), silty banks and substrate. Low gradient, summer base flows probably create isolated pools with subsurface flow.	Rohnerville road stream crossing culvert is probably a complete barrier to juvenile salmonids

Current Conditions

Habitat inventories were conducted by CDFG on three of the tributaries in the Middle Subbasin. All three of these streams are contained in the Strongs Creek watershed (Table 15 & Figure 9). Strongs Creek and North Fork Strongs Creek were both sampled in 1993. An unnamed tributary to Strongs Creek, locally referred to as Mill Creek, was surveyed in 2004. Each of these inventories was completed in one reach.

Table 15. Middle Subbasin streams surveyed by CDFG.

Stream	Year of Survey	Survey length (miles)	Percent of stream surveyed	Number of Reaches
Mill Creek	2004	0.2	9	1
North Fork Strongs Creek	1993	1.2	46	1
Strongs Creek	1993	0.6	11	1

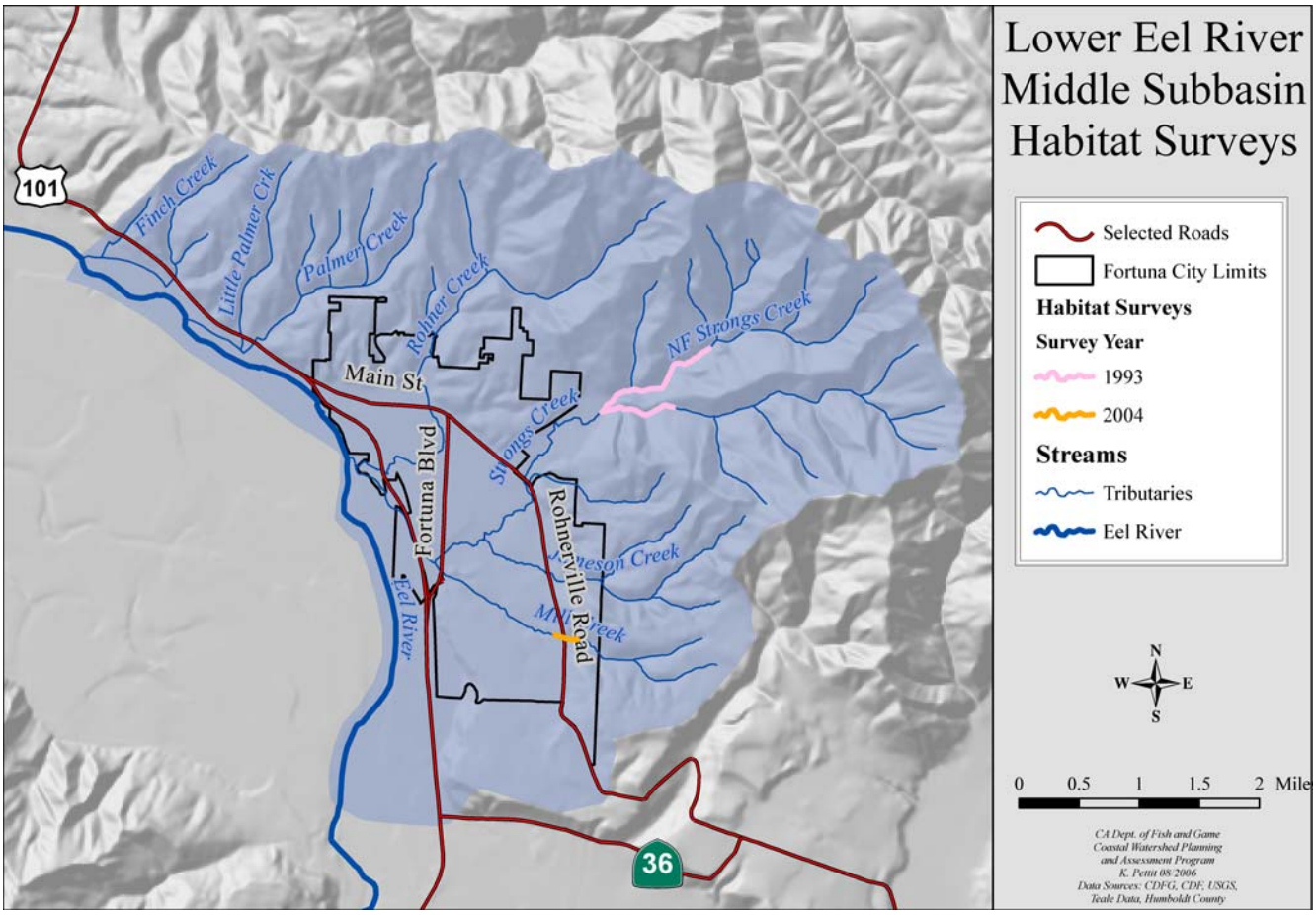

Figure 9. Habitat surveys were conducted by CDFG on three tributaries of the Middle Subbasin.

Canopy Density

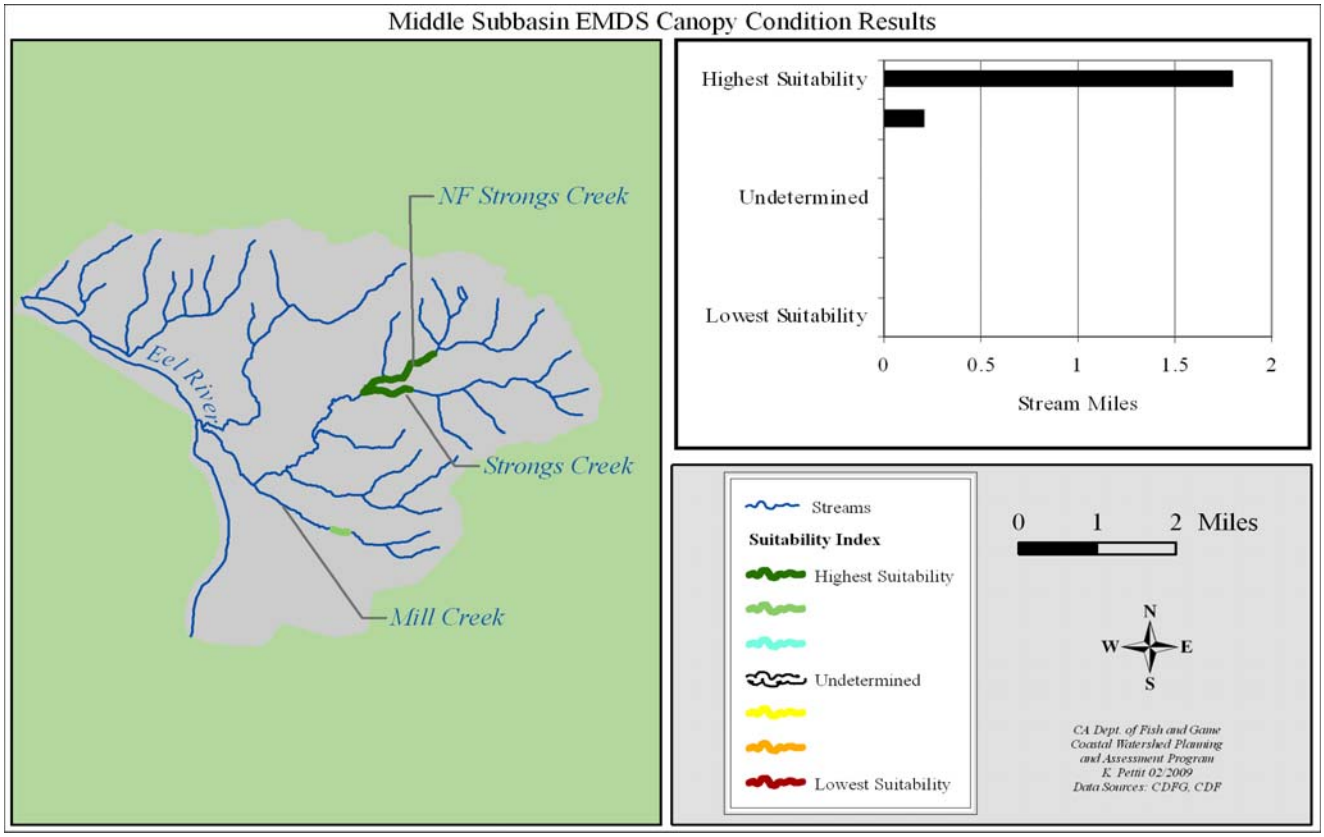

Figure 10. EMDS canopy results for the Middle Subbasin by surveyed stream miles.

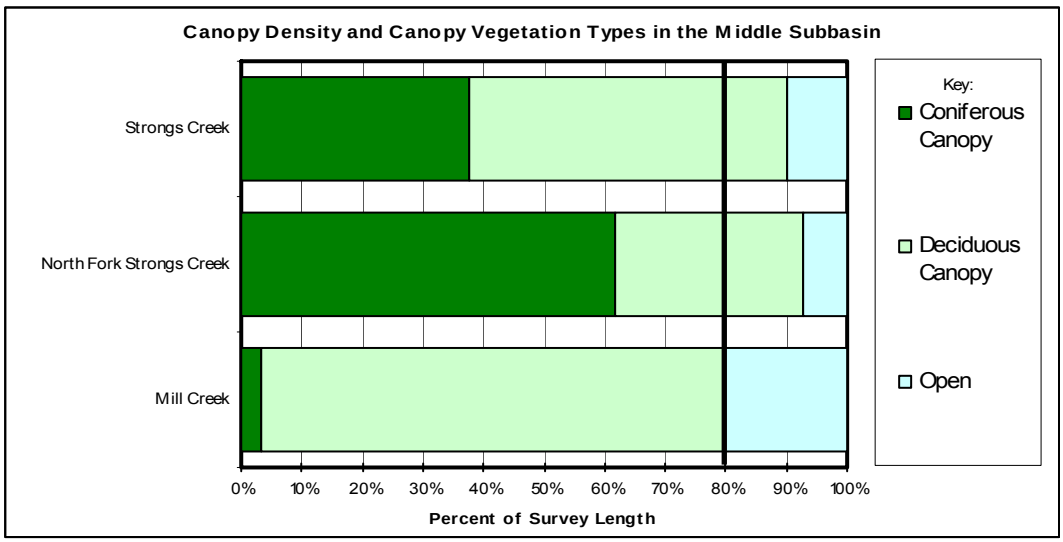

Figure 11. The relative percentage of coniferous, deciduous, and open canopy covering surveyed streams in the Middle Subbasin.

Averages are weighted by unit length to give the most accurate representation of the percent of a stream under each type of canopy. Streams are listed in descending order by drainage area (largest at the top).

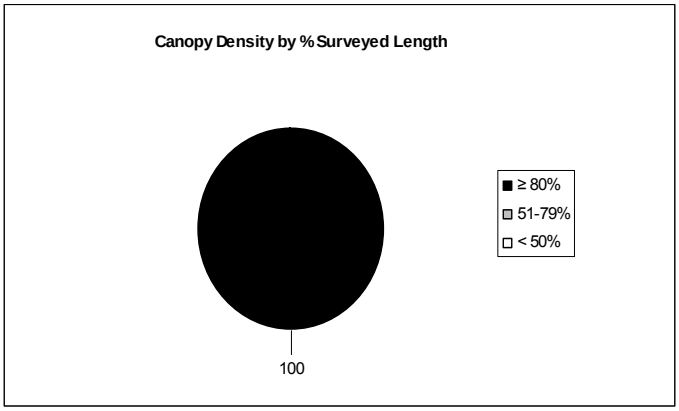

Figure 12. Canopy Density in the Middle Subbasin.

Significance: Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Stream water temperature can be an important limiting factor of salmonids. Generally, canopy density less than 50% by survey length is below target values and greater than 80% fully meets target values.

Findings: Canopy density measurements of all three surveyed streams in the Middle Subbasin met or exceeded the CDFG's target value of 80%. North Fork Strongs Creek had the greatest canopy cover at 93%, followed by Stro Canopy Density in the Middle Subbasin.ngs Creek at 90%. Mill Creek met the target value of 80% canopy density primarily composed of deciduous cover. These survey results translate into canopy density condition EMDS truth scores of highest and moderately high suitability ratings. Overall, canopy density in the Middle Subbasin was excellent based on target values.

Habitat Categories

Table 16 Middle Subbasin percent occurrence and percent by length of pool, run, riffle, and dry habitats.

Stream	Stream Order	Survey Length (miles)	Pool, Riffle, Run % Occurrence	Pool: Riffle: Run % total length	Dry % Total Length	Culvert % Total Length
Mill Creek	1	0.2	39:30:26	18:19:48	0	15
North Fork Strongs Creek	1	1.2	54:21:24	56:18:26	1	0
Strongs Creek	2	0.6	46:26:28	45:24:32	0	0

Findings: All three of the surveyed tributaries had a greater number of pools by occurrence than riffles. Additionally, North Fork Strongs Creek and Strongs Creek had a greater length in pools than in riffles and had over 30% of their stream length in pools. Mill Creek had significantly less pool habitat when measured by length rather than occurrence.

North Fork Strongs Creek had 1% of its length in dry habitat and Mill Creek had 15% of its length in culvert. Dry units measured obviously indicate poor conditions for fish and are further discussed in the Fish Passage Barriers section.

Significance: Productive anadromous streams are composed of a balance of pool, riffle and run habitat and each plays an important role as salmonid habitat. Looking cumulatively at pool, riffle, and run relationships helps characterize the status of these habitat types and also provides a measure of stream habitat diversity and suitability for fish.

A pool: riffle ratio of approximately 1:1 is suggested as a desirable condition for most wadeable, anadromous, fish bearing streams, but it is not applicable for evaluating salmonid suitability of all stream reaches and channel types (Rosgen 1996). However, pool: riffle relationships showing an over abundance of riffles or runs that may indicate aggraded channel conditions or lack of scour objects needed for pool formation. Additionally, pool frequency by percent length is preferable to pool frequency by occurrence because the latter may give a false impression of health if there are numerous, shallow, short pools as a result of aggradation (NMFS and Kier 2008).

Pool Depth

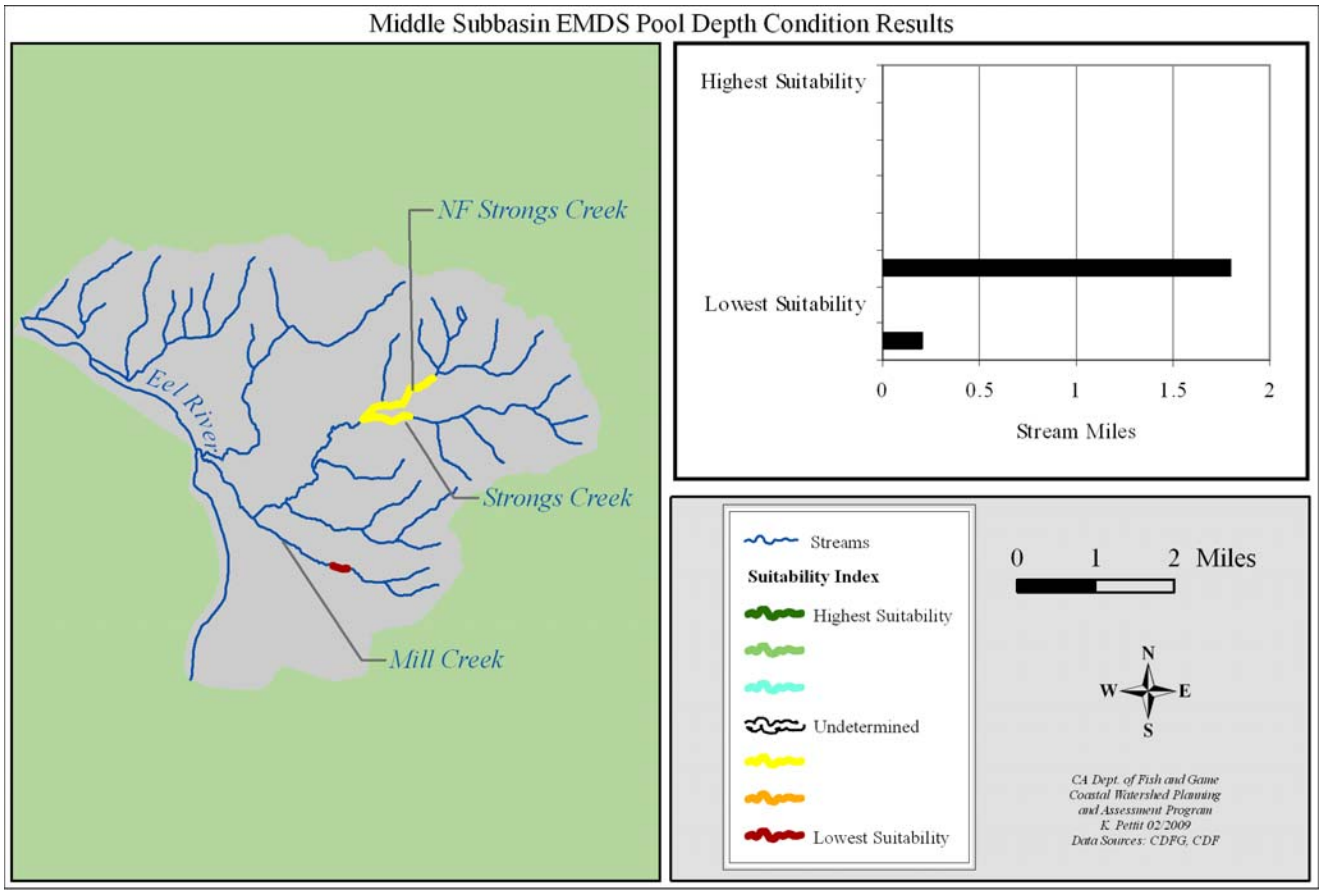

Figure 13. EMDS pool depth results for the Middle Subbasin by surveyed stream miles.

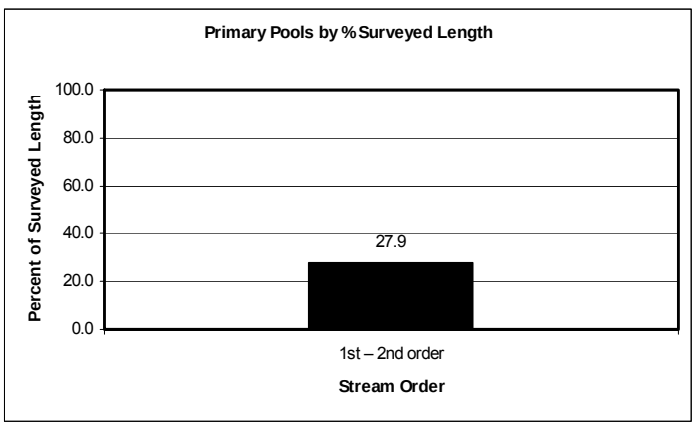

Figure 14. Primary Pools in the Middle Subbasin.

Table 17. Percent length of a survey composed of pools in the Middle Subbasin.

Stream	Stream Order	Percent all measured pools by survey length	Percent pools of depth <2 ft by survey length	Percent pools of depth 2 ft - 2.9 ft by survey length	Percent pools of depth 3 ft – 4 ft by survey length	Percent pools of depth > 4 ft by survey length	Percent pools within target range (>2 ft) by survey length
Mill Creek	1	15.23	12.68	2.55	0	0	2.55
North Fork Strongs Creek	1	55.08	23.64	20.16	5.96	5.32	31.44
Strongs Creek	2	43.32	14.74	16.16	11	1.42	28.58

Significance: Primary pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas. Generally, a stream reach should have 30 – 55% of its length in primary pools to be suitable for salmonids. In first and second order streams, primary pools are those of greater than 2 feet deep.

Findings: All streams in the Middle Subbasin were below target values for primary pool depth. North Fork Strongs Creek had the most pools within the target range by survey length at almost 32%, followed by Strongs Creek at nearly 29%. Mill Creek had the lowest amount of target value pools at under 3%, and only 15% of its surveyed length being made up by pools in general. Approximately 28 percent of the surveyed length of streams of the Middle Subbasin measured pool depths of greater than 2 feet. EMDS suitability ratings for pool depth show that the greatest length (over 1 mile of stream) measured highest suitability (North Fork Strongs).

Pool Shelter

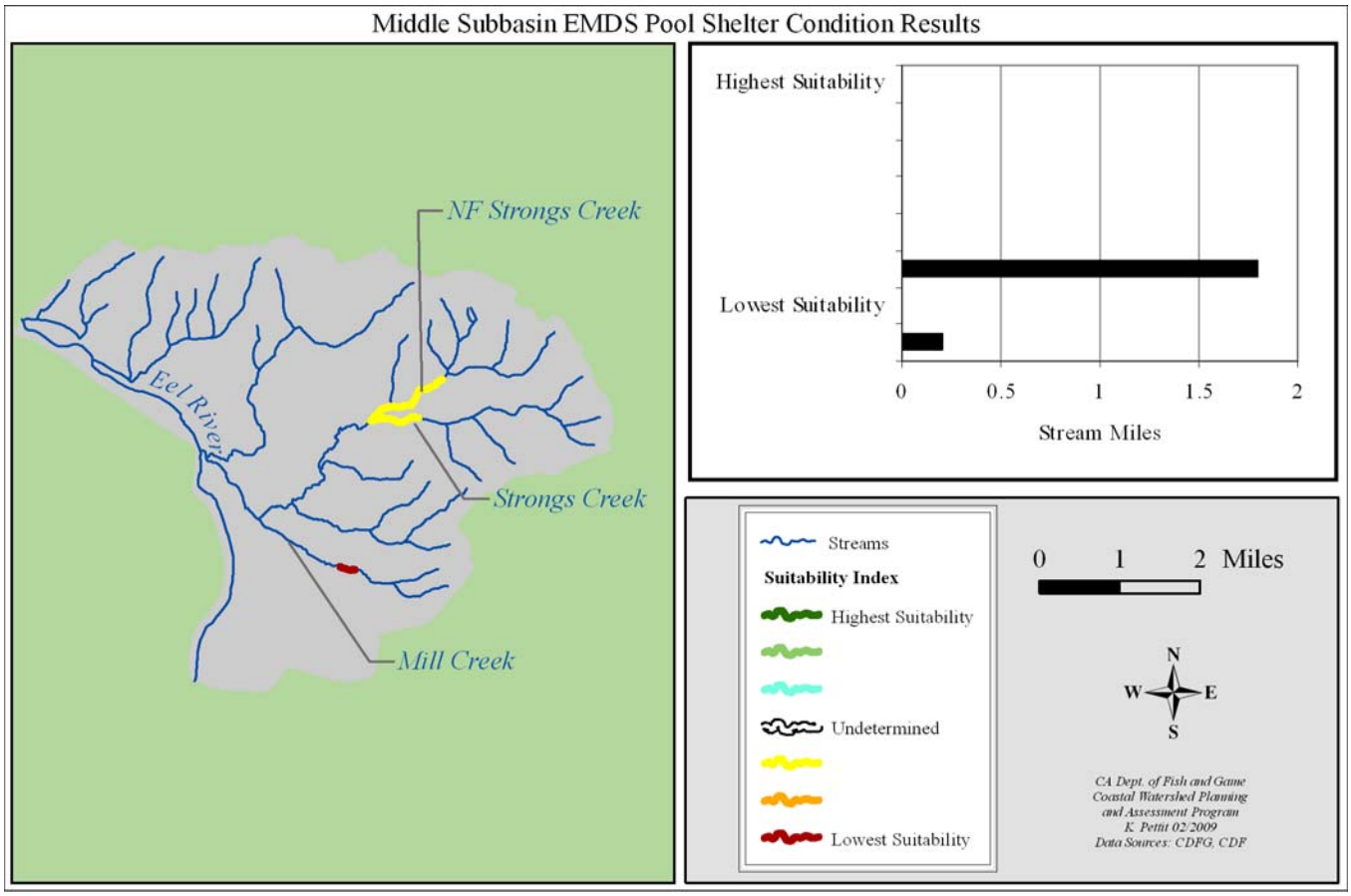

Figure 15. EMDS pool shelter results for the Middle Subbasin by surveyed stream miles.

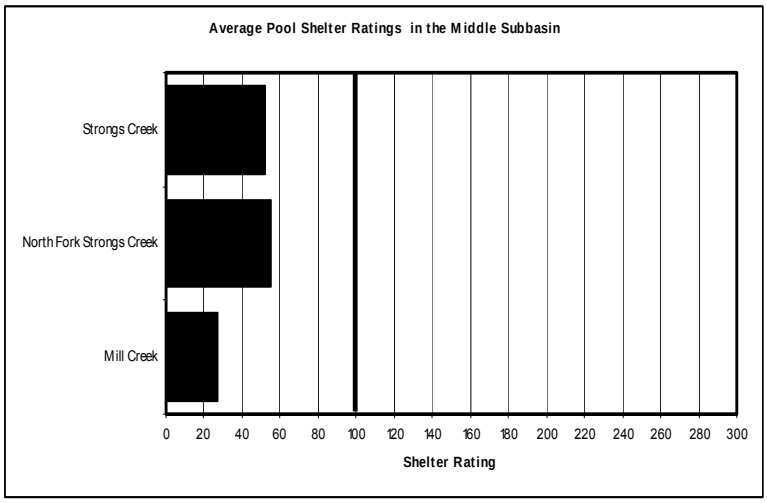

Figure 16. Average pool shelter ratings from CDFG stream surveys in the Salt River Subbasin.

Streams are listed in descending order by drainage area (largest at the top).

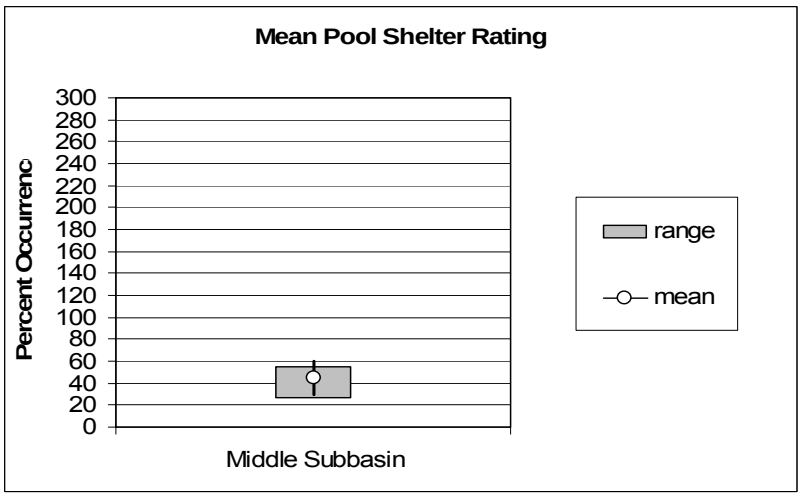

Figure 17. Pool shelter in the Middle Subbasin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described and rated in CDFG surveys.

Table 18. Mean percent of shelter cover types in pools for surveyed tributaries in the Middle Subbasin.

Stream	Undercut Banks	Small Woody Debris	Large Woody Debris	Root Mass	Terrestrial Vegetation	Aquatic Vegetation	White Water	Boulders	Bedrock Ledge
Mill Creek	7.8	36.1	0	11.1	18.9	0	0	16.1	10
North Fork Strongs Creek	17.6	14.7	51.6	6.8	0.1	0	0.5	4.9	3.8
Strongs Creek	0	12	50.8	16.5	3.4	0	0	15	2.3

Significance: The pool shelter rating is a relative measure of the quantity and percent composition of small woody debris, root wads, boulders, undercut banks, bubble curtains, and submersed or overhanging vegetation in pool habitats. These elements serve as complex instream habitat with protection from predation, rest areas from high velocity flows, and separate territorial units to reduce density related competition. Shelter ratings of 100 or less indicate that shelter/cover enhancement should be considered.

Findings: Pools shelter ratings for surveyed streams in the Middle Subbasin were all well below the target value of 100%. North Fork Strongs Creek had the highest shelter rating at only 55%. Pool shelter rating in Mill Creek was 27%. Within the Middle Subbasin, the overall average pool shelter rating was less than 50%, which translates into primarily unsuitable conditions overall (over 1.5 miles of moderately unsuitable conditions.).

In addition to complexity rating, instream shelter composition is also collected during habitat inventories. Pool cover types are identified, and the measure of the area occupied within the habitat unit is given as a mean percentage, which is estimated from an overhead view. Pool cover provides fish with protection from predation, a reduction in water velocity and competition, and provides habitat complexity. There are a total of nine cover types that are cataloged during habitat inventories. Strongs Creek and North Fork Strongs Creek both contained over 50% large woody debris. The major cover type in Mill Creek was small woody debris.

LWD

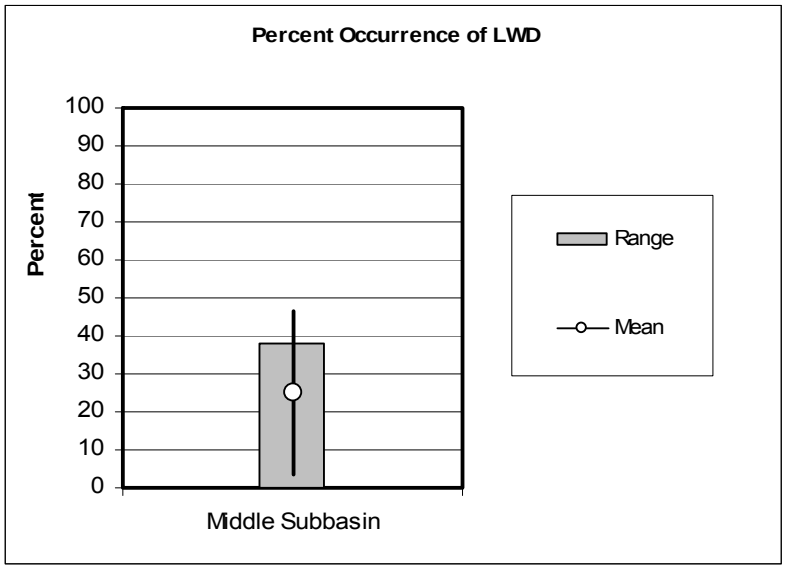

Figure 18. Large Woody Debris (LWD) in the Middle Subbasin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, etc.) is described in CDFG surveys. The dominant shelter type is determined and then the percentage of a stream reach in which the dominant shelter type is provided by organic debris is calculated.

Significance: Large woody debris shapes channel morphology, maintains organic matter, and provides essential cover for salmonids. There are currently no target values established for the % occurrence of LWD.

Findings: The average percent occurrence of LWD for the Middle Subbasin was 25. Large woody debris readings ranged from 0 to 38 over the three streams. The dominant shelter type recorded in most stream reaches was large woody debris.

Cobble Embeddedness

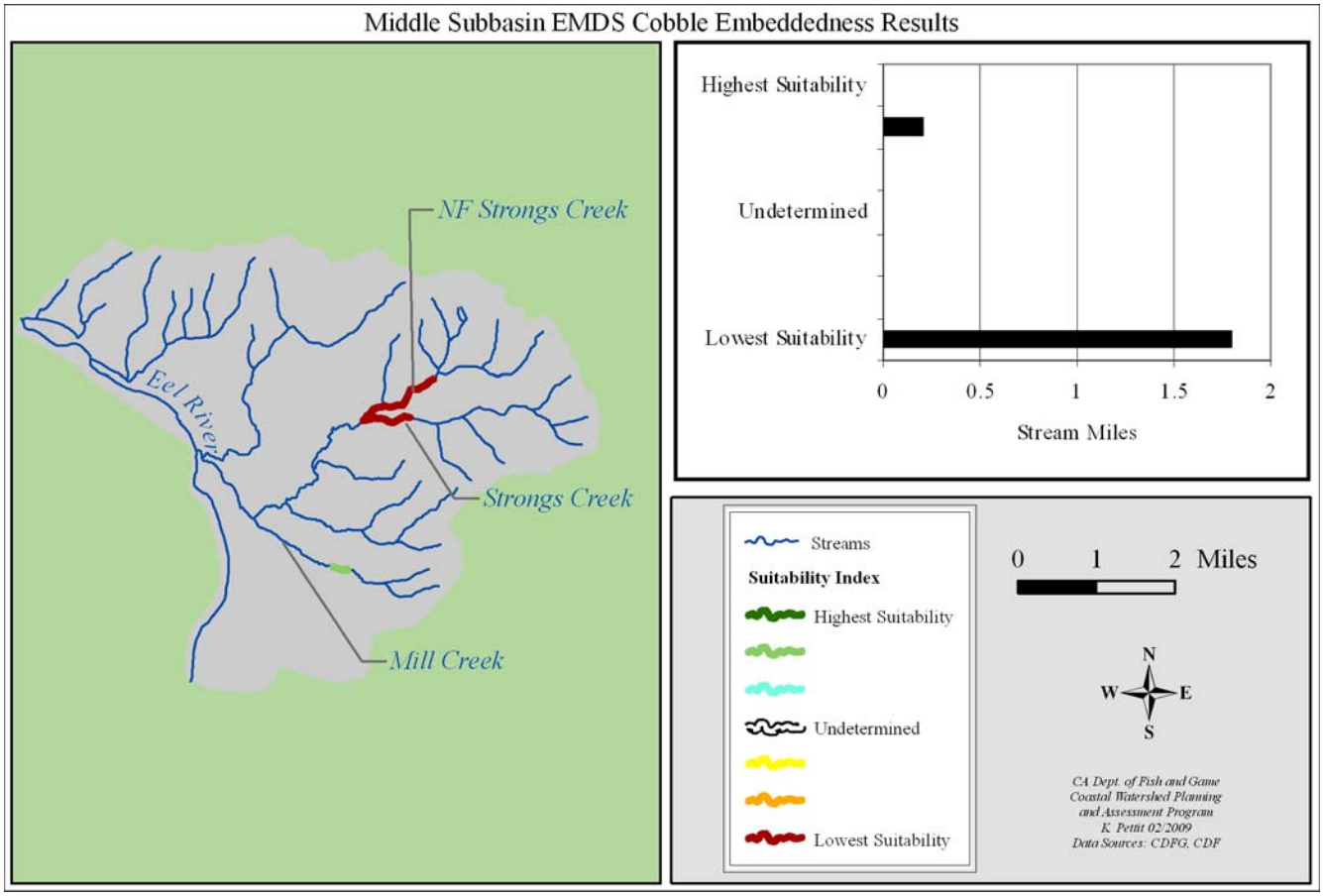

Figure 19. EMDS cobble embeddedness results for the Middle Subbasin by surveyed stream miles.

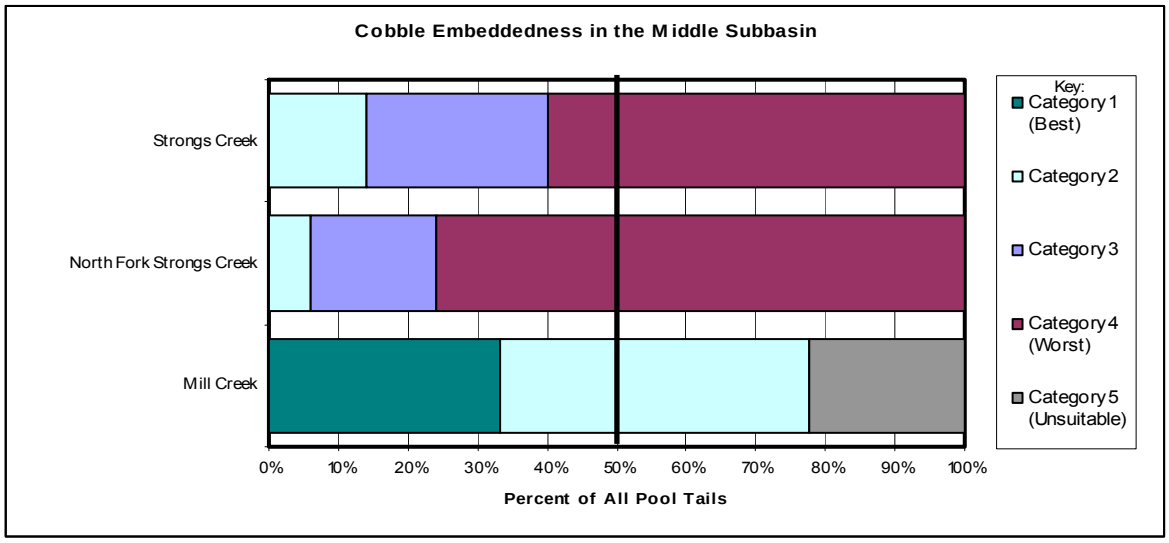

Figure 20. Cobble embeddedness categories as measured at every pool tail crest in surveyed streams in the Middle Subbasin.
Streams are listed in descending order by drainage area (largest at the top).

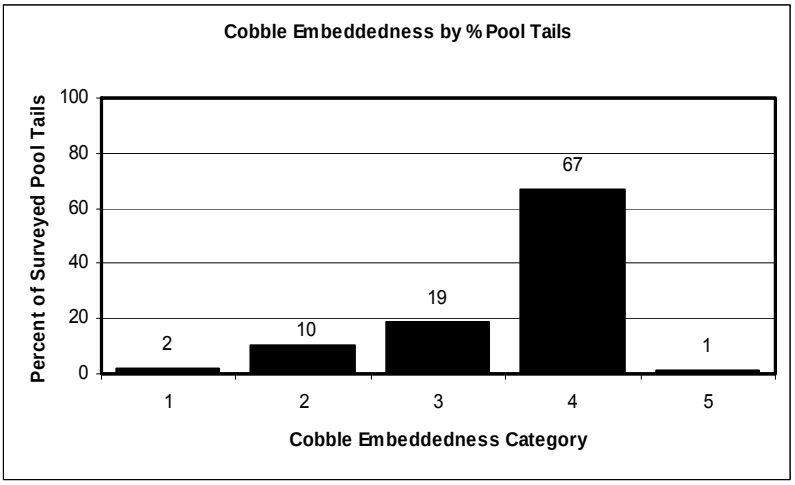

Figure 21. Cobble Embeddedness in the Middle Subbasin.

Cobble Embeddedness will not always sum to 100% because Category 5 (not suitable for spawning) is not included.

Significance: Salmonid spawning depends heavily on the suitability of spawning gravel; fine sediments decrease successful spawning and incubation. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded, and category 4 is 76-100% embedded. Excessive accumulations of fine sediment (>50%) reduce water flow (permeability) through gravels in redds which may suffocate eggs or developing embryos. Excessive levels of fine sediment accumulations over gravel and cobble substrate also may alter insect species composition and food availability for growing fish. Consequently, cobble embeddedness categories three and four are not within the fully supported range for successful use by salmonids. Category five was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate like sand, bedrock, log sills, boulders or other considerations.

Findings: Of the three streams surveyed in the Middle Subbasin, none met the target value for cobble embeddedness. However, approximately 78% of Mill Creek does meet values considered suitable for salmonids (categories 1 and 2, combined). In contrast, 86% of Strongs Creek and 94% of North Fork Strongs Creek measurements are unsuitable for salmonid spawning. Category 4 embeddedness, considered the worst category by the target values, was the most abundant measurement by percentage of surveyed pool tails. By surveyed length, embeddedness conditions of the Middle Subbasin were primarily of the lowest suitability using EMDS truth values.

Water Quality

Water Temperature

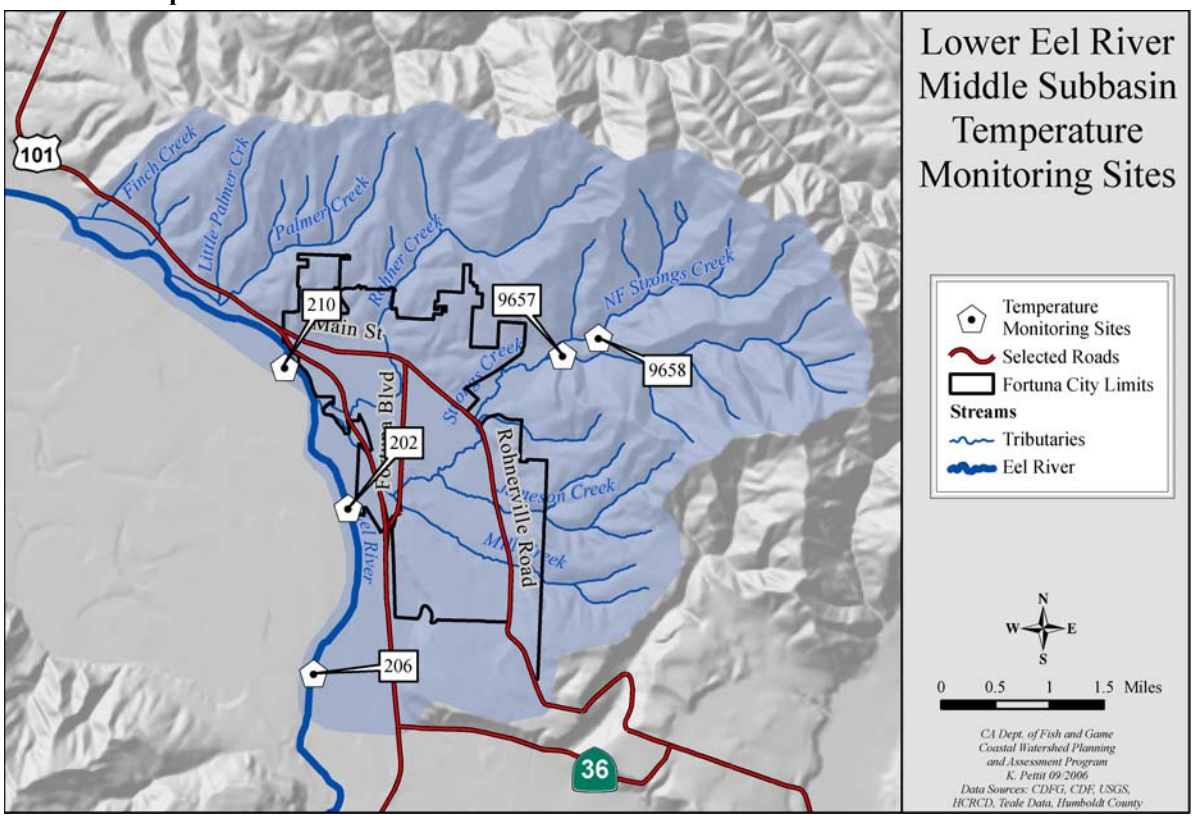

Figure 22. Locations of temperature monitoring sites in the Middle Subbasin.

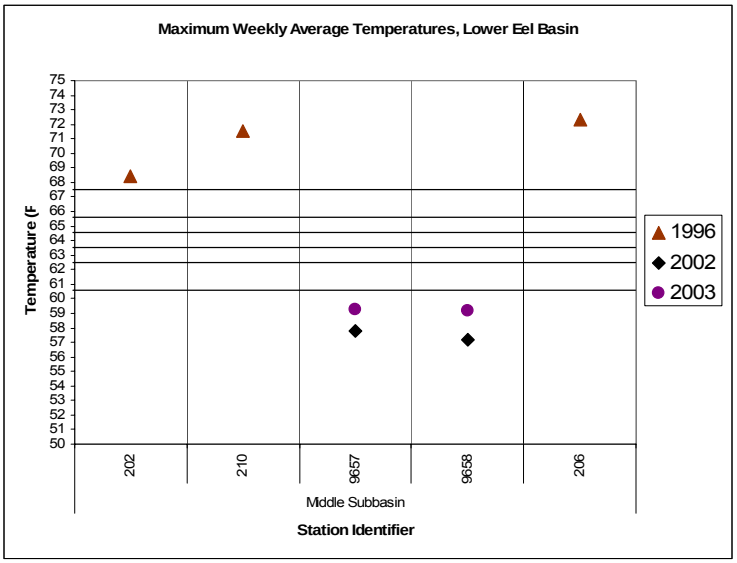

Figure 23. Maximum weekly average temperatures recorded at sites in the Middle Subbasin.

Table 19. Maximum weekly average temperatures and maximum daily average temperatures collected in the Middle Subbasin.

Creek	Site	MWAT Range (°F)	Max Daily Average (°F)	Years of Data
Fully Suitable (50-60°)				
Strongs Creek	9657	58-59	59	2
North Fork Strongs Creek	9658	57-59	59	2
Fully Unsuitable (≥68°)				
Mainstem Eel River	202	68	69	1
Mainstem Eel River	206	72	73	1
Mainstem Eel River	210	72	72	1

Significance: Water temperature affects salmonids during all life stages and can be a significant limiting factor for salmonid reproduction and survival. The CWPAP has defined suitability ratings for MWATs as: fully suitable at 50-60°, moderately suitable at 61-62°, somewhat suitable at 63°, undetermined at 64°, somewhat unsuitable at 65°, moderately unsuitable at 66-67°, and fully unsuitable at ≥68°.

Findings: Water temperature gages were deployed at five locations within the Middle Subbasin (Figure 22). Only two of these were deployed in Eel River tributaries and have more than one year of data. These two sites, located at Strongs Creek and North Fork Strongs Creek, were the only sites in the Middle Subbasin to acquire MWATs considered fully suitable (Table 19). The temperature data loggers on Strongs and North Fork Strongs Creeks were both deployed over the same period of time, and obtained similar results.

The other three temperature monitoring sites were located in the mainstem Eel, and therefore expectedly recorded overall temperatures that were much higher. These three locations were sampled over one season, and each obtained MWATs above 68°F. However, no locations within the Middle Subbasin obtained seasonal maxima considered lethal for fish (≥ 75°F).

The Fortuna Creeks Project has been monitoring water temperature since 1997 in Strongs, Mill, and Rohner Creeks and the Eel River. Temperatures are taken once per month with a handheld thermometer, and often the summer months are not sampled. Most of the averaged temperatures fell within the fully suitable range with the following exception (Cole 2003):

Water temperatures on Rohner Creek were recorded at 75ºF (August, only one year was sampled), this temperature is potentially lethal for salmonids if cooler refuge is not available.

Water Chemistry

Significance: Water chemistry interacts with basic trophic levels affecting the production and availability of food for aquatic organisms. Nutrients are often limiting factors in the biological capacity of a stream yet a proper balance is needed to prevent eutrophication. Pollutants are a concern where they interfere with the biological function of aquatic organisms, or can be a threat to those that consume them. Large sources of nutrients and pollutants are commonly municipal and industrial wastewater facilities, storm runoff, and agricultural operations. Naturally occurring nutrients and heavy metals are often found in much smaller concentrations.

Table 20. NCRWQCB water quality objectives for the Eel River (NCRWQCB 2006d).

Parameter	Standard
Dissolved Oxygen	Above 7.0 mg/L 100% of the time Above 7.5 mg/L 90% of the time Above 10.0 mg/L 50 % of the time);
Conductivity	Below 375 micromhos 90% of the time Below 225 micromhos 50% of the time
Total Dissolved Solids	Below 275 mg/L 90% of the time Below 140 mg/L 50% of the time
pH	Between 6.5 and 8.5

Findings:

Water Chemistry Studies

The Fortuna Creeks Project of Fortuna High School has been involved in water quality measurements on Mill, Strongs, and Rohner Creeks since 1997. After the Fortuna Creeks Project partnered with the Community Clean Water Institute in 2002 sampling began at two Eel River sites upstream and downstream of the Strongs Creek confluence (Cole 2003). There are a total of nine sampling sites with two sites on each of the above mentioned streams, an additional one on Strongs Creek near the confluence with Eel River, plus the two on the Eel River. Geographic coordinates are recorded for each site and are available on www.fortunacreeks.com.

Data is collected once per month on dissolved oxygen, temperature, conductivity, turbidity, and pH. In 2003, a student at Humboldt State University, Jennifer Cole, compiled the data up to that point and summarized the results (Cole 2003). The data she presented (with the exception of temperature) was averaged over the six years of study (1997 – 2003) and indicated that most creeks fell within acceptable ranges for coho salmon, the most sensitive of salmonids, with the following exceptions:

- Average conductivity in Rohner Creek was also above levels recommended for coho salmon (375 micromhos) from November through May; in Strongs Creek from June through October, and in Mill Creek in October and November;
- Average turbidity levels were above recommended levels for coho (30 NTUs) for 9 (Rohner Creek), 8 (Strongs Creek), or 4 (Mill Creek) months out of the year;
- Average dissolved oxygen fell below 7.0 in Rohner Creek in August, September and October, in Strongs Creek in August, and in Mill Creek in August.

The HCRCD studied water quality conditions in the Eel River in 1996 and 1997, including temperature and macro-invertebrate surveys. Macro-invertebrate communities are closely linked to water quality and are used to determine if a water body has been impacted and to what degree. Strongs Creek was surveyed in the spring and in the fall of 1996 for species richness and diversity and consistently scored in the "highly impacted" range. The reason proposed for this result is the urban watershed that feeds Strongs Creek (HCRCD 1998).

Another important water quality concern in this subbasin is the increased amount of chemical pollutants from urban runoff in Fortuna. Newly created impervious areas have increased runoff to urban streams (FEMA 1981 as cited in Mintier and Associates 2006). Impervious surfaces such as cement and pavement accumulate chemical pollutants from automobile traffic and other sources (Wheeler et. al 2005). When it rains, water running over these surfaces mobilizes chemicals. The chemicals are then brought into the storm water system and eventually streams. Although no specific tests of chemicals have been conducted in Fortuna's streams, urban runoff in general is known to mobilize chemicals such as trace elements, pesticides, copper, and volatile organic compounds (Hamilton et. al 2004). Chemical pollutant testing has not been carried out in Fortuna's creeks to assess the impact of urban runoff.

Findings:

Wastewater Treatment Facility

Fortuna operates a wastewater treatment facility on 180 Dinsmore Drive, just west of Highway 101. This plant was constructed during the 1970s, though an earlier plant was constructed in the 1950s. Wastewater during average flows is treated to secondary treatment standards using screening, grit removal, influent pumping, primary sedimentation, activated sludge processes, secondary sedimentation, chlorination, de-chlorination, as well as anaerobic biosolids digestion, dewatering and composting. The facility discharges between 1 and 5 million gallons per day (mgd) of effluent with a peak capacity of 7mgd, and averages 1.5mgd during dry months. Effluent is discharged into Strongs Creek at the confluence with the Eel River between October 1st and May 14th. During the winter season, if influent exceeds 3-4 mgd, it is diverted and stored in three equalization ponds before being returned for treatment during lower flows. Between May 15th and September 30th, treated effluent is discharged into gravel bar percolation ponds adjacent to the Eel River.

The equalization ponds only had a one to two day capacity during wet weather and needed approximately one week of dry weather to recover (Mintier and Associates 2006). An upgrade to increase capacity was completed in March 2007. A new permit will go into effect for this facility in June 2007 and will require the relocation of summer percolation ponds as well as a compliance schedule for the reduction of three priority pollutants (copper, chlorodebromomethane, and dichlorobromomethane). Priority pollutants are recognized has having heightened detrimental effects on living organisms. Additionally, the dilution ratio requirement of receiving bodies to effluent (100:1) is not being met at the discharge point in Strongs Creek. An alternative discharge location will be required through the new permit.

High flows in Strongs Creek were backing up discharge and damaging the chlorine contact chamber at the plant, spurring a Cease and Desist order in 1997. Fortuna constructed a new chlorine contact chamber to resolve the issue and the order was rescinded in 2001. However, in 2004, the treatment plant had three chlorine limit violations - one maximum and two minimum values that violated the permit level. Sewer overflows that occurred in the system were caused by high flows and collection system stoppages (Mintier and Associates 2006). Currently, the chlorine contact chambers are functioning properly and are not a threat to water quality (Lisa Bernard personal comm).

Fish Passage Barriers

Several fish passage barrier issues have been identified in the Middle Subbasin. The following discussion of road crossings or other naturally occurring structures were identified as the most significant fish passage barriers, hindering the upstream and downstream movement of adult and juvenile steelhead.

On Palmer Creek, the culvert located below Highway 101 was noted as a fish passage barrier in 1997 (HCRCD) and no fish were found upstream of this culvert by CDFG in 2000. Baffles were installed in the culvert in 2000 to improve fish passage. However, the 2005 Fish Passage database notes that this culvert was assessed as a partial barrier to salmonids. Moreover, the stream link between the culvert and the Eel River is also tenuous for fish passage. Just to the north in French Creek, the Highway 101 culvert is also a potential barrier to fish passage (CDFG 2005). Unlike Palmer Creek it has yet to be modified to improve fish passage.

Several possible barriers to fish passage were noted by CDFG on Rohner Creek in 1982. This survey is quite outdated and further investigation of possible barriers on Rohner Creek is necessary. The 2005 Fish Passage database notes a possible barrier at the stream crossing of Rohnerville Road.

Strongs Creek is crossed by many roads. Crossings at Rohnerville Road and South Fortuna Boulevard have not been assessed for potential fish passage problems. The Highway 101 culvert was assessed and found to be a partial barrier and ranked as medium priority for restoration. The railroad crossing bridge was found not to be a barrier to salmonids (CDFG 2005).

Two lower tributaries of Strongs Creek, Mill Creek and Jameson Creek have fish passage issues related to their culverts located under Rohnerville Road. The culvert on Mill Creek was identified as a likely complete barrier to juvenile salmonids (Figure 24) (CDFG 2005). North of Mill Creek, the culvert on Jameson Creek was considered a complete barrier to fish passage (2008). According to CDFG (2005) Jameson Creek contains two additional upstream culverts that are potential barriers to fish passage.

Sometimes, large debris accumulations in streams can cause fish passage barriers. These are noted in CDFG stream inventories. Stream inventories in the Middle Subbasin found possible problems of this sort on Strongs and North Fork Strongs Creeks.

Figure 24. Outlet of culvert where Rohnerville Road crosses Mill Creek, tributary to Strongs Creek, June 18, 2008.

Habitat Conclusions

Streams surveyed before 1990 and habitat inventories from 1993 and 2004 were compared to indicate changes between historic and current conditions. Data from older stream surveys provide a snapshot of the conditions at the time of the survey. Terms such as excellent, good, fair, and poor are based on the judgment of the biologist or scientific aid who conducted the survey. The results of historic stream surveys are qualitative and cannot be used in comparative analyses with quantitative data provided by habitat inventory surveys with any degree of accuracy. However, the two data sets can be compared to show general trends.

Where habitat data were available from both older stream surveys and recent stream inventories it appeared that spawning habitat remained similar (Table 21). There was not enough information to draw conclusions about changes in canopy, pool depth, and pool shelter.

Instream habitat conditions were generally poor in this subbasin at the time of more recent CDFG surveys. Surveyed reaches fell below target values and were evaluated as unsuitable for salmonids by EMDS for pool quality, depth, and shelter (Table 22) - thus these habitat factors are likely limiting to salmonid populations.

Canopy density was suitable on all three surveyed creeks. However, current canopy density measurements do not take into account differences between smaller, younger riparian vegetation versus the larger microclimate controls that are provided by old growth forest canopy conditions. Summer water temperature measurements did show that water temperatures were suitable for salmonids in Strongs and the North Fork of Strongs Creeks. Summer water temperatures were unsuitable for salmonids in the mainstem Eel River.

Water temperature is likely not a limiting factor for salmonids in surveyed streams in this subbasin, though high water temperatures in the Eel River during the summer months likely limit salmonid productivity in the mainstem. Therefore, cooler pockets where tributaries enter the mainstem may provide important patches of cooler water for salmonids at these times.

Cobble embeddedness was suitable on Mill Creek and unsuitable in the other two surveyed tributaries. A lack of suitable spawning gravels is likely limiting salmonids in the subbasin.

Available water chemistry data from Rohner, Strongs, and Mill Creeks indicate that conductivity and turbidity levels were above those recommended for coho salmon. Moreover, dissolved oxygen was below the recommended level for coho salmon. Therefore, these conditions may be limiting factors for salmonid production.

Table 21. Comparison between historic habitat conditions with current habitat inventory surveys in the Middle Subbasin.

Stream	Canopy Cover		Spawning Conditions		Pool Depth/Frequency		Shelter/Cover		Summary of Changes from Historic to Current
	Historic	Current	Historic	Current	Historic	Current	Historic	Current	
Strongs Creek	ND	Fully suitable	Little to no spawning gravel	Fully unsuitable	Shallow	Fully unsuitable	ND	Unsuitable	Spawning habitat remained similar
North Fork Strongs Creek	Second growth redwood canopy	Fully suitable	Mostly fine sediment	Fully unsuitable	ND	Fully unsuitable	ND	Unsuitable	Spawning habitat remained similar

Where multiple years of historic streams surveys were available, the oldest surveys were used.
*ND is no data available

Table 22. EMDS Anadromous Reach Condition Model results for the Middle Subbasin.

Stream	Year	Canopy	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Mill Creek	2004	++	---	---	---	++
North Fork Strongs Creek	1993	+++	--	-	-	---
Strongs Creek	1993	+++	--	-	-	---
Middle Subbasin		++	--	-	-	--

Key: +++ = Highest Suitability U= Insufficient Data or Undetermined --- = Lowest Suitability

Restoration Projects

There have been eighteen restoration projects completed in the Middle Subbasin. Half of these fall into the public involvement category. These include conferences and workshops that are held at the Fortuna River Lodge, but may not necessarily pertain to the Middle Subbasin. Another prominent restoration activity is upslope management. Five ongoing forest management programs are being conducted by the CDF to improve forest and watershed health. Fish passage improvements have also been important in this urban watershed. These projects are listed below.

- CDF Timber/Forest Management Plan;
- CDF forest health improvement via thinning;
- Strongs Creek re-vegetation and removal of non-native plants and trash;
- Temperature and macro-invertebrate monitoring by HCRCD;
- Fish Passage inventory protocol training;
- Technical training for rural landowners to improve and maintain roads;
- Presentation on conditions of the Eel River watershed to local landowners;
- "Salmon in the Classroom" curriculum;
- Salmonid Restoration Federation Conference;
- Strongs Creek watershed restoration training;
- Rohner Creek culvert upgrade;
- Palmer Creek fish passage improvement under Highway 101.

More information such as date and specific location can be found on CalFish (www.calfish.org) or on the Natural Resources Project Inventory online database (www.ice.ucdavis.edu/nrpi/).

Another restoration program not captured in the above databases comes out of the Fortuna School District. Fortuna High School's Fortuna Creeks Project was established in 1989 to restore and maintain the riparian ecosystem along Rohner Creek. In 1995, the group expanded their scope to include the rest of the Fortuna streams – Palmer, Mill, and Strongs Creeks – and the Eel River. Throughout the years, students have participated in riparian vegetation planting, trash clean-ups, riparian bird nest-box installations, stream surveys for spawning salmonids and aquatic invertebrates, and water quality sampling. This program has focused on planting trees to create riparian habitat while creating strong working relationships between the program and the private landowners in the subbasin (Halstead 2007, Fortuna Creeks Project website).

Integrated Analysis

Analysis of Tributary Recommendations

In addition to presenting habitat condition data, all CDFG stream inventories provide a list of recommendations that address those conditions that did not reach target values (see the Fish Habitat section of this subbasin). In the Middle Subbasin, three streams were inventoried, and recommendations for each were selected ranked by a CDFG biologist (Table 23). The tributary recommendation process is described in more detail in the Synthesis section of the Basin Profile.

In order to compare tributary recommendations within the subbasin, the recommendations of each stream were collapsed into five target issue categories (Table 24). The top three recommendations of each stream are considered to be the most important, and are useful as a standard example of the stream. When examining recommendation categories by number of tributaries, the most important target issue in the Middle Subbasin is Erosion/Sediment.

However, comparing recommendation categories in the subbasin by number of tributaries can be confounded by the differences in the length of survey for each tributary. Therefore, the number of stream miles within the subbasin assigned to various recommendation categories was calculated (Figure 25). By examining recommendation categories by number of stream miles, the most important target issue remains Erosion/ Sediment. Gravel/Substrate, and recommendations involving livestock and fish passage are also an important target issues. Because of the high number of recommendations dealing with these target issues, high priority should be given to restoration projects that emphasize sediment reduction as well as livestock management and fish passage.

Table 23. Occurrence of stream habitat inventory recommendations for streams of the Middle Subbasin.

Stream	Survey Length (mile)	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
Mill Creek	0.2	2		3							1
North Fork Strongs Creek	1.2	2	1	6		5		4	3	7	
Strongs Creek	0.6	4	3	7		6		5	1	2	

Table 24. Top three ranking recommendation categories by number of tributaries in the Middle Subbasin.

Middle Subbasin Target Issue	Related Table Categories	Count
Erosion / Sediment	Bank / Roads	4
Riparian / Water Temp	Canopy / Temp	1
Instream Habitat	Pool / Cover	0
Gravel / Substrate	Spawning Gravel / LDA	2
Other	Livestock / Barrier	2

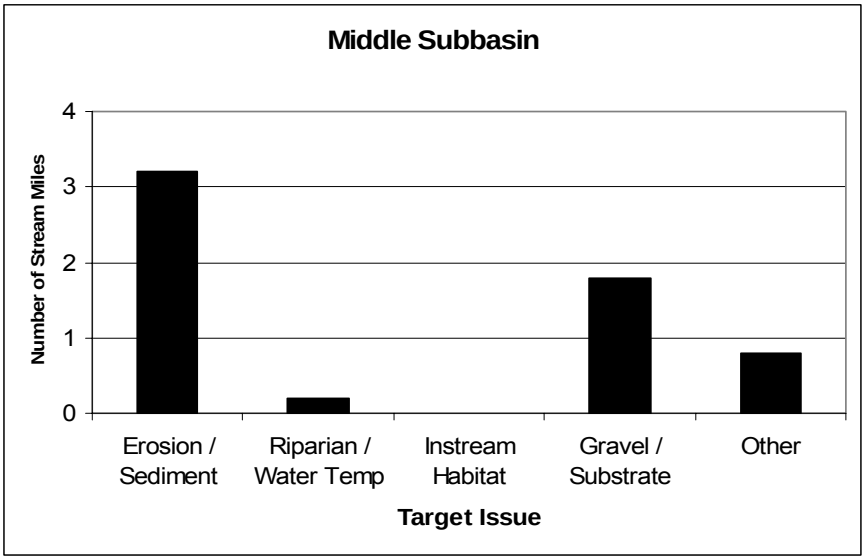

Figure 25. Recommendation target issues by stream miles for the Middle Subbasin.

Refugia Areas

The interdisciplinary team identified and characterized refugia habitat in the Middle Subbasin by using professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by the EMDS at the stream reach scale.

The most complete data available in the Middle Subbasin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered. Salmonid habitat conditions in the Middle Subbasin on surveyed streams are generally rated as medium potential refugia. Palmer, Strongs, and North Fork Strongs Creeks provide the best salmonid habitat in this subbasin, while Rohner Creek and unnamed tributary provide low quality refugia. The following refugia area rating table summarizes subbasin salmonid refugia conditions.

Table 25. Refugia of streams of Middle Subbasin

Stream	Refugia Categories				Other Categories		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area	Data Limited
Palmer Creek			x				x
Strongs Creek			x				
Rohner Creek				x			x
Unnamed tributary (Mill Creek)				x			x
North Fork Strongs			x				x

Key Subbasin Issues

- Urbanization and increased residential development have generated negative effects on streams;
- Altered flow regimes;
- Addition of pollutants;
- Fish passage barriers where roads cross streams;
- Erosion from roads, construction wastes, and ground disturbance;
- There is concern about unrestricted stream access of livestock in agricultural areas;
- Erosion related to timber harvest on unstable soils is a concern;
- There is concern about the impact of gravel mining on the mainstem Eel River;
- Instream habitat conditions for salmonids are thought to be poor.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the Middle Subbasin?

Findings and Conclusions:

- Three tributaries in the Middle Subbasin have been inventoried between 1993 and 2004 by the CDFG. These data, in addition to other fish studies have confirmed, among other species, the presence of coho and steelhead. Some historical and anecdotal accounts (dating back to the early 1950s) also list the presence of these salmonid species in several Middle Subbasin tributaries;
- Historically, coho salmon were found in Palmer and Strongs creeks and potentially Rohner Creek; however, in recent years they have only been detected (1995) in Strongs Creek;
- Steelhead trout were historically found in Palmer, Rohner, Strongs, and North Fork Strongs Creeks. In recent years, steelhead have only been detected in Strongs and North Fork Strongs Creeks;
- Cutthroat trout have also been observed during several surveys of Strongs and North Fork Strongs Creeks between 1984 and 1995. The Eel River is the current southern extent of coastal cutthroat trout (Miller and Lea). It is believed that Eel River cutthroat live out their entire lifecycle in fresh or brackish water;
- Sacramento pikeminnow have been documented as present in several surveys beginning in the late 1990s and are now common in areas of the lower river. Pikeminnow compete with and prey upon juvenile salmonids.

What are the current salmonid habitat conditions in the Middle Subbasin? How do these conditions compare to desired conditions?

Findings and Conclusions:

Flow and Water Quality:

- Flow has been changed through the construction of hardened surface storm drain systems along streams. These changes in direction and flow are especially apparent on streams that run through the city of Fortuna during the rainy season, as is evidenced in flooding and drainage issues;
- Water quality is most likely impacted by cattle that have direct access to Strongs Creek;
- Low summer flows result in dry or intermittent reaches on streams in the Middle Subbasin, which may be stressful to salmonids;
- The Fortuna Creeks Project found that turbidity levels stressful to salmonids were reached during the rainy winter months. These high levels of turbidity, which are particularly apparent in Strongs and Rohner Creeks, occur during salmon and steelhead spawning season.

Erosion/Sediment:

- Excessive sediment in stream channels has resulted in an overall loss of spawning, rearing and feeding habitat for salmonids. High sediment levels are confirmed by embeddedness measurements in surveyed reaches;
- Livestock have unrestricted access to many of the Middle Subbasin tributaries, such as Palmer, Strongs, Mills, and Finch creeks, resulting in stream bank erosion;
- Soils in streams of the Middle Subbasin are prone to erosion, and slides and streambank failures have been observed to contribute fines to the streams.

Riparian Condition/Water Temperature:

- Water temperature data in the Middle Subbasin are not systematic and limited. Water temperatures collected over the six-year sample period demonstrate stressful (above 68ºF) and occasionally lethal (above 75ºF) conditions, particularly on Rohner Creek;
- Water temperature data collected during summer CDFG habitat inventories indicate acceptable water temperatures, however these data are limited and inconclusive;
- All surveyed reaches in the Lower Eel Basin tributaries met the target value of 80% canopy coverage. Coniferous canopy was most abundant on two streams; deciduous canopy was more abundant on one;
- The Fortuna Creeks Project found that stressful turbidity levels are reached during the rainy winter months. These high levels of turbidity, which are particularly apparent in Strongs and Rohner Creeks, occur during spawning season.

Instream Habitat:

- None of the surveyed streams met target values of pool depth;
- Quality pool structure is generally lacking in Middle Subbasin streams; no surveyed streams met standards for pool shelter (100). Pool shelter ratings ranged from fully unsuitable to somewhat unsuitable levels.

Gravel/Substrate:

- Spawning gravels in Strongs and North Fork Strongs Creeks are found in few reaches. Additionally, redds have been observed as crowded and superimposed during spawning surveys;
- None of the CDFG surveyed streams of the Middle Subbasin met target values for cobble embeddedness.

Refugia Areas:

- Salmonid habitat conditions were generally rated as medium potential refugia. Palmer, Strongs and North Fork Strongs Creeks provided the best salmonid habitat in this subbasin. Mill Creek has the potential to have quality habitat if restoration and barrier projects were implemented.

Barriers and other concerns:

- A culvert on Mill Creek (RM 1.3) and Rohnerville Road may not meet CDFG and NOAA Fisheries fish passage guidelines;
- A culvert on Jameson Creek and Rohnerville Road does not meet CDFG and NOAA Fisheries fish passage guidelines;
- Palmer Creek has problems with fish passage due to a barrier in the 800 foot culvert under Highway 101.
- When flows are sufficiently high, the Eel River floods into treatment ponds of the Fortuna Wastewater Treatment Plant;

What are the impacts of geologic, vegetative, fluvial, and other natural processes on watershed and stream conditions?

Findings and Conclusions:

- Natural erosion rates are high due to:
  - The major rock underlying the subbasin is alluvium, which constitutes 70% of the subbasin. The other bedrock, also sedimentary, is Pliocene marine. Both of these geologic types are highly erodible;
  - Tectonic uplift has increased the erosion potential of the area and seismic activity remains strong in the Middle Subbasin. Though slopes are relatively stable, streams in the area are affected by sediment deposits from steep slopes in tributaries upstream;
  - Rapid incision rates of the mainstem and its tributaries have left a series of river terrace deposits perched steeply above the current stream channels which contribute fine sediments through slope instability and dry ravel;
  - The Little Salmon fault cuts through this basin, weakening bedrock and increasing the potential for seismic triggering of landslides;
- Floods periodically occur due to high winter precipitation levels and extremely altered runoff rates;
- During the winter rainy season, heavily silted water flows through the steep upstream terrain, which affects turbidity and sediment levels in streams;
- The predominant vegetation is conifer at 36%. Of this, 67% is composed of vegetation of the Redwood Alliance. Conifer canopy was greater than deciduous canopy over surveyed streams in this subbasin. Crown diameters of coniferous vegetation ranged from saplings to greater than 40 feet.

How has land use affected these natural processes?

Findings and Conclusions:

Changes in basin due to land use:

- Sedimentation and in-filling as a result of land development and subdivision activities, gravel mining and timber harvesting practices have resulted in an overall reduction in channel area, and consequently in available salmonid habitat;
- Fortuna grew from one square mile in 1950 to 4.68 square miles in size in 2006. This represents a change from approximately 4% to 19.5% of the subbasin;
- The Fortuna annual average population growth rate from 1980 to 2005 was 1.6%. If the city continues to grow at this rate the population will rise from 11,250 to approximately 17,000 in the next 25 years (Mintier and Associates 2006);
- There were 4,729 housing units in Fortuna in 2005. If current growth rates continue, Fortuna will require 2,298 new housing units by 2030 (Mintier and Associates 2006);
- Additionally, it is projected that there will be a need for an additional 852,866 square feet of commercial, retail, and manufacturing space by 2030 (Mintier and Associates 2006). Increased development in Fortuna,

especially in the southern and eastern parts of the city, has increased runoff from newly created impervious areas (FEMA 1981 cited in Mintier and Associates 2006);

- Projects related to the expansion of Fortuna's urbanization have adversely affected the area's streams in both water quality and riparian and instream habitats.

Possible effects seen in stream conditions:

Instream habitat conditions for salmonids are thought to be poor:

- Low summer flows are exacerbated by land and stream disturbances and result in dry or intermittent reaches on streams, which are stressful to salmonids;
- Excessive sediment in stream channels has resulted in an overall loss of spawning, rearing, and feeding habitat for salmonids. High sediment levels are confirmed by embeddedness measurements in surveyed reaches. Moreover, none of the surveyed streams met target values of pool depth;
- The Fortuna Creeks Project found that stressful turbidity levels are reached during the rainy winter months. These high levels of turbidity, which are particularly apparent in Strongs and Rohner creeks, occur during spawning season;
- Quality pool structure is generally lacking in Middle Subbasin streams; no surveyed streams met standards for pool shelter. Pool shelter ratings ranged from fully unsuitable to somewhat unsuitable levels;
- Spawning gravels in Strongs and North Fork Strongs creeks are found in only a limited number of reaches. Additionally, crowded and superimposed redds have been observed during spawning surveys;
- None of the CDFG surveyed streams of the Middle Subbasin met target values for cobble embeddedness.
- Winter floods are increasingly common due to high winter precipitation levels, increased runoff, and undersized storm water drainage structures. Areas with current flooding include the North Fortuna Drainage Area, Rohner Creek, the lower reaches of Strongs Creek, and Jameson Creek at the confluence with Strongs Creek (Winzler and Kelly 2005);
- Many of the storm drains and culverts in Fortuna are undersized (Winzler and Kelly 2005), increasing the velocity of flows during precipitation events;
- Strongs, Mill and Rohner Creeks have been modified where they flow through Fortuna to eliminate their floodplains, increasing the volume and velocity of flows during precipitation events;
- Development of the commercial shopping center along Mill Creek has greatly reduced the riparian area and hydrology of the stream channel. During large precipitation events, the stream overflows its banks and has caused stranding of steelhead in the adjacent fields. The riparian corridor needs to be expanded and a flow study developed to address the frequent stream bank overflow issues, which is impacting stream habitat and steelhead populations;
- Although no specific tests of chemicals have been conducted in Fortuna's streams, urban runoff in general is known to mobilize chemicals such as trace elements, pesticides, copper, and volatile organic compounds (Hamilton et al. 2004);

There is concern about unrestricted stream access of livestock in agricultural areas:

- Livestock grazing operations occur in approximately 23% of subbasin;
- Impacts from livestock grazing have been noted during stream surveys on Strongs and North Fork Strongs creeks. Although no specific tests of nutrients and/or coliform bacteria have been conducted in these creeks, levels of these constituents often exceed water quality standards in areas with extensive livestock use;

Erosion related to timber harvest on unstable soils is a concern:

- The impact of previous techniques and harvest amounts are evident in the braiding of the Eel River from the mouth of Van Duzen River to Fernbridge that has occurred since 1956. A general flattening and

widening of the river bed is also apparent (Humboldt County 1992);

- The impact of previous techniques and harvest amounts are evident in the braiding of the Eel River from the mouth of Van Duzen River to Fernbridge. These impacts were magnified by the 1955 and 1964 floods. A general flattening and widening of the river bed is also apparent (Humboldt County 1992);
- Timber harvest, while less of an issue than in the past, still occurred in the headwaters of all of the creeks in this subbasin from 1988 to 2005. Erosion related to timber harvest on unstable soil is a concern, such as the recent timber harvesting in the headwaters of Strongs and North Fork Strongs creeks. This area is made up of the Wildcat Formation, which is largely comprised of fine sediment and is highly erosive;

There is concern about the impacts of historic and current gravel mining operations on the mainstem Eel River:

- There are eleven gravel mining sites in this subbasin that remove over 5,000 cy/yr of aggregate. The volume of aggregate removed has decreased significantly since 1996. Prior to 1996, average extraction volumes ranged from 500,000cy/yr to 700,000cy/yr;
- The USACE has concluded that sand and gravel mining extractions are not excessive or occurring at rates that are too high to negatively impact channel morphology in the basin based on the increase of shoreline sediment. However, as bed-load data are not well known, it is difficult to set adequate extraction rates and volumes;
- Most of the concern in managing gravel mines is in the reconfiguration of the low flow channel. To this end, trench, alcove, or wetland pit mining are recommended over bar skimming, which has been shown to increase low flow channel width (USACOE 2003). Without the revision of extraction amounts and techniques, impacts to salmonids would be significant and would likely include loss of deep holding pools during adult migration, and loss of cover, suitable temperature, and complex habitat for juvenile salmonids;

Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for steelhead production?

Findings and Conclusions:

- Based on available information for this subbasin, it appears that salmonid populations are limited by:
  - Low summer flows;
  - High levels of fine sediments in streams;
  - Loss of habitat area and complexity;
  - Shortage of areas with suitable spawning gravel in tributaries;
  - High summer water temperatures;
  - Competition with Sacramento pikeminnow;
  - Restricted access by culverts.

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Barriers to Fish Passage

Streams	Draft Recommendation Activities XXX = Highest Priority		
	Replace or modify culvert in order to meet CDFG and NOAA Fisheries fish passage guidelines	**Continue efforts to identify and alleviate fish passage impediments at culverts or other road crossings.**	**Carefully modify log debris accumulations in tributaries over time, with attention paid to resultant downstream sediment loading**
Palmer Creek		X	
Strongs Creek	XX	X	XXX
Rohner Creek		X	
Unnamed tributary (Mill Creek)	XX		

Jameson Creek	X	X	
North Fork Strongs		X	X

Flow and Water quality

Streams	Draft Recommendation Activities XXX = Highest Priority	
	Ensure that water diversions used for domestic or irrigation purposes bypass sufficient flows to maintain all needs of fishery resources	**Ensure that inadequately treated wastewater is not discharged to streams**
Eel River	X	X
Unnamed tributary	X	
Finch Creek	X	
Little Palmer Creek	X	
Palmer Creek	X	
Strongs Creek	XX	X
Rohner Creek	XX	
Unnamed tributary (Mill Creek)	XX	
Jameson Creek	XX	
North Fork Strongs	XX	

Runoff

Streams	Draft Recommendation Activities XXX = Highest Priority				
	Consider adopting a city ordinance in Fortuna to limit the amount of impervious cover in new developments	**The Fortuna City Community Development Department should require development methods that incorporate on-site storm water detention and infiltration for all new developments to minimize the amount of runoff entering the drainage system. Methods include detention basins, vegetated swales, buffer strips, and other bio-retention methods.**	**The Fortuna City Community Development Department should require that new development not increase the existing estimated 25-year peak runoff volume from a site. Any increase in total runoff beyond the peak 25-year event resulting from new development should be retained or detained on site**	**Implement a channel and drainage basin maintenance program to ensure drainage channels and basin function as designed in Fortuna**	**Ensure that flood control projects, such as culvert replacement, creek widening, creek rerouting, and stream bank stabilization do not impair anadromous salmonid migration and juvenile rearing habitat.**
Strongs Creek	X	XX	X	X	XX
Rohner Creek	X	XX	X	X	XX
Unnamed tributary (Mill Creek)	X	XX	X	XX	XXX
Jameson Creek	X	XX	X	X	
North Fork Strongs	X	XX	X	X	XX

Erosion and Sediment Reduction

Streams	Draft Recommendation Activities XXX = Highest Priority		
	Prevent livestock from accessing streams through the use of livestock management fencing	**Conduct an upslope erosion inventory in order to identify and map stream bank and road-related sediment sources. Sites should be prioritized and improved**	**Stabilize eroding stream banks with appropriately designed structures and vegetation**
Strongs Creek	X	XXX	X
Rohner Creek			X
Unnamed tributary (Mill Creek)			X
North Fork Strongs	X	XXX	X

Riparian and Instream Habitat

Streams	Draft Recommendation Activities XXX = Highest Priority			
	Consider replanting of native species, like willow, alder, redwood and Douglas fir in areas with exotic vegetation	**Consider thinning hardwoods to increase growth of conifers where riparian forest is strongly dominated by hardwoods and shade canopy will not be adversely affected**	**Increase depth, area or shelter complexity in pools, by adding LWD or combinations of boulders and LWD. This must be done where banks are stable, or in conjunction with stream bank armor to prevent erosion**	**Expand spawning area by trapping and sorting spawning gravels**
Strongs Creek	X		X	X
Unnamed tributary (Mill Creek)	X	X		
North Fork Strongs			X	X

Research and Monitoring

Streams	Draft Recommendation Activities XXX = Highest Priority				
	Monitor streams near land development activities for turbidity and drainage issues	**Consistently collect water quality data, including temperature, dissolved oxygen, and water chemistry throughout the year for several years in order to accurately characterize conditions**	**Conduct biological sampling to determine salmonid usage and populations**	**Inventory habitat in urban streams**	**Conduct substrate sampling to determine if gravels are suitable for salmonid spawning**
Palmer Creek		X	X	X	X
Strongs Creek	X				
Rohner Creek	X		X	X	X
Unnamed tributary (Mill Creek)	X		X		
Jameson Creek	X				
North Fork Strongs	X				

Education and Community Outreach

Streams	Draft Recommendation Activities XXX: Highest Priority			
	Support programs that participate in monitoring the state of urban streams, like the Fortuna high school's Fortuna Creeks Project	**Improve educational and community outreach by partnering with the City of Fortuna and through participation in events like Fortuna Creek Days**	**Consider a signage program for urban creeks to increase awareness of use by anadromous salmonids**	**Establish greenbelts along creeks in Fortuna**
Eel River	X	X	X	X
Strongs Creek	X	X	XX	XX
Rohner Creek	X	X	XX	XX
Unnamed tributary (Mill Creek)	X	X	X	X
Jameson Creek	X	X	X	X
North Fork Strongs	X	X	X	X

Subbasin Conclusions

Streams in the Middle Subbasin are heavily affected by urbanization, as many flow directly through Fortuna, the area's population center. As such, they are subject to degradation as a result of high levels of storm water runoff, addition of solid wastes, and erosion from roads. Residential development in the area is increasing, which brings with it watershed impacts in the form of construction wastes, and ground disturbance. Agricultural practices are also impacting the streams in this subbasin, and are evidenced primarily by the unrestricted stream access of livestock. The geology and climate of the area accentuate sediment delivery to

the streams. Water quality data are lacking, and necessary in order to adequately compare current conditions with those of pre-development, as well as to monitor changes in the watershed. As such, streams in this subbasin face serious challenges typical of urban streams with native salmonids.