Salt River Subbasin

The story of the Salt River Basin is one of hydrologic manipulation, human disturbance, and resultant dysfunction. The Salt River was the main vector of trade and transportation in the days of early settlement on the Eel River, and supported a shipping industry from 1860's until the early part of the 20th century. What was once a tidally influenced slough that measured 200 feet across and 15 feet deep at Port Kenyon (River Mile 4.1), is now a marsh without a defined channel. The channel of the Salt River is clogged with sediment eroded from its tributaries and as a result, adjacent roads, houses, and pastures on the delta are flooded annually causing damage to both private and public infrastructure. There are several issues that prohibit the Salt River from functioning in a natural manner:

- Sediment, from upslope and stream bank erosion, enters the mainstem from the tributaries in large volumes and deposits in the Salt River channel; reducing the channel capacity;
- The reduction of tidal influence caused by the construction of levees and tide gates in the western delta, has lessened the systems ability to clear sediment deposits from the channel;
- Extensive channelization and realignment of the Salt River tributaries have dramatically changed the discharge and sediment equation as well as the drainage network;
- The problems of flooding and sediment deposition have been made worse by the prolific growth of instream vegetation;
- In channel bedload transport from periodic Eel River floodwaters has practically been eliminated by levee construction in the eastern delta.

The fundamental problem with the Salt River is that it has filled with sediment faster than it could be removed naturally because channel cleansing forces have been practically eliminated. Since settlement, Salt River Delta residents have been faced with repeated high water events that have resulted in the loss of property and capital. There have been numerous attempts to control flood events on the delta that have indirectly perpetuated annual flooding. The residents in the Salt River Basin are seeking a solution on how best to restore the Salt River into a hydrologically and ecologically functional river while maintaining socio-economic needs. This restoration effort is supported by a myriad of public entities.

Inclusive of the Wildcat tributaries the Salt River Basin is 31,260 acres and is located in Humboldt County, California approximately 15 miles south of Eureka. The city of Ferndale is the major population center within the Salt River Basin.

Hydrology

The Salt River Basin is comprised of two significant ecological units; the Salt River Delta, and the tributaries that drain the Wildcat Range (Figure 2).

- The **Salt River Delta**, as defined by this report, refers to the gently sloping alluvial floodplain that comprises the southern tier of the larger Eel River Delta.
- The **Wildcat tributaries**, as defined in this report, refer to those tributaries that flow from the Wildcat Hills across the Salt River Delta including: Coffee, Williams, Francis, Reas, Smith, and Russ creeks. Centerville Slough also originates in the Wildcat Range and is a tributary to the Salt River via Cuttoff Slough.

Salt River Delta

The Salt River flows across the Salt River Delta in a 'westerly direction and runs south of and almost parallel' to the Eel River before entering the Eel River Estuary 0.8 miles from the mouth of the Eel River (USDA 1993). Although the Salt River is a distinct ecological unit, it is intricately linked to the Eel River Estuary. The Salt River is not a river in and of itself, but rather a remnant channel of the Eel River (Slocum 2001). Historically, the Salt River was largely influenced by tidal ebb and flow and was referred to as the 'principal slough' tributary to the Eel River Estuary (Westdahl 1888; in Roberts 1992). With a significantly reduced tidal prism, which is the volume of water exchanged during a daily tide cycle, the Salt River's function as a slough has been marginalized**.**

In the mainstem Salt River there has been a drastic decrease in permanent length due to channel aggradation from excessive upslope erosion. The permanent channel of the Salt River has become much smaller from a historic 13.4 miles of permanent channel to 4.8 miles currently.

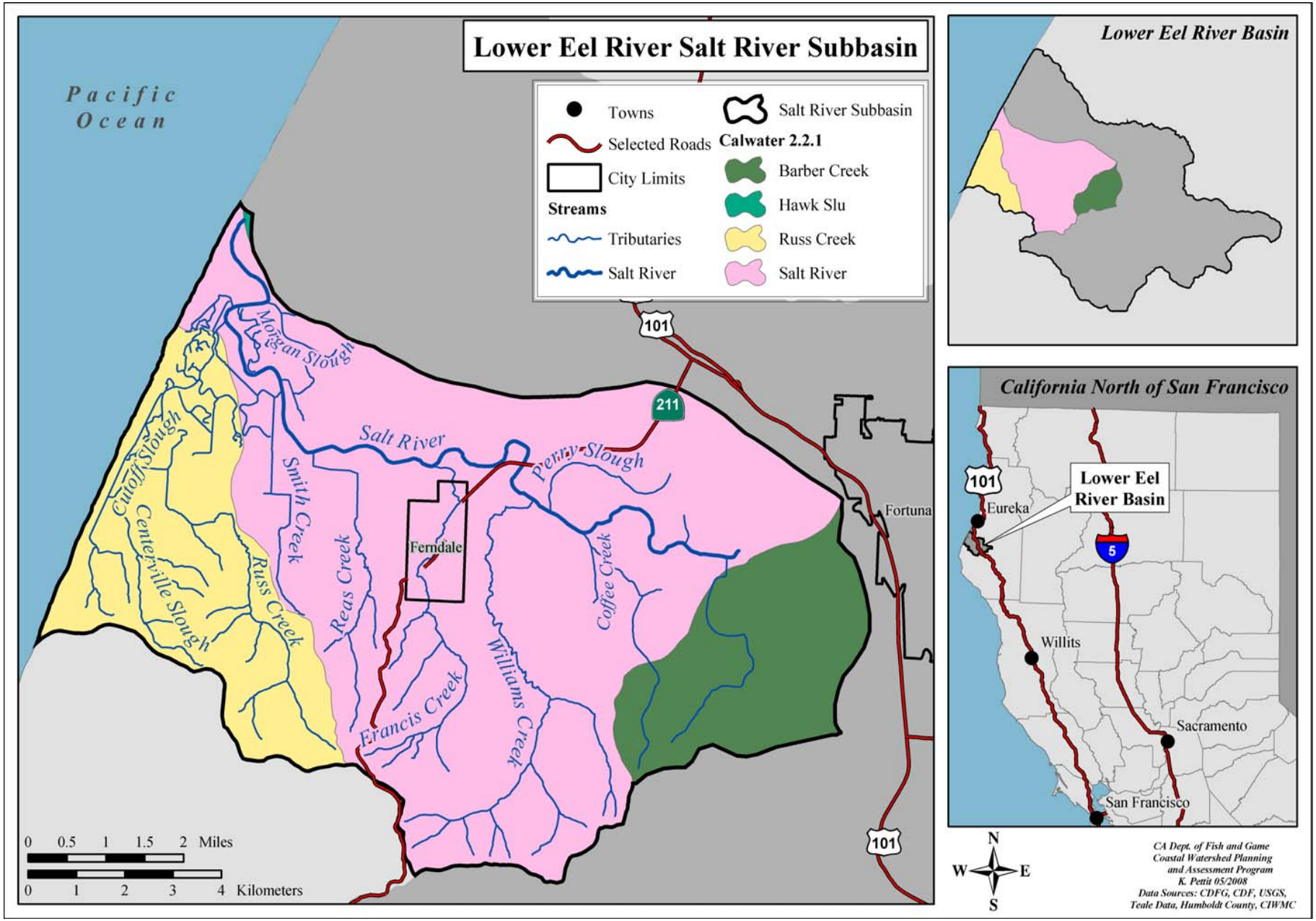

Figure 1. Salt River Subbasin locator map and CalWater Units.

The Salt River Delta is characterized by its relatively flat topography; delta elevations range from sea level to about 80 feet above sea level. In 2004, the Salt River Delta drainage area was measured to be 10,100 acres, which is a reduction from 17,650 acres before 1975.

One of the earliest insights of the conditions of the Salt River comes from Ferdinand Westdahl during a reconnaissance mission for the U.S. Coast and Geodetic Survey in 1888.

> *"The principal slough to the southward of the (Eel) river is called the Salt River. It is connected with the Eel River in periods of freshets, when the waters of the latter river run into it by several small channels too shallow to admit immense drift-logs and snags which abound in Eel River. The Salt River is therefore comparatively deep and free from snags and offers better facilities for shipping than the main river. Salt River is at all times a tidal stream, almost equally active throughout the year" (Westdahl 1888; in Roberts 1992).*

Wildcat Tributaries

The southern boundary of the Salt River Delta is marked by the toe of the Wildcat Hills (Figure 2). The average elevation of the Wildcat Hills is about 800 feet; the highest point is 1,750 feet. The Wildcat Hills can be characterized by their steep topography with slopes that often exceed 100%. Average hill slope in the area is 42% (USDA 1992). The steep hillsides of the upper Wildcat tributaries are sharply contrasted with their flat alluvial canyon floors. The valley floors of the Wildcat tributaries have in places been converted to pasture. The trans-delta reaches of the Salt River tributaries flow across the Salt River Delta before they coalesce with the Salt River. Urban development and agricultural modifications have severely impacted the trans-delta reaches of the Wildcat tributaries.

Before 1975, the upper Salt River Basin consisted of four anadromous streams and seven smaller drainages with a total land area of 12,775 acres (Table 1).

Currently, the Salt River has three potentially anadromous streams and four smaller drainages with a total land area of 7,440 acres. This dramatic change in watershed size is due to a complicated series of natural and human-induced events which are explained below.

Table 1. Salt River tributary information

	Salt River Mile(Miles)	Drainage Area[1](Square Miles)	Elevation Range(Feet)	Stream Order	Permanent Stream Length[3](Miles)	Intermittent Stream Length[3](Miles)
Morgan Slough	0.3	-	-		1.3	-
Cuttoff Slough	1.1	-	-		2.2	-
Unnamed Slough[2]	-	0.55	9 to 500		1.3	-
Centerville Slough[2]	-	1.30	30 to 1000		2.6	1.8
Russ Creek[2]	-	3.65	20 to 1550	1	5.2	1
Smith Creek	2.4	0.30	35 to 950	1	2.6	1.9
Unnamed Tributary	2.8	0.63	30 to 900		-	0.2
Reas Creek	3.4	2.03	40 to 1500	1	3.5	0.7
Francis Creek	5.1	3.18	60 to 1500	2	4.3	0.6
Williams Creek*	7.5	5.89	50 to 1750	2	7.2	0.6
Perry Slough*	7.7	-	-	I	-	2.2
Unnamed Tributary*	7.9	0.77	40 to 950	1	-	-
Coffee Creek*	8.3	0.79	40 to 925	I		2.5
Unnamed Tributary*	10	0.88	50 to 925	I		0.2
TOTAL AREA		**19.96**				

1 Watershed areas include only the upland wildcat drainage and not any portion of the delta.
2 Tributaries to Cuttoff Slough.
3 Tributary lengths provided by CDFG river mile and stream length estimates for the Eel River Basin based upon 2004 field observation and mapping.
* Williams Creek, Coffee Creek and two unnamed tributaries are now tributary to the Old River.

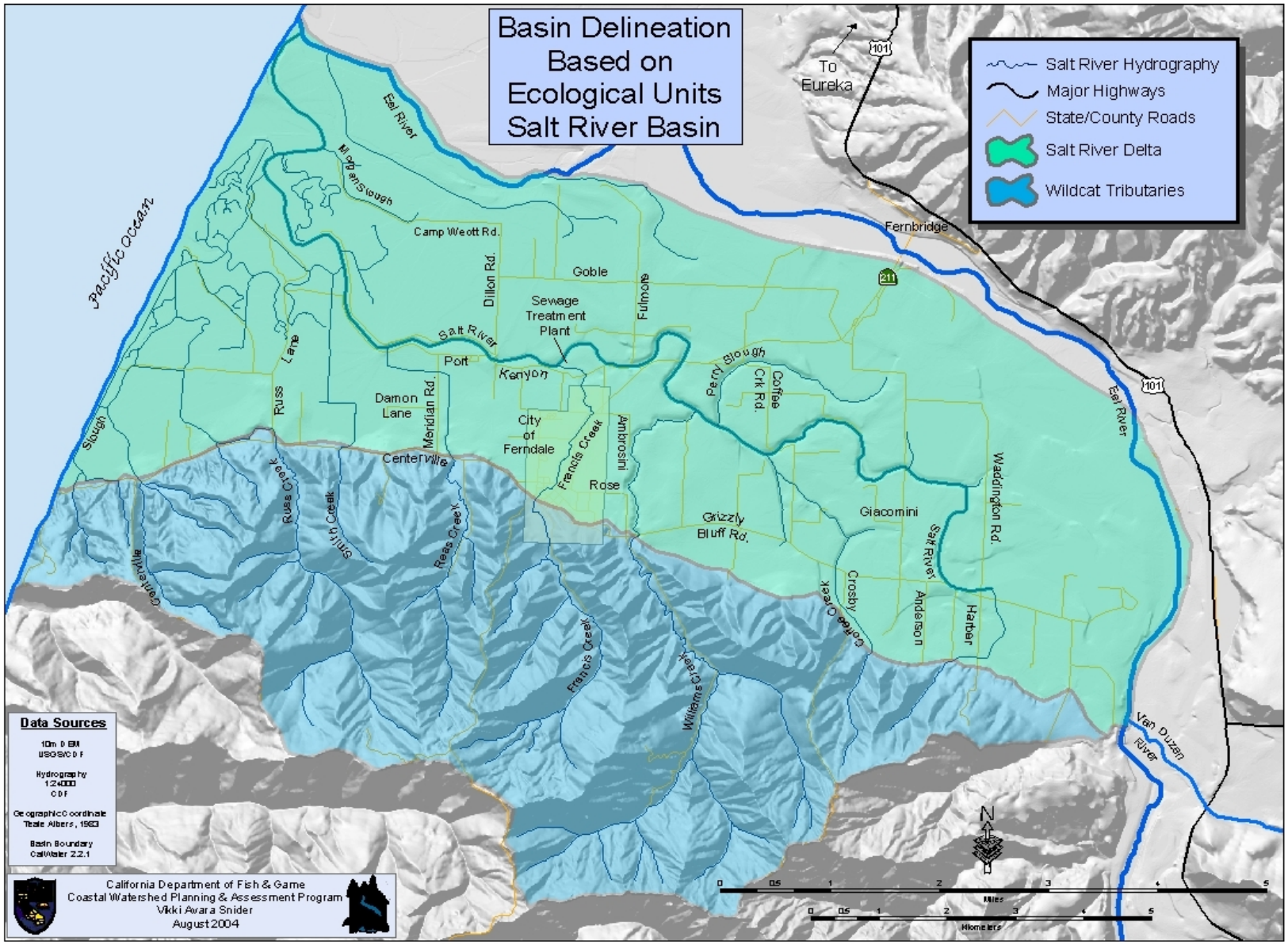

Figure 2. Assessment Area: Salt River Delta and Wildcat Tributaries.

Floods

The north coast of California is dominated by intense, short duration rainstorms in the winter, with peak flows that are among the highest on record for the western United States (Sommerfield 2002). The winter peak flows often cause severe flooding on the Eel River Delta; in fact, the Federal Emergency Management Agency (FEMA) has designated practically the entire delta as a floodway. Flooding has always been a part of life on the Delta; however, the effects of floods have become more severe as the flood capacity of the Salt River and the greater Eel River Estuary have been significantly reduced through anthropogenic activities.

There have been numerous large floods on the Delta; the most notable and destructive include 1955 and 1964. The flood of 1964 was the largest recorded flood to occur in the Eel River Watershed and has been referred to as a system reset event for the Salt River. It is the 1964 flood that has been identified as the beginning of the end of the Salt River channel. The 1964 flood occurred following a post-war logging boom that was associated with an extensive increase in road building and watershed disturbance which caused excessive erosion and runoff from the hillsides that were carried into the river. Forty years later, the effects of the 1964 flood continue to present resource management dilemmas in the Eel River Watershed.

The 1964 flood had significant environmental and economic ramifications on the Salt/ Eel River Delta. The U.S Army Corps of Engineers indicated that the Salt River agricultural land was devastated with up to four feet of silt and sands being deposited in the Eel River Valley (McLaughlin and Harradine in USDA 1993). According to the analysis completed by the Soil Conservation Service of data published in 1965, roughly 5,100 acre feet of sand and 6,300 acre-feet of silt were deposited over 13,000 acres in the Salt /Eel River flood plain as an immediate consequence of the 1964 event (USDA 1993). In addition many homes were lost and approximately 2,000 cows perished in the storm. The flood of 1964 caused significant environmental damage in the Eel River Delta that continues to have lasting effects that are mostly related to increase in sediment deposition and a decrease in channel capacity.

Table 2. Historic floods of the Eel River. Flood stage for Fernbridge is 20 feet.

Date	Flood Level at Fernbridge
12/23/1964	29.5
12/22/1955	27.7
1/16/1974	26.33
2/18/1986	26
12/11/1937	25.4
1/9/1995	25.31
1/1/1997	25.22
2/8/1960	24.85
3/30/1974	24.81
1/24/1970	24.8
2/28/1940	24.43
1/5/1966	24.2
12/19/1981	23.7
1/27/1983	23.6
1/21/1993	23.46

Flood control in the Eel River Delta has been the topic of much debate over the years. It was proposed in 1937 that the Eel River, from Fernbridge downstream, be dredged in a straight line and reinforced with levees. The intention of the proposal was to simulate the state of the Eel River during settlement and to lessen the losses accrued during flood periods. At that time in 1937, 100 acres of land was being eroded annually (Anonymous 1937). Ultimately, the project was not acted upon; however, flood control and bank protection remains a major concern on the banks of the Eel River. The idea of bank protection and flood control resurfaced after the 1964 flood. The Army Corps of Engineers proposed building 30 miles of levees on the lower Eel River, beginning at the Van Duzen River. The plan of improvement also included construction of levees on the Salt River extending upstream to Port Kenyon. Due to legislation in the early 1970's, a 12 year moratorium was placed on levee construction on the Eel River and the improvement plans were tabled (Monroe 1974).

Geology

The high levels of sedimentation of the Salt River and its aquatic resources are in part due to the highly erodable nature of the local geology. Poorly consolidated, sedimentary rock formations coupled with dynamic, regional tectonism and a great amount of rainfall create a consistent background contribution of fine sediment into the Salt River system.

The Salt River Subbasin is located in a broad alluvial valley filling the lower extent of the on-land portion of the Eel River syncline and shares the valley with the Estuary Subbasin at its northern edge. The Salt River Subbasin is flanked on its southern side by sedimentary formations of the Wildcat group. Its western edge is flanked by marine shoreline deposits and extensive sand dunes. Under the current alluvium the basin is composed of sedimentary formations of the Wildcat group.

Compositional overview

Based on the USGS Geology of the Cape Mendocino, Eureka, Garberville, and Southwestern part of the Hayfork 30 x 60 Minute Quadrangles and Adjacent Offshore Area, Northern California geologic map of California, the superficial geology in the Salt River Subbasin is composed entirely of Cenozoic sedimentary rocks (Figure 3). Alluvium makes up the majority of the area at 38.8% (Table 3). The remaining area is dominated by sedimentary rock types of the Wildcat group and poorly – unconsolidated river terrace deposits. Coastal dunes make up the remainder of the subbasin. Almost five percent of this subbasin has been mapped as Quaternary landslides.

Table 3. Rock types of the Salt River Subbasin.

Rock Type	% of Basin	Description
Alluvium	38.8	Unconsolidated river sediments within the active influence of streams.
Dunes	3.0	Wind blown sand deposited along the shoreline as dunes.
Landslides	4.9	Unconsolidated, poorly sorted river sediments that have been uplifted above the active stream influence.
Terrace deposits	18.6	Unconsolidated, poorly sorted river sediments that have been uplifted above the active stream influence.
Wildcat Group	34.6	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.

The Wildcat Group which makes up the hills that flank the Salt River to the south consist of sediments which washed into and filled in the Eel River syncline in the range of 13 million to 1 million years ago (Table 4). During this time the plunging Eel River syncline was inundated by the ocean as evidenced by the numerous marine fossils which abound within the steep canyon walls. As the Eel River syncline completely filled with over 10 thousand feet of sediment the region was undergoing uplift related to accretionary tectonics of the Pacific Northwest. As late as 500 thousand years ago there started an accelerated bout of uplift brought on by the encroachment of the Mendocino Triple Junction which continues to this day. The high rate of uplift has caused the streams to rapidly incise creating very steep canyon walls with slopes often greater than 100%. The “soft” nature of this sedimentary bedrock, the steep slopes, and large amount of seasonal precipitation trigger an abundance of landslides in this area.

Table 4. Wildcat group rock formations.

Wildcat Group	Description
Carlotta formation	Predominately non-marine sandstone, conglomerate, and claystone gradationally overlying Scotia Bluffs Formation; deposits are poorly consolidated.
Scotia Bluffs sandstone	Fine-grained, massive semiconsolidated sandstone with minor amounts of siltstone, mudstone, and pebbly conglomerate
Rio Dell formation	Interbedded mudstone, semiconsolidated sandstone, and siltstone; landslide failures along the interface between sandstone and mudstone beds are common, particularly along the coast.
Eel River formation	Mudstone, siltstone, and sandstone; unit is sheared in places
Pullen formation	Mudstone, diatomaceous mudstone, and local sandstone; highly sheared.

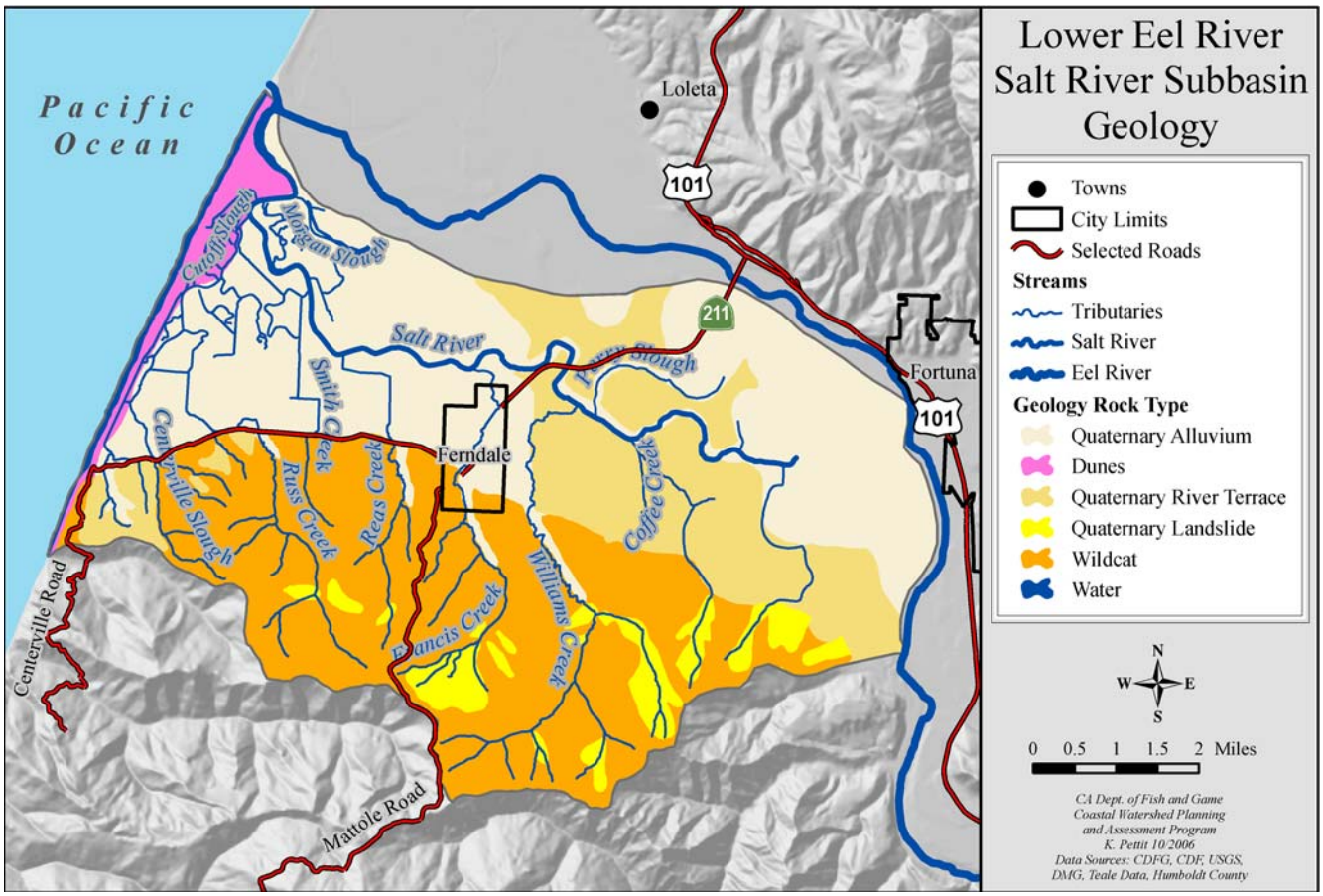

Figure 3. Geology of the Salt River Subbasin.

Landslides

The layers of sediment within the Wildcat Group were deposited relatively horizontally but have since been tectonically uplifted, tilted, and folded. On the southern side bedding plains dip towards the valley axis. The sedimentary layers that make up the Wildcat group 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. Landsliding is most common in zones between mudstone and sandstone beds of the Rio Dell formation during storm saturation events.

Earthquakes and Faults

Complex tectonic interactions of the Mendocino triple junction, its northward migration, the subduction of the Gorda Plate under the North American Plate combine to make this region one of the most seismically active on the continent. Compressional and translational stresses have created a vast "fold and thrust" belt in which the Salt River Subbasin exists. Several active faults in the area are capable of creating large earthquakes. Large earthquakes tend to trigger landslides in steep terrain as well as liquefaction of unconsolidated sediments in low-lying areas.

The Cascadia Megathrust is located offshore adjacent to this area. This is the current subduction zone allowing the Gorda Plate to move underneath the North American Plate. This megathrust can generate earthquakes of M~8 and greater. It is estimated from Japanese tsunami records that in January of 1700 an M~9 earthquake was generated along this megathrust. Large megathrust events also tend to generate tsunamis that wash into the estuary further modifying its morphology. The Cascadia Megathrust is believed to have an earthquake recurrence rate of roughly 500 - 600 years (Witter & Patton 2006). Based on evidence from the stratigraphic record this area has undergone several episodes of very rapid uplift and/or subsidence associated with megathrust earthquakes.

According to Li, sudden subsidence has occurred in the Eel River Delta 300, 800, 1200, 1500 and 2000 years before present. "Submergence strata of the buried vegetation layer in the Eel River Delta seems too wide spread, too large, and too sudden to be attributed to anything other than coseismic subsidence" (Li 1992).

Essentially, the mouth of the Eel River suddenly dropped in elevation five times in the past 2000 years; however, the change in elevation is not occurring equally across the mouth of the Eel. An average subsidence rate has been calculated, 1mm/ year in the northern area, and 3.6 mm/year in the southern area (Li 1992). The unequal subsidence in the Eel River Delta will dictate where the river runs its course as it finds the areas with the lowest elevation.

During intense seismic events liquefaction of estuarine sediments is also common. The 1906 M7.8 earthquake along the San Andreas fault caused significant landsliding into Salt River. Port Kenyon was reported to have subsided by several feet and a half-mile wide landslide at Centerville Beach was triggered during this event (Dengler 2006).

The 1992 Cape Mendocino earthquake triggered "localized slope failures and fissures along roads and steep hillsides in the Wildcat Hills" (USDA 1992). In the headwaters of Francis Creek a 15-20 acre earthslump was reactivated. The landslide was actually part of a larger slide that extends across the entire headwaters of Francis Creek. The earthquake trigged slope failures were the primary contributors to increased instream turbidity that was observed after the quake. It is likely that the landslides in the headwaters of Francis Creek were a large contributor to the further silting-in of the confluence of the Salt River and Francis Creek in the past thirteen years. It was recommended by the Soil Conservation Service that a sediment basin at the mouth of Francis Creek be considered to limit the sediment contributions into the Salt River. Stabilization of the large slide was 'neither technically nor economically feasible' (USDA 1992).

The Ferndale fault runs through the southern portion of the Salt River Subbasin. Ferndale fault and the Russ fault cut across this subbasin. Both of these faults disrupt bedrock and are capable of producing earthquakes. 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 Eel river syncline, although not a fault, runs under this subbasin and may contort from time to time shifting the landscape and triggering issues related to sedimentation. The Cascadia Megathrust and the San Andreas fault have historically caused earthquakes large enough to alter the morphology of this subbasin.

Sedimentation

Historic landuse practices in the greater Eel River Watershed such as timber harvest, agricultural conversion, road building and the construction of the Northwestern Pacific Railroad intensified erosion and affected Eel River depositional areas like the Salt River. "The Eel River has the highest recorded average annual suspended sediment yield per square mile of drainage area of any river of its size or larger in the USA (31 million tons per year). The Eel River carries fifteen times as much sediment as the Mississippi River and more than four times as the Colorado River (Brown, Ritter 1971). The suspended sediment load recorded at Scotia during the 1964 flood was 160 million tons, representing 51% of the entire Eel River suspended load computed for the 10 year study at the Scotia Station (Brown, Ritter 1971).

Erosion and landslides are the means by which the Eel River Delta was formed through deposition of alluvial material, which is the principle reason the delta is such fertile agricultural property. Although high levels of suspended sediment are the norm in the Eel River, the rate of watershed disturbances is of particular concern to resource managers. A study of the continental shelf deposits offshore from the mouth of the Eel River indicates that there has been a sudden, three-fold increase in the rate of sedimentation since 1954. The study also indicates that major floods after 1950 have had a "more pronounced effect on coastal sediment delivery and accumulation than previous recorded events of similar magnitude"(Sommerfield 2002). This increase in sediment delivery and accumulation in the Eel River depositional areas such as the delta has had dramatic effects on the productivity of the Eel River fishery and has increased sediment deposition in the Eel River Estuary.

The largest source of suspended sediment within the Salt River Basin is derived from the Wildcat

tributaries. A study conducted during 1994 estimated that 11,400 tons of sediment flow into the Salt River each year. Since that time one of the Salt Rivers largest contributors of suspended sediment, Williams Creek, no longer flows or contributes sediment into the Salt River, reducing the annual sediment yield to the Salt River to 6,140 tons/ year. The diversion of the Williams Creek was largely due to its high rate of sediment contribution to the Salt River (5,240 tons/ year), which over the years reduced the channel capacity.

Figure 4. Preventable (left) and non-preventable erosion (right).

The high rate of sediment coming from the Wildcat tributaries has been utilized locally to raise the elevation of adjacent pastures. This practice has caused flood waters to inundate public roads now that the elevation of pastures is sometimes higher than the roads. Deposition, although locally problematic, reduces the amount of suspended sediment that reaches the Salt River; however, it is often costly for private parties and public entities:

- Salt River channel has aggraded 20 feet near Riverside Ranch (Section 28, T3N, R2W); and 10 feet in area between Dillon Road and the Salt River and Francis Creek confluence (Section 35, T3N, R2W) by 1987 (USDA 1987);
- Williams Creek deposited 5 to 6 feet of sediment on the Salt River floodplain near its confluence with the Salt River (Section 1, T2N, R2W) (USDA 1987);
- A fence installed along Reas Creek in 1984 was completely buried three years later (USDA 1987);
- In 1989, 4,038 tons of sediment were deposited on 4.6 acres at the outlet of Russ Creek, a volume of sediment that would cover a football field two feet high (USDA 1989);
- In 1999- 2001, the City of Ferndale paid $80,000 to clean up the silt that had deposited within their jurisdiction (Taubitz, 2001);
- In 2000-2001, from October to February, an estimated three feet of silt had deposited in lower Francis Creek (Taubitz 2001).

Table 5. Salt River has two major problems concerning sediment: factors that increase sediment deposition and factors that reduce the Salt Rivers capacity to flush the sediment to the ocean (USDA 1993).

Factors that increase the volume of sediment entering the mainstem of the Salt River	Factors that decrease the channel cleansing capacity
Naturally high levels of erosion in the Wildcat tributaries.	Low gradient of the Salt River Delta.
Natural erosion rates have increased due to past and present land use activities such as timber harvest, pasture conversion, road construction, sand quarries and riparian deforestation.	Potential for uplift and subsidence occurring unequally throughout the Eel River Delta, creating changes of landscape.
Channelization and realignment of the Wildcat tributaries in their lower reaches results in greater suspended sediment reaching the Salt River.	Willow growth in the Salt River channel is prolific, which slows water velocity.
Earthquakes in the basin are common and of a large magnitude.	Loss of cross-sectional area of all portions of the Eel River Estuary and its tributaries.
	Reduction of tidal prism, caused by construction of levees and the installation of tide control structures.
	Leonardo levee has almost eliminated Eel River flood waters from entering the eastern portion of the Salt River.

Table 6. Sediment yield to the Salt River channel from upland subwatersheds- average annual estimates for watershed conditions originally published in 1993. Adapted to reflect changes in watershed conditions since 1993.

Sub-Watershed Number	Upland Tributary Name	Watershed Area	Sediment Yield to base of Wildcats from All Sources		Sediment at the Base of Wildcats (%)		the Salt River Channel (%)			Avg. Annual Sediment yield to Salt River Channel (tons / year)		
		acres	(tons/year)	(tons/acre-year)	Bed	Wash	Bed	Wash	Total Load	Bed	Wash	Total
1	Cuttoff Slough	360	870	2.4					50			440
2	Centerville Slough	1020	2700	2.6					50			1350
3	Russ Creek	2080	3790	1.8					10**			380
4	Smith Creek	160	700	4.3					35			250
5	Unnamed #5	420	520	1.2					35			180
6	Reas Creek	1210	2690	2.2	60	40	40	98	63	650	1050	1540
7	Francis Creek	1990	5480	2.8	55	45	5	75	34	150	1850	2000
8	Williams Creek	3660	9960	2.7	47	53	10	90	52	470	4750	5,240
9	Unnamed #9	590	580	1					0			0*
10	Coffee Creek	350	1050	3					0			0*
11	Unnamed #11	470	930	2					0			0*
Total Average		12300 (rounded)	29300 (rounded)	2.4					39			11,400 (rounded)
Adapted Total Average									27*			6140*

* The Salt River is completely blocked by sediment just downstream of the Williams Creek confluence; recalculated to reflect change

** Russ Creek flow is being diverted during the wet season and spread onto pasture to raise the level of the ground

Bed = Bed Material Load
Wash= Wash Load

Figure 5. Reas Creek upstream of Meridian Road on October 20th, 2004

Figure 6. Reas Creek upstream of Meridian Road on December 3rd, 2004.

Soils

There are 15 major soil types on the Salt River Delta. The soils on the Salt River Delta can be characterized as very deep soils with small changes in slope located at low elevations and formed on mixed alluvium. The defining features among the soils in the Salt River Delta are their location upon the delta and their subsequent interaction with water.

The USDA Natural Resource Conservation Service (NRCS) has classified almost the entire Salt River Delta as prime farmland (if irrigated) with the exception of the Wigi and Occidental Soil Series. The Wigi and Occidental soil types are located at the western edge of the delta in poorly drained areas and they are both influenced by the tide and have high salinity contents. The Wigi and Occidental soil series are described as being "neither wooded nor farmable under natural conditions" (NRCS Draft Soil Series 2004). Due to reclamation activities, the hydrology of the Occidental soil series has been altered in "some or all areas of the map unit… and the soil characteristics indicate that hydric soil conditions existed prior to alteration of drainage" (NRCS Draft Soil Series 2004). Many of the dominant soils in the delta region are classified as hydric soils including: Worsick, Weott, Swainslough, Arlynda, Loleta, Jollygiant, Occidental, and Wigi.

A comprehensive view of the soil composition and distribution in the Salt River Delta may provide a valuable resource management tool. Soil maps help in wetland identification. With comprehensive soils information, restoration designs can aim to recreate tidal and or freshwater wetlands in appropriate locations. Soil information also indicates areas that are environmentally sensitive or areas that could be managed differently than adjacent soil types.

Fluvial Geomorphology

There has been significant change in the hydrology of the Salt River Basin since 1850. The naturally functioning systems that fashioned the Salt River into a navigable stream no longer exist. Changes in the Salt River were the result of:

- Land reclamation;
- Construction of levees and the installation of tide gates;
- Channelization of the Salt River tributaries;
- Rampant growth of instream vegetation (see pg 23).

Land Reclamation

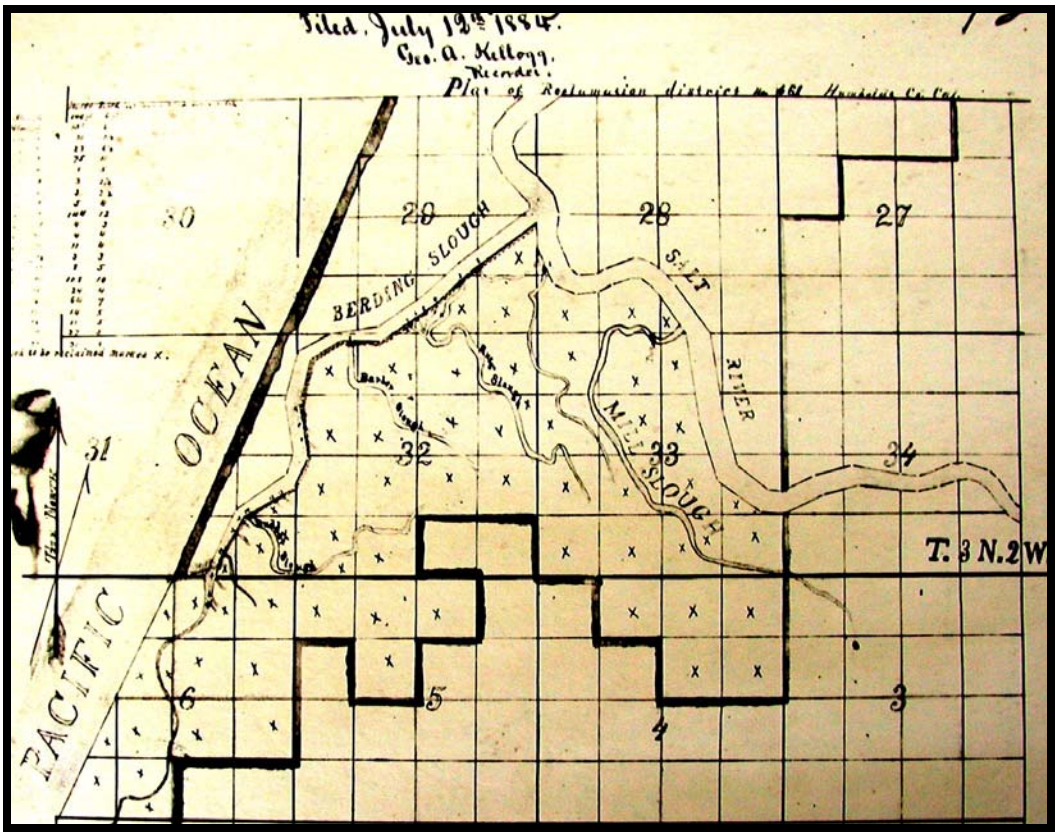

Figure 7. Plan of reclamation of the Salt River tidelands in 1884.

The caption reads: "Land to be reclaimed marked X". The reclaimed area in this map adds up to 2,025 acres.

Tidelands

When the Salt River Delta was first settled by Seth Louis Shaw in 1852, much of the land was considered worthless as it consisted of wetlands and salt marsh. Large scale reclamation activities began in western Salt River Delta in 1884 when the Reclamation District was formed (Eidness, Van Kirk 1988).

> *"This enterprise is to add to our resources about 2,000 acres of valuable farming and grazing land, which heretofore has been entirely valueless… In order to make the land of any value whatever it is necessary that all salt water should be kept off it, and it is to this end the work is being done. The land is intersected by many small sloughs, and through the western end of the district runs quite a body of water known as the Centerville Slough. It is the intention to dam all these small sloughs near the point where they branch from the main body of water, putting floodgates in the dams, thus forming a complete system of drainage which will leave the large body of marsh land as dry as the land on the adjoining hills" (Ferndale Enterprise, 1884 in Eidness, Van Kirk, 1988).*

Only four years after the Reclamation District was formed, Ferdinand Westdahl, a US Coast and Geodetic surveyor, wrote of the changes that occurred on the Salt River Delta:

> *Nearly all the small sloughs have been injudiciously dyked across their mouths, and even some of the large sloughs have been stopped up, as for instance the Centerville Slough, which has a dam across it. The dyked sloughs rapidly fill up and thus the tidal area is being decreased and the volume of water flowing in and out through the entrance lessened" (Westdahl 1888; in Roberts 1992).*

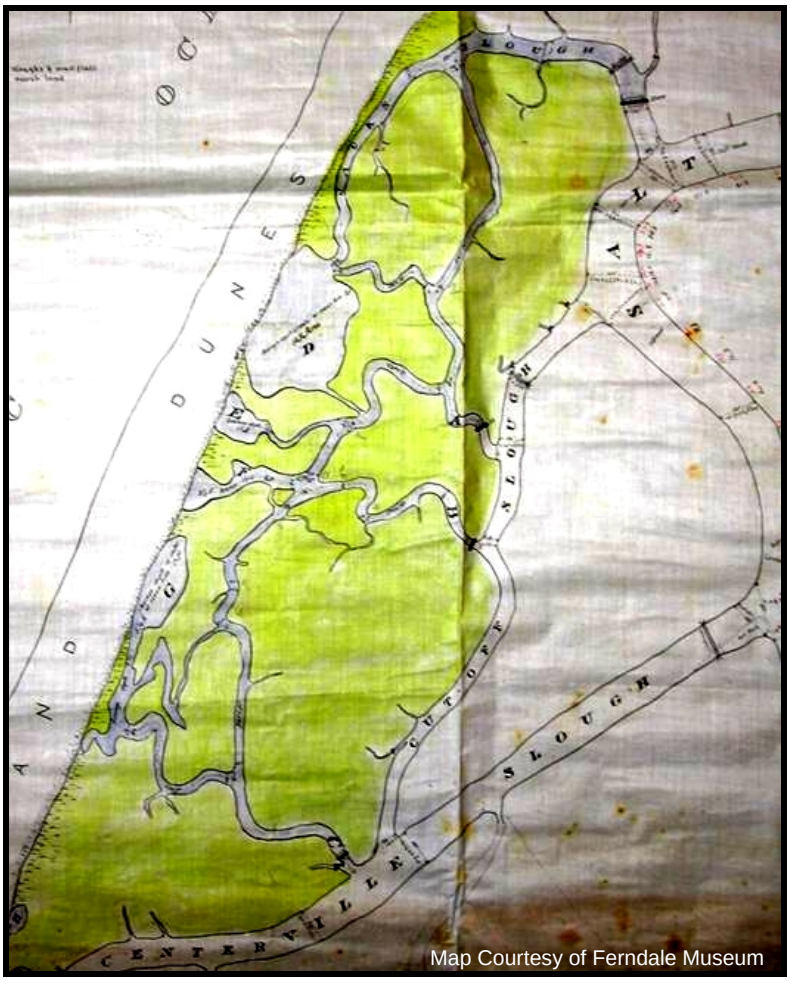

Figure 8. Map of the Centerville Slough area concerning the Supreme Court Trial in 1901.

The highlighted area is that which had been cut off to tidal influence by 1898.

Table 7. Tidal area of Salt River measured in 1901 in reference to figure XZ.

Tidal area cutoff to tidal influence	332 acres
Area included in sloughs and mudflats	48 acres
Tidal capacity in sloughs	437,000 yd^3
Tidal capacity of adjacent marsh which is flooded at high tide	458,000 yd^3
Tidal capacity of area	895,000 yd^3
Tidal prism of Salt River	2,700,000 yd^3
Tidal prism of area cut off	877,000 yd^3

The ecological benefits and channel maintenance features of wetlands and tidelands were not fully understood or appreciated in the 19th century. Reclamation activities were likely seen as a positive step toward harnessing the agricultural potential of the fertile soils of the Eel River Delta. However, the negative effects of the reclamation efforts of the Centerville area became apparent when navigation on the Salt River was impeded by the sediment that was quickly filling the Salt River channel and its tributaries. In 1898, R.W. Robarts, proprietor of the Port Kenyon shipping industry, filed a lawsuit against Z. Russ and Sons Co. over the legality of the dams and tide gates installed in the Centerville Slough region (Figure 8). In 1898, the court ruled in favor of Russ and Sons; however, the decision was later overturned by the Supreme Court in 1901 (Ferndale Enterprise 3/5/1901 in Eidness, Van Kirk 1988). The 1901 decision was based on the fact that "no owner of the tide lands of any harbor, bay, inlet, estuary, or other navigable water in this state, shall be permitted to destroy or obstruct the free navigation of such water" (CA Supreme Court 1901). It was found that reclamation activities in Centerville Slough reduced the size of the tidal prism in the Salt River and was deemed to be an obstruction of the free navigation of the Salt River. Regardless, the Salt River shipping industry ended soon thereafter largely due to a dramatic increase in sediment deposition.

In 1901, the tidal prism of the Salt River was estimated to be 2,700,000 cubic yards (Table 7). Evidence from the 1901 Supreme Court trial indicates that efforts to reclaim 332 acres of tideland west of Cutoff Slough reduced the Salt River tidal prism by 33%. Historic maps have confirmed that 2,360 acres of tidal lands adjacent to the Salt River were reclaimed by 1900 (Kellogg 1884; CA Supreme Court 1901). It is estimated that that an additional 560 acres of tide lands were likely reclaimed in what is now the Riverside Ranch property. In total, an estimated 2,900 acres of former tidelands in the Salt River Basin were reclaimed prior to 1900.

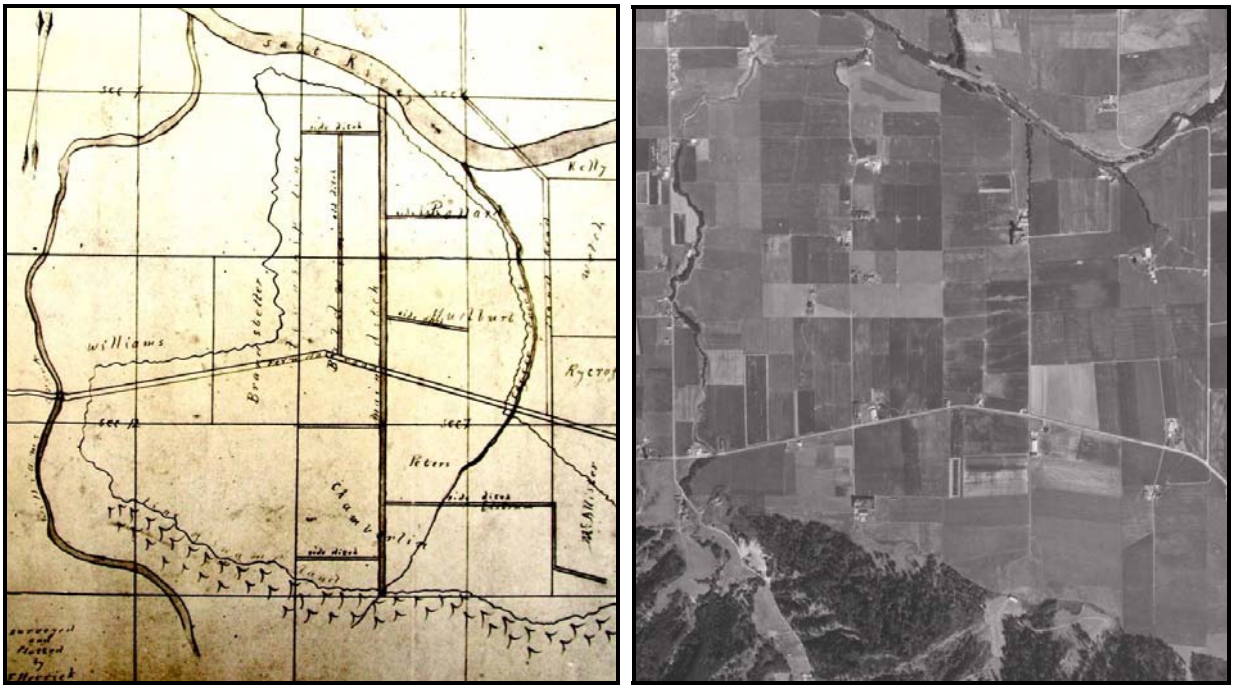

Figure 9. Map of Coffee Creek wetland that was drained in the late 1800s (left).
Aerial photograph of the same location in 1965 (right).

Freshwater Wetlands

Prior to Euro-American modification, a large freshwater wetland occupied the land between Williams Creek and Coffee Creek south of the Salt River (Figure 9). R.F. Herrick, a county surveyor in the late 1800's, designed a drainage system to drain the Coffee Creek wetland. The drainage system involved 1.3 miles of main drainage channel and 2.4 miles of side ditches. The map indicates that the southern bank of the Salt River was 9 feet above the bottom of the channel. The swamp land at its lowest point was five feet below the bank of the Salt River at a distance of 1¼ miles from the south bank of the Salt River. Based off the historic drainage map the wetland was measured to be approximately 700 acres. The presence of other freshwater wetlands upon the Salt River Delta is unknown, but it is likely that other freshwater wetlands existed on the Salt River Delta at the toe of the Wildcat Range.

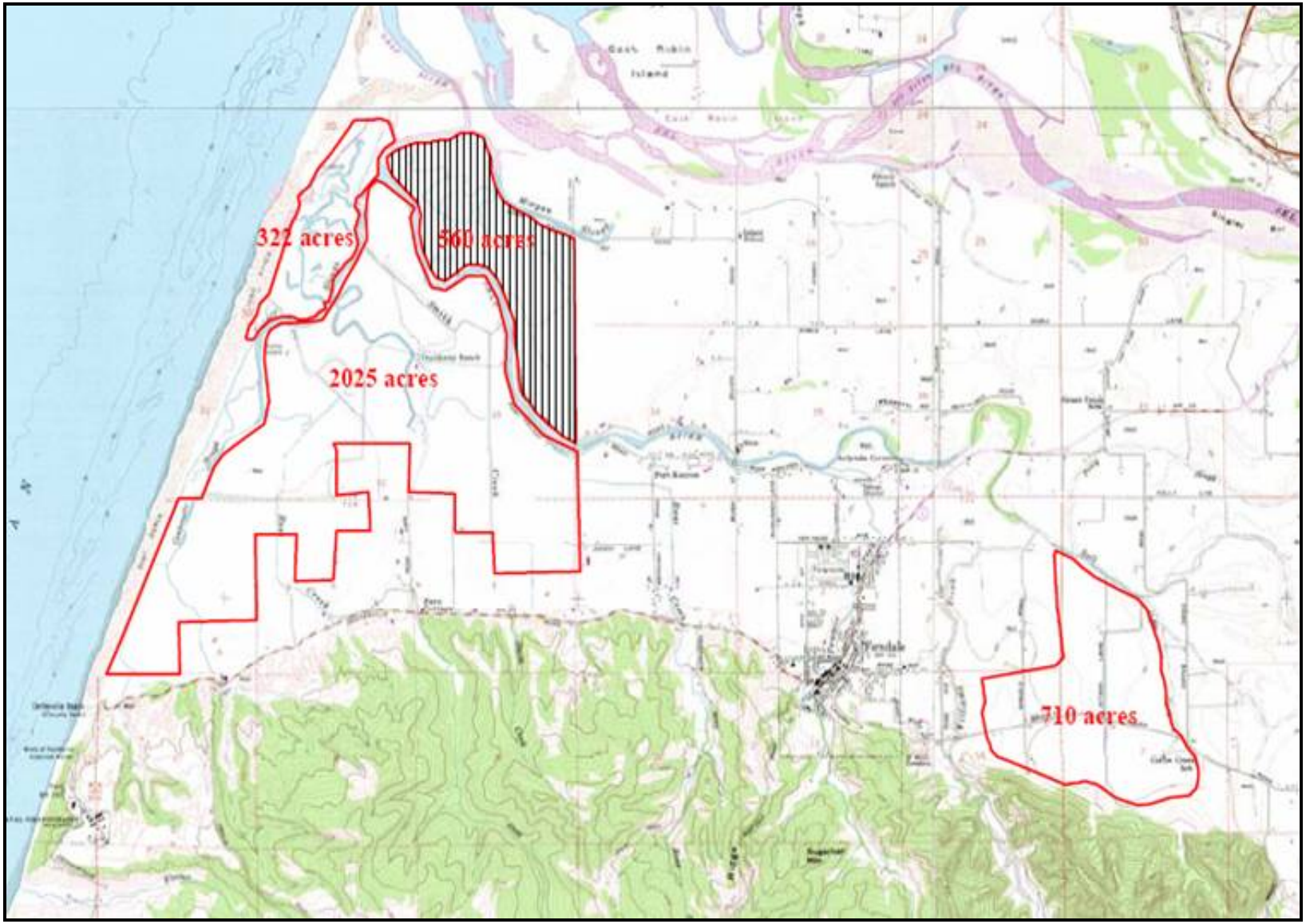

Figure 10. Wetlands and tidelands that are known to have been reclaimed. The area in black is estimated; the remaining areas have been confirmed with historic documentation.

Levees and Tide Gates

The interface between land and water throughout the Salt River Delta is, in general, controlled by an extensive network of levees. The intention of the levees was to control flood waters and to convert tidelands into productive agricultural land.

Leonardo Levee

The Salt River is often referred to as a hanging channel of the Eel River indicating that the Salt River channel was the former path of the Eel River. Floodwater from the Eel River jumped its banks and entered the floodplain from the eastern side of the delta and flowed through abandoned meander channels and coalesced with the Salt River. Landowners on the eastern side of the delta received the brunt force of the flood waters and finally built an earthen levee in 1967 in an effort to quell the force of floodwaters from the Eel River (Questa 1991).

The Leonardo Levee, as it is known locally, is located near the south eastern boundary of the Salt River Delta. It is estimated that the Leonardo Levee could provide protection up to the ten year frequency flood event and has been successful at keeping flood waters from inundating the southern side of the Eel River Delta. Since its construction, the levee has been breeched twice and repairs have been made by the Army Corps of Engineers under the disaster assistance program (Questa 1991).

The floodwaters from the Eel River were partly responsible for keeping the Salt River channel free of sediment and debris. The Leonardo Levee represents one of the causes of the sediment constriction that has diverted the eastern basin from the mainstem Salt River. An option outlined in the USDA Local Implementation Plan was to modify the Leonardo Levee 'to allow the flushing flows from the Eel River through the Salt River' (USDA 1993). This option would require extensive dredging, maintenance and infrastructure changes and therefore was not considered a viable option at that time.

Tide Gates

The impact of tide gates is a general problem that has recently generated interest among the natural resource conservation community in the Pacific Northwest, particularly considering the recent interest in the importance of estuaries in the life cycle of salmonids. The effects of tide gates on estuarine function include the elimination of upland tidal flooding and changing velocity, turbulence and pattern of freshwater discharge that fluctuates between water stagnation and flushing flows (Giannico, Souder 2004). There are six operational tide gates in Salt River that are used in conjunction with dams and levees to keep the tide from inundating low lying areas.

Tide gates create new physical, chemical and biological environments on both sides of a levee that may not be conducive to the native biota. Physical changes that commonly take place as a result of tide gates are an increase in water temperatures and a change in channel morphology. Chemical changes that commonly take place behind tide gates include an increase in nutrient concentration, an increase in turbidity, and reductions in dissolved oxygen and pH. (Giannico, Souder 2004).

In addition to water quality issues, the biological impact of tide gates that is relevant to the Salt River is the obstruction of fish migration. In the case of anadromous salmonids, tide gates prevent migration and impact the quality of their habitats (Giannico, Souder 2004). The duration that a tide gate is closed, the size of the opening and the velocity of water moving back and forth through the tide gate are all factors that influence the daily and annual migration of salmonids. Another biological impact of tide gates is to change the composition and abundance of aquatic plants. The slough channels become choked with submergent and emergent aquatic vegetation. On a site reconnaissance in July 2004, Cuttoff Slough was filled with the submergent plant eel grass on the upstream and downstream sides of the tide gate.

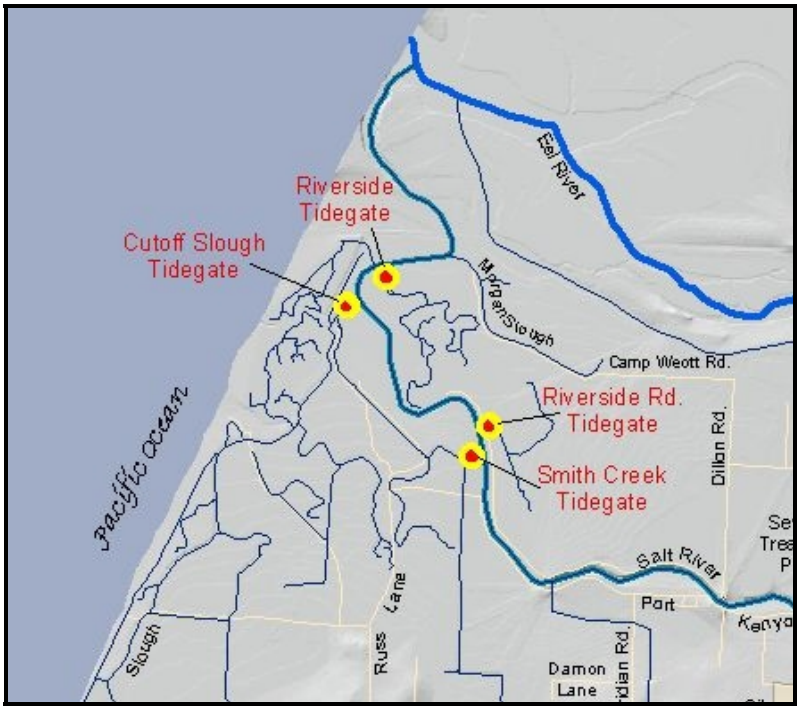

Figure 11. Tide gates in the Salt River system.

An option outlined in the Salt River Local Implementation Plan was to remove the tide gates in the Salt River. Tide gate removal would restore tidal action to the marsh areas behind the tide gates and would increase channel scour downstream of the existing tide gates; however, it was determined that tide gate removal would result in slightly less channel scour in reaches upstream of existing tide gates. The 1993 plan determined that tide gate removal would not result in decreased sedimentation upstream of Smith Creek and therefore was not considered a viable option. Tide gate modification for the purpose of salmonid habitat improvement and for the improvement of salmonid access was not considered in the 1993 plan. Fish-friendly modifications can be made to existing tide gates to allow for the passage of salmonids, such as, installing small fish doors attached to buoys within the large floodgates. Fish passage through tide gates should be considered in final restoration initiatives.

Figure 12. Cutoff Slough tide gate

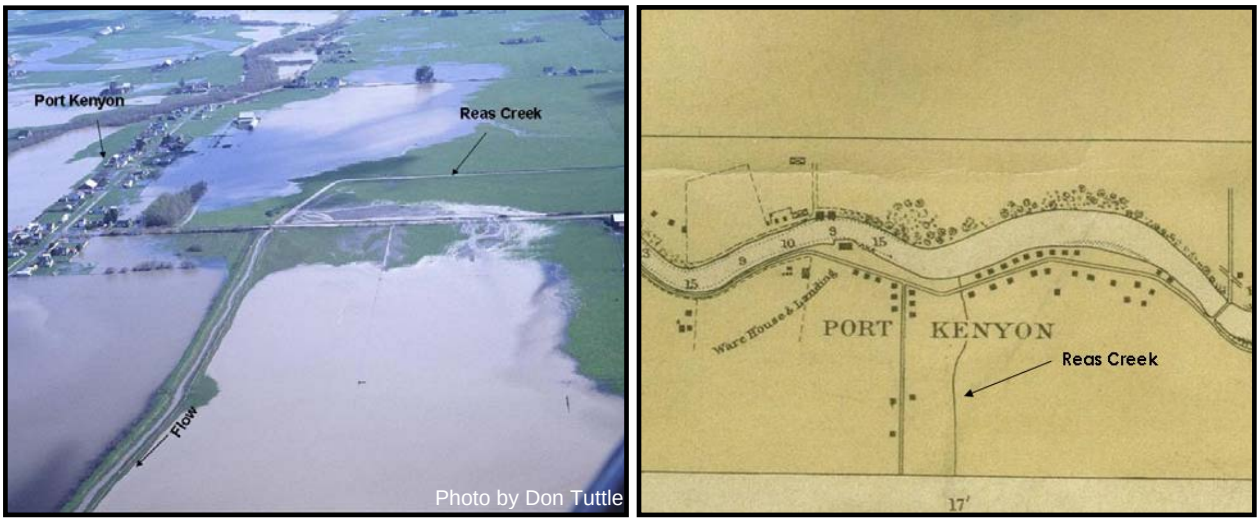

Figure 13. Reas Creek in its lower reaches has been realigned and channelized as it runs 8,200 feet across the Salt River Delta (Left),
One of the historic paths of Reas Creek in 1921 flowed straight through Port Kenyon (Right). The channel alteration increased the length of Reas Creek across the delta by 30%.

Channelization

Portions of the Wildcat tributaries, as they flow across the floodplain, have been channelized and converted from a distributory, meandering flow regime into a swift channelized flow regime to accommodate for agriculture and residential growth. Many times realignment and channelization took place to correspond with property boundaries, to raise the elevation of pastures, and for irrigation purposes. Often this channelization has reduced the local stream gradient, which has caused the realigned reaches to fill with sediment (USDA 1993). There have been unanticipated consequences from the modification of the Wildcat tributaries in the trans-delta reaches that have resulted in a change in both the sediment budget and hydrologic flow regime in the Salt River.

In order to control the flow of the tributaries, levees have been built to contain creeks in a predictable and controlled path. Reas Creek is contained in levees the entire length across the delta (Figure 13) Several historic maps have shown that the path of Reas Creek has been in three distinct configurations since Euro-American settlement. The trans-delta reach of Reas Creek from Centerville Road to the Salt River confluence is now 2,360 feet longer than it was in 1921 (Figure 13). Currently, Reas Creek also has two 90 degree angles, which are not part of the natural channel configuration. The channelization and lengthening of the trans-delta reach of Reas Creek is suspected of causing problems related to sediment deposition and discharge within Reas Creek as well as in the Salt River.

In 1999, a levee was constructed without appropriate permitting on Williams Creek from the mouth extending upstream 2,500 feet to Ambrosini Lane. The Williams Creek levee constitutes development under the Coastal Act and should have required a coastal development permit. The construction of the levee may have affected the flow of peak high water events. Enforcement action is currently pending concerning the Williams Creek levee construction, and should be resolved soon.

Channelization creates a homogenous stream reach. Typically, rivers are described by their diversity of meanders, pools, riffles and runs; but when a river or stream is channelized the diversity of habitats and channel roughness is reduced. Roughness can be described as channel features that slow water velocity, create a diversity of habitat types, and form and maintain a channel that is appropriate for the amount of discharge, suspended sediment, and bedload.

A problem arises when the flow regimes of the tributaries do not match that of its receiving waters. Most tributary streams in the North Coast enter a

larger, more robust stream with sufficient hydrological energy to manage sediment deposition in the receiving waters. This is not the case in the Salt River Basin. Because of the difference in flow regimes between the mainstem and its tributaries, the Salt River becomes inundated with great volumes of water that have high concentrations of suspended sediment, which then deposit in the Salt River channel.

The Old River and Perry Slough

Figure 14. Aerial Photographs of the confluence of Williams Creek and the Salt River 1996 (left), 2000 (right).
Note the change in the Williams Creek drainage in the center of the photos from a westward course in the Salt River (left) to an eastward course into the Old River (right). This action has caused a 42% reduction in Salt River Watershed size.

In the past 25 years, the four eastern-most drainages to the Salt River have been diverted from the mainstem Salt River into the Old River via Perry Slough creating a new watershed. In 1978, a sediment plug completely blocked the Salt River channel (RM 7.7); diverting the flow of Coffee Creek into the Old River channel. In 1998 Williams Creek (R.M. 7.5) was also diverted into the Old River. The Old River/ Perry Slough system is an ephemeral watercourse, meaning that is dry in the summer. Old River flows north under the Old River bridge that crosses Highway 211 and meets the Eel River 0.7 miles downstream of Fernbridge (Eel River Mile 5.8).

The diversion of Williams Creek was attributed to a tree that fell across the channel and was deemed to be a natural event; however, due to excessive aggradation, channel capacity in the upper reaches of the Salt River has been decreasing annually for the past century and the obstruction in the channel can be considered as the straw that broke the camels back. Enforcement action concerning the Salt River diversion near Williams Creek is currently pending. Williams Creek was the largest sub-watershed in the Salt River and as such was the largest source of flow and the largest contributor of sediment to the mainstem. Because of the diversion, sediment delivery to the Salt River was reduced by 33%; however, the sediment problem with Williams Creek has simply been transferred to Old River/ Perry Slough.

The diversion of Williams Creek is a point of contention within the basin because the change in channel course has benefited some while burdening others (Ferndale Enterprise Jan. 28, 1999). The Old River/Perry Slough is not a perennial watercourse and as such has no value for anadromous salmonids. The diversion has eliminated fish passage to a once anadromous stream and reduced the drainage area of the Salt River Basin by 42%. Francis Creek now functions as the eastern extent of the headwaters of the Salt River.

Table 8. Hydrological changes have reduced the size of the Salt River Basin and have created the Old River/ Perry Slough Basin.

Estimated Wildcat tributary land area (1850)	12,775 acres
Estimated Salt River Delta land area (1850)	17,650 acres
Estimated total Salt River Basin (1850)	**30,425 acres**
Wildcat tributary land area draining to the Salt River (2004)	7,440 acres
Salt River Delta land area (2004)	10,100 acres
Total Salt River Basin (2004)	**17,540 acres**
Old River / Perry Slough watershed (2004)	12,885 acres

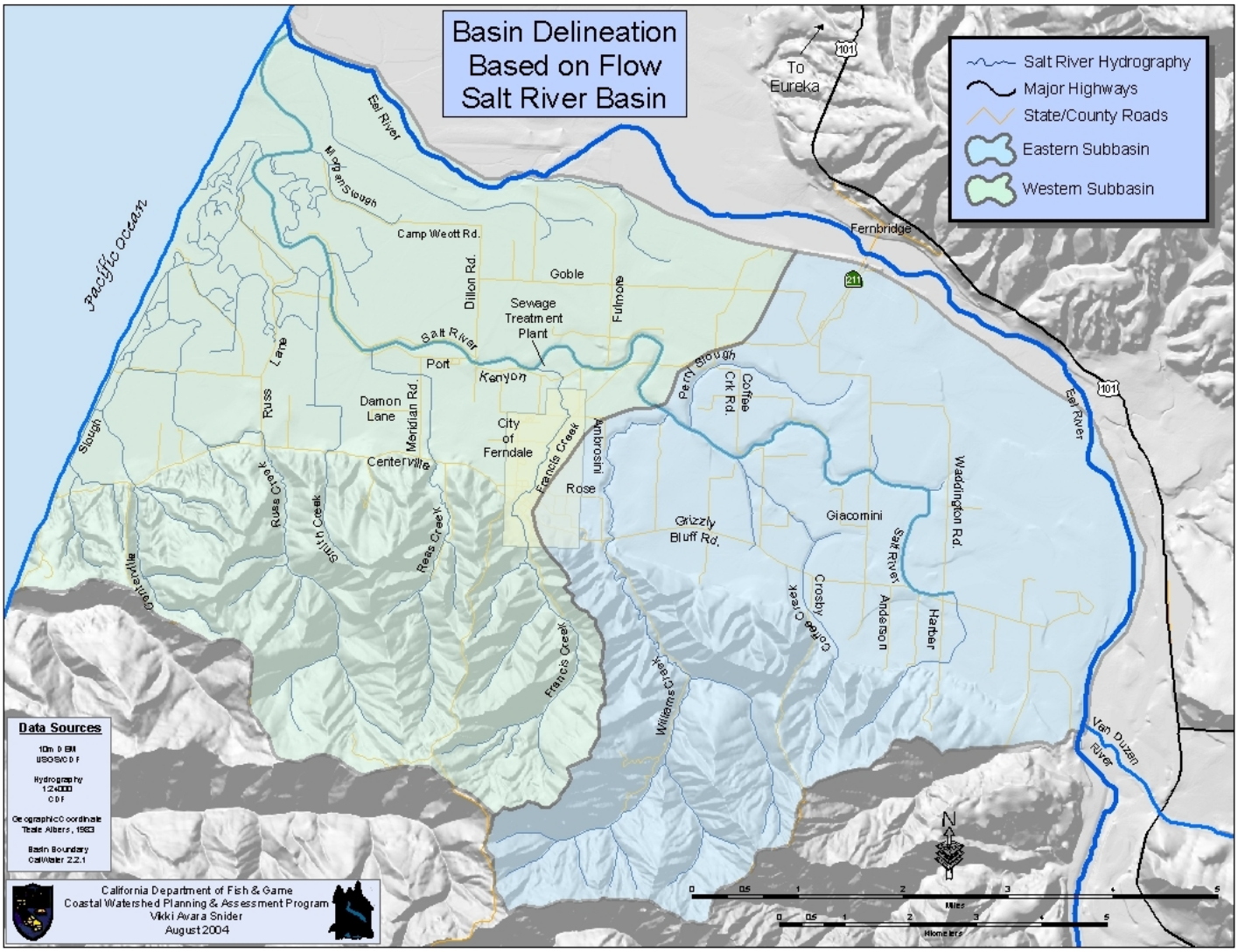

Figure 15. Salt River and Old River Watersheds, 2004.

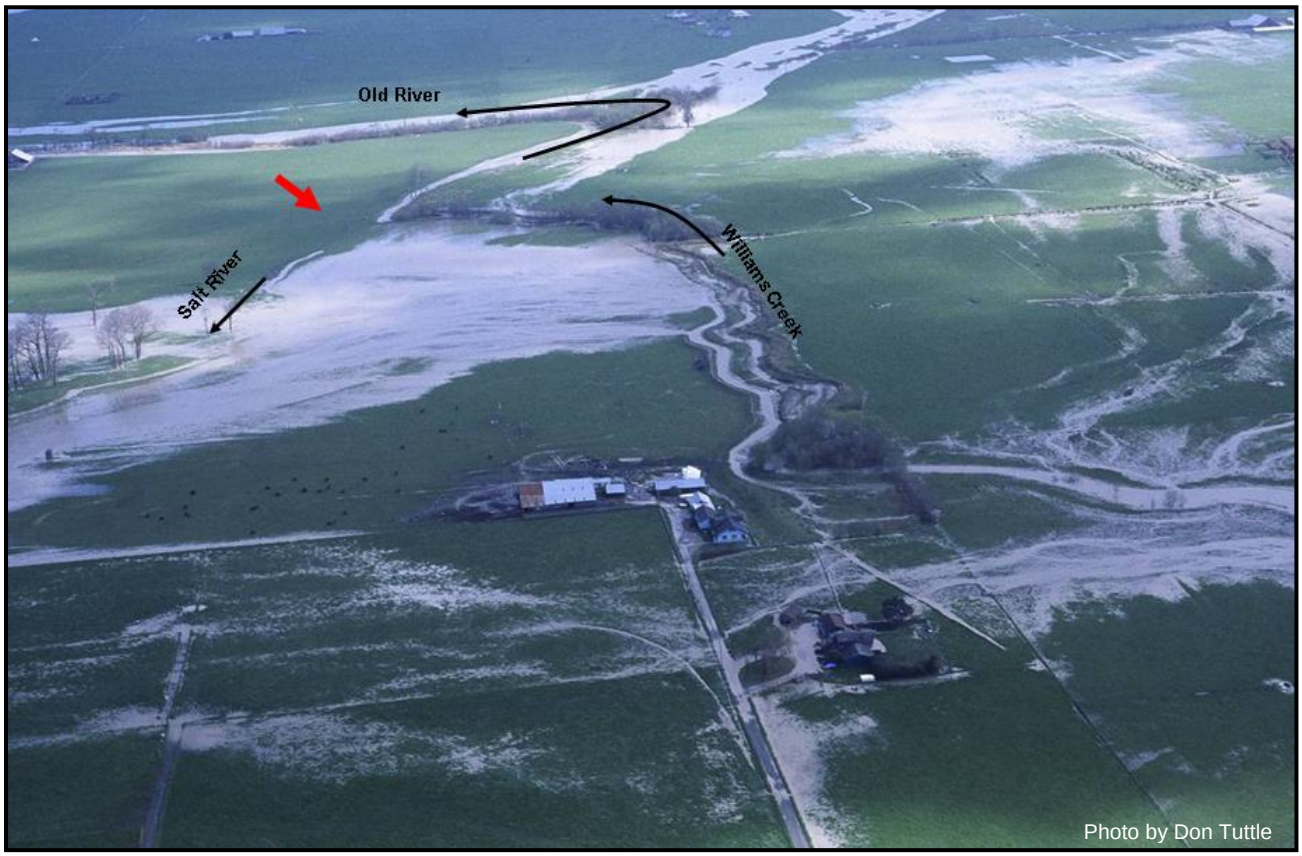

Figure 16. Williams Creek, Salt River and the Old River in February 2004.
Red arrow indicates the sediment plug in the Salt River at river mile 7.5.

Vegetation

Historic Vegetation Composition

In its pristine state, the Salt River Delta would have likely been dominated by a flood plain forest and water related features such as sloughs, freshwater wetlands, tributaries, tidelands, and mudflats. The floodplain forest would have been comprised of a mix of spruce forest and willow/ alder riparian forest with occasional presence of Redwood. In the vicinity of tributaries and other drainage features, the floodplain forest would have been bordered by wetlands and meadows/ fern prairies. The floodplain forest would have gradually transitioned into an estuarine wetland in the vicinity of Smith Creek. Historical reports, maps and photographs have shown that the Salt River Delta was once densely vegetated with a diversity of vegetation types:

- Fern prairies in the Ferndale area and Waddington area (Genzoli, 1972);
- Freshwater wetlands near the confluence of Williams Creek and Salt River (Herrick, 1880);
- A mix of pine and Sitka spruce forests (Westdahl, 1888);
- Riparian forests of alder, willow near watercourses (Schoolcraft 1853 in Eidness and VanKirk, 1988);
- An estimated 3,000 acres salt marsh and mudflats in the southwestern delta sections (Kellogg, 1884);

Early descriptions of the conditions of the Salt River Delta include field notes from George Gibbs in 1851.

> *"Much of this is, however, covered in thickets of willows. etc., and is subject to floods in the rainy season. Those tracts above the reach of the freshets are generally of fern prairies, rich, but not easily subdued. In approaching the coast, the country is much cut up with sloughs, communicating with the river, and near the mouth consists of salt marsh and tide-land…Game is*

excessively abundant, including deer, elk, bear, and all the fall and wintering ducks, geese, brandt, cranes, and other water fowl" (Schoolcraft 1853 in Eideness and Van Kirk 1988).

Ferdinand Westdahl, an employee of the U.S. Coast and Geodetic Survey described the changes in vegetation in the Eel River Delta region from the period between 1872 and 1888.

"The entire delta of the river has been covered with forests of pine, spruce, and here and there redwood, with alder growing near the water courses. The town of Ferndale consisted then of but a small number of houses and Port Kenyon was an unbroken forest. Now the two places almost merge into one another." Looking east from the ocean, "the forest formed an almost unbroken line across the low land. A great many houses are seen on the hills to the southward of the valley and the timber on these hills is greatly thinned out…these forests have nearly all cleared away, the timber remaining only in bunches" (Westdahl 1888 in Roberts 1992).

Current Vegetation Composition

Currently, 86% of the Salt River Delta is in agricultural production leaving 14% of the remaining land area for urban/ suburban development, roads, shrub land and riparian forests. To obtain this level of agricultural production, dramatic changes to the character of the delta have been made. As indicated above by historical reports, there were once many water related features on the Salt River Delta including: freshwater wetlands, tidelands, sloughs, and meandering tributaries. After 150 years, the wetlands have been drained, the tidelands cut off, the sloughs marginalized and the tributaries channelized.

Based on GIS analysis, the subwatersheds of the Salt River Basin are dominated by hardwood forests and areas of mixed conifer forests. Typical forest composition in the Wildcat tributaries consists of Sitka spruce, Douglas-fir, grand fir, alder, and big leaf maple. Hardwood forests compose 91% of the stream canopy cover in the Wildcat tributaries assessed by CDFG in 2003 and 2004.

Instream Vegetation

Prior to human settlement, instream vegetation growth in the Salt River was controlled by salt water intrusion and scouring river flow that maintained channel morphology. Halophytes, saltwater tolerant plants, were the only plants able to grow in or near the lower reaches of the Salt River.

By 1900, many changes had occurred in the Salt River Basin that drastically changed the hydrology of the system for the worse. In response to the degrading channel conditions in the mainstem Salt River, landowners cut the instream and riparian willows to keep the Salt River free of debris and sediment. Landowners were able to keep the entire river clear of vegetation by individually managing the willow growth adjacent to their property. The 1941 aerial photograph of the Salt River shows a river system that has no canopy cover from Arlynda Corners to the ocean. The manual removal of willows in the mainstem Salt River was curtailed by CDFG in the late 1970's. Now the growth of willows and other freshwater vegetation in the Salt River channel between Francis Creek and Reas Creek is prolific and represents one of the causes for the Salt Rivers dysfunction.

Instream vegetation slows water velocity causing suspended sediment to fall out of suspension and deposit on the channel bottom. The cycle of instream vegetative growth and sediment deposition is self perpetuating. The Salt River channel in some areas has completely filled with sediment and instream vegetation; functioning now more as a wetland than a river. The encroachment of freshwater vegetation in the Salt River channel can be attributed to a number of factors including a loss of tidal prism, excessive sediment deposition in the mainstem Salt River, a reduction in hydrologic energy caused by the construction of the Leonardo levee, and a mandate that stopped the unregulated removal of trees from the riparian corridor of the Salt River.

Managing Riparian Areas

Riparian areas are identified by soil characteristics and distinctive vegetation. Vegetation in a riparian area grows on or near the bank of a stream on soils that exhibit some wetness characteristics during some portion of the growing season. Riparian areas are often thought of as the terrestrial extension of an aquatic habitat.

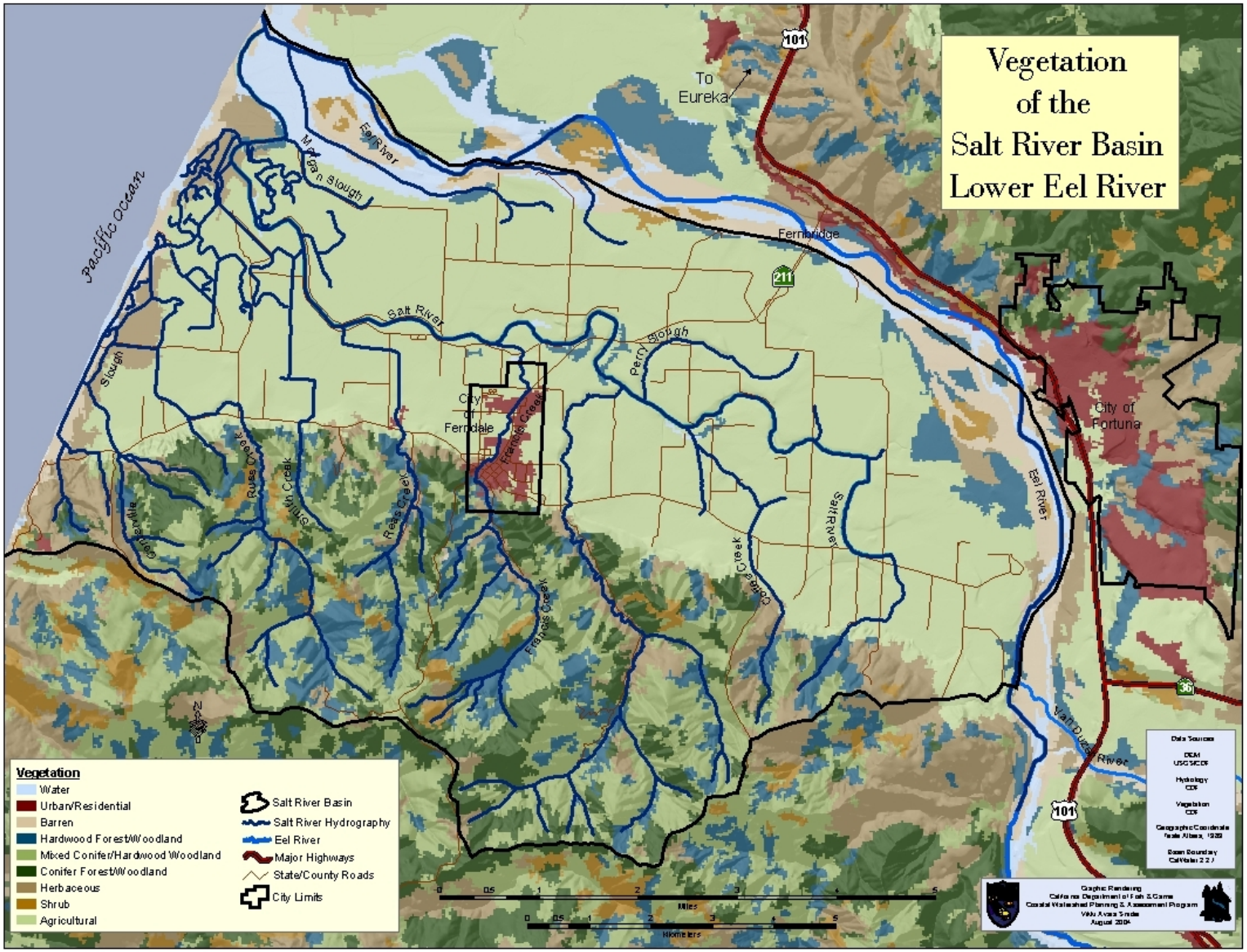

Figure 17. Vegetation types on the Salt River Delta and Wildcat tributaries.

Riparian corridors are the critical link between terrestrial and aquatic systems which allow for a rich diversity of terrestrial and aquatic plants and animals. According to the California Department of Fish and Game *Salmonid Stream Habitat Restoration Manual*, approximately 95% of the historic riparian habitat has been lost in California. California residents, landowners, and agencies are becoming increasingly interested in promoting and enhancing watershed processes; particularly riparian corridor management. Often riparian corridors are enhanced to provide shade canopy to decrease and maintain water temperature. A fully functioning riparian corridor can help maintain channel integrity, reduce erosion damage to adjacent lands, as well as filter sediment and pollutants.

Riparian Deforestation

Riparian corridors in the Salt River Basin are, in places, lacking riparian vegetation; particularly, the Wildcat tributaries. The trans-delta reaches of the Salt River tributaries, such as in Reas Creek tend to have little to no riparian vegetation. Riparian deforestation typically results in a decline of ecological integrity (MacGibbon 2001) including**:**

- Increased instream nuisance vegetation and periphyton;
- More rapid and extensive changes in bed morphology;
- Increased magnitude and intensity of floods;
- Changes in seasonal flow patterns, especially in summer low flows;
- Loss of native fisheries habitat due to increased summer maximum temperature;
- Decreased water quality including reductions in dissolved oxygen;

Although it is not indicated on Figure 17, cattle grazing occurs in Williams, Francis, Reas and Russ creeks. These valleys provide valuable grazing land; however, the impacts of cattle on stream quality are apparent. It should be noted that there are only a few areas in the Salt River Basin with riparian exclusion fencing. In stream reaches that are heavily impacted by livestock, exclusionary fencing can give the stream bank enough protection to recreate healthy stands of native vegetation. By fencing riparian areas, stream health will be promoted by limiting the direct input of nutrients and bank trampling until riparian vegetation reaches mature development and can withstand stock impacts. Free access of livestock to streams greatly accelerates stream bank erosion (MacGibbon, 2001):

- Intensive grazing of stream banks reduces the ability of the bank to resist the erosive forces of flooded streams;
- Treading and trampling of banks exposes soil to erosion;
- Livestock accessing the stream for water tend to cut their own paths which can become drainage points for runoff and sources of sediment and nutrient to the stream;
- The sheer weight of cattle can accelerate stream bank slumping.

Table 9. Vegetation habitat types in the Eel River Estuary.

The following information is a summary of the vegetation survey of the Eel River Delta that was written by Annie Eicher and Mignonne Bivin as part of the larger Biological Conditions of the Eel River Delta that was prepared for the Eel River Conservation District in 1991

Riparian Forest: Near-stream fringe of vegetation bordering the Eel and Salt Rivers	• Habitat type with the highest species diversity; • Most common species includes: arroyo willow (*Salix lasilepis*) 70% occurrence, 30% cover. Other willow species includes Pacific willow (*S. lasiandra*), Sitka willow (*S sitchensis*); • Red alder (*alnus rubra*) – Common component of riparian forest canopy- 50% occurrence and 17% cover; • Black cottonwood (*Populus trichocarpa*) occurred occasionally, tended to be the dominant species where it was found, and reached 60 feet tall; making it the tallest tree in riparian; • Dominant shrub: California blackberry (*Rubus vitifolius*) 87% frequency, 22% cover. Thimbleberry (*R. parviflora*) was common, salmonberry (*R spectabilis*) was occasional; • Herb Stratum includes: stinging nettle (*urtica dioica*), poison hemlock (*conium maculatum*), cow parsnip (*hercleum lanatum*), sword fern (*polystichum munitum*), and horsetail (*Equisetum*);
Riparian Scrub Shrub: Riparian areas lacking woody vegetation and poorly developed herb stratum.	• Occurs in places on the Eel that typically receive high water, occurring on rocky alluvium; • Sitka spruce , black cottonwood were co-dominant; • Arroyo willow, sandbar willow and pacific willow were common members of the scrub- shrub.
Levees*:* Human-made barrier between surface water and adjacent land and often separates streams from its floodplain.	• Vegetation varied based on adjacent vegetation type; • Mostly coyote brush (*Baccharis pilularis var consanguinea*).
Sand Dunes: Coastal strip north and south of the mouth of the Eel River.	• Dominated by European beach grass (*Ammophila arenaria*) (80% occurrence, 48% cover), an introduced non-native invasive weed; • Beach layia (*layia carnosa*), an endangered dune species. Estimated cover of beach layia is 1-5 %.
Pasture: Majority of the delta is low-lying lands that are in agricultural production.	**Upland:** Species composition depends upon what is planted in adjacent lands. • Kentucky bluegrass (*Poa pratensis*), perennial ryegrass (*Lolium perenne*), clover (*Trifolium spp*.), field mustard (*Brassica campestris*), creeping buttercup (*Ranunculus repens*)
	Wet Fresh: Includes areas that are typically ponded or temporarily flooded by freshwater runoff. • Creeping spikerush (*Eleocharis palustris*), spreading bentgrass (*Agrostis stolonifera*), silverweed (*Potentilla anserine*), creeping buttercup, soft rush, manna grass (*Glyceria occidentalis*), dock (*Rumex spp*.), canary grass (*Phalaris arundinacea*)
	Wet Brackish: Includes areas that receive tidal seepage from adjacent or nearby tidal sloughs. • Spreading bentgrass, creeping spikerush, silverweed, dock,

Salt Marsh: Occurs near the mouth of the Eel and Salt River and on islands, bordering a network of tidal sloughs	• Historic range greatly reduced;
	• Lowest species diversity of delta habitat types, which is characteristic of salt marshes;
	• Dominant plant species was Chilean cordgrass (*Spartina densiflora*) introduced from Chile in 1860 (80% occurrence, 37% cover);
	• Common salt marsh plants include natives:
	  • perennial pickleweed *(Salicornia virginica)*;
	  • salt grass (*Distichlis spicata*);
	• Areas characterized as a less saline environment supported:
	  • tufted harigrass (*Deshampsia caespitosa*);
	  • alkali bulrush (*Scirpus robustus*);
	  • lyngbye'e sedge (*Carex Lygbyeii*);
	• Rare endemic, **Humboldt Bay gumplant** (*Grindelia stricta spp. Blakei*). Endemic to Humboldt Bay and the Eel River delta- mean cover 3%;

Vegetative Cover Type	Percent of Subbasin	Primary Vegetation Type	Percent of Cover Type
Agriculture	50	Agriculture	100
Mixed (conifer stand with hardwood)	17	Sitka spruce Alliance	44
		Douglas-Fir – Grand fir Alliance	31
		Sitka spruce – Grand fir Alliance	25
Hardwood	10	Red alder Alliance	85
		Black cottonwood Alliance	7
		Mixed riparian hardwoods Alliance	3
		Willow Alliance	3
		Freemont cottonwood Alliance	2
Herbaceous	9	Annual Grass/Forb alliance	93
		Pickleweed – Cordgrass Alliance	7
Conifer	9	Sitka spruce Alliance	46
		Douglas-Fir – Grand fir Alliance	40
		Sitka spruce – Grand fir Alliance	12
		Sitka spruce – Redwood Alliance	2
		Monterey Cypress Alliance	<0.5
Barren	3	Barren	58
		Dunes	42
Shrub	1	Willow (Riparian Scrub) Alliance	58
		North Coastal Shrub Alliance	42
Urban	1	Urban	100

Land and Resource Use

Historic Land Use

Native Inhabitants

Wiyot people have inhabited California's north coast since time immemorial. The ancestral lands of the Wiyot people start at Little River and continue down the coast to Bear River Ridge, then inland to the first set of mountains. Modern towns that are within traditional Wiyot territory include McKinleyville, Blue Lake, Arcata, Eureka, Kneeland, Loleta, Fortuna, Ferndale, and Rohnerville.

This area has long been renowned for its majestic redwood forests and abundant salmon runs. Before the coming of European settlers, Wiyot people were centered on Wigi (Humboldt Bay) and inland to the first set of mountains. Wiyot people would hunt the area's wildlife, fish for salmon, and gather roots for medicine, food and basketry. Major village sites were located along the rich waterways such as the Wiyot (Eel River), from which the Wiyot people derived their name; Potowat (Mad River), Iksori (Elk River); and today's Van Duzen River.

There were smaller villages located inland and along sloughs and smaller waterways that led to Wigi. The village of Wotwetwok was located along Oka't (Salt River) and had numerous families living in it. The families would fish, hunt, and gather along Oka't and use it to navigate to Wiyot and then out to the Pacific Ocean. With the European development of Ferndale and the Eel River delta, these families were displaced from Wotwetwok and the Oka't area to make way for cattle that the settlers brought to the area.

Before 1850, Wiyot people were numbered in the several thousands. By 1860, there was an estimated population of only 200 people left. By 1910, there were less than 100 Wiyot people estimated to live within ancestral Wiyot territory. This rapid decline in population was due to disease, slavery, family displacement, murder, and massacres.

Currently, there are approximately 150 residents that reside on the 88 acres that make up the Table Bluff Reservation. The reservation is located 16 miles south of Eureka near Loleta. Additionally, there are 300+ enrolled tribal members that are living off the reservation in the surrounding cities and towns, or elsewhere within the United States.

Submitted by Marnie Atkins, Cultural Director
Table Bluff Reservation- Wiyot Tribe

Shipping

Port Kenyon was established on the banks of the Salt River around 1876, with the intention of establishing a trade route from the Eel River to San Francisco. At that time, the Salt River was large enough to accommodate relatively large boats, the steamer Thomas A. Whitelaw was 136 feet long and had a depth of 13'3 feet (Edeline 1983). The Thomas A. Whitelaw was the first ship commissioned to make regular runs between Ferndale and San Francisco (*Where the Ferns Grew Tall* 1977). According to testimony given by Andrew Swickard in 1899, the width of the Salt River at the confluence with the Eel River was 380 feet. At that location Mr. Swickard also stated that the maximum depth was 18 feet at mean high tide. The width of the Salt River near Port Kenyon was approximately 200 feet wide and was 15 feet deep (USDA 1993). The Eel River shipping industry began in earnest in 1870 and came to an end in 1909 after the steamer *Argo* was beached on the Eel River spit.

Figure 18. Steamer Argo docked at Port Kenyon

The transportation of goods from the fertile soil of the Eel River Delta to San Francisco was a constant dilemma. The residents of the Salt River Delta lived in relative isolation as they were separated from Humboldt Bay by Table Bluff, and the Eel and Salt rivers. Ferries were one of the only means by which they could cross the Eel River. There were four ferries that operated on the Eel River from 1861 to around 1916 (*Where the Ferns Grew Tall* 1977). The ferries stopped operating shortly after the completion of Fernbridge.

Several bridges were built across the Salt River and its various sloughs; however, few structures remained permanent on the delta after the torrents of the Eel River. A shipping industry was the only means by which the residents could efficiently export their goods, but even the shipping was unreliable. The passage into the Eel River presented many ships with troubles, which worsened as the channel filled with sediment. At the request of local residents, government surveyors assessed the possibilities of establishing a permanent shipping industry out of the Eel River. A canal through Table Bluff was suggested to transport goods from the Eel directly to Humboldt Bay (Rees 1917). Other infrastructural improvements were suggested including jetties off the mouth of the Eel River. It was noted by the chief engineer that navigational improvements on the Eel River could also serve as efforts to control the river during flood periods. Government investment and interest was denied on the account of the Eel Rivers close proximity to Humboldt Bay and the unpredictable nature of the Eel River.

Transportation on the north coast changed quickly with the shipping success of Humboldt Bay, the advent of the Northwestern Pacific Railroad, and the later proliferation of the automobile and subsequent highway construction. The shipping industry out of Port Kenyon existed for almost 40 years; however, access through the Eel River spit worsened annually and was particularly dangerous during the late summer. Regardless, the forty years of shipping out of Port Kenyon helped to establish Ferndale as the agricultural center of Humboldt County.

Navigation of the Eel River was limited by several factors:

- Ecological changes induced by dramatic land use changes made shipping impossible as the river became too shallow;

- There were not enough exports to facilitate an Eel River shipping industry;
- Technological advances in transportation made the development of the Eel River shipping industry unnecessary.

Timber Harvest

The Enterprise Lumber Mill opened in 1878 operating on the west bank of the Salt River, at the mouth of Soulay Slough, 4 miles from the confluence with the Salt and Eel River and 1 mile from Port Kenyon (Edeline 1983). The mill was able to cut 20 thousand feet of redwood and 15 thousand feet of spruce and pine per day, which were abundant on the Salt River delta. "Timber supply for the mill was inexhaustible, as there were millions of spruce and pine trees within a five mile radius from the mill, and on the Eel River countless millions of redwoods" (Edeline 1983). A new mill was built in 1887 that cut on average 28 thousand feet per day. Timber products were exported from Port Kenyon to San Francisco. When the ships stopped coming to Port Kenyon, the mill was primarily reliant on local demand because Humboldt Bay had become the primary port for trade on the North Coast.

Current Land Use

Agricultural Land Use

The Salt River Delta is approximately 17,695 acres, of which approximately 15,243 acres are in agricultural production (LaVen 1994). Dairy farming is the dominant type of agriculture on Salt River Delta. Other agricultural activities include the production of beef cattle, hay, silage and corn. As of 1994, the average dairy farm size was 162 acres. The peak population of dairy cows on the Salt River delta occurred in 1965 with over 18,500 cows being milked; in 1994, there were approximately 14,500 cows (LaVen 1994).

Specific land practices in the delta region are dependent upon proximity to the Salt River and Pacific Ocean. In general, land management becomes more difficult and more complex as one approaches the tidal zone and less complex in the Grizzly Bluff area (LaVen 1994). Some pastures in the Salt River region are grazed year-round; however, most cows are generally pastured from late April through October or November. During the rainy season, cows are often confined either using free stalls, unpaved lots with limited housing or open corrals lined with three to four feet deep wood chips (USDA 1993).

Much of the Salt River Delta is classified as prime farm land by the United States Department of Agriculture. Prime farm land is classified based on: soil quality, growing season and available water capacity to produce high yields economically. There is a sizeable portion, mostly in the western delta that is too wet and too saline to be considered prime farmland.

There are 13 organic dairies in Humboldt County, 11 of which are located on the Eel River Delta and 8 are located within the project area. Organic dairy farms in the Salt River Delta comprise approximately 3,500 acres, which is roughly 23% of the land in agricultural production in the Salt River Delta (Eicher 2004). The USDA has defined organic foods as "a production system that is managed to respond to site specific conditions by integrating cultural, biological and mechanical practices that foster cycling of resources, promote ecological balance and conserve biodiversity" (Greene 2001). The conversion of conventional farms to organic farms on the Salt River Delta was precipitated by the higher prices paid for organic dairy products. Existing pasture-based dairy farming on the Salt River Delta lends itself to a relatively easy conversion to qualify to the USDA organic standards.

Urbanization

The urban area of Ferndale is 540 acres or 0.85 square miles. The population of the City of Ferndale is 1,382 as of 2000 (US Census 2000). Urbanization in the Ferndale area is an important management concern in the Salt River Basin. The City of Ferndale is straddled upon Francis Creek and also encompasses two significant drainages known as East side and West side drainages.

The upper portion of Francis Creek flows through steep forested hills where livestock grazing and timber harvest are the major land use. Two miles of lower Francis Creek have been channelized and straightened through downtown Ferndale. Additionally, the Ferndale wastewater treatment facility is located at the confluence of Francis Creek and the Salt River.

The 1854 and 1894 maps of Francis Creek clearly show the confluence of a tributary in the vicinity of Port Kenyon Road, which is now known as East side drainage (Figure 19). In addition to draining the eastern part of Ferndale, East side drainage receives overflow from both Francis and Williams Creek (Spencer Engineering 2004b). Due to a century's worth of modifications, East side drainage no longer has a confluence with Francis Creek. During the rainy season East side drainage now flows down Market Street ditch across Port Kenyon Road and into 'Lake Vevoda.' This configuration of East side drainage causes several private landowners significant risk of flooding and loss of agricultural production and is a concern of the City of Ferndale.

The Westside drainage consists of a network of street gutters, drainage channels and culverts (Spencer Engineering 2004b). According to Spencer Engineering Inc. the drainage channels are densely vegetated and draining at full capacity. Westside drainage runs north toward Port Kenyon Road where "runoff ponds, percolates, or drains west in a small agricultural ditch (Spencer Engineering 2004b)."

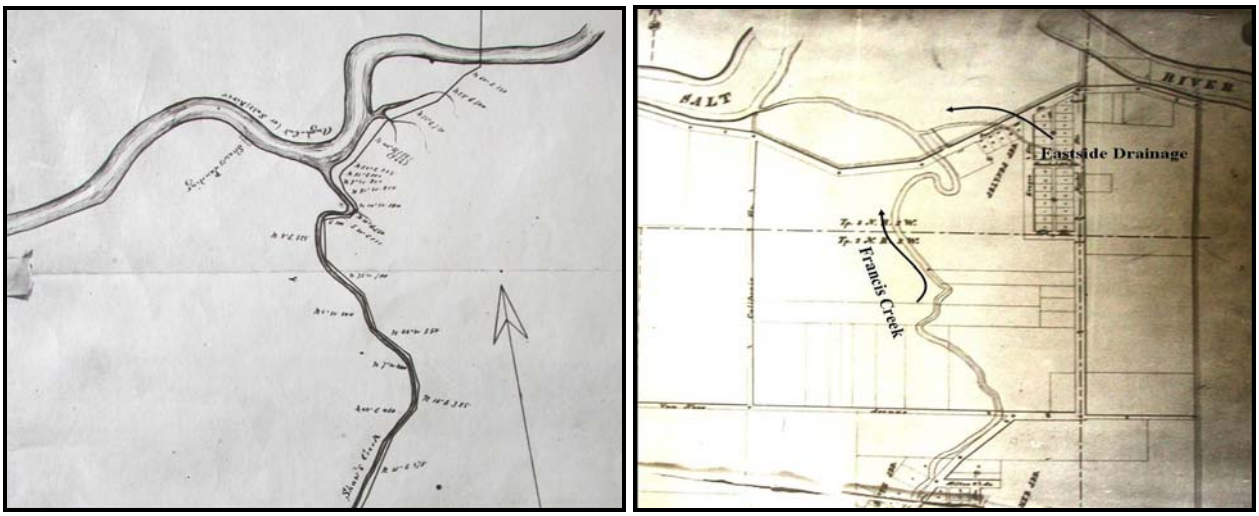

Figure 19. The confluence of Francis Creek and the Salt River and Eastside Drainage in 1854 (left) and in 1894 (right).

In 1986, the Ferndale City Council recognized flooding and erosion hazards into its general plan. Flooding of Francis Creek had caused business and property losses and required expenditures for stream bank repair and city cleanup. In 1990, the Drainage Master Plan was adopted by the City of Ferndale, which has since been updated in April, 2004. The Drainage Master Plan sought to identify drainage problems, establish prioritized drainage projects and to improve the flood capacity of Francis Creek.

In the past, the flood capacity of Francis Creek had been restricted by culverts, bridges, sediment build-up instable banks and debris. A series of flood mitigation projects on Francis Creek have improved Francis Creek flood capacity from 250 cfs to 750 cfs. Flood mitigation funding for Francis Creek was provided through various sources including: Federal Emergency Management Agency (FEMA), Caltrans, and California Department of Water Resources Urban Streams Project. At least $1,034,000 of monies were spent on Francis Creek improvements from 2000 to 2002 (Spencer Engineering, 2004b). The first of three flood mitigation phases began in 2000 and phase 2 and 3 were completed by 2002. Various methods were used to widen and improve the Francis Creek channel including: large rock slope protection, re-vegetation with native plant species to enhance stream bank functions and provide canopy cover, and instream habitat enhancement structures.

The City of Ferndale has identified eight major drainage problem areas in its 2004 Drainage Master Plan. To address the identified drainage problems the city expects that $1,028,000 is necessary to complete the various projects. The city has also identified the need to develop a Market Street Drainage Plan which would identify drainage problems and solutions in the Eastside drainage. Ultimately, the Eastside drainage needs to be reintroduced into Francis Creek near its historic confluence.

Non-urban development in the Salt River Basin is another concern that is a risk to the existing quality of

life, available farmlands, and water quality caused by new erosion sources.

Recreation and Public Lands

Russ Park, a 105 acre tract, was donated to the City of Ferndale by Mrs. Zipporah Patrick Russ in 1920. The land was given to the city under the conditions 'that the property be used forever as a park and recreation grounds…as a refuge and breeding place for birds.' Russ Park is dominated by second growth Sitka spruce and grand fir and interspersed with western red cedar, and Douglas fir. Estimates place the oldest tree in Russ Park as 130 years old.

Forest Management

Each year, timber harvest occurs on an average of 0.8% of the Salt River Subbasin. Since 1999, each of the tributary watersheds except for Coffee Creek has had harvesting occur, although the majority of these areas have only been entered (harvested) once or twice.

Timeline

The Salt River Basin has undergone significant changes and modification since Euro-American settlement of the Eel River Delta 150 years ago. Many of the modifications have had unforeseen cumulative ecological and hydrological impacts. The rate of change in the system over the last 150 years has been slight; however, the Salt River has now reached a point where the change has rendered the system hydrologically incompetent.

Pre-1850	**The Eel River Delta is home to the Wiyot people, the Wildcat Range representing the southern extent of the Wiyot territory;**
1852	**The Shaw brothers settle the land near the current site of Ferndale;**
≈1884	**An extensive system of levees is constructed in the estuary adjacent to the Salt River. An estimated 2,900 acres of tideland are reclaimed for agriculture and at least 700 acres of freshwater wetland are reclaimed near Williams Creek;**
≈1890	**Four dams with tide control devices are constructed in sloughs tributary to the Salt River. These dams contribute to the reduction of the Eel River Estuary tidal prism;**
1901	**U.S Court of Appeals recognizes that the tide control structures on Centerville Slough have negative effects on the navigability of the Salt River;**
1911	**Fernbridge is completed connecting Eel River Delta, Bear River, and Mattole Valley residents to the Humboldt Bay region;**
1955	**Second largest flood recorded on the Eel River: discharge peaks at 27.7 feet at Fernbridge;**
1964	**Largest recorded flood in the Eel River: discharge peaks at 29.5 feet at Fernbridge;**
1967	**The Leonardo Levee is constructed in the southeastern delta to reduce Eel River flooding;**
≈1970	**Department of Fish and Game curtails the unregulated cutting of riparian vegetation in the Salt River Basin;**
1975	**Ferndale wastewater treatment plant is built at the confluence of Francis Creek and Salt River;**
1978	**Sediment plug forms in the Salt River channel upstream of Williams Creek (R.M 7.7) diverting Coffee Creek flow from the Salt River Basin into the Old River/ Perry Slough;**
1987	**The Eel River Conservation District (RCD) is formed by popular vote in March, with the primary purpose of addressing resource problems associated with sedimentation and flooding along the Salt River;**
1988	**The Eel River RCD requests assistance from the USDA Soil Conservation Service to investigate problems associated with accelerated sedimentation in the Eel River Estuary and Salt River channel;**
1989	**Army Corps of Engineers (USACE) funding that had been approved in 1986-1987 to address flooding in the Salt River is denied. USACE determined that the Salt River problems were associated with drainage and not flooding and therefore did not qualify as a Corps project;**

1990 **Ferndale publishes their Master Drainage Plan that identifies drainage problems in the Francis Creek watershed;**

1992 **Ferndale Earthquake (M 7.1) triggers landslides in Francis Creek and elsewhere in the watershed and causes coastal uplifting near Petrolia;**

1993 **The Salt River Basin- Local Implementation Plan is published by the USDA- Soil Conservation Service;**

1996 **Riparian vegetation hanging in the Salt River channel is removed from Riverside Ranch to Francis Creek by the California Conservation Corps;**

1997 **Federal listing of coho salmon as "threatened" under the Endangered Species Act;**

1998 **Sediment plug forms downstream of Williams Creek (RM. 7.5) diverting the flow into the Old River/ Perry Slough making Francis Creek the headwaters of the Salt River. A total of 42% of the Salt River Basin is diverted into the Old River/ Perry Slough;**

1999 **Federal listing of Chinook salmon as "threatened" under the Endangered Species Act;**

2000 **City of Ferndale, begins work on the Francis Creek flood mitigation project funded through the Department of Water Resources -Prop. 13 and Caltrans;**

2000 **Federal listing of steelhead trout as "threatened" under the Endangered Species Act;**

2002 **Francis Creek flood mitigation project reaches completion with funding from Department of Water Resources Urban Streams Project;**

2002 **State listing of coho salmon as "threatened" under the California Endangered Species Act;**

2003 **Army Corps of Engineers begins to draft the Salt River Project Management Plan under the aquatic ecosystem restoration program;**

2004 **Salt River Advisory Group (SRAG) is established to build a partnership between private landowners living adjacent to the Salt River and public groups including:**

- **California Department of Fish and Game;**
- **Humboldt County Resource Conservation District;**
- **Natural Resource Conservation Service;**
- **City of Ferndale;**
- **California Coastal Conservancy;**
- **Humboldt County;**

2004 **Funding for the Army Corps of Engineers aquatic ecosystem restoration program on the Salt River restoration is eliminated;**

2004 **Four hundred thousand dollars of funding for the Salt River project is secured through extensive contractual agreements with two state agencies; CA Department of Fish and Game (CDFG) and CA Coastal Conservancy (CC);**

2004 **An extensive amount of work has been completed on the Salt River Project to date:**

- **Salt River aerial photo composite maps provided by Humboldt County;**
- **Salt River Bibliography and Literature Search Report;**
- **Congressman Thompson requests appropriations for the Salt River;**
- **NRCS-Watershed Planning Services unit pledges assistance;**
- **Salt River and Francis Creek Thalweg and Channel Survey conducted by Spencer Engineering;**
- **Aerial reconnaissance Salt River flood conditions on 2/18/04 conducted by Humboldt County;**
- **NRCS releases draft report of the Salt River rare plant survey by NRCS landscape ecologist;**

- **CDFG publishes draft stream / fishery survey reports on Francis, Williams, Russ and Reas creeks;**
- **CDFG establishes contract with Northwest Resources to conduct upslope erosion assessment;**
- **CDFG releases draft Salt River Watershed Assessment with recommendations;**
- **Estuarine hydrological analysis is initiated in May 2005**

1963

1965

2000

2004

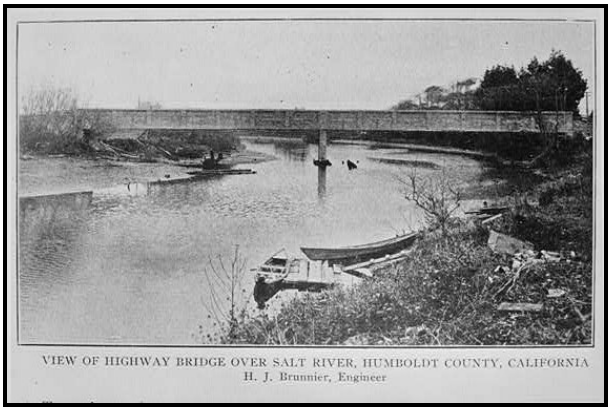

Figure 20. Aerial view of Salt River at Dillon Road Bridge in 1963, 1965, 2000, 2004. Cross-section view of Valley Flower Bridge (Dillon Road Bridge) from 1920 (left) and early 1990's (right)

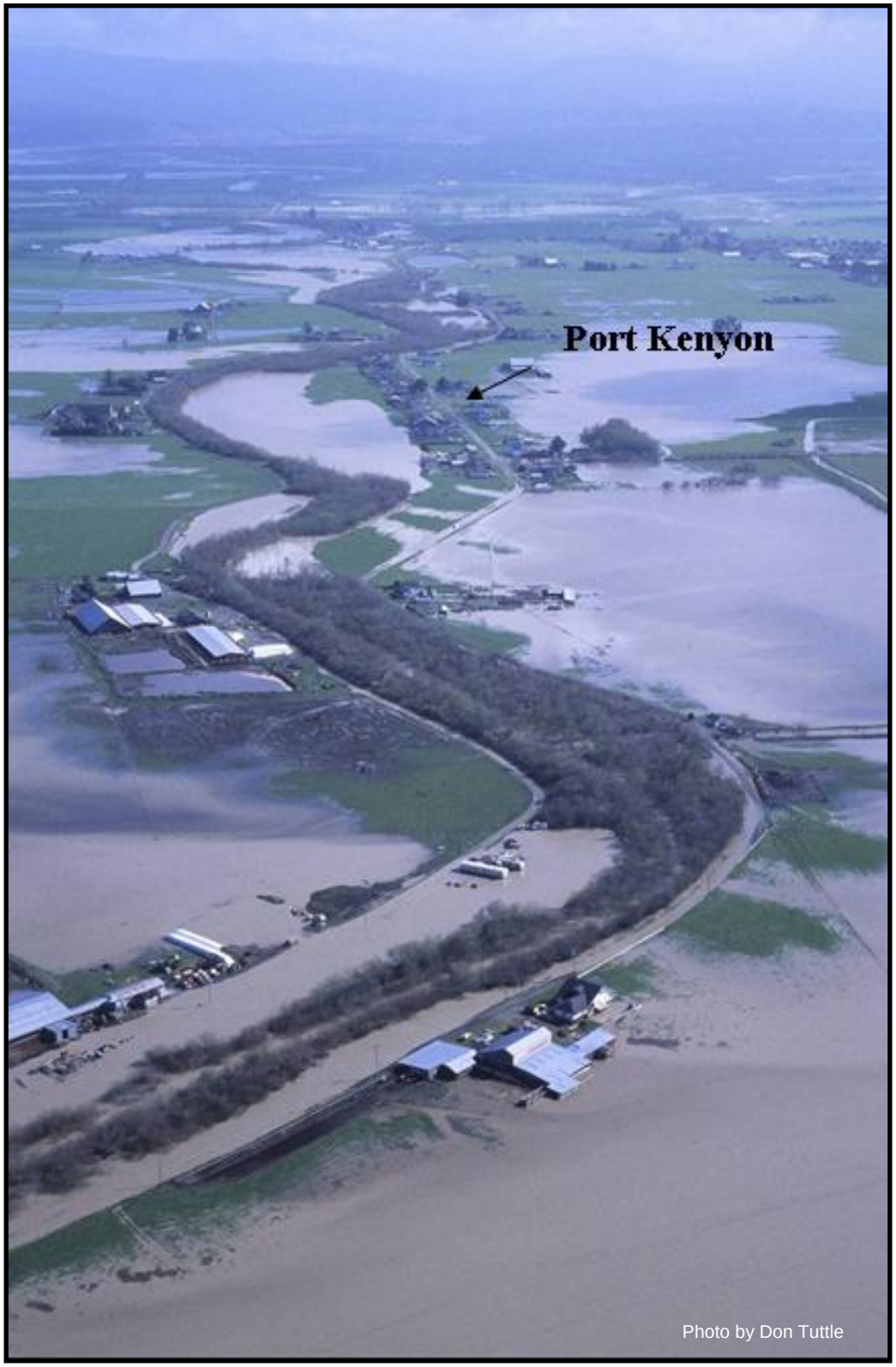

Figure 21. The Salt River during February 2004.