Appendix F

PSIAC Model: Sediment Yields in Sub-watersheds of the Petaluma River

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Southern Sonoma County
Resource Conservation District
Petaluma, CA.
October, 1998

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Summary

The Pacific Southwest Inter-Agency Committee (PSIAC) is an empirical model that can be used as a watershed assessment tool to estimate average annual rates of sediment yield. Sediment yield may be defined as the volume of sediment that reaches some arbitrary point in the watershed. For the Petaluma watershed, that arbitrary point is the valley floor where the gradient of each creek levels out and the sediment drops out.

In the Petaluma watershed, Lichau, Willow Brook, Lynch, Adobe and San Antonio were evaluated using the PSIAC model. These five sub-watersheds were chosen based on a number of factors including historical data available, accessibility and existing riparian habitat. The primary factor was watershed size and its potential to deliver sediment into the Petaluma River.

In using the PSIAC model, nine factors were evaluated and assigned a rating. This assessment includes the surface geology, soils, climate runoff, topography, ground cover, land type, upland erosion and channel erosion/sediment transport in each sub-watershed. Each factor is evaluated independently and assigned a rating. The nine values are then summed up for a total rating. A rating sheet developed by PSIAC from empirical data correlates total rating values to average annual sediment yield. PSIAC results are initially reported in acre-feet per square mile per year. Conversion to tons per acre per year requires assuming a unit density of the sediment, which typically ranges from 70 – 110 pounds per cubic foot. We assumed average density for clay loam and soils of equal density which is representative of the area in this study.

In the course of using the PSIAC model in the Petaluma watershed, cross checks were performed to evaluate the model's effectiveness. An analysis, by the U.S. Geological Survey, of sediment transport and yield to the San Francisco Bay system between 1909 – 1966 was used to compare with values generated by the PSIAC model. Natural Resources Conservation Service TR-55 program was used to estimate runoff and peak discharge for Lynch Creek, which was then used to help assign ratings for the runoff subfactor for each of the subwatersheds.

The PSIAC model generated sediment yield values close to actual sediment yield data gathered from USGS. This cross-check adds confidence in the values from the PSIAC model. However, used as a watershed assessment planning tool, these values are best used to compare the sub-watersheds in terms of relative sediment contribution to valley floor and Petaluma River and not primarily used as data.

Recommendations:

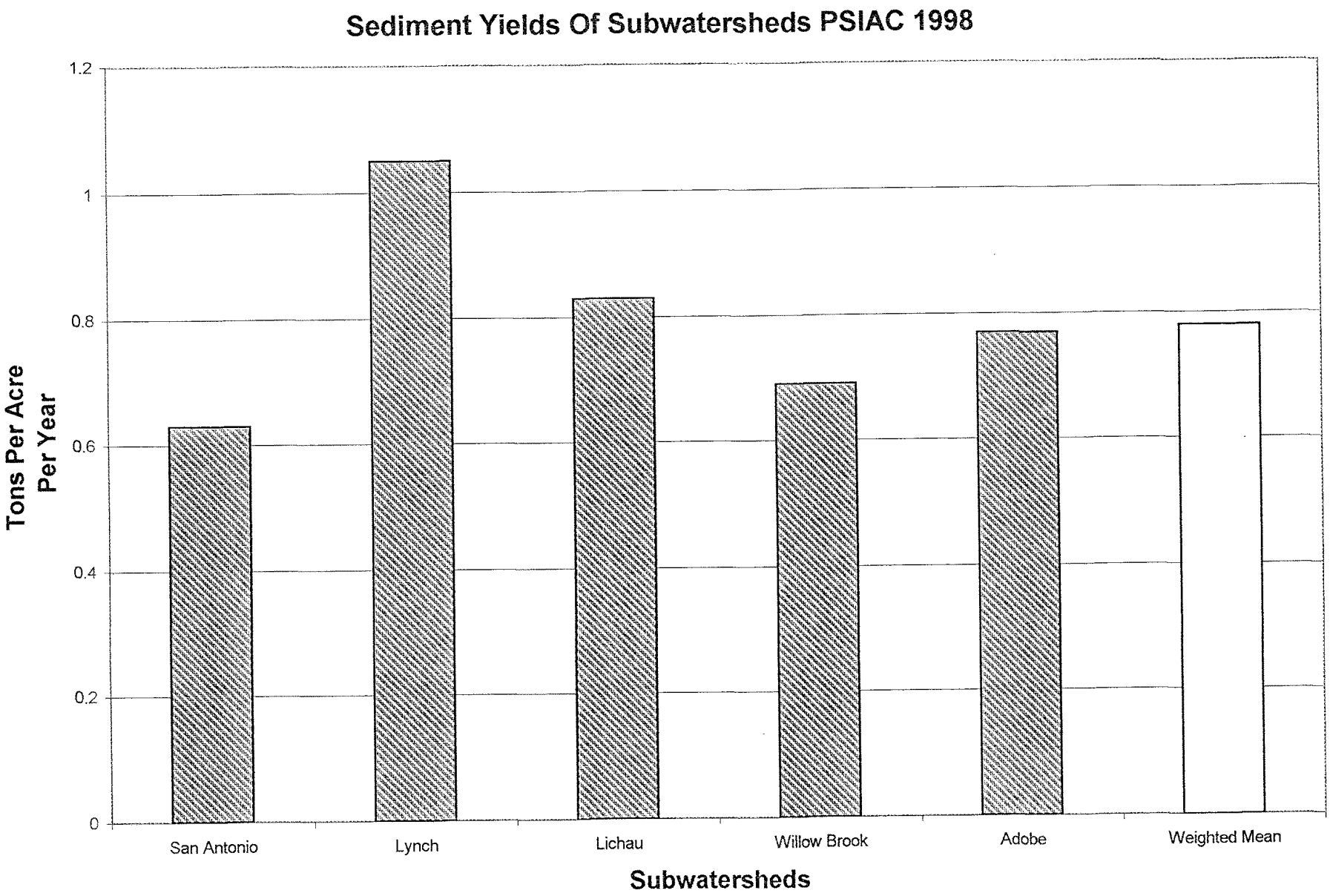
A criteria should be developed to prioritize the sub-watershed in terms of sediment reduction potential and/or technical feasibility. Elements of the criteria may include results of this sediment yield report, land ownership, potential cooperators, road

network, feasibility of restoration, erosion control (variety of treatment options, heavy equipment vs. hand work, impacts of work, accessibility), and other pertinent factors. Sub-watersheds determined to have higher potential or priority would require detailed erosion and sedimentation field studies to determine specific treatment options.

1998 PSIAC Sediment Yield Factors Table

Criteria (range)	Geology (0-5)	Soils (0-10)	Climate (0-10)	Runoff (0-10)	Topography (0-20)	Cover (-10-10)	Land Management (-10-10)	Upland Erosion (-10-10)	Channel Erosion & Sediment Transport (0-25)	Total (1-135)	Sediment Yield (tons per acre per year)	Sediment Yield (tons per square mile per year)	Density of Sediment (lbs per cubic foot) *	Approximate Area In (acres)	Approximate Area in (square miles)
San Antonio	3	6	5	5	6	-7	-6	3	12	27	0.63	403	84	22400	35
Lynch	3.3	5.1	5	7	8	-4	-5	8	15	42	1.05	677	84	2200	3.44
Lichau	2.5	5	5	7	7	-5	-2	5	10	35	0.83	531	84	2700	4.22
Willow Brook	2.7	4.9	5	7	5	-6	-5	4	12	30	0.69	439	84	2800	4.38
Adobe	1.5	5.9	5	6	8	-7.4	-5.9	7	13	33	0.77	494	84	3500	5.47
Weighted Mean											0.78	499	84		
Totals														33600	52.51

* Average density of clay type soil


Sediment Yields Of Subwatersheds PSIAC 1998
Tons Per Acre Per Year
1.2
1
0.8
0.6
0.4
0.2
0
San Antonio
Lynch
Lichau
Willow Brook
Adobe
Weighted Mean
Subwatersheds

Methods & References

Geology:

United States Geological Survey
Geology maps 1974

Soils:

Natural Resources Conservation Service
Climate data, 1965

Climate:

NOAA Atlas 2 Volume XI-California
Local Knowledge

Runoff:

Sonoma County Soil Survey
Hydrologic Soil Group
Estimated development using:
USGS Topographical Maps
Aerial Photography 1993

NRCS TR-55 program used on Lynch Creek

Topography:

Delineated sub-watersheds on USGS Quad sheets,
Estimated average slope for each watershed

Field observation

Effective Ground Cover:

Aerial photography
Field observation

Land Use and Management Quality:

Field observation
Local Knowledge

Upland Erosion:

Aerial Photography
Field observation

Channel Erosion and Sediment Transport:

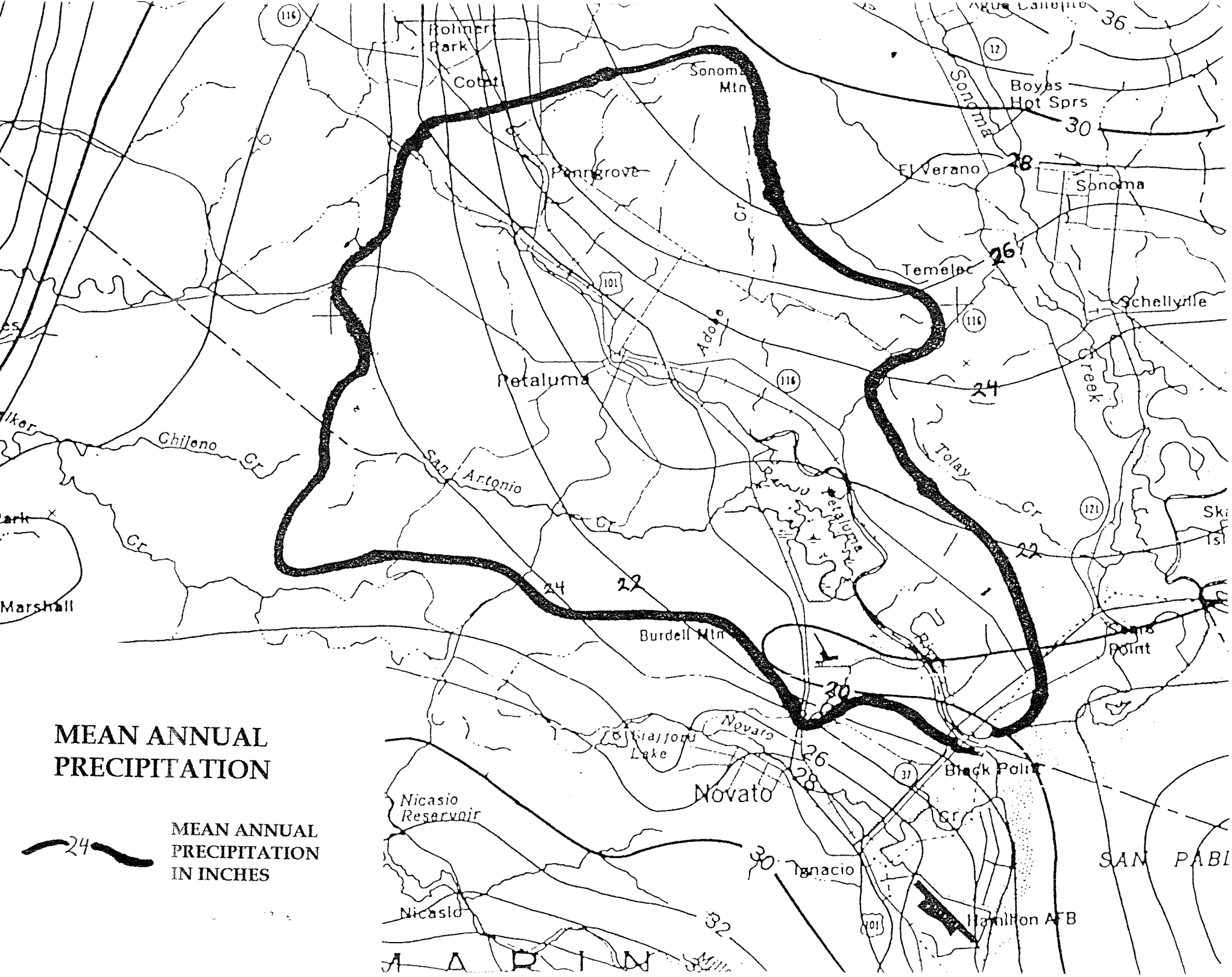
Field observation

Petaluma Watershed Soils

Soils listed for each sub-watershed from most prominent to least prominent
All soils except those with an * are in the Soil Survey of Sonoma County

	Creek	Lichau	Willow Brook	Lynch	Adobe	San Antonio
Tons/Acre-Year		0.83	0.69	1.05	0.77	0.63
		(Average Annual sediment yield estimated using PSIAC)				
Most Prominent Soils		GoF, RaC, CfA DbD, CtC, SoF	CeA, DbC, GID CtC, HcD, RaD	CeA, DbC, GIE RcD, ShF	GgE,DbD, ShF LaF	LsF2, 184* ZaB, 105* 163*

* These soils are from the Soil Survey of Marin County
105 Bluchar
163 Saurin
184 Tocaloma


MEAN ANNUAL PRECIPITATION
24
MEAN ANNUAL PRECIPITATION IN INCHES
Bolinas Park
Cotati
Sonoma Mtn
Penngrove
Petaluma
Adobe Cr
Chileno Cr
San Antonio Cr
Marshall
Burdell Mtn
Tolay Cr
Sonoma
Boyes Hot Sprs
El Verano
Sonoma
Temelec
Schellville
Petaluma River
Black Point
Novato
Novato Creek
Stafford Lake
Nicasio Reservoir
Nicasio
Ignacio
Hamilton AFB
Point
36
30
28
26
24
22
32

Major Tributaries of Petaluma Watershed

Creek	Estimated Slope Percent Length/Area=Slope	Length in Feet For each creek	Estimated Area Acres
Lichau	14	35,980	2,700
Willow Brook	11.6	24,430	2,800
Lynch	15.5	21,490	2,200
Adobe	16.7	24,500	3,500
San Antonio	13	53,970	22,400
Total		160,370	33,600

* List arranged clockwise starting at headwaters.

The equation used to determine the estimated slope percent was $S=hL/A$
S = slope of the subwatershed
h = contour interval
L = length of the watercourse in the subwatershed
A = Area

GRAPHICAL PEAK DISCHARGE METHOD Version 2.00

Project : psiac User: dl Date: 11-12-98
County : sonoma State: ca Checked: ____ Date: _____
Subtitle: petaluma sub-watersheds Lower Creek

Data: Drainage Area : 2200 * Acres
Runoff Curve Number : 83 *
Time of Concentration: 0.04 * Hours
Rainfall Type : IA
Pond and Swamp Area : NONE

Storm Number	1	2	3	4	5	6
Frequency (yrs)	2	5	10	25	50	100
24-Hr Rainfall (in)	3.5	4.5	5.0	5.5	6.0	7.0
Ia/P Ratio	0.12	0.09	0.08	0.07	0.07	0.06
Used	0.12	0.10	0.10	0.10	0.10	0.10
Runoff (in)	1.86	2.73	3.17	3.63	4.09	5.03
Unit Peak Discharge (cfs/acre/in)	0.248	0.251	0.251	0.251	0.251	0.251
Pond and Swamp Factor 0.0% Ponds Used	1.00	1.00	1.00	1.00	1.00	1.00
Peak Discharge (cfs)	1014	1503	1751	2002	2257	2773

* - Value(s) provided from TR-55 system routines

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : psiac User: dl Date: 11-12-98
County : sonoma State: ca Checked: ____ Date: _____
Subtitle: petaluma sub-watersheds
Subarea : 2200

COVER DESCRIPTION		Hydrologic Soil Group A	B	C	D
		Acres (CN)			
OTHER AGRICULTURAL LANDS					
Pasture, grassland or range	fair	-	-	-	1650(84)
Woods - grass combination	good	-	-	-	550(79)
Total Area (by Hydrologic Soil Group)					2200

SUBAREA: 2200 TOTAL DRAINAGE AREA: 2200 Acres WEIGHTED CURVE NUMBER: 83*

* - Generated for use by GRAPHIC method

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Project : psiac User: dl Date: 11-12-98
County : sonoma State: ca Checked: ____ Date: _____
Subtitle: petaluma sub-watersheds

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.5	300	10	e					0.031
Shallow Concent'd		300	7.5	u					0.002
Open Channel		21490	15.5		.035280		53		0.012
						Time of Concentration =			0.04*

--- Sheet Flow Surface Codes ---

A Smooth Surface	F Grass, Dense	--- Shallow Concentrated ---
B Fallow (No Res.)	G Grass, Burmuda	--- Surface Codes ---
C Cultivated < 20 % Res.	H Woods, Light	P Paved
D Cultivated > 20 % Res.	I Woods, Dense	U Unpaved
E Grass-Range, Short	J Range, Natural	

* - Generated for use by GRAPHIC method

Total Yield Comparison: 1998 PSIAC vs. USGS Water-Resources Investigations 80-64 "Sediment Transport of streams tributary to San Francisco, San Pablo, and Suisun bays, California, 1909-1966"

1998 PSIAC Results:

499 Tons per square mile per year X 52.51 Square Miles (Estimated Area) =

26,202 Tons per Year

USGS Water-Resources Investigations Sediment Yield:

517 Tons per Square Mile per year X 52.51 Square Miles =

27, 148 Tons per Year

PSIAC Sediment Yield Factor Rating Sheet 1991 Rev.

Watershed:_____ State:_____ Condition: Present, FWOP, FWP, Fire

Geomorphic Unit_____ Names:_____ Date

Map_____ Location: T____R____, S____, ____1/4____1/4____1/4

(a) Surface Geology Geologist	(b) Soils Soil Scientist	(c) Climate Local Knowledge	(d) Runoff Hydrologist	(e) Topography Map & Field
(5) a. Marine shales and related mudstones and siltstones	(10) a. Fine textured; easily dispersed; saline-alkaline; high shrink-swell characteristics b. Single grain silt and fine sands	(10) a. Storms of several days' duration with short periods of intense rainfall b. Frequent intense convective storms c. Freeze-thaw occurrences	(10) a. High peak flows per unit area b. Large volume of flow per unit area	(20) a. Steep upland slopes (in excess of 30%) b. High relief; little or no floodplain development
(3) a. Rocks of medium hardness b. Moderately weathered c. Moderately fractured	(5) a. Medium textured soil b. Occasional rock fragments c. Caliche layers	(5) a. Storms of moderate duration and intensity b. Infrequent convective storms	(5) a. Moderate peak flows per unit area b. Moderate volume of flow per unit area	(10) a. Moderate upland slopes (less than 20%) b. Moderate fan or floodplain development
(0) a. Massive, hard formations	(0) a. High percentage of rock fragments b. Aggregated clays c. High in organic matter	(0) a. Humid climate with rainfall of low intensity b. Precipitation in form of snow c. Arid climate, low intensity storms d. Arid climate; rare convective storms	(0) a. Low peak flows per unit area b. Low volume of runoff per unit area c. Rare runoff events	(0) a. Gentle upland slopes (less than 5%) b. Extensive alluvial plains % Slope %Area = ____ x ____ = ____ ____ x ____ = ____ ____ x ____ = ____ ____ x ____ = ____ ____ x ____ = ____ Weighted Slope %_____ Rating Chart (e) on back
Factor Value				

(f) Effective Ground Cover Land Use Planner Range Conservationist	(g) Land Type and Management Quality Land Planner	(h) Upland Erosion Geologist	(i) Channel Erosion and Sediment Transport Geologist
(10) Ground cover does not exceed 20% a. Vegetation sparse; little or no litter b. No rock in surface soil cover	(10) a. Almost all of area overgrazed or historic overgrazing impacts still active b. All of area recently burned c. Roads in need of O & M or improved design d. Almost all of area is badlands with minimal armor	(25) a. More than 50% of the area characterized by concentrated flow erosion with increasing gully development	(25) a. Eroding banks, continuously or at frequent intervals, with deep flows of long duration. b. Active headcuts and degradation in tributary channels
(0) Cover not exceeding 40% a. Noticeable litter b. If trees present, understory not well developed	(0) a. <50% of area overgrazed or with historic overgrazing impacts still active b. <50 % area recently logged c. Ordinary road and other construction d. Almost all of area is badlands with 50% of area covered with armor	(10) a. About 25 % of the area characterized by concentrated flow erosion with increasing gully development	(10) a. Moderate flow depths, medium flow duration with occasionally eroding banks or bed
(-10) a. Area completely protected by vegetation, rock fragments, litter b. Little opportunity for rainfall to reach erodible material	(-10) a. No recent logging b. Good grazing management or historic overgrazing impact under control c. Badland are totally armored	(0) a. No apparent signs of erosion	(0) a. Wide shallow channels with flat gradients and short flow duration b. Channels in massive rock, large boulders, or well vegetated c. Artificially controlled channels
Rating Chart (f) on back Veg.____% Litter____% Rock____% Total Cover_____%		Rating Chart (h) on back	
Factor Value			

	Subtotal (a) - (g)	Subtotal (h) - (i)	Total Rating____ = _____ ac.ft./sq.mi./yr.

(instructions on reverse side)

(AcFt/mi ^{2}) X (3) Conversion Factor = ____Tons/acre

Sheet _____of _____

Instructions: Interpolation between sediment yield levels in each factor may be made. High values for columns (a) through (g) should correspond to high values for (h) and (i). If the difference between the total (a) through (g) and the total of (h) and (i) is greater than 10 points, then either a field related justification is necessary or the factor ratings should be revaluated. The total rating should be reviewed from a field perspective with this question: "Does this ratin reflect field observations of erosion and sediment yield for the geomorphic unit?"

Factor (e) Chart Topography

%	Pts	%	Pts
>30	- 20	18 - 20	- 10
29 - 19		17 - 18	- 9
28 - 18		15 - 17	- 8
27 - 17		14 - 15	- 7
26 - 16		12 - 14	- 6
25 - 15		11 - 12	- 5
24 - 14		9 - 11	- 4
23 - 13		8 - 9	- 3
22 - 12		6 - 8	- 2
21 - 11		5 - 6	- 1
		<5	- 0

Factor (f) Chart Effective Ground Cover

%	Pts
<20--	10
25--	8
30--	5
35--	3
40--	0
45--	-1
50--	-2
55--	-2
60--	-3
65--	-4
70--	-5
75--	-6
80--	-7
85--	-7
90--	-8
95--	-9
100--	-10

Factor (h) Chart Upland Erosion

%	Pts
50--	25
45--	22
40--	19
35--	16
30--	13
25--	10
20--	8
15--	6
10--	4
5--	2
0--	0

Total Rating vs Annual Sediment Yield Chart

Pts	ac-ft/sq mi	Pts	ac-ft/sq mi	Pts	ac-ft/sq mi	Pts	ac-ft/sq mi
1	<0.10	41	0.36	81	1.52	121	6.44
2	<0.10	42	0.37	82	1.58	122	6.67
3	<0.10	43	0.39	83	1.64	123	6.92
4	<0.10	44	0.40	84	1.70	124	7.17
5	0.10	45	0.42	85	1.76	125	7.44
6	0.10	46	0.43	86	1.82	126	7.71
7	0.11	47	0.45	87	1.89	127	8.00
8	0.11	48	0.45	88	1.96	128	8.29
9	0.11	49	0.48	89	2.03	129	8.59
10	0.12	50	0.50	90	2.11	130	8.90
11	0.12	51	0.52	91	2.18	131	9.23
12	0.13	52	0.54	92	2.26	132	9.57
13	0.13	53	0.56	93	2.35	133	9.92
14	0.14	54	0.58	94	2.43	134	10.29
15	0.14	55	0.60	95	2.52	135	10.66
16	0.15	56	0.62	96	2.61		
17	0.15	57	0.64	97	2.71		
18	0.16	58	0.66	98	2.81		
19	0.16	59	0.69	99	2.91		
20	0.17	60	0.72	100	3.02		
21	0.18	61	0.74	101	3.13		
22	0.18	62	0.77	102	3.25		
23	0.19	63	0.80	103	3.36		
24	0.20	64	0.82	104	3.49		
25	0.20	65	0.86	105	3.62		
26	0.21	66	0.89	106	3.75		
27	0.22	67	0.92	107	3.89		
28	0.23	68	0.95	108	4.03		
29	0.23	69	0.99	109	4.18		
30	0.24	70	1.02	110	4.33		
31	0.25	71	1.06	111	4.49		
32	0.26	72	1.10	112	4.65		
33	0.27	73	1.14	113	4.82		
34	0.28	74	1.18	114	5.00		
35	0.29	75	1.23	115	5.19		
36	0.30	76	1.27	116	5.38		
37	0.31	77	1.32	117	5.57		
38	0.32	78	1.37	118	5.78		
39	0.33	79	1.42	119	6.00		
40	0.34	80	1.47	120	6.21		

Notes: