Figures

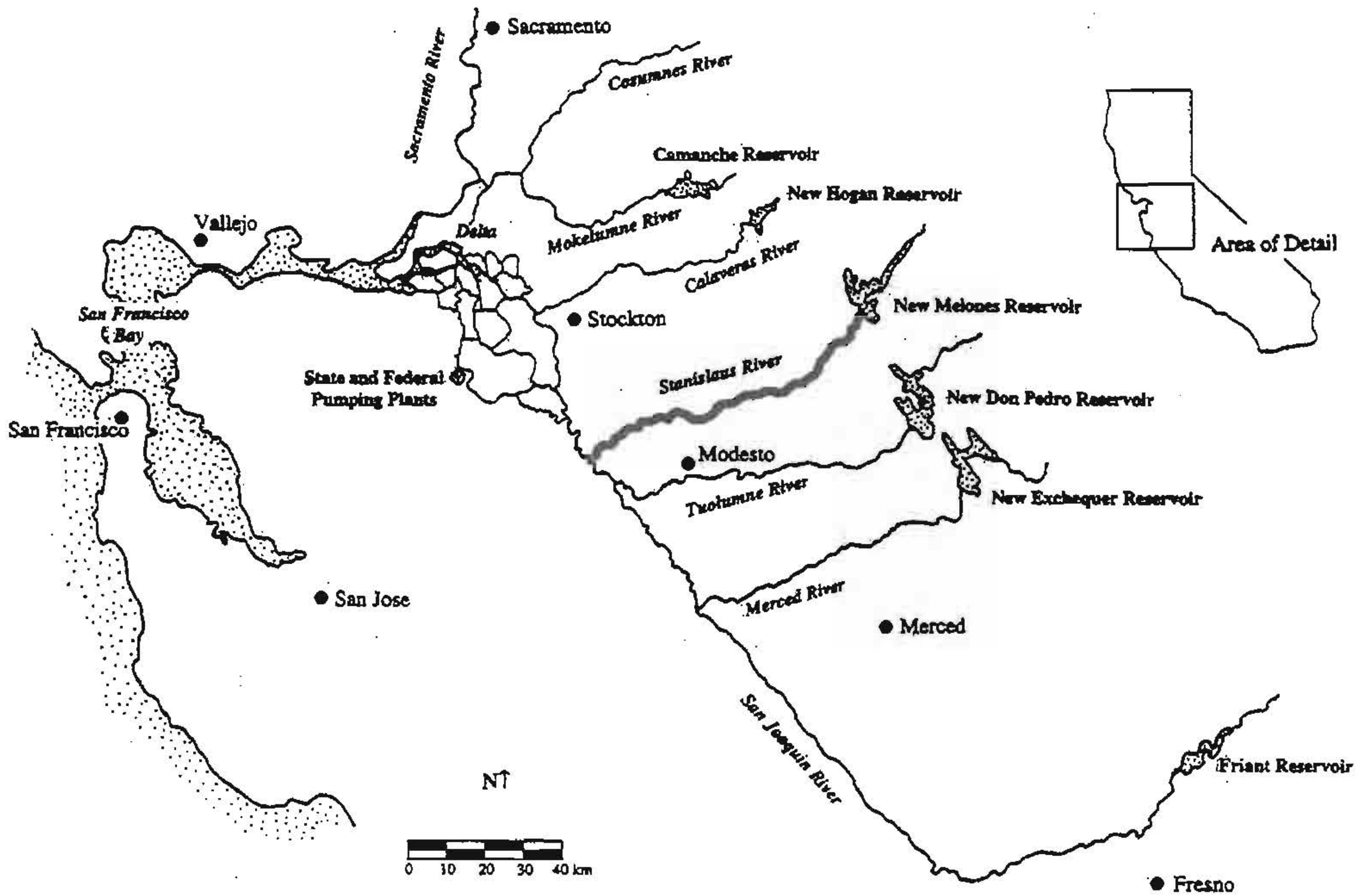


Figure 1.1: Stanislaus River Location Map, California. The Stanislaus River (highlighted) is the northernmost large tributary to the San Joaquin River basin, one of the two large river systems in California that drain Central Valley and adjacent mountain waters into the San Francisco Bay. The Stanislaus runs 120 miles in length, with headwaters at 11,000 foot elevation in the western Sierra Nevada. The river drains 1,100 square miles. The study reach is located in the lowest half of the watershed, from RM 41 at Oakdale to RM 59 at Goodwin Dam. *(Map adapted from Kondolf et al. 1996a).*

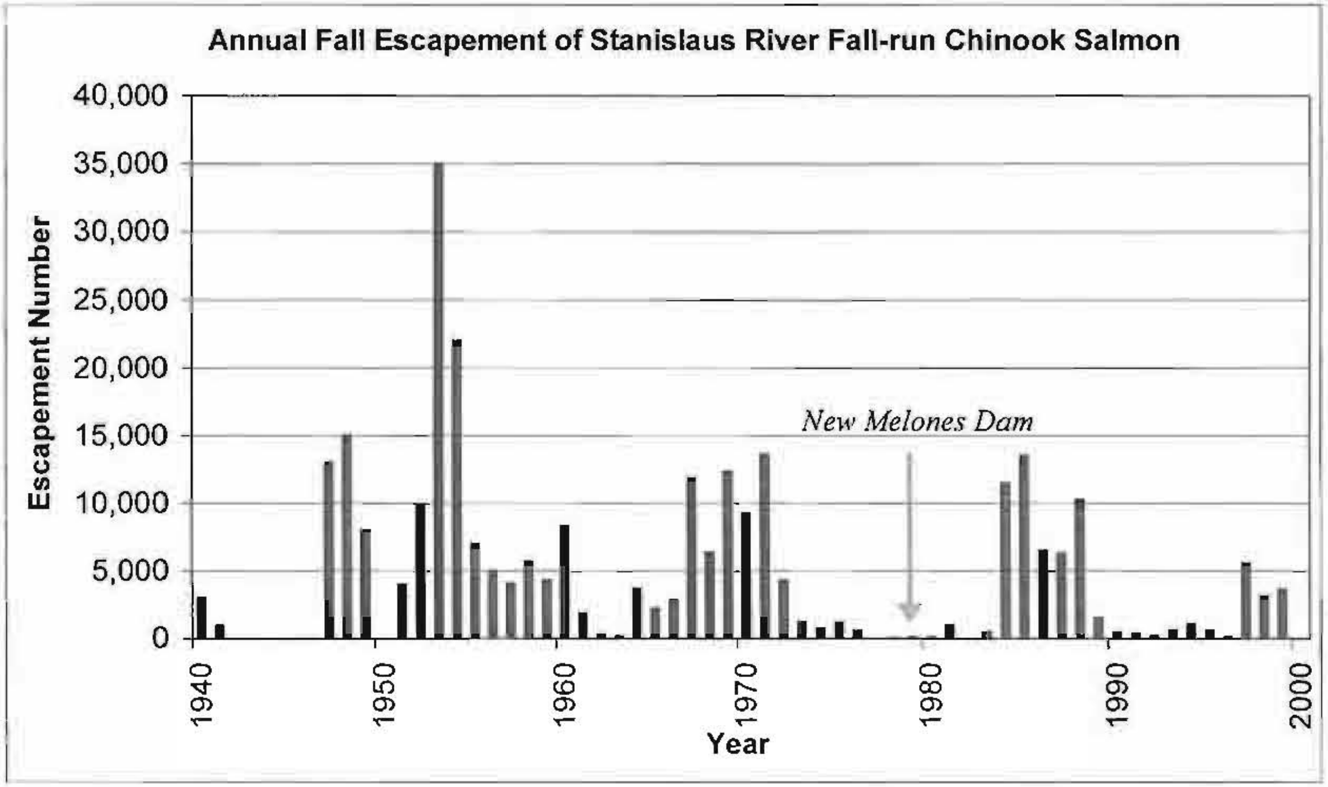
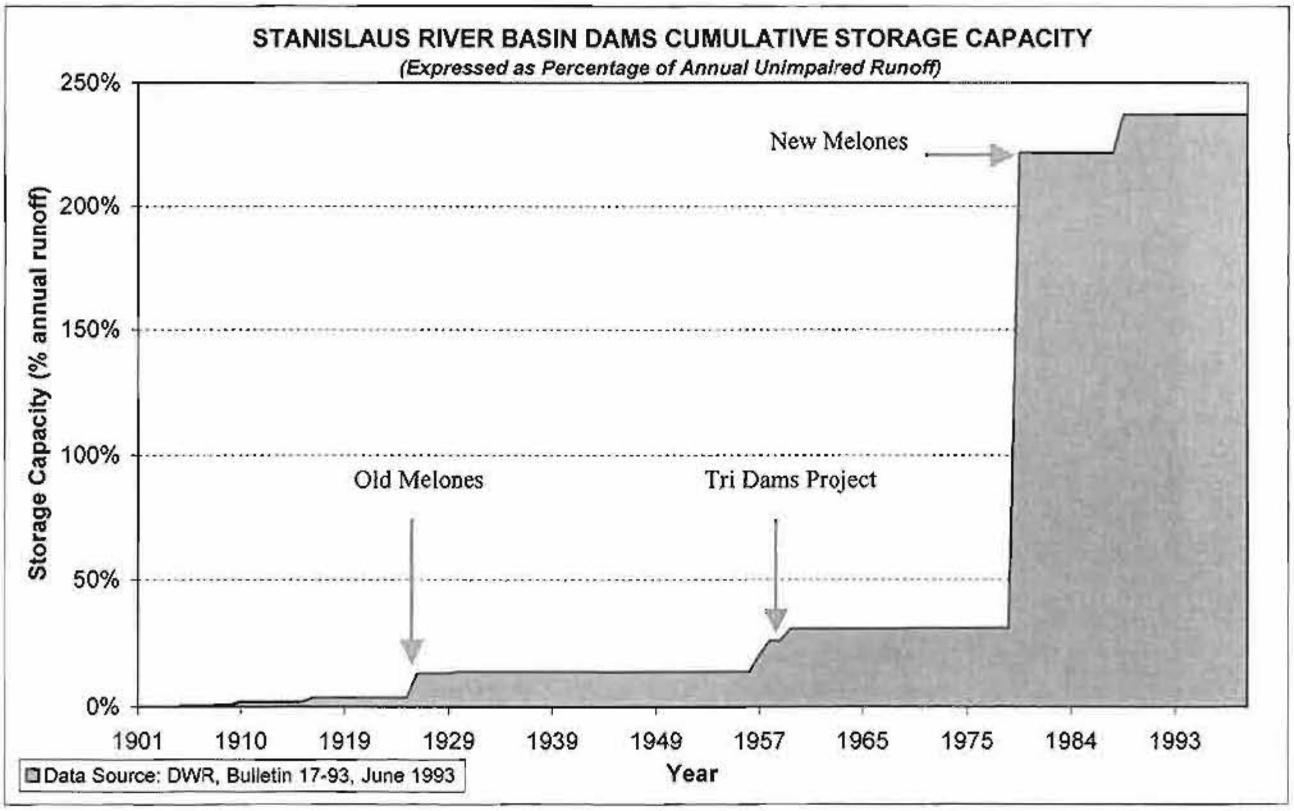


Figure 1.2: Annual Stanislaus River Fall-run Chinook Salmon Escapement. Note the high of 35,000 spawners in 1953 and recent low of less than 300 fish in 1991-2. New Melones dam was built in 1978. *(Fall run escapement data source: Scott Spaulding, USFWS, Presented July 2000)* .

Year	Quantity	Year	Quantity
1940	3,000	1971	13,621
1941	1,000	1972	4,298
1942	nd	1973	1,234
1943	nd	1974	750
1944	nd	1975	1,200
1945	0	1976	600
1946	nd	1977	0
1947	13,000	1978	50
1948	15,000	1979	100
1949	8,000	1980	100
1950	0	1981	1,000
1951	4,000	1982	0
1952	10,000	1983	500
1953	35,000	1984	11,439
1954	22,000	1985	13,473
1955	7,000	1986	6,497
1956	5,000	1987	6,292
1957	4,090	1988	10,212
1958	5,700	1989	1,510
1959	4,300	1990	480
1960	8,300	1991	394
1961	1,900	1992	255
1962	315	1993	677
1963	200	1994	1,079
1964	3,700	1995	611
1965	2,231	1996	160
1966	2,872	1997	5,583
1967	11,885	1998	3,147
1968	6,385	1999	3,619
1969	12,327	2000	nd
1970	9,297		



Photograph of New Melones Dam: Constructed 1979, Capacity: 2,400,000 acre feet, or 200% of average unimpaired runoff. (Photo source: USBR webpage).

Figure 2.1: Stanislaus River Dams Capacity. Incremental increase in storage capacity expressed as a percentage of mean annual runoff. Note the most noticeable jumps occur in 1926 with the construction of Old Melones dam, 1957-8 with the Tri-dams project, 1979 with New Melones dam (see photo below), and 1988 with New Spicer Meadows. See Table 2.1 for details regarding calculations.

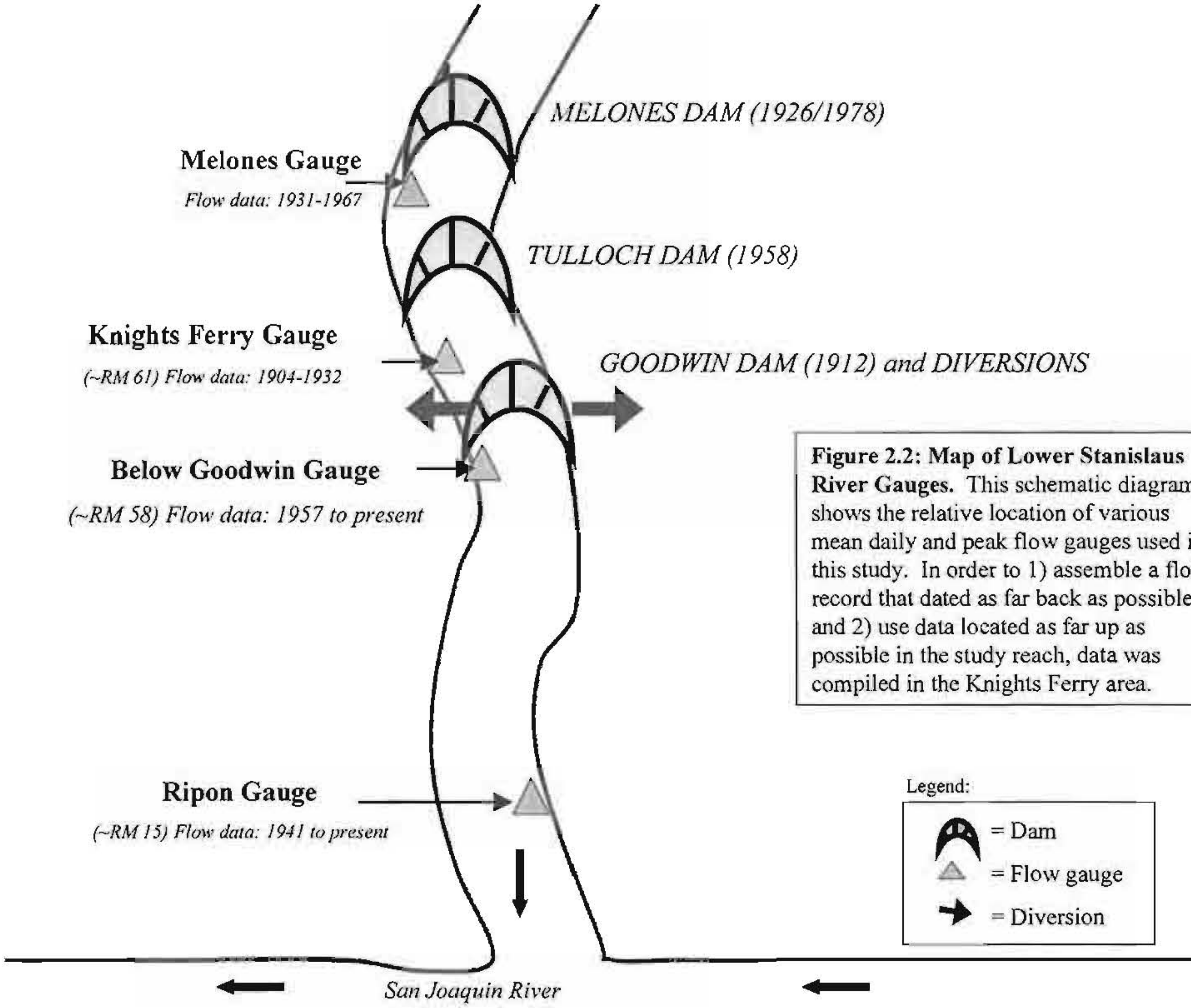


Figure 2.2: Map of Lower Stanislaus River Gauges. This schematic diagram shows the relative location of various mean daily and peak flow gauges used in this study. In order to 1) assemble a flow record that dated as far back as possible and 2) use data located as far up as possible in the study reach, data was compiled in the Knights Ferry area.

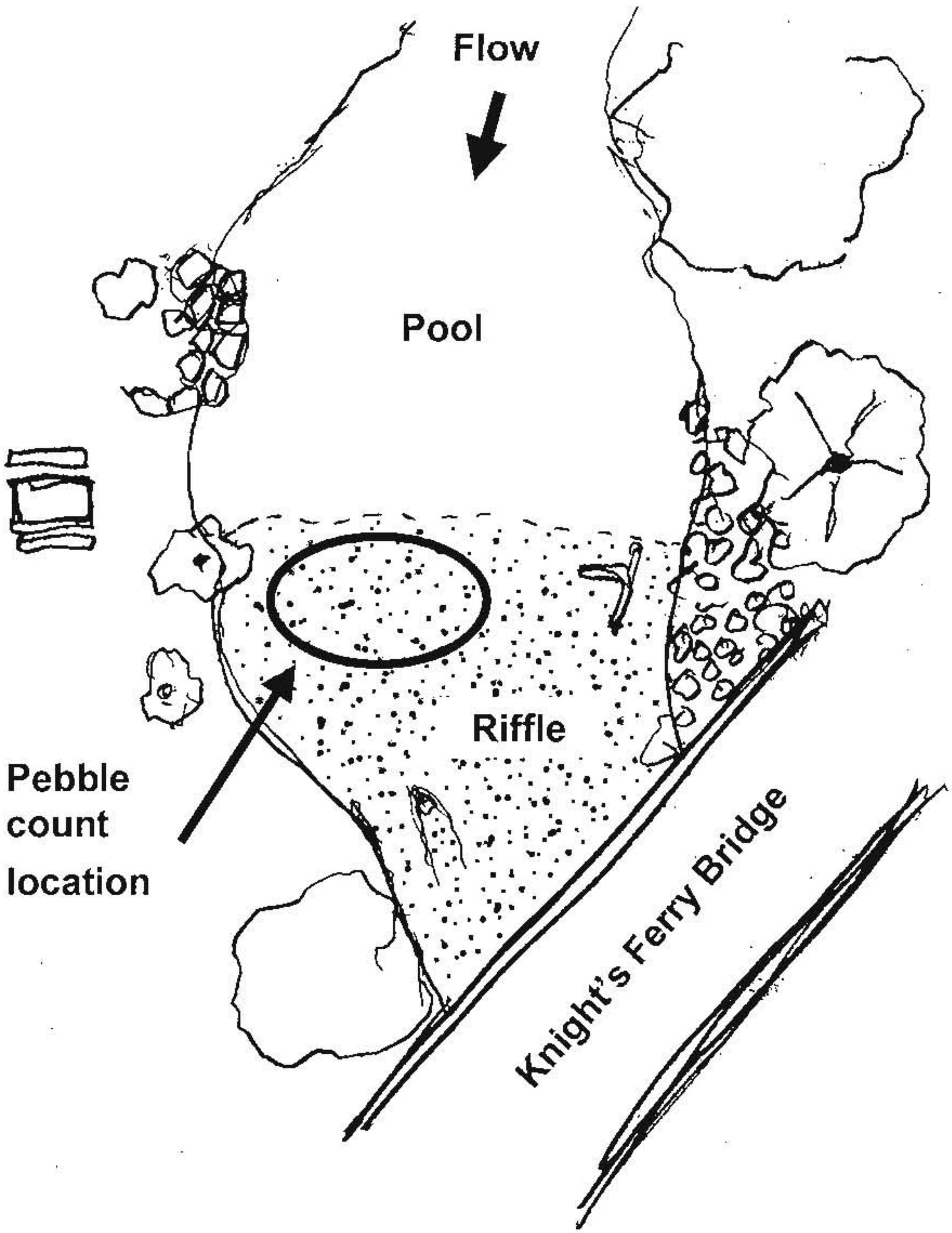
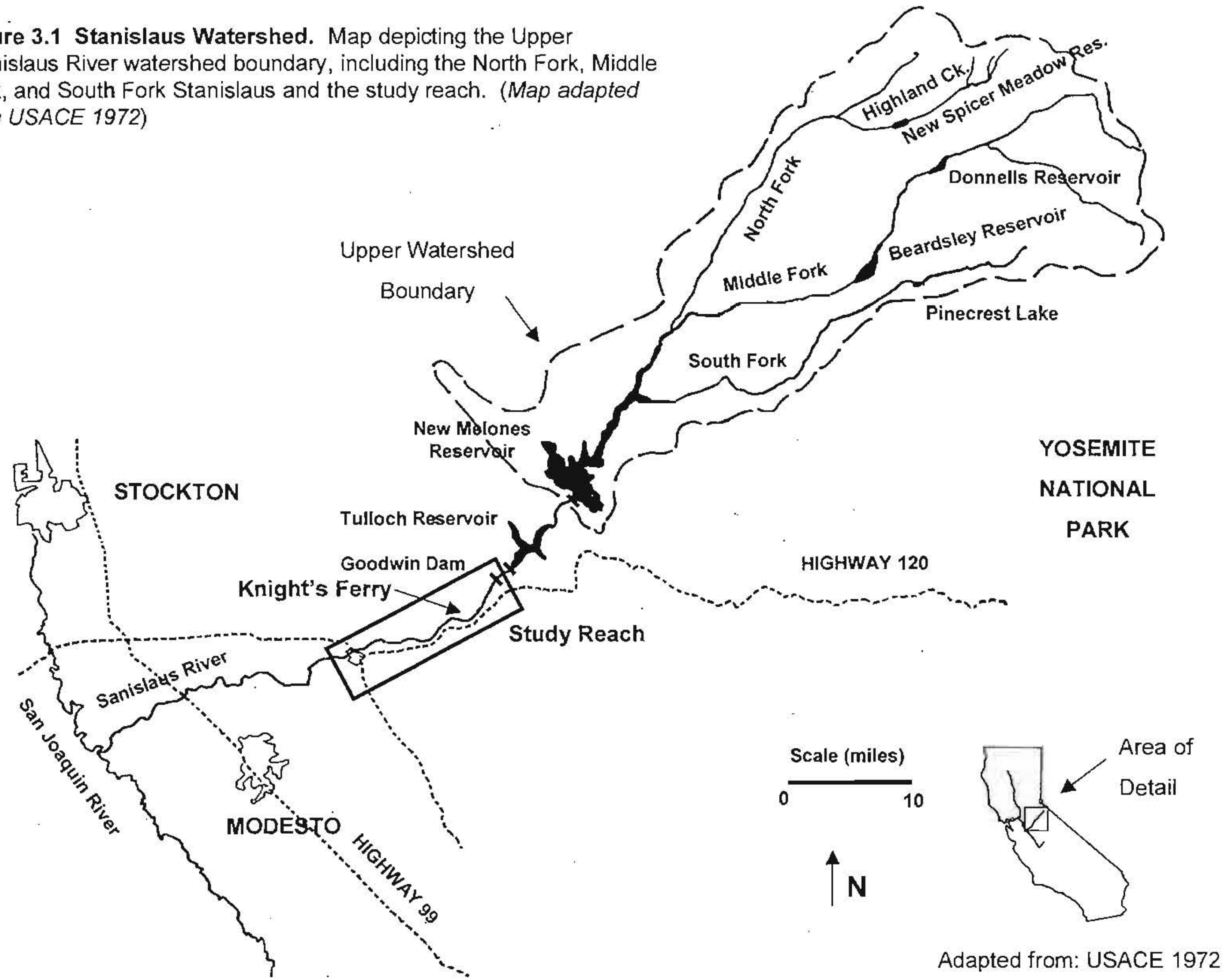


Figure 2.3: Representative Location of Pebble Count at Riffles. We conducted Wolman Pebble Counts at the head of the riffle, as this figure illustrates. Adapted from field sketch made at Riffle R1, immediately upstream of the new Knight's Ferry Bridge.

Figure 3.1 Stanislaus Watershed. Map depicting the Upper Stanislaus River watershed boundary, including the North Fork, Middle Fork, and South Fork Stanislaus and the study reach. (*Map adapted from USACE 1972*)



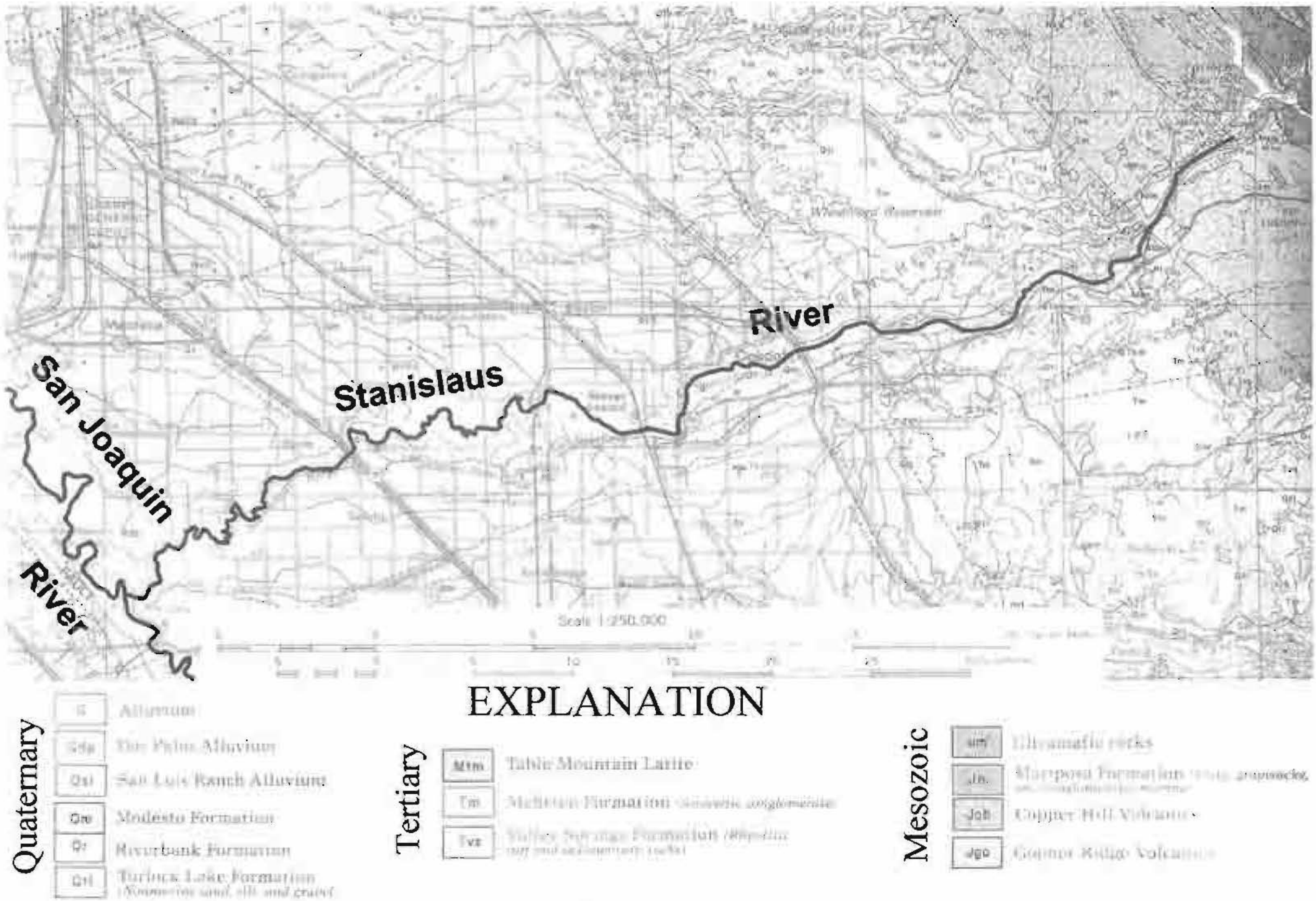


Figure 3.2: Geologic Map of the Stanislaus River Basin. Figure showing the geology of the lower Stanislaus River (highlighted in blue) from Tulloch Reservoir to the confluence with the San Joaquin River (highlighted in blue). Below Goodwin Canyon the channel cuts through alluvial deposits. Adapted from Wagner et al. 1991.

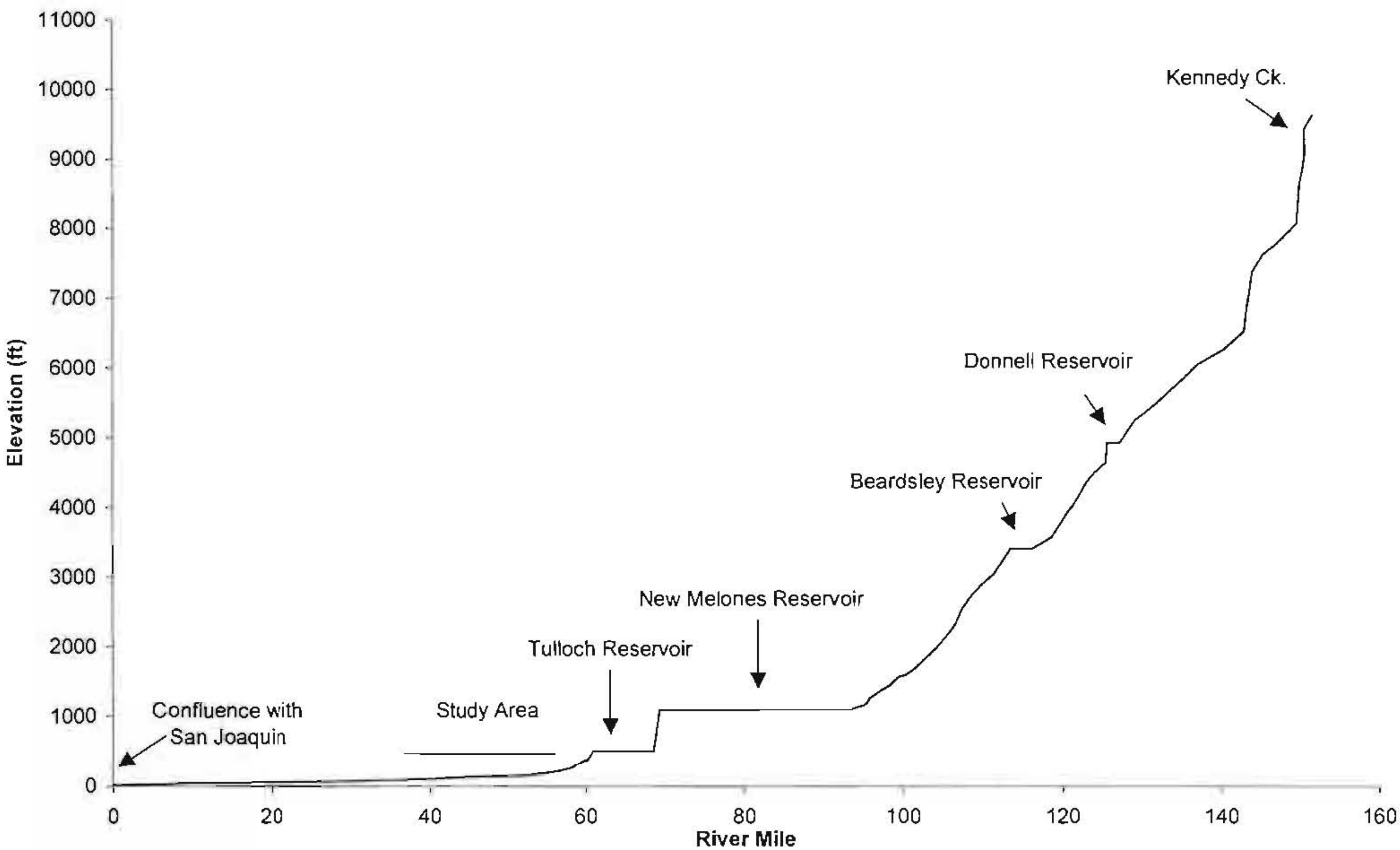


Figure 3.3: Longitudinal Profile of the Stanislaus River. This elevation profile was created by tracing the Stanislaus River from the Confluence with the San Joaquin to the headwaters. The spot elevation points were generated from USGS 30 meter DEM data. The average slope of the watershed from the headwaters to New Melones Reservoir is 2.1%, and the average slope from New Melones Reservoir to Goodwin Dam is 0.5%. Figure 3-4 provides more detail of the reach from Goodwin Dam to the Confluence with the San Joaquin River. *(Data source: Nation Geographic Maps CA Series digital USGS 1:24,000 topographic maps and Topo! Software).*

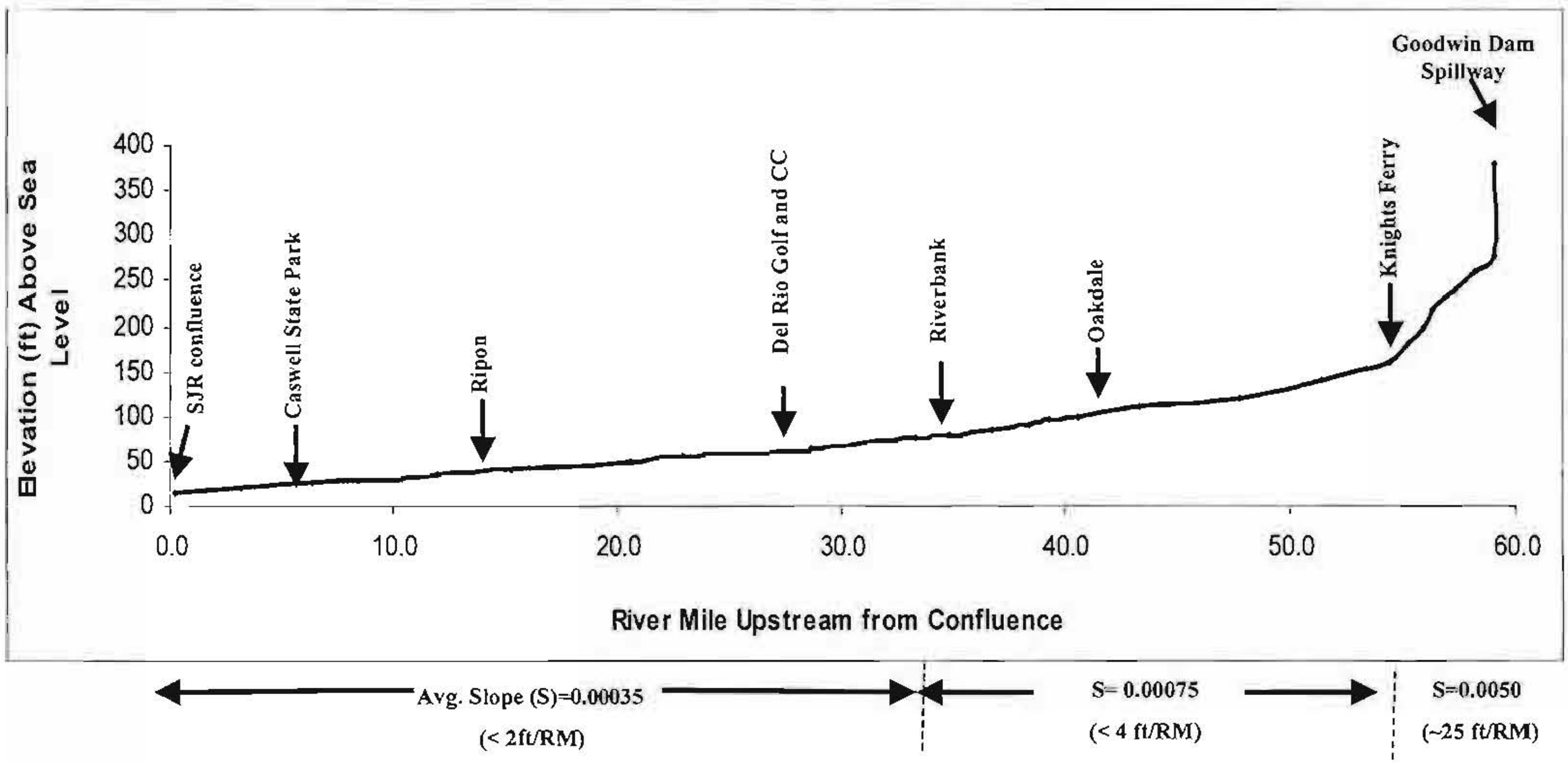


Figure 3.4: Lower Stanislaus River Longitudinal Profile (vertically exaggerated). *Using the elevations and river mileage from USGS 1: 24,000 (7.5 min) topographic maps, we estimate average slopes from Goodwin Dam to the confluence with the San Joaquin River. The lowest reach, from the confluence to Riverbank, is composed of Holocene alluvium deposits and has an average gradient less than 2 ft/river mile. The reach between Riverbank and Knights Ferry descends an average of 4 ft/RM with Riverbank formation materials also present. From Knights Ferry to Goodwin Dam, slopes average 25 ft/RM with Gopher Ridge volcanics present in the uppermost reach. (Geology summarized from Wagner et al. Geologic Map of SF-San Jose Quadrangle).*

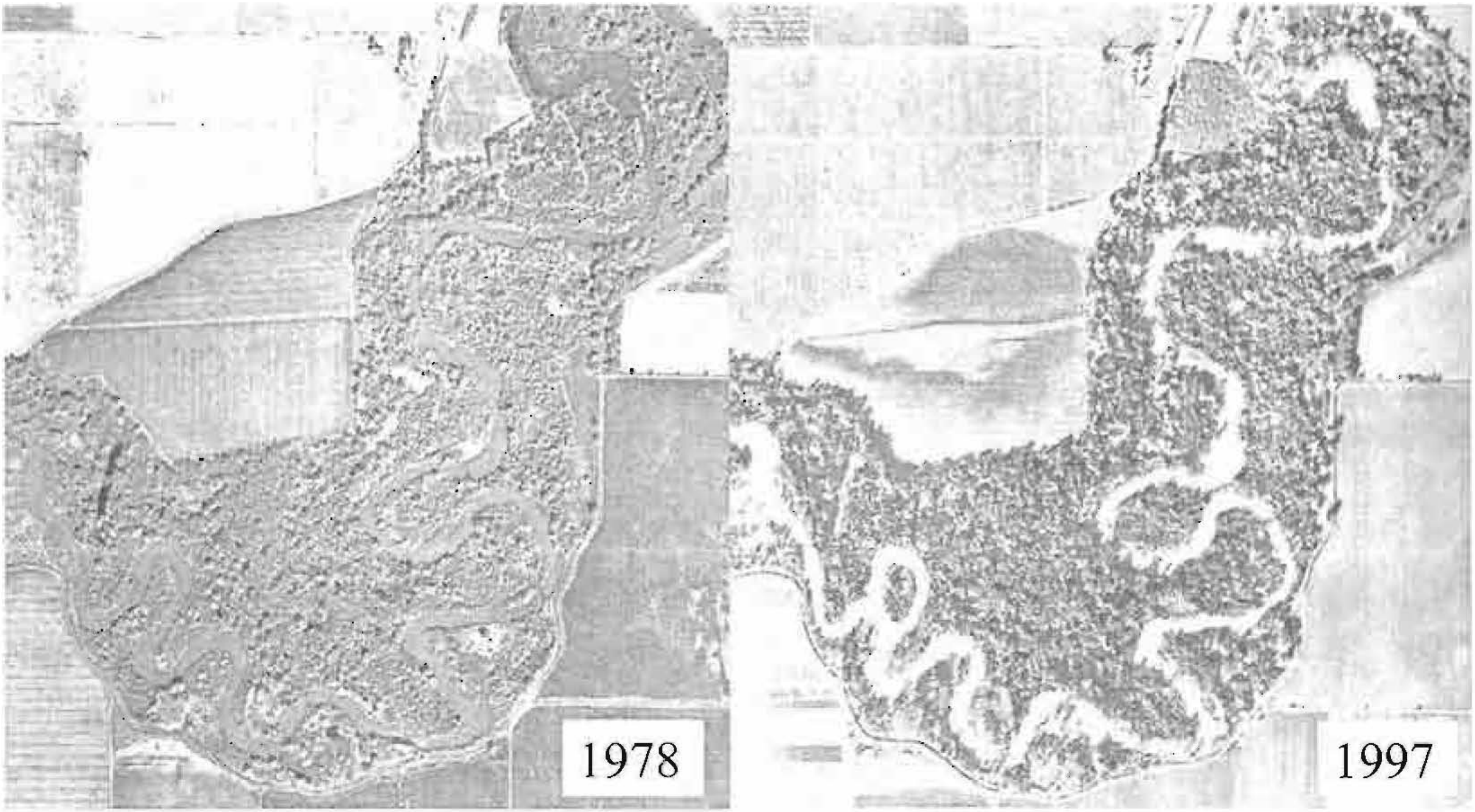


Figure 3.5: Caswell Memorial Park. As these two aerial photographs demonstrate, active channel meandering and avulsion are evident at Caswell Memorial Park, where there is minimal confinement by artificial levees. (Source: 1978– USACE, 1:12,000, can #693, ~3, 180 cfs; 1997– USACE, 1:12,000, can #991, ~6, 340 cfs).

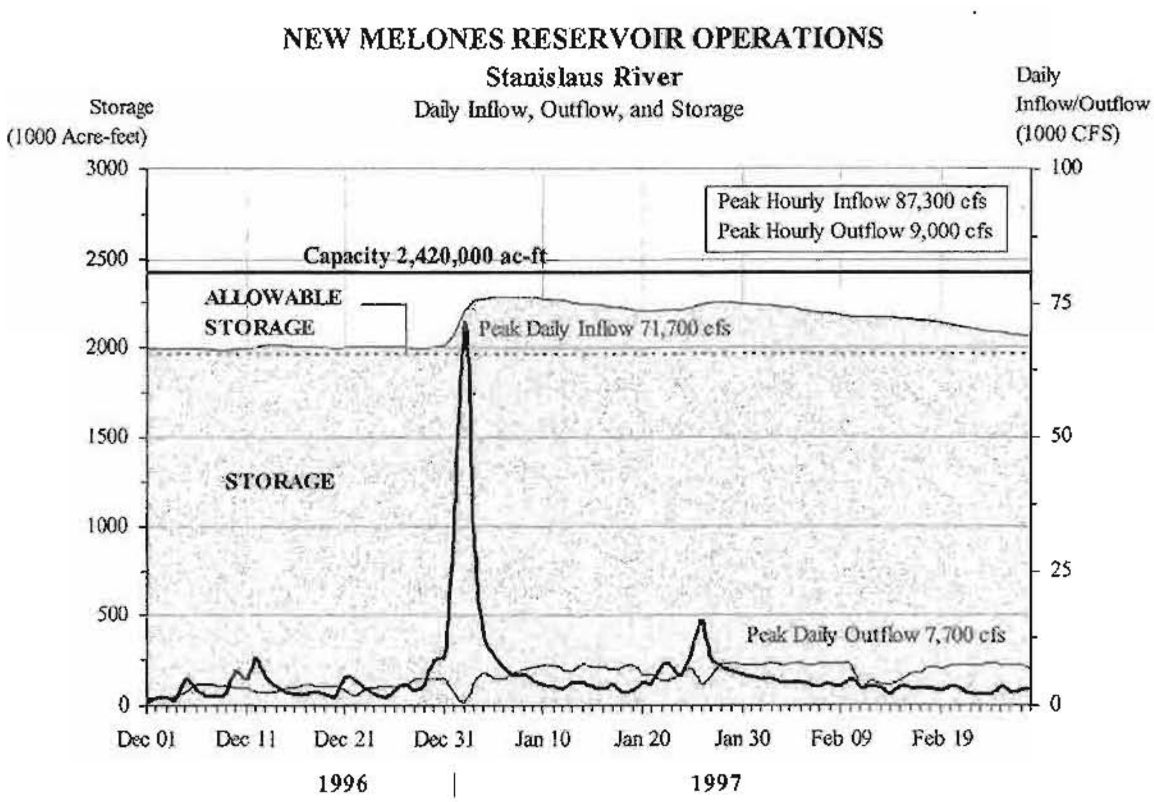
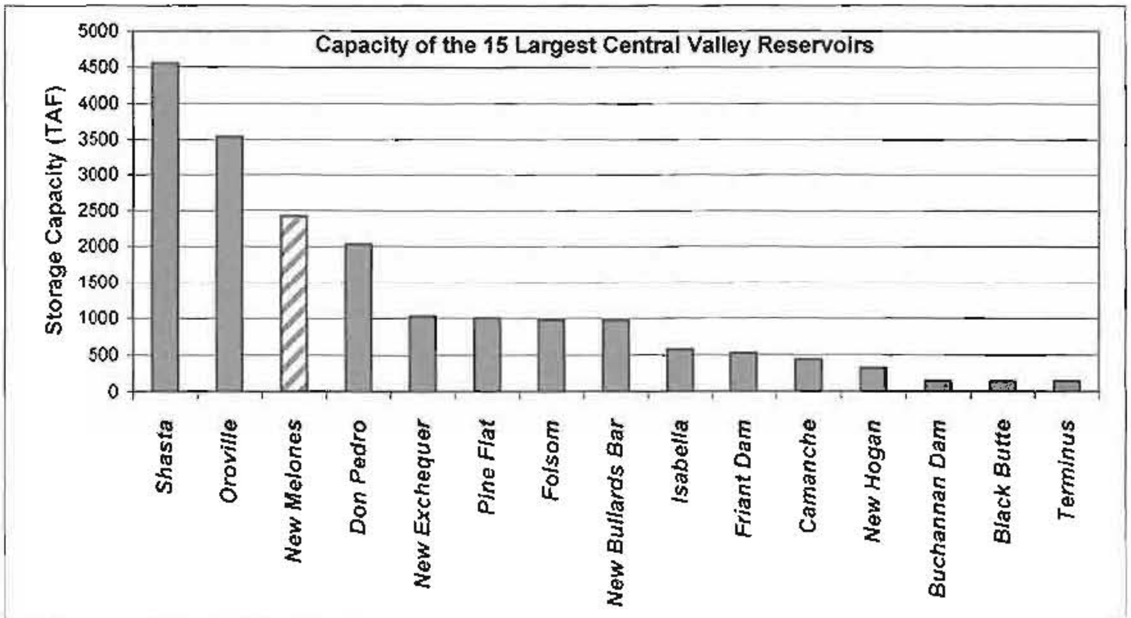
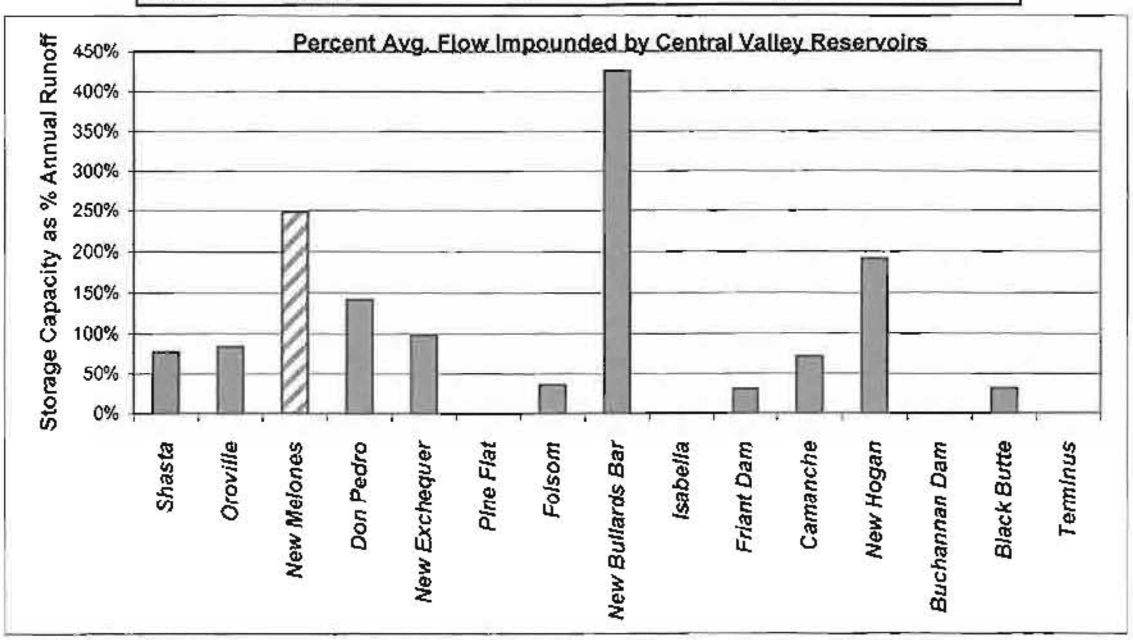


Figure 3.6: Performance of New Melones Dam in the January 1997 Floods. This 1997 flood hydrograph from the USACE Post Flood Assessment presents daily time series data for hydrologic conditions and reservoir operations during the 1997 rain flood event (USACE 1999). Inflow (cfs) and outflow (cfs) from New Melones dam is plotted for a three month period around the 1996-1997 flood event. Note that even though 71,700 cfs was flowing into New Melones, its capacity of 2.4 maf (over 200% of average annual unimpaired runoff) allowed for a maximum release of 7,700 cfs. Flow releases are limited to less than 8,000 cfs in the Lower Stanislaus River. *(Source: USACE Post-Flood Assessment, March 1999, Appendix E).*

Figure 3.7: Central Valley Reservoirs Capacity and Percent Impoundment of Average River Flow



River	Dam Name	Capacity (TAF)[1]	Avg. Runoff (TAF)	% Runoff Impounded
Sacramento	Shasta	4,552	5,898	77%
Feather	Oroville	3,538	4,226	84%
Stanislaus	***New Melones***	***2,420***	***974***	***248%***
Tuolumne	Don Pedro	2,030	1,436	141%
Merced	New Exchequer	1,025	1,045	98%
Kings	Pine Flat	1,000	n.a.	n.a.
American	Folsom	977	2,718	36%
Yuba	New Bullards Bar	966	227	426%
Kern	Isabella	568	n.a.	n.a.
San Joaquin	Friant Dam	521	1,698	31%
Mokelumne	Camanche	431	603	71%
Calaveras	New Hogan	317	166	191%
Chowchilla	Buchannan Dam	150	n.a.	n.a.
Stony Creek	Black Butte	144	460	31%
Kaweah	Terminus	143	n.a.	n.a.



Data Source: [1]*: USACE Post Flood Assessment, page 3-4 and A25-10. Storage rounded to nearest 1000 AF.*

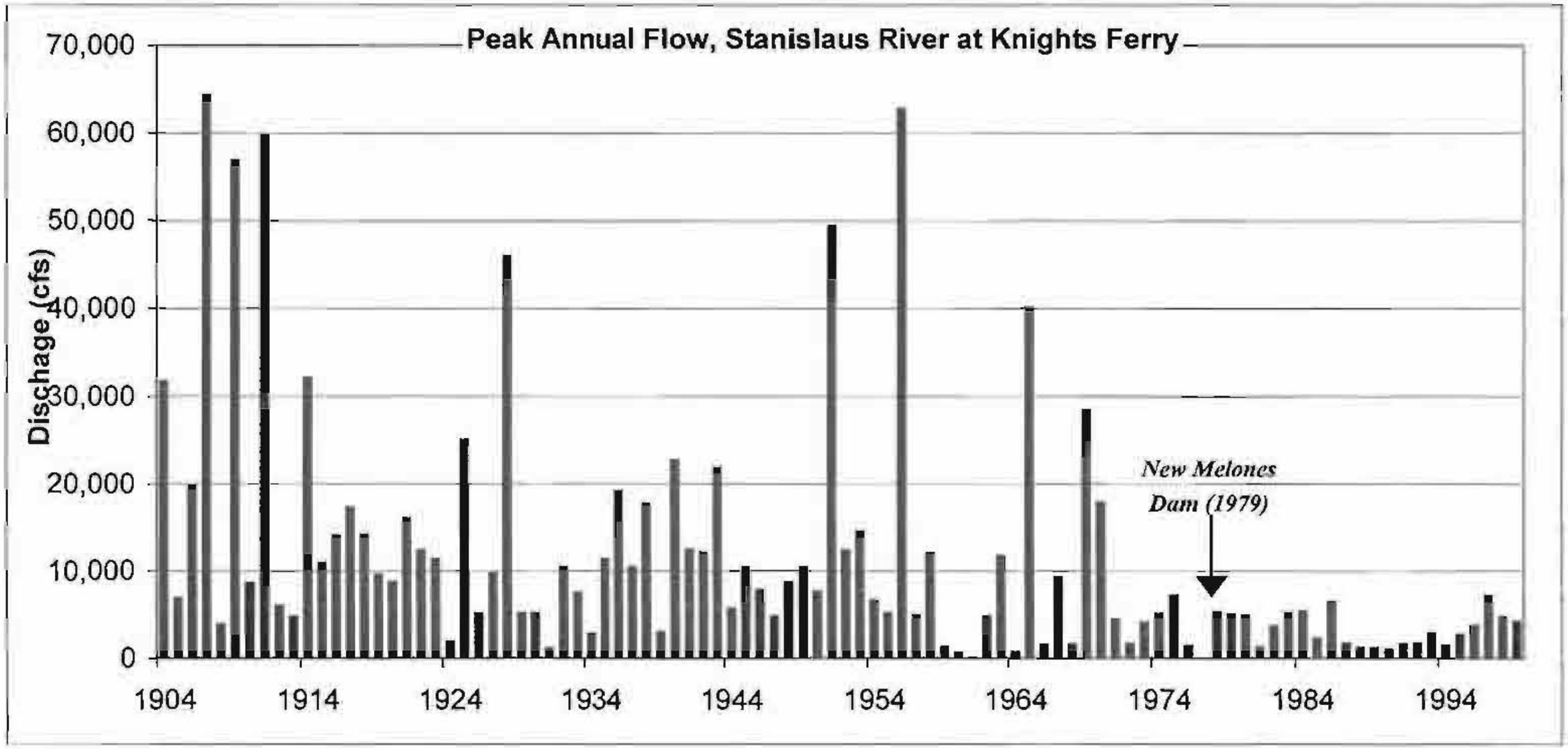


Figure 4.1: Annual Peak Flow, Stanislaus River at Knights Ferry, 1904-1999. Graph of all peak flows since 1904. Compiled with peak flow data from the gauges: Stan River near Knights Ferry (#11300000) 1904-1932; Melones Powerhouse (#11299500) 1933-1955; and Goodwin Dam near Knights Ferry (#1102000) 1956-1999. Note the pre-New Melones dam high of 64,500 cfs on March 19, 1907 and post-New Melones dam peak of 7,350 cfs on January 3, 1997. New Melones dam was authorized for construction, in part, based on the flood management benefits it would provide.

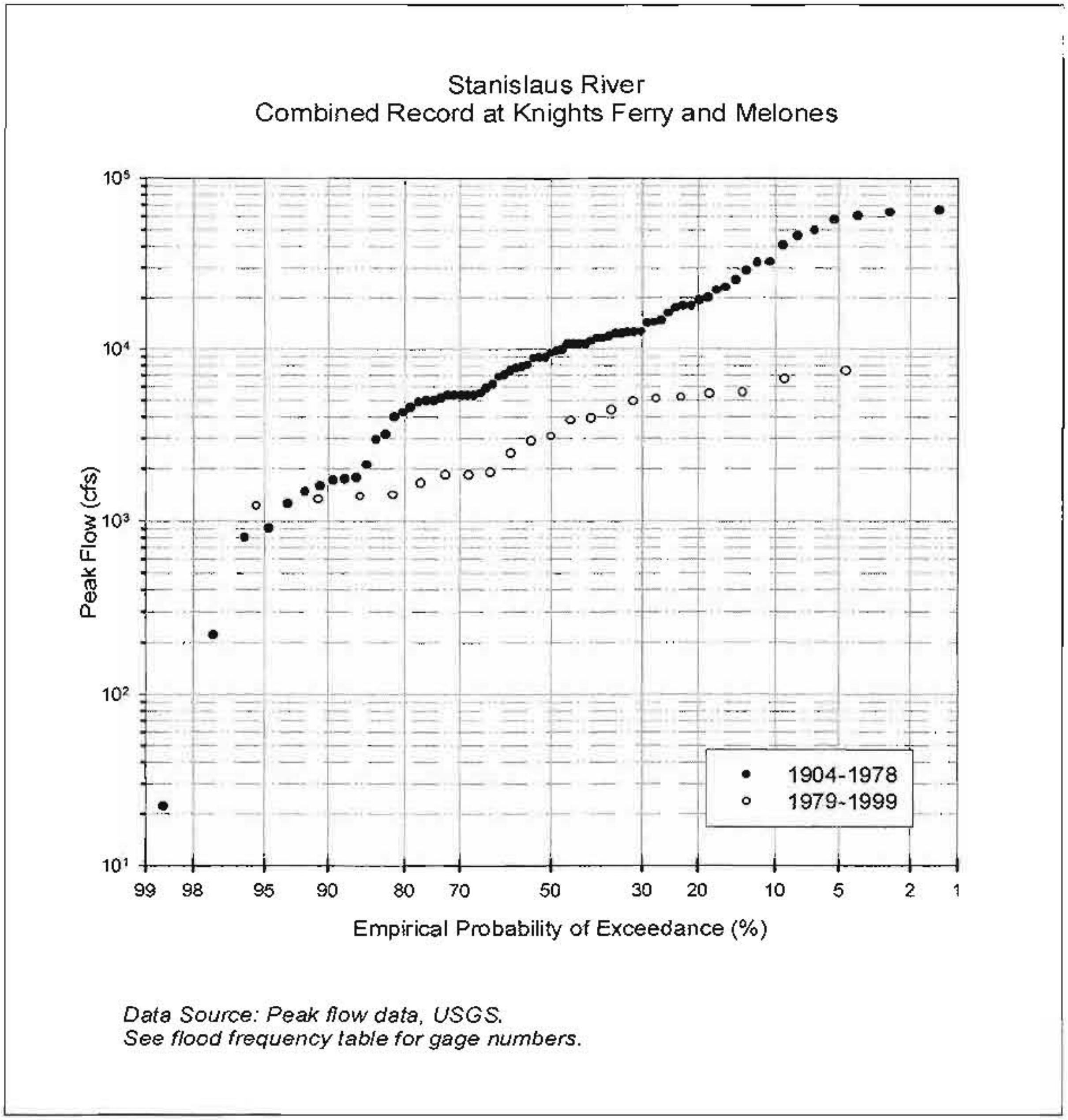


Table 4-2

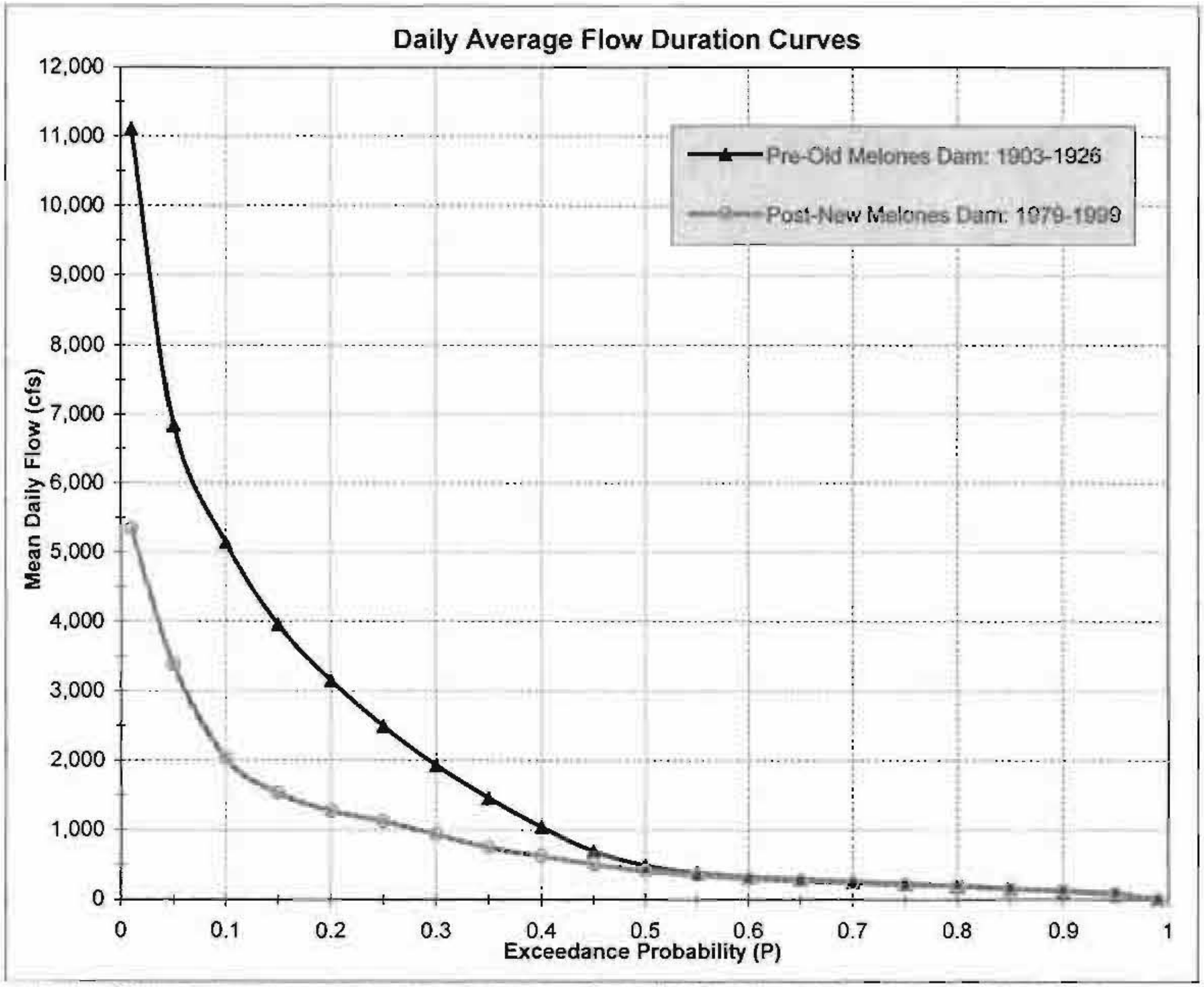
$Q_{Return\ Period}$ (cfs)	*Approx.* **Pre NM**	*Approx.* **Post NM**
$Q_{1.5}$	5,380	1,840
Q_2	9,430	3,070
Q_5	19,100	5,300
Q_{10}	35,000	6,600
Q_{25}	60,000	7,350+ **

***: insufficient data to estimate the Q_{25} due to only 21 years of post NM dam data.*

Figure 4-2: Flood Frequency Plots, Stanislaus River. Annual maximum flood frequency plots for Pre-New Melones dam (1904 -1978) and Post- New Melones dam (1979 -1999) flows near Knights Ferry (drainage area 905 to 986 mi^2). Gage numbers for each period are detailed in Table 4-1. The approximate flows associated with the $Q_{1.5}$, Q_2, Q_5, Q_{10}, and Q_{25} are summarized in **Table 4-2**.

Figure 4.3: Flow Duration Analysis for Pre-Old Melones Dam and Post-New Melones Dam Study Periods.

Exceedance Probability	Pre- OM Mean Daily Flow (cfs)	Post- NM Mean Daily Flow (cfs)
0.01	11,110	5,330
0.05	6,840	3,380
0.1	5,140	2,030
0.15	3,960	1,530
0.2	3,150	1,270
0.25	2,490	1,120
0.3	1,930	933
0.35	1,460	742
0.4	1,040	622
0.45	694	505
0.5	488	407
0.55	380	345
0.6	320	299
0.65	288	270
0.7	258	241
0.75	226	212
0.8	195	202
0.85	160	156
0.9	120	136
0.95	76	93
0.99	7	6
mean flow =	1767	868



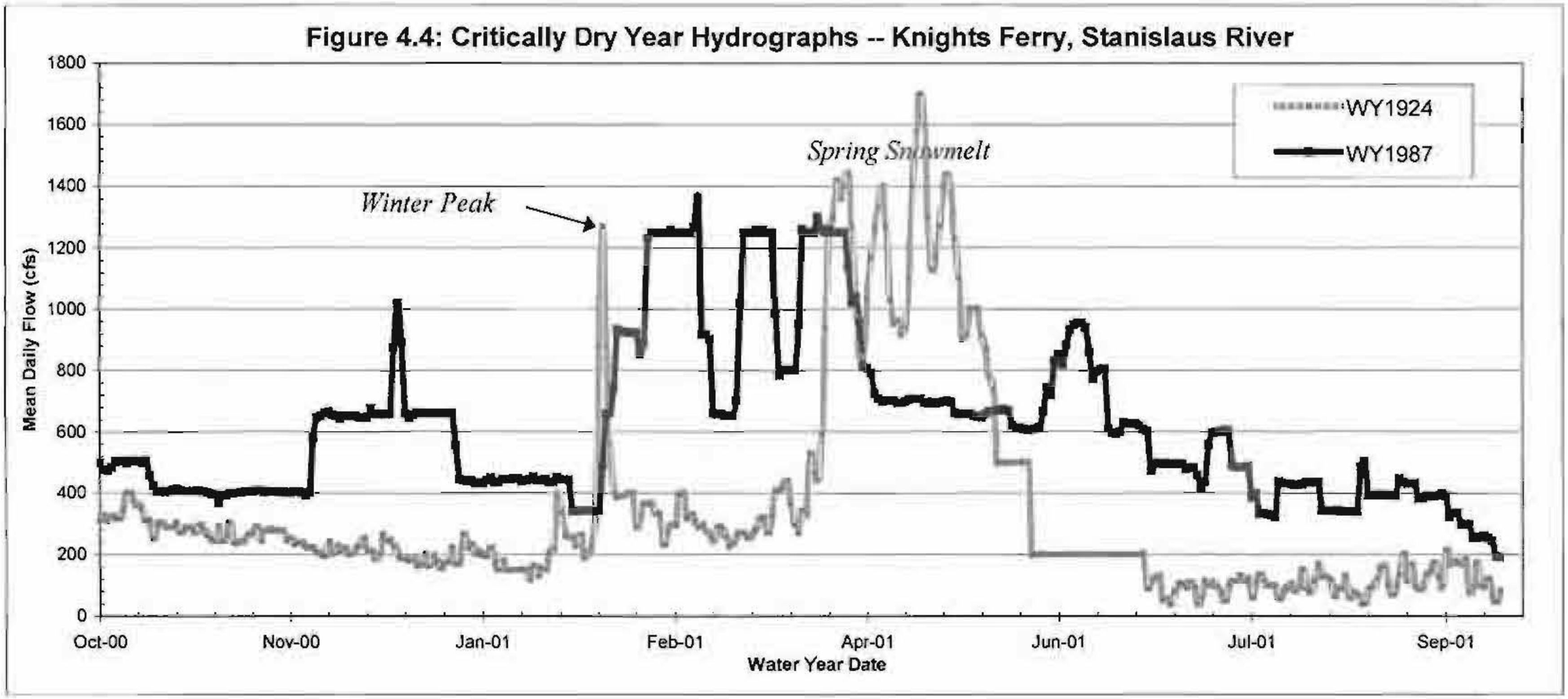
Data Source:

Pre- Old Melones dam: May 19, 1903 to Jan. 31, 1926: 1903-1914 data from USGS WS Papers #299, 361, 391. 1903-1908 data, only gage height and rating tables available, requiring data conversion to cfs. Data from "Stan River at Knights Ferry" gage, #11302000. Begins May 19, 1903 and Ends Sept. 30, 1914.

1915-1926 data from USGS webpage http://waterdata.usgs.gov/nwis-w/CA/data.components/hist.cgi?statnum=11300000. Gauge name: "Stan. River near Knights Ferry." Period begins Dec. 18, 1915 and ends Jan. 31, 1926, with stopping point chosen based on construction of Old Melones dam in 1926.

Data concerns: No data available from Oct. 1, 1914 to Dec. 17, 1915; 1903-1914 gauge below Goodwin dam, 1915-1926 data from 2 miles upstream of Goodwin dam.

Post New Melones dam: Jan 1, 1979 to Sept. 30, 1999: USGS webpage http://waterdata.usgs.gov/nwis-w/CA/data.components/hist.cgi?statnum=11302000. Gauge name: "Stan River below Goodwin near Knights Ferry."

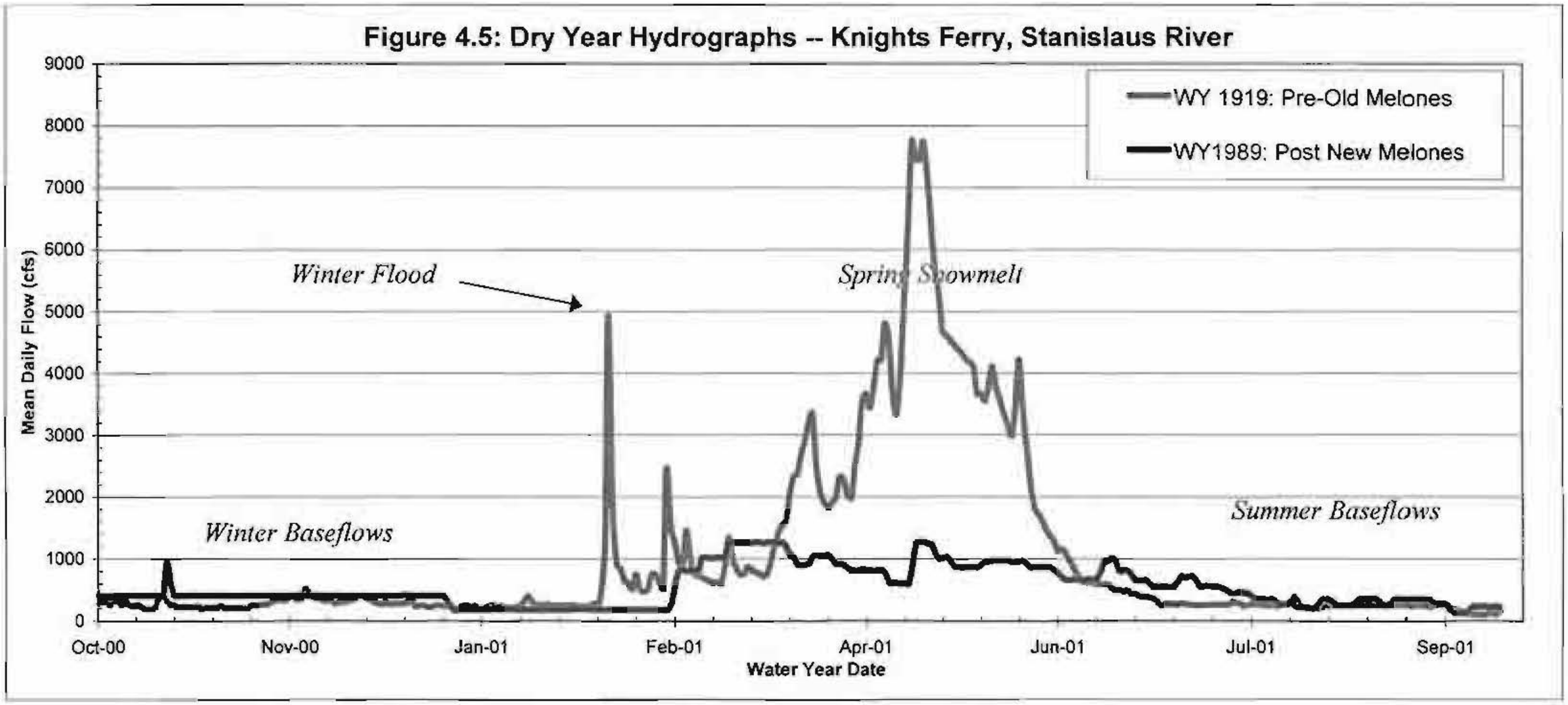


Notes: ***1924 Unimpaired Flow is over 100 TAF less than 1987 flows, but is the only "critically dry" year designated pre- Old Melones dam***

"Critically Dry" Year designation comes from McBain and Trush (2000) ranking in Tuolumne River with adjustments based on Stanislaus (SNS, sensor #65) data at http://cdec.water.ca.gov/cgi-progs/selectQuery

WY 1924 data, gage #11300000, near Knights Ferry, from USGS webpage (Unimpaired flow .26 maf)

WY1987 data, gage #11302000, below Goodwin dam, from USGS webpage (Unimpaired flow ..37 maf)

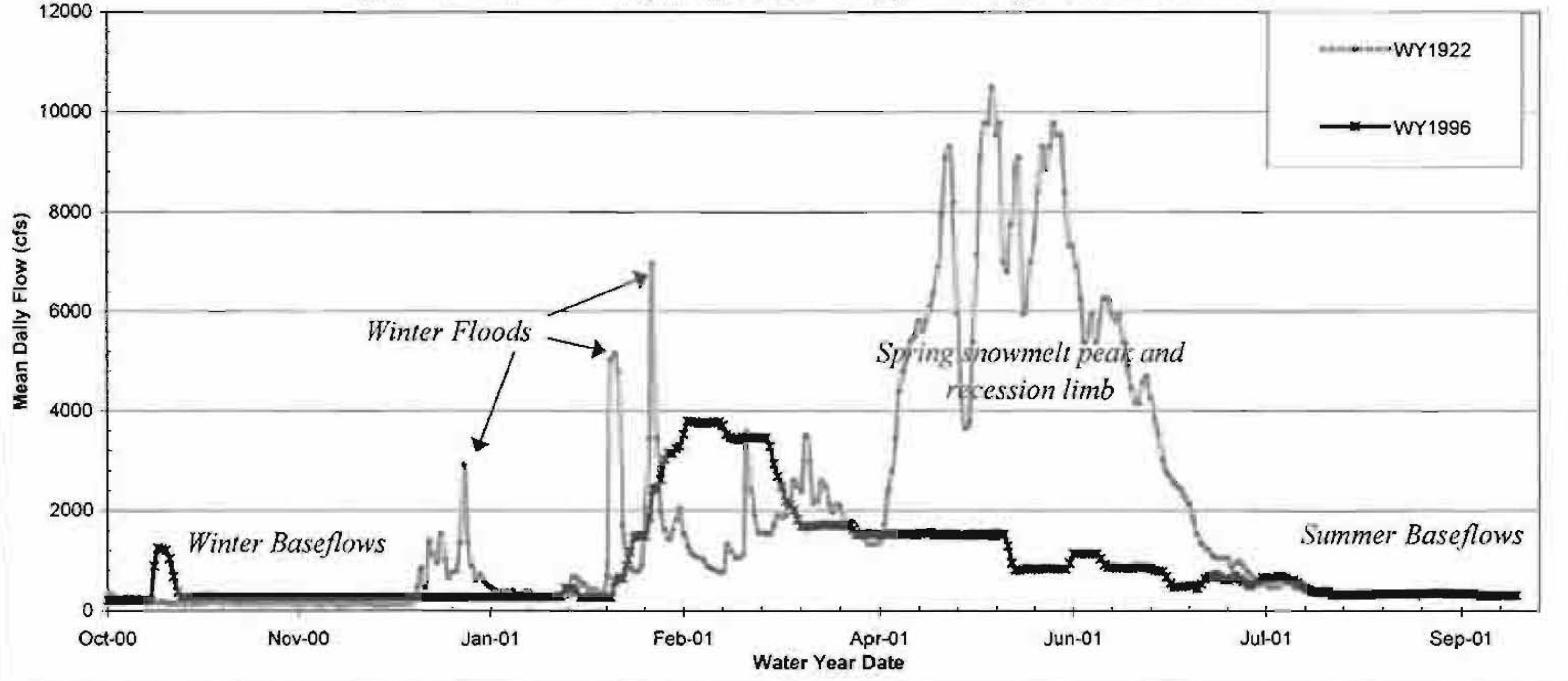


Notes: "Dry" Year designation comes from McBain and Trush (2000) ranking in Tuolumne River with adjustments based on Stanislaus (SNS, sensor #65) data at http://cdec.water.ca.gov/cgi-progs/selectQuery

WY 1919 data, gage #11300000, near Knights Ferry, from USGS webpage (Unimpaired flow .77 maf)

WY1989 data, gage #11302000, below Goodwin dam, from USGS webpage (Unimpaired flow .78 maf)

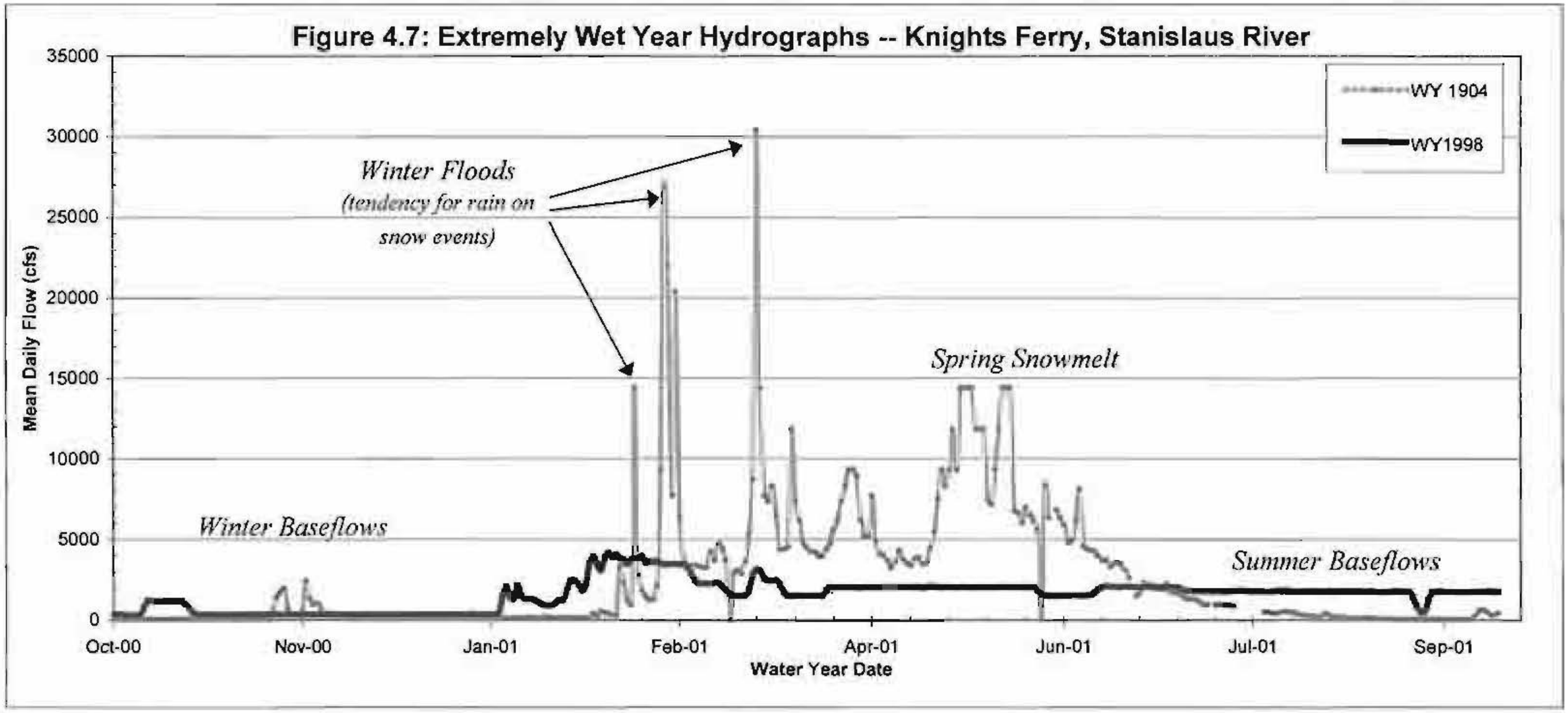
Figure 4.6: Wet Year Hydrographs -- Knights Ferry, Stanislaus River



Notes: "Wet" Year designation comes from McBain and Trush (2000) ranking in Tuolumne River with adjustments based on Stanislaus (SNS, sensor #65) data at http://cdec.water.ca.gov/cgi-progs/selectQuery

WY 1922 data, gage #11300000, near Knights Ferry, from USGS webpage (Unimpaired flow 1.43 maf)

WY1996 data, gage #11302000, below Goodwin dam, from USGS webpage (Unimpaired flow 1.49 maf)



Notes: "Extremely Wet" Year designation comes from McBain and Trush (2000) ranking in Tuolumne River with adjustments based on Stanislaus (SNS, sensor #65) data at http://cdec.water.ca.gov/cgi-progs/selectQuery

WY 1904 data, gage #11302000, near Knights Ferry, from WSpaper299 (Unimpaired flow =2.05 maf)

WY1998 data, gage #11302000, below G+B4oodwin dam, from USGS webpage (Unimpaired flow= 2.09 maf)

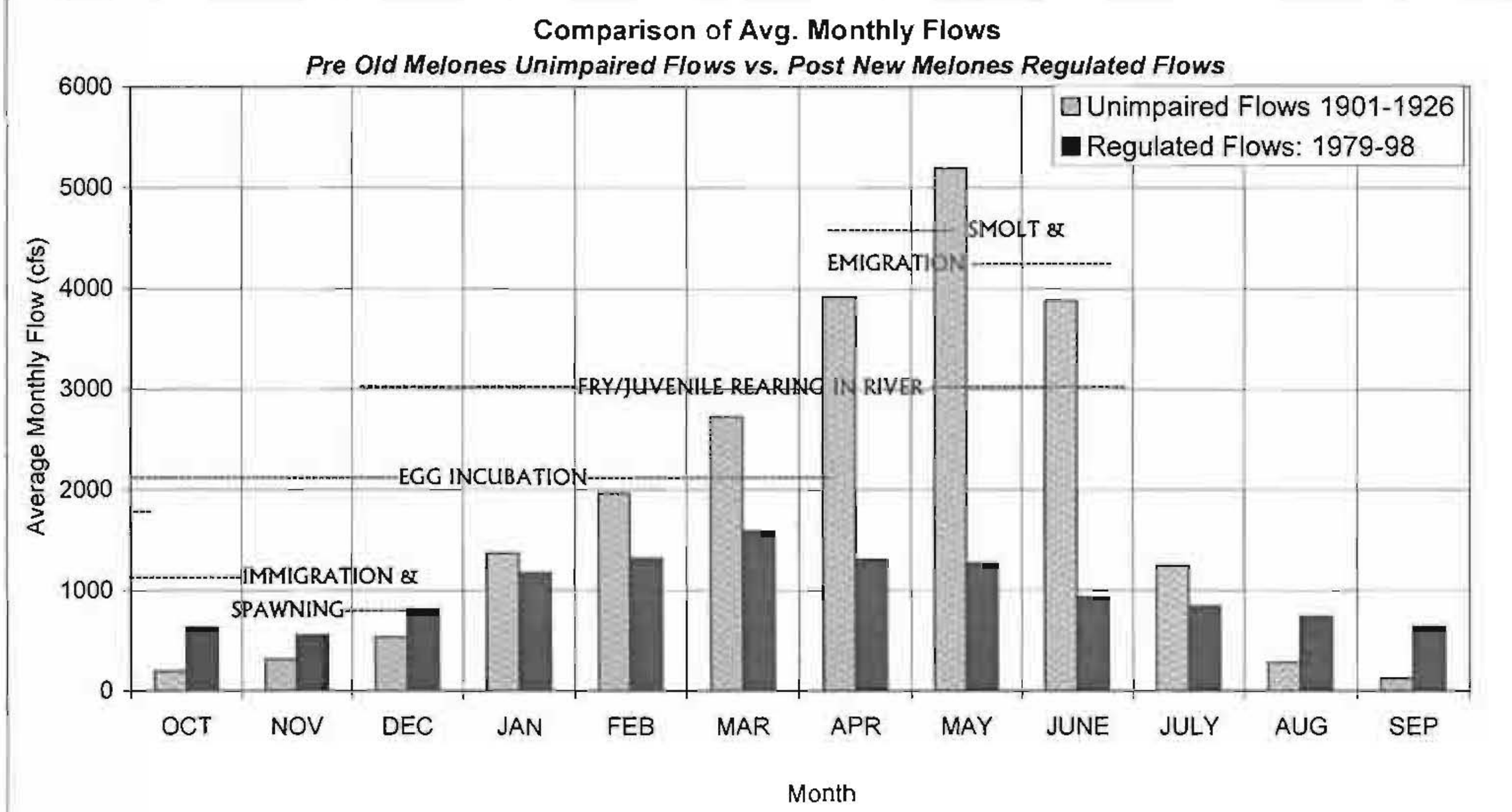


Figure 4.8: Comparison of Average Monthly Flows, Stanislaus River. The following graph compares average unimpaired monthly flows from before Old Melones dam (1901-1926) with regulated monthly flows following construction of New Melones dam (1979-1999). Basin dams impounded less than 4% of the average annual unimpaired runoff during the 1901-1926 period (see ***figure 2-1***). Note the significant reduction in winter and late spring average flows and the increase in summer monthly flows. Life cycle of the Stanislaus River fall-run chinook salmon is related to the average annual runoff patterns.

Data Source: Unimpaired flows from "Full Natural Flow" data, USGS gauge at Stanislaus R-Goodwin (SNS), Sensor #65, Elev. 252'.
http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=SNS&sensor_num=65&dur_code=M&start_date=1903&end_date=now
Post New Melones dam regulated flows from analysis of mean daily flow data using the Indicators of Hydrologic Alteration Model (IHA) (Schneider, May 2000).

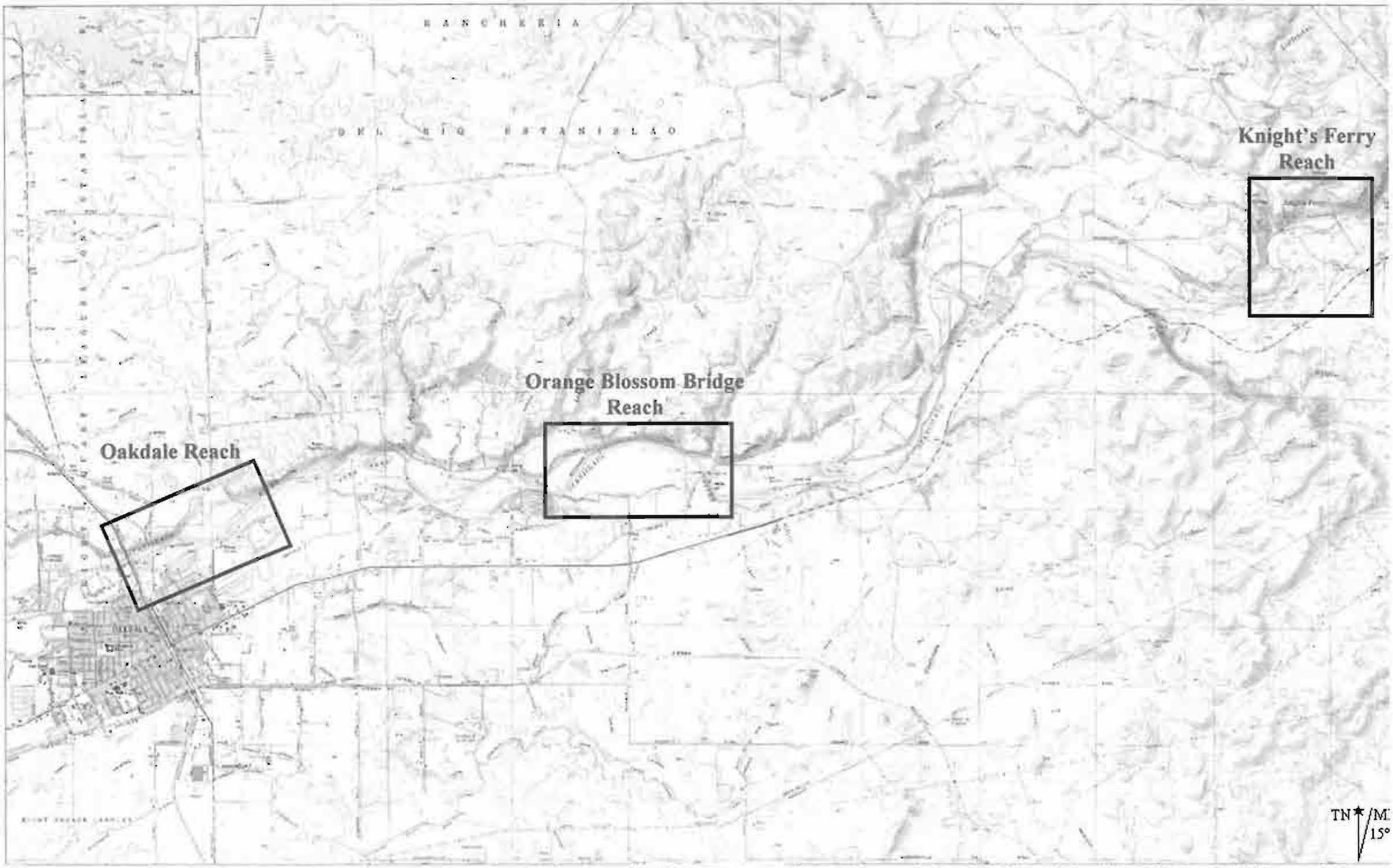


Figure 5.1: Location Map of the Three Selected Sites. The boxes show the location of the three areas of detailed analysis with historical aerial photographs from 1937, 1957, and 1998. The Knight's Ferry Reach is illustrated in Figure 5.2 and the Orange Blossom Bridge Reach is illustrated in Figure 5.3, and the Oakdale Reach is illustrated in Figure 5.4. Source: USGS 1:24,000 topographic map from Topo! Software.

Figure 5.2

Knight's Ferry (RM 54.7 to 53.1)

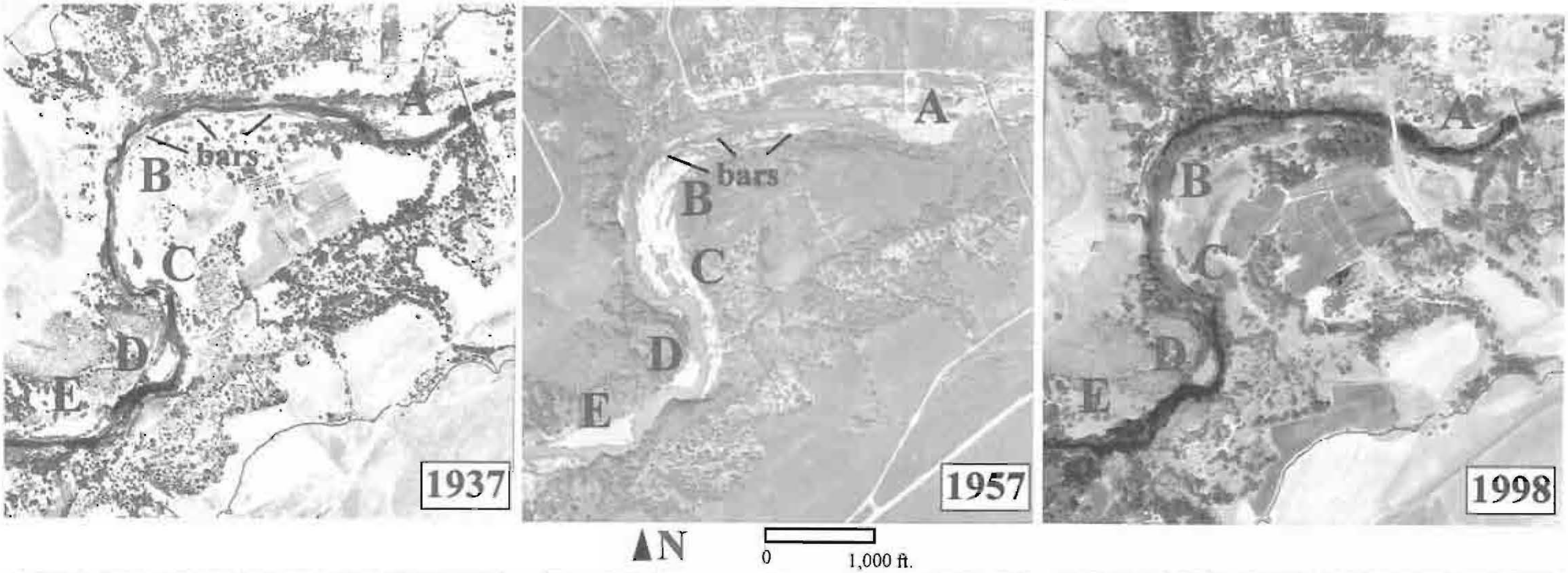


Photo #1 Bedrock control at Point E, Lava Bluffs

Photo #2 Bedrock Control at Russian Rapids (Point B) also note dense riparian vegetation. Riffle R6.

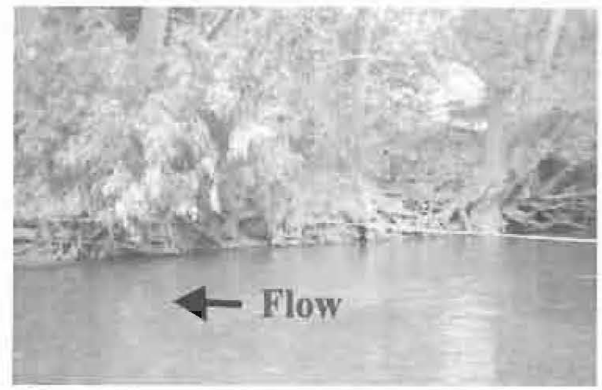


Photo #3 Dense Riparian vegetation and evidence of incision at Riffle R78.

Figure 5.3

Orange Blossom Bridge (RM 47.4 to 45.5)

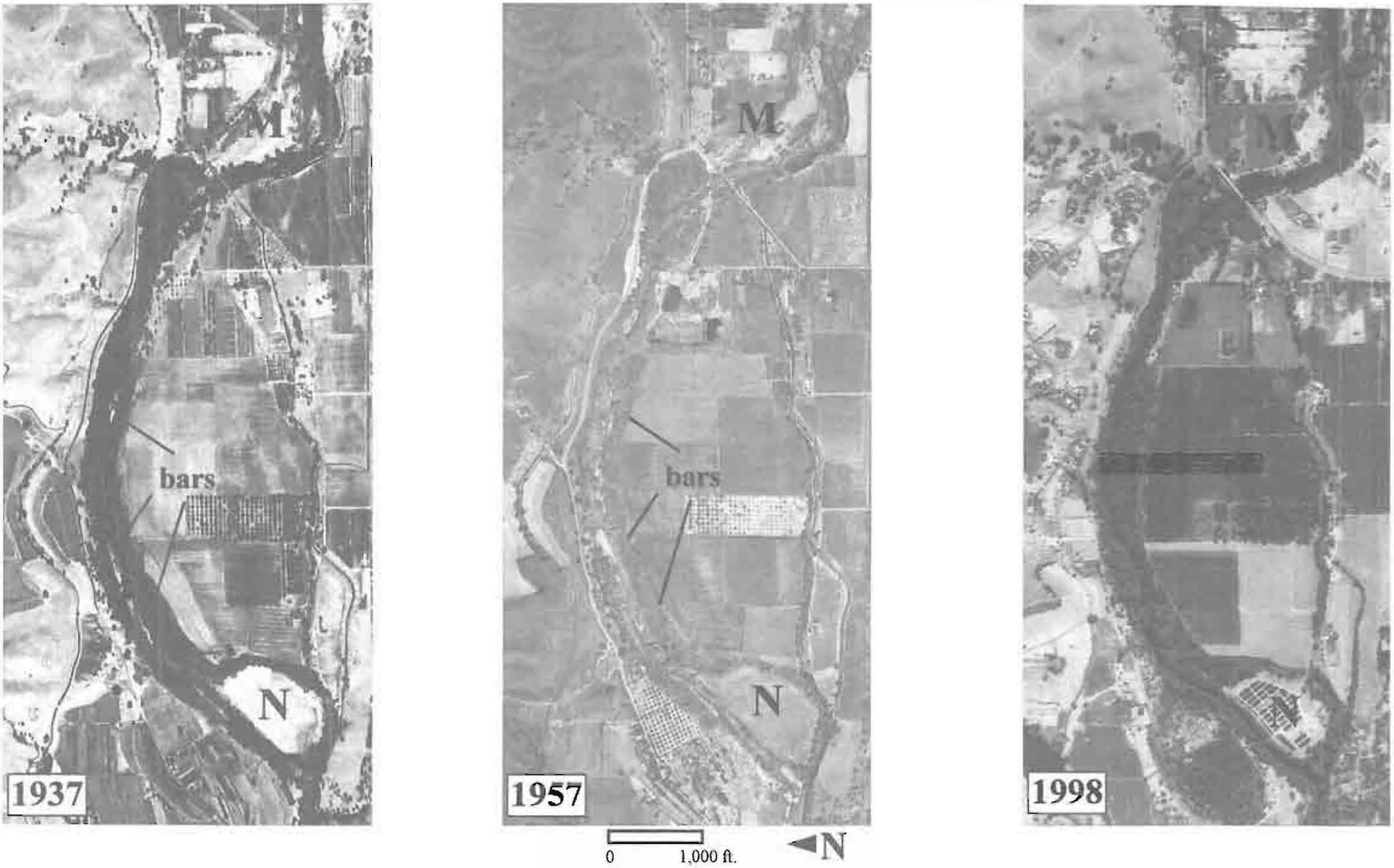


Figure 5.4

Oakdale (RM 42.4 to 41.2)

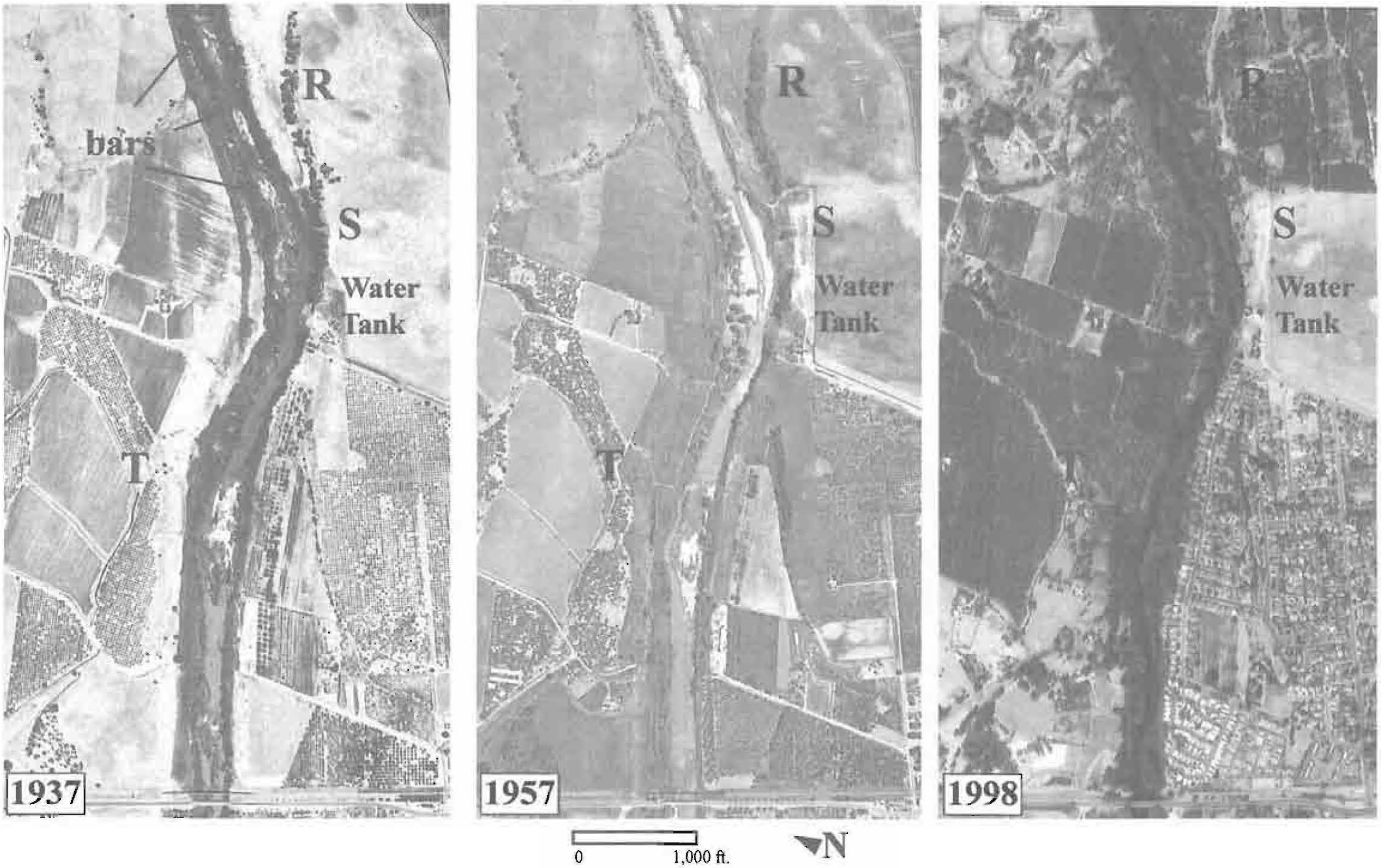


Figure 5.5: Root Crown Exposure at R78, Stanislaus River. (RM 40: 375cfs). Note the vegetation encroachment and extent of root wad exposure at this site, indicating channel incision and erosional processes (Photo, K. Schneider, 10/27/99).

Figure 5.6: Erosion at R58, Stanislaus River. (RM 45, 375cfs). Significant erosion below the stairway in the background has been observed in the last couple of years at Riffle 58. Gravel additions as part of the Knights Ferry Gravel Replenishment Project limit the ability to quantify the channel incision at this site due to the addition of spawning gravels for Chinook Salmon. (Photo, K. Schneider, 10/27/99).

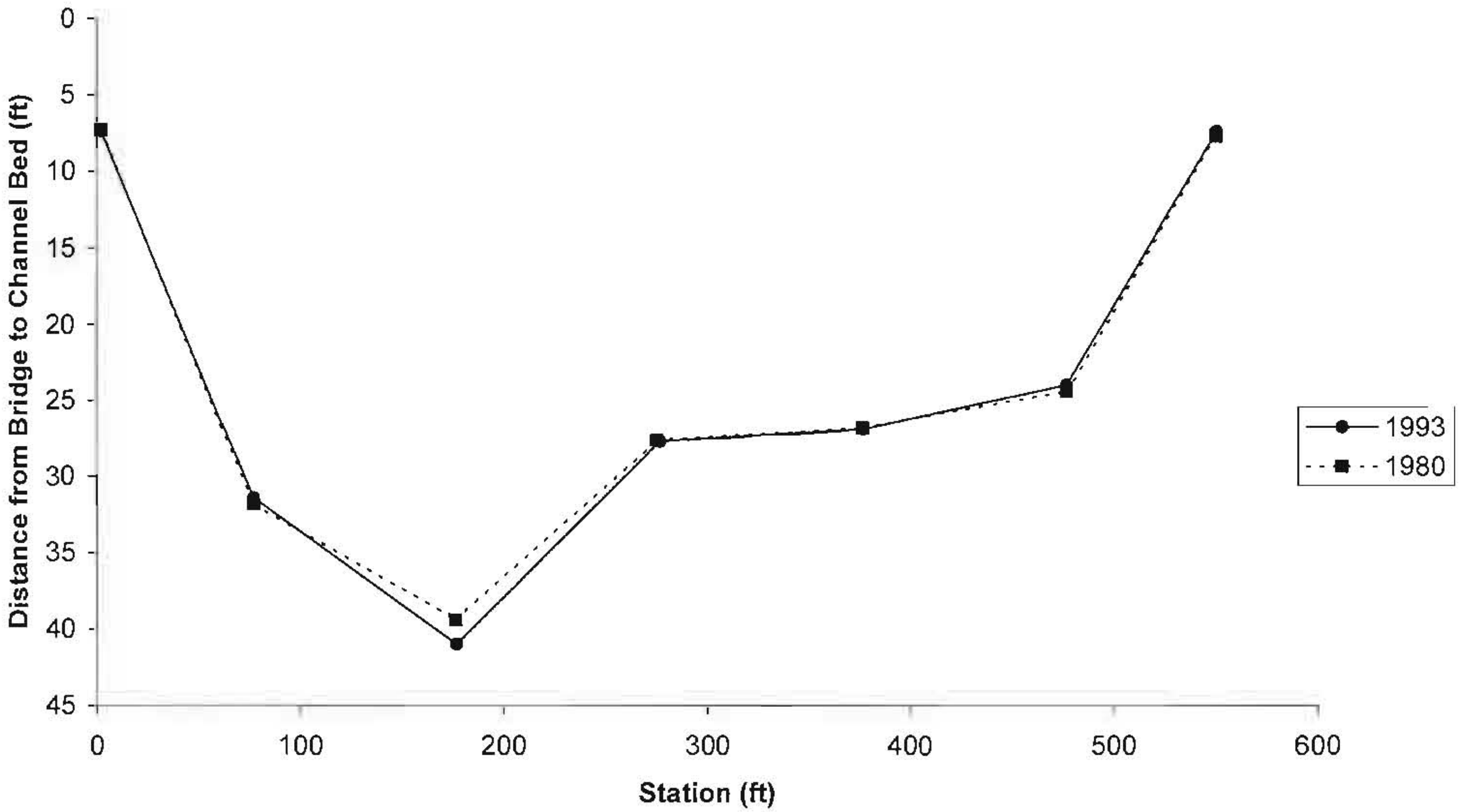


Figure 5.7: Orange Blossom Bridge Historical Cross Section. This figure shows two cross sections taken from Caltrans bridge survey reports from 1980 (dashed line) and 1990 (solid line). The difference between the cross sections shows 1.6 ft of incision.

Figure 5.8: Cross Section Russian Rapids

(R5: Mesick, Nov. '98 survey; all units in ft)

Cross Section	$Area_{BF}$ (ft^2)	$Depth_{BF}$ (ft)	Slope n	Slope S	Vel.[3] (ft/s)	Q_{BF}=V*A (cfs)	FF Return Interval (yrs)[4] Post NM	FF Return Interval (yrs)[4] Pre NM
R5: Post Dam Actual[1]	512	7.2	0.028	0.0012	6.87	**3,519**	~2.1	~1.22
R5: Pre Dam Estim.[2] - 2' incision	446.7	5.2	0.028	0.0012	5.53	**2,472**	~1.7	~1.18
R5: Pre Dam Estim.[2] - 3' incision	380.1	4.2	0.028	0.0012	4.80	**1,824**	~1.4	~1.15

[1]: *Bankfull estimated by assuming the slope break occurs at the end of Mesick (1998) cross section.*

[2]: *Incision is assumed to be uniform across the cross section for calculations. Root crowns indicate ~0.5-1 meter of incision, so various estimates are used in calculations.*

[3]: *Velocity estimated with the Manning's equation,* $V=(1.49/n)(R.)^{.66}(S)^{.5}$. *Hydraulic radius R is approximated as =D*

[4]: ***Annual duration** flood frequency data used to estimate return interval for bankfull flows since partial duration series data is not available for the Stanislaus River.*

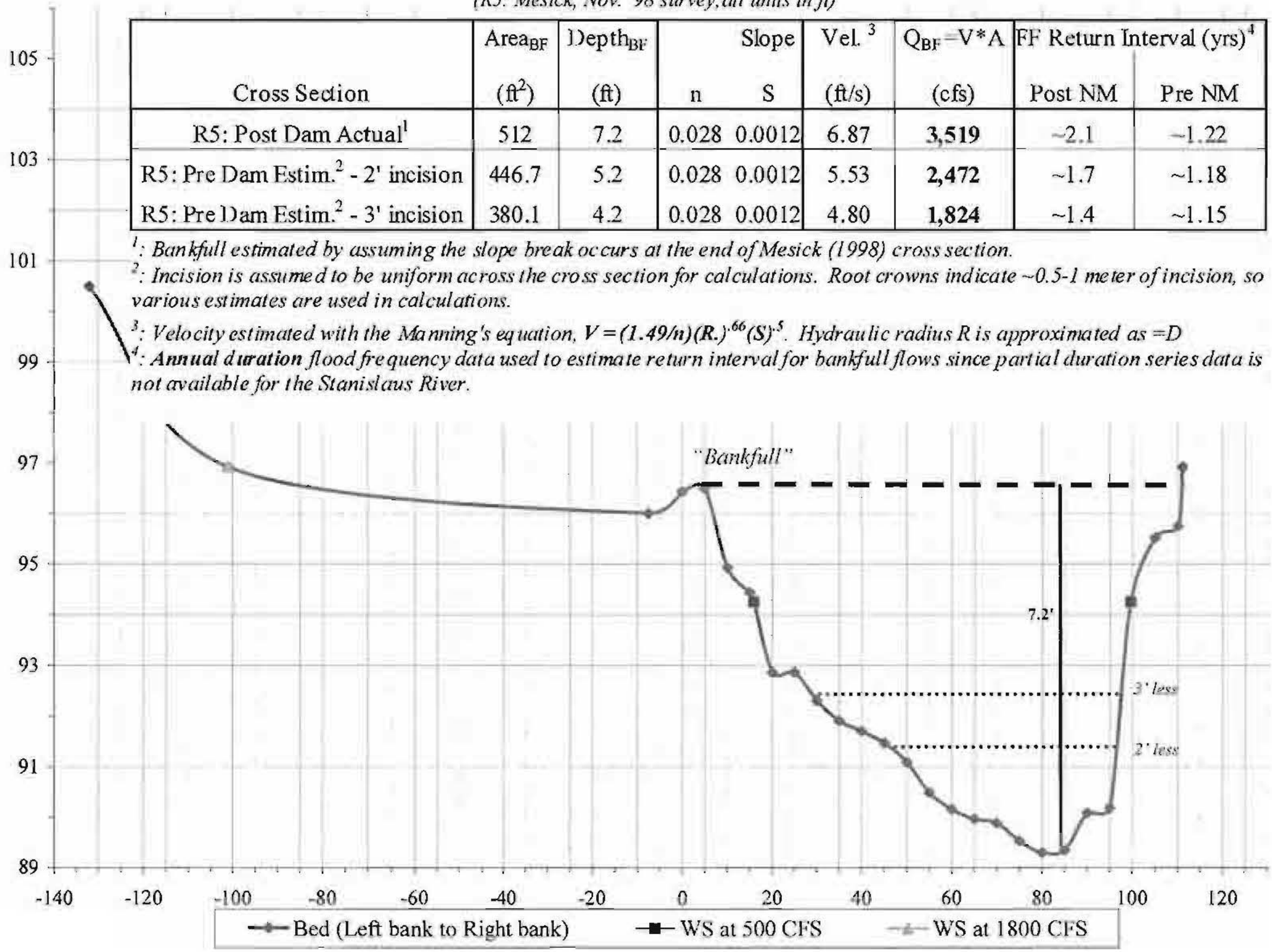


Figure 5.9: Cross Section near Lover's Leap

(R20: Mesick, Nov. '98 survey, all units in ft)

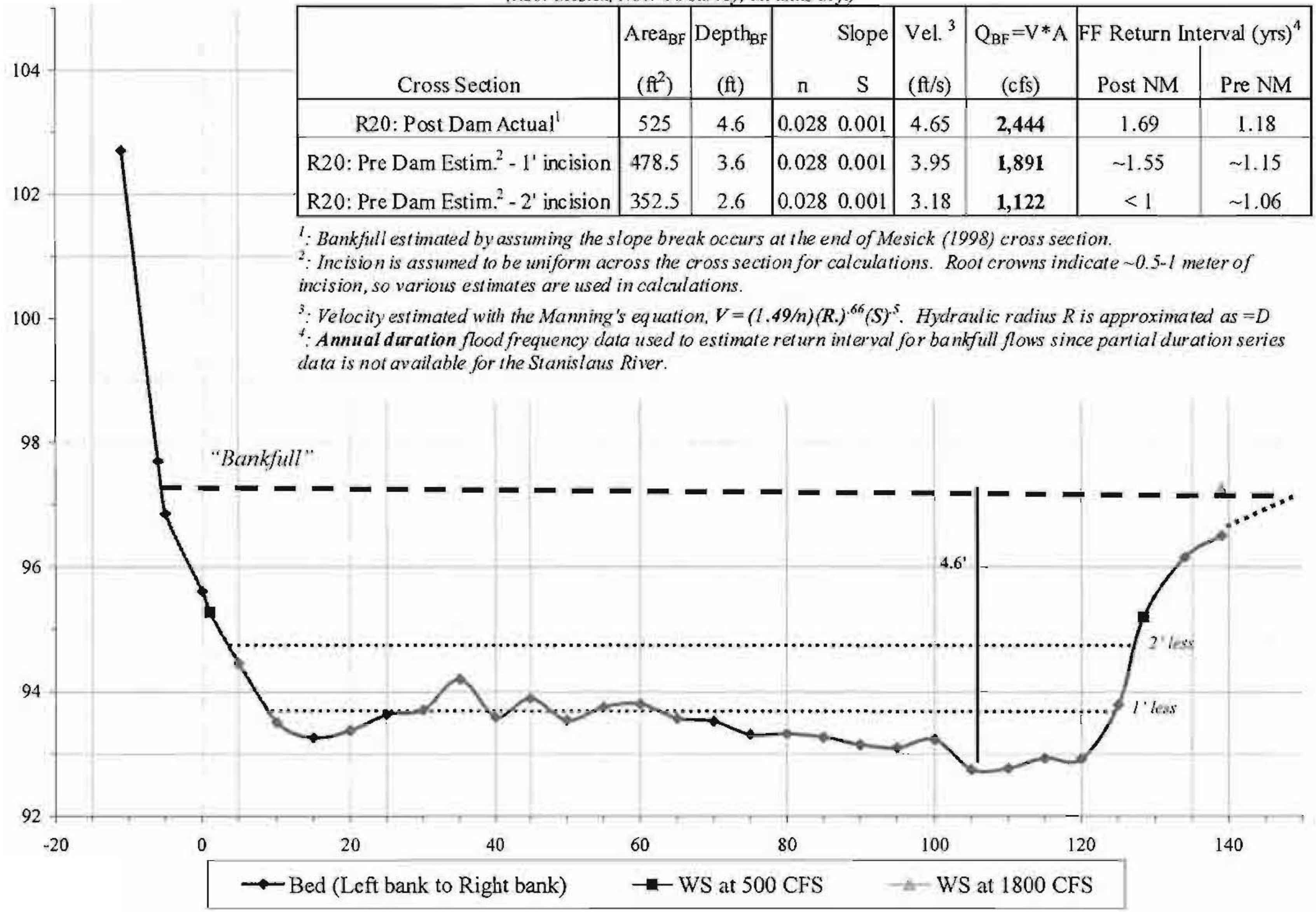
Cross Section	$Area_{BF}$ (ft^2)	$Depth_{BF}$ (ft)	n	Slope S	Vel.[3] (ft/s)	$Q_{BF}=V*A$ (cfs)	FF Return Interval (yrs)[4] Post NM	Pre NM
R20: Post Dam Actual[1]	525	4.6	0.028	0.001	4.65	**2,444**	1.69	1.18
R20: Pre Dam Estim.[2] - 1' incision	478.5	3.6	0.028	0.001	3.95	**1,891**	~1.55	~1.15
R20: Pre Dam Estim.[2] - 2' incision	352.5	2.6	0.028	0.001	3.18	**1,122**	< 1	~1.06

[1]: Bankfull estimated by assuming the slope break occurs at the end of Mesick (1998) cross section.

[2]: Incision is assumed to be uniform across the cross section for calculations. Root crowns indicate ~0.5-1 meter of incision, so various estimates are used in calculations.

[3]: Velocity estimated with the Manning's equation, $V=(1.49/n)(R.)^{.66}(S)^{.5}$. Hydraulic radius R is approximated as =D

*[4]: **Annual duration** flood frequency data used to estimate return interval for bankfull flows since partial duration series data is not available for the Stanislaus River.*



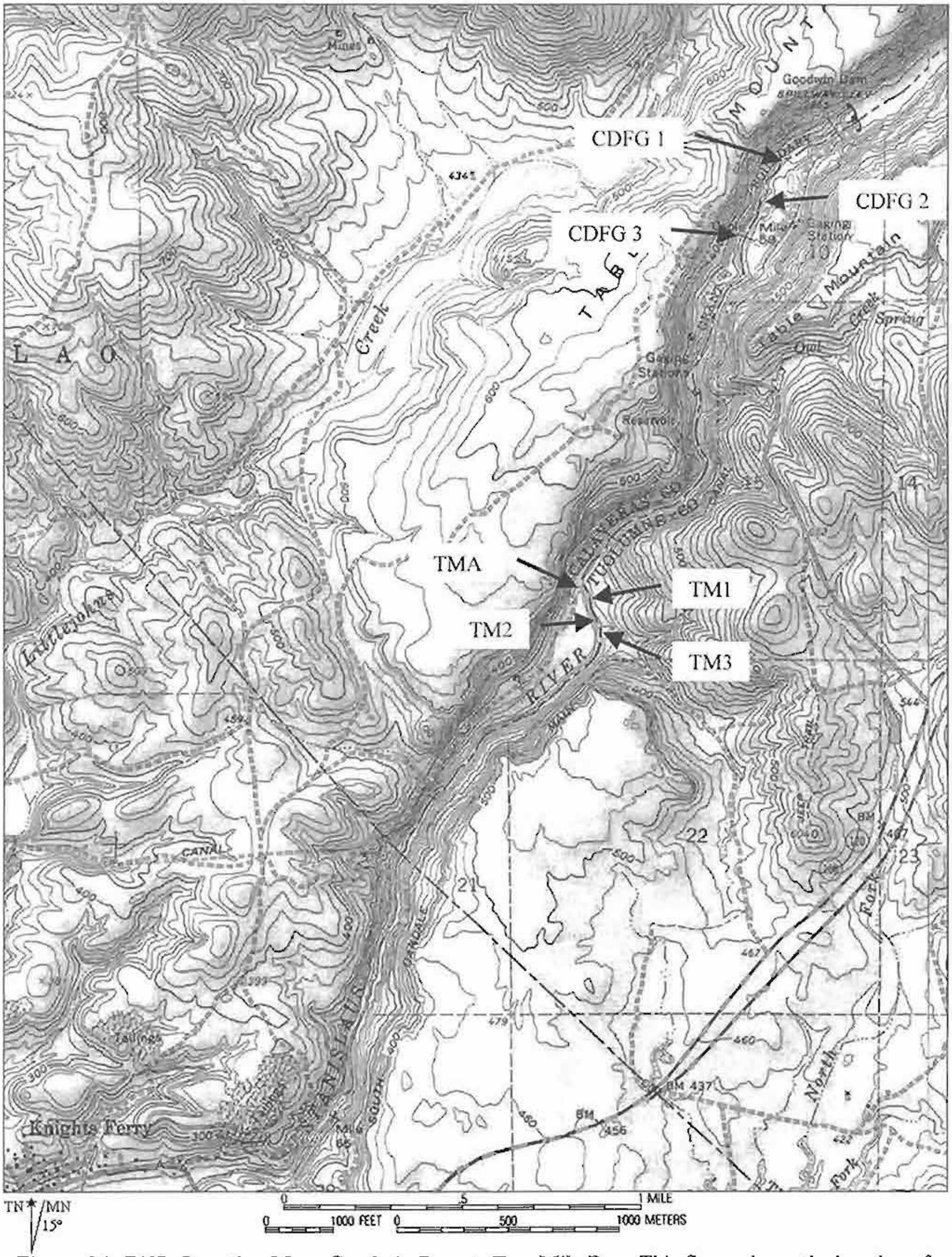


Figure 6.1: Riffle Location Map: Goodwin Dam to Two Mile Bar. This figure shows the location of historical spawning rifles from DWR 1994, CDFG 1972, CMC 2000, and our study that we re-visited.

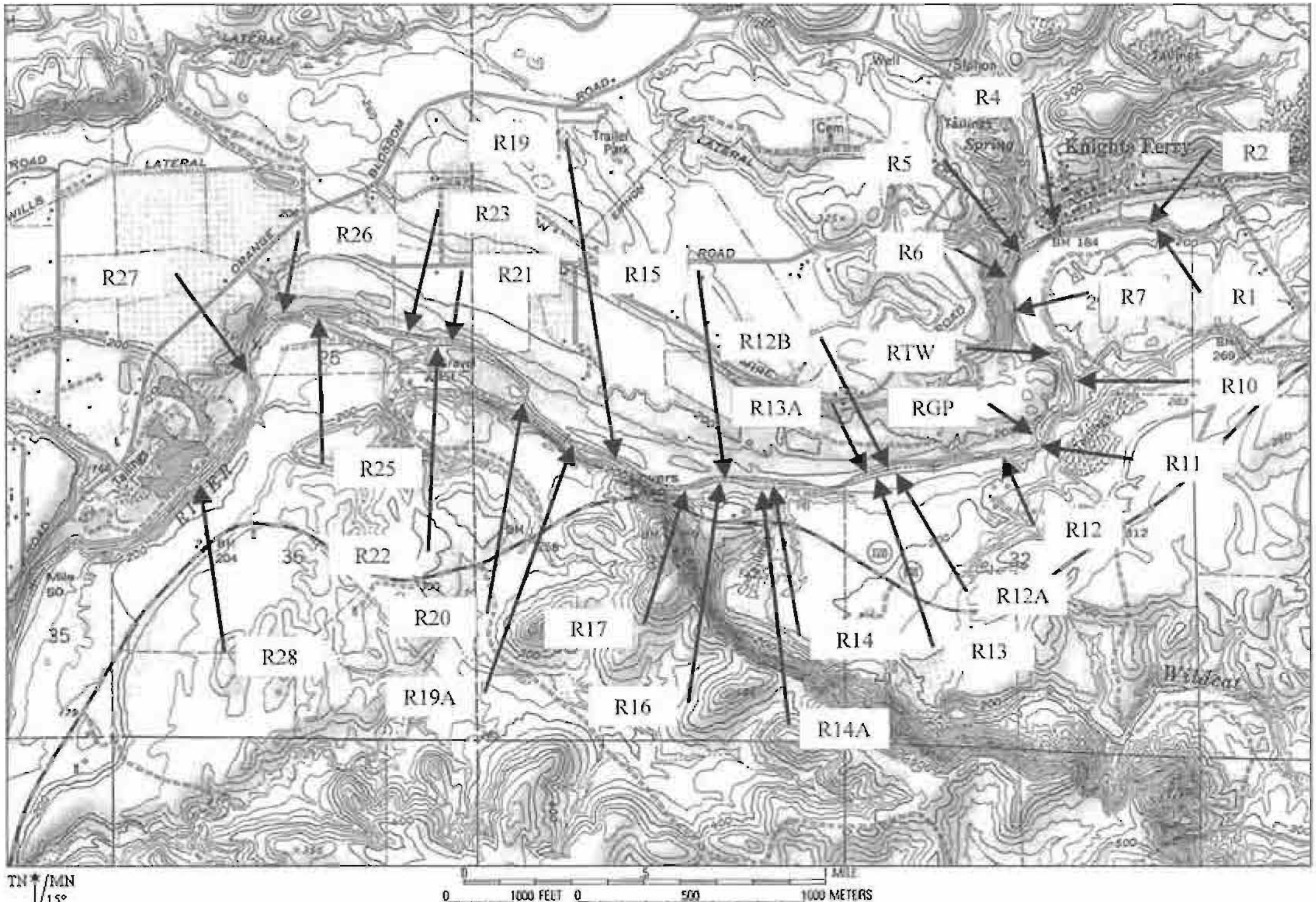


Figure 6.2: Riffle Location Map: Knight's Ferry to R28. This figure shows spawning riffles from DWR 1994, CDFG 1972, CMC 2000, and our study that we re-visited.

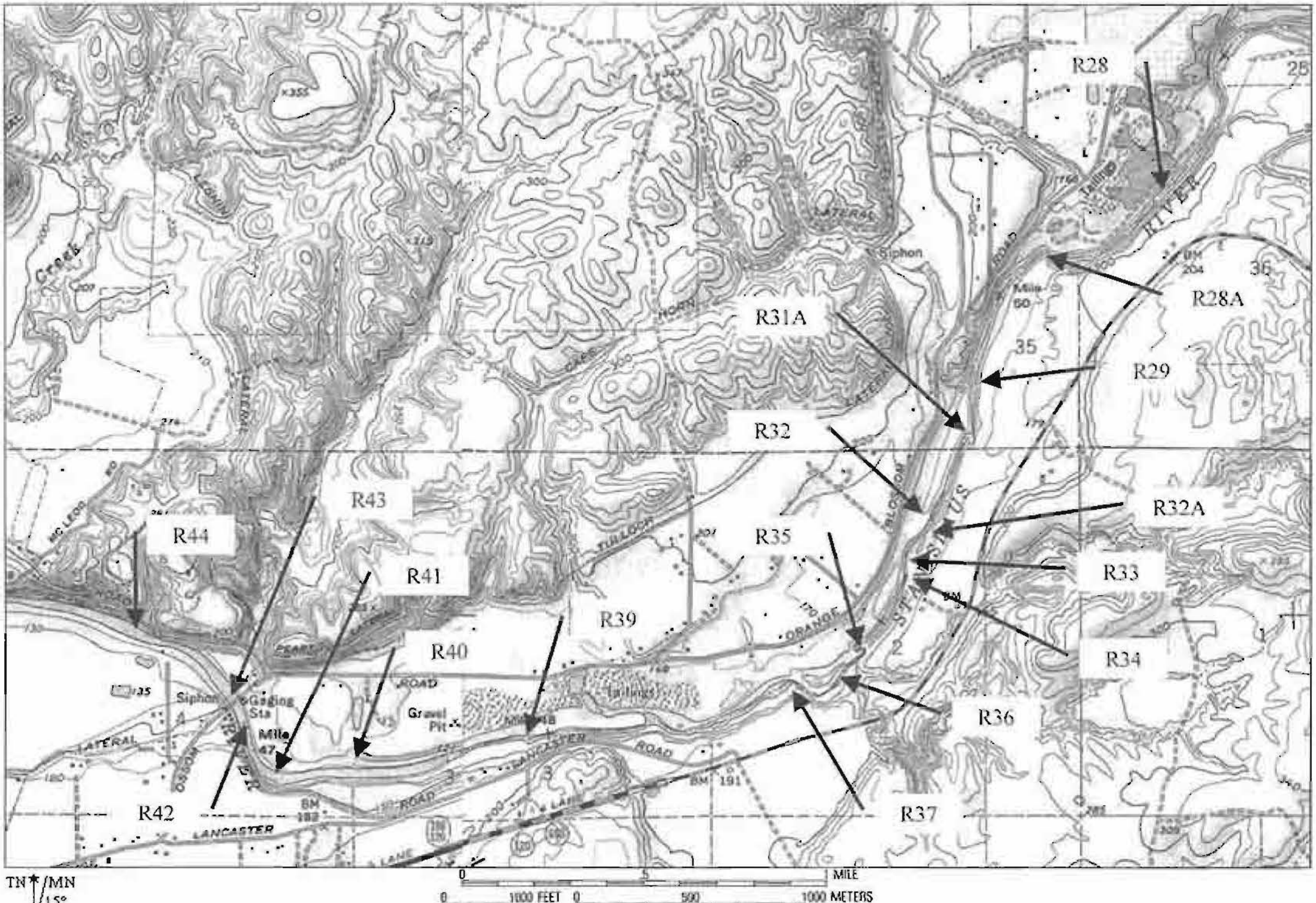


Figure 6.3: Riffle Location Map: R28 to Orange Blossom Bridge. This figure shows spawning riffles from DWR 1994, CDFG 1972, CMC 2000, and our study that we re-visited.

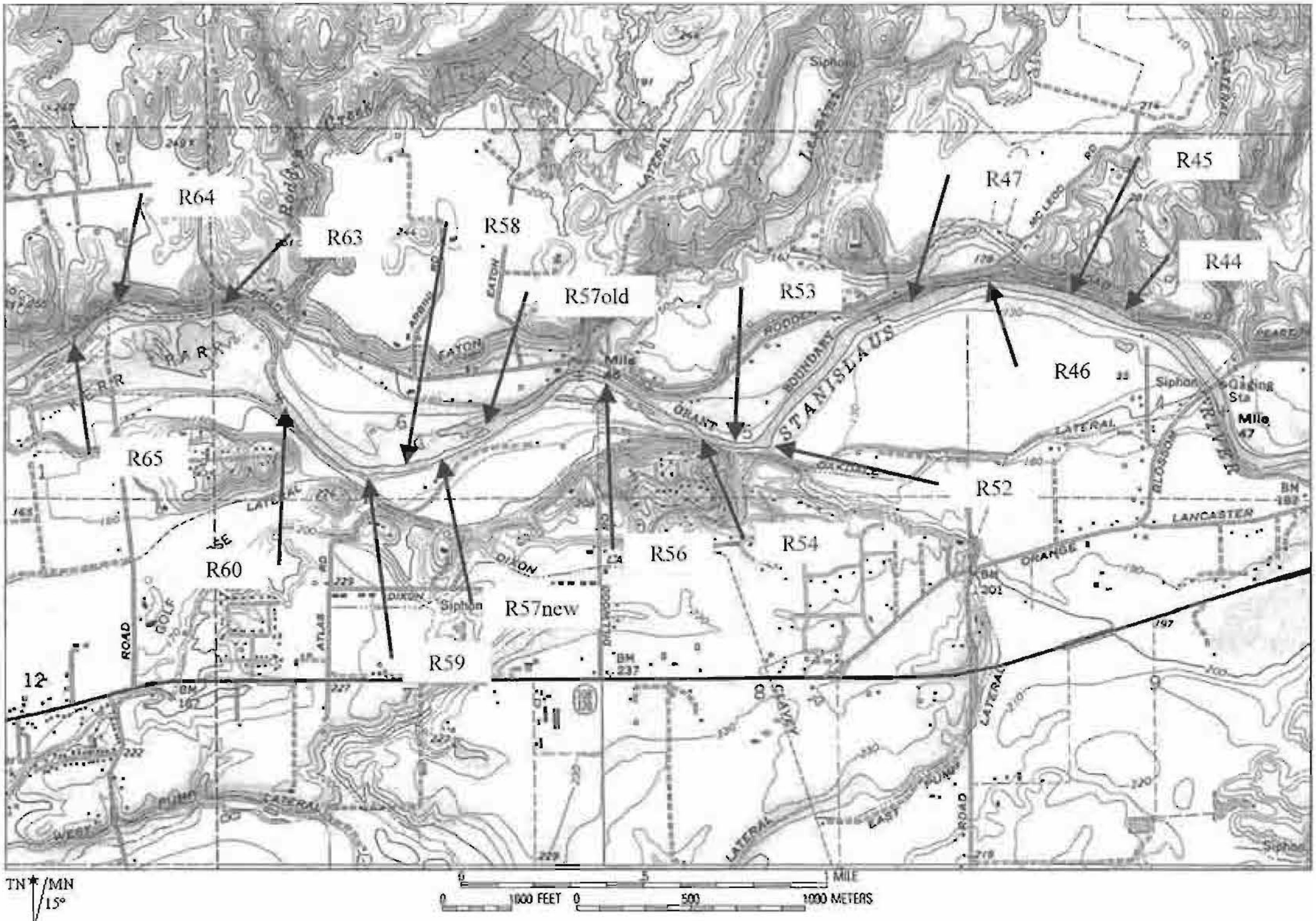


Figure 6.4: Riffle Location Map: Orange Blossom Bridge to Kerr Park. This figure shows spawning riffles from DWR 1994, CDFG 1972, CMC 2000, and our study that we re-visited.

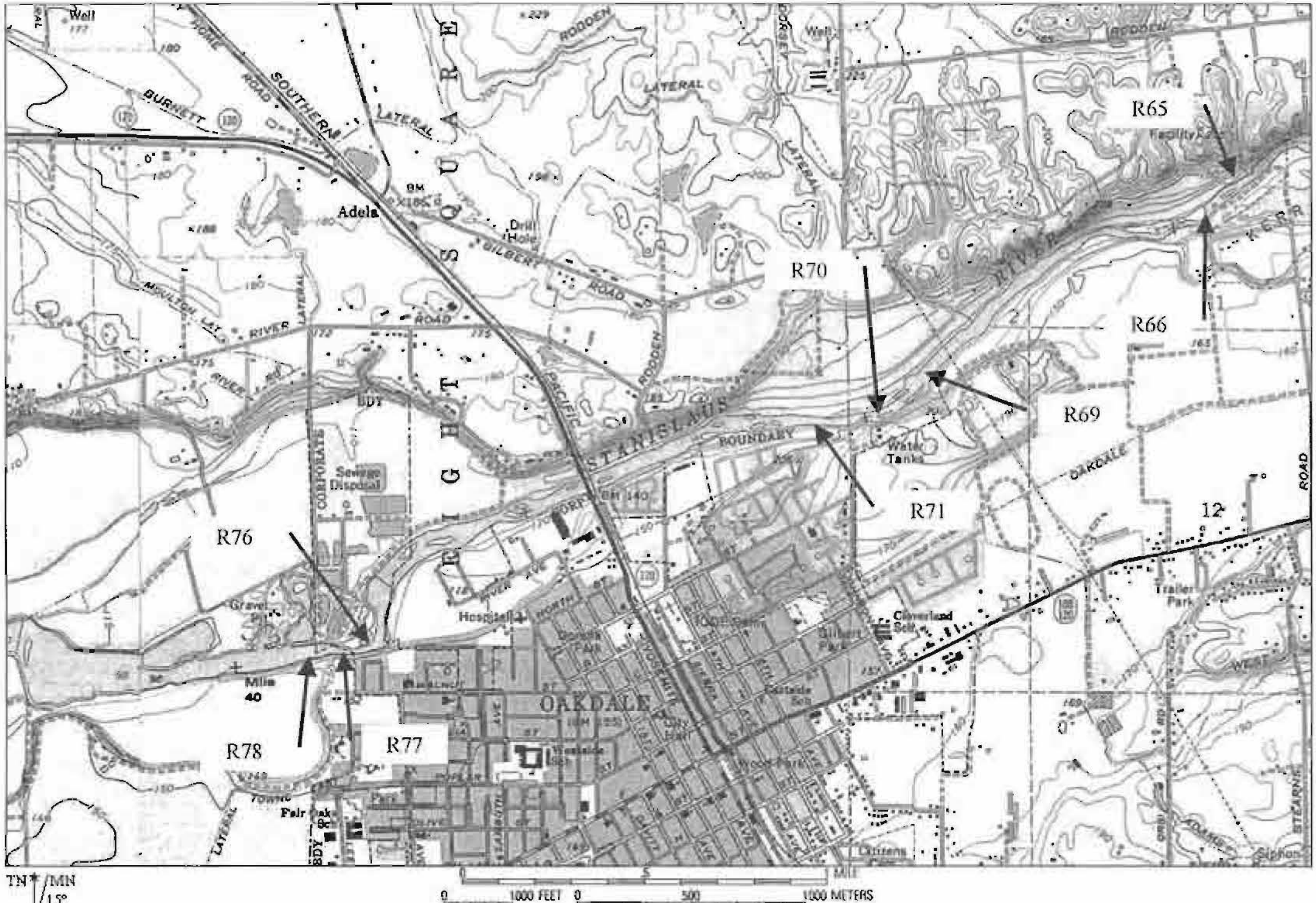


Figure 6.5: Riffle Location Map: Kerr Park to Oakdale. This figure shows spawning riffles from DWR 1994, CDFG 1972, CMC 2000, and our study that we re-visited.

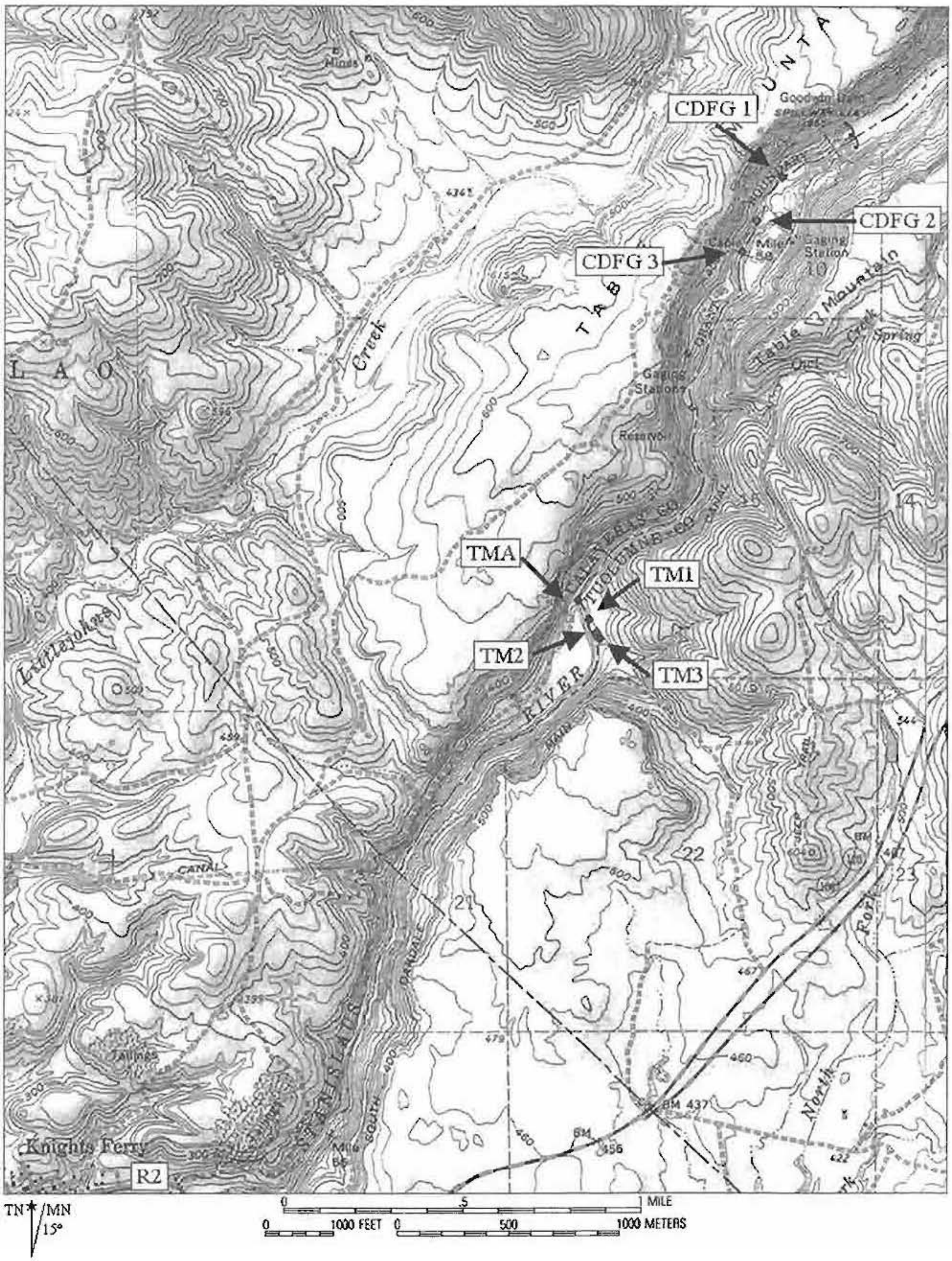


Figure 6.6: Observed Spawning Locations: Goodwin Dam to Two Mile Bar. This figure shows the location of observed spawning salmon or fresh redds during our study.

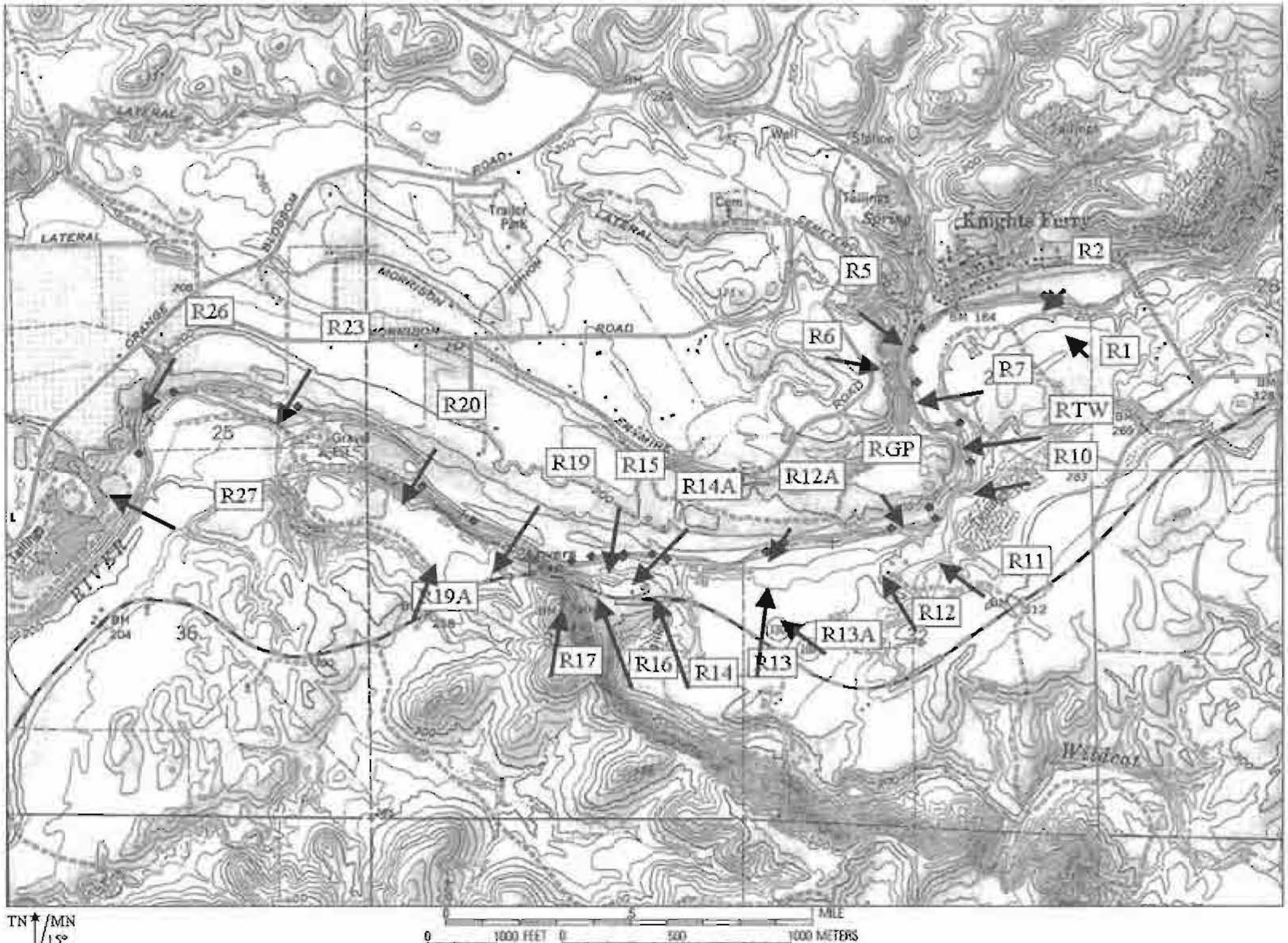


Figure 6.7: Observed Spawning Locations: Knight's Ferry to R27. This figure shows the location of observed spawning salmon or fresh redds during our study.

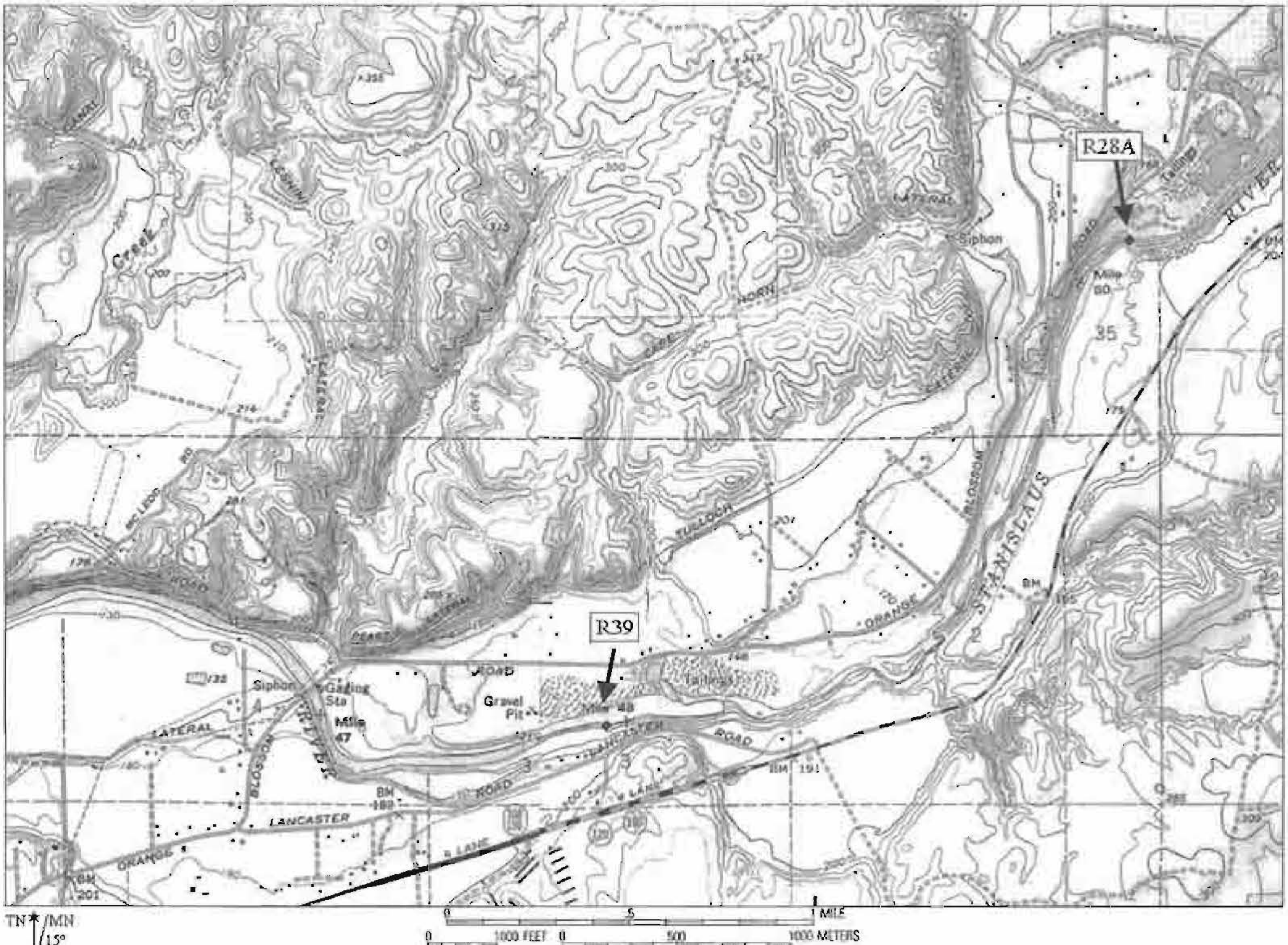


Figure 6.8: Observed Spawning Locations: R28 to R39. This figure shows the location of observed spawning salmon or fresh redds during our study.

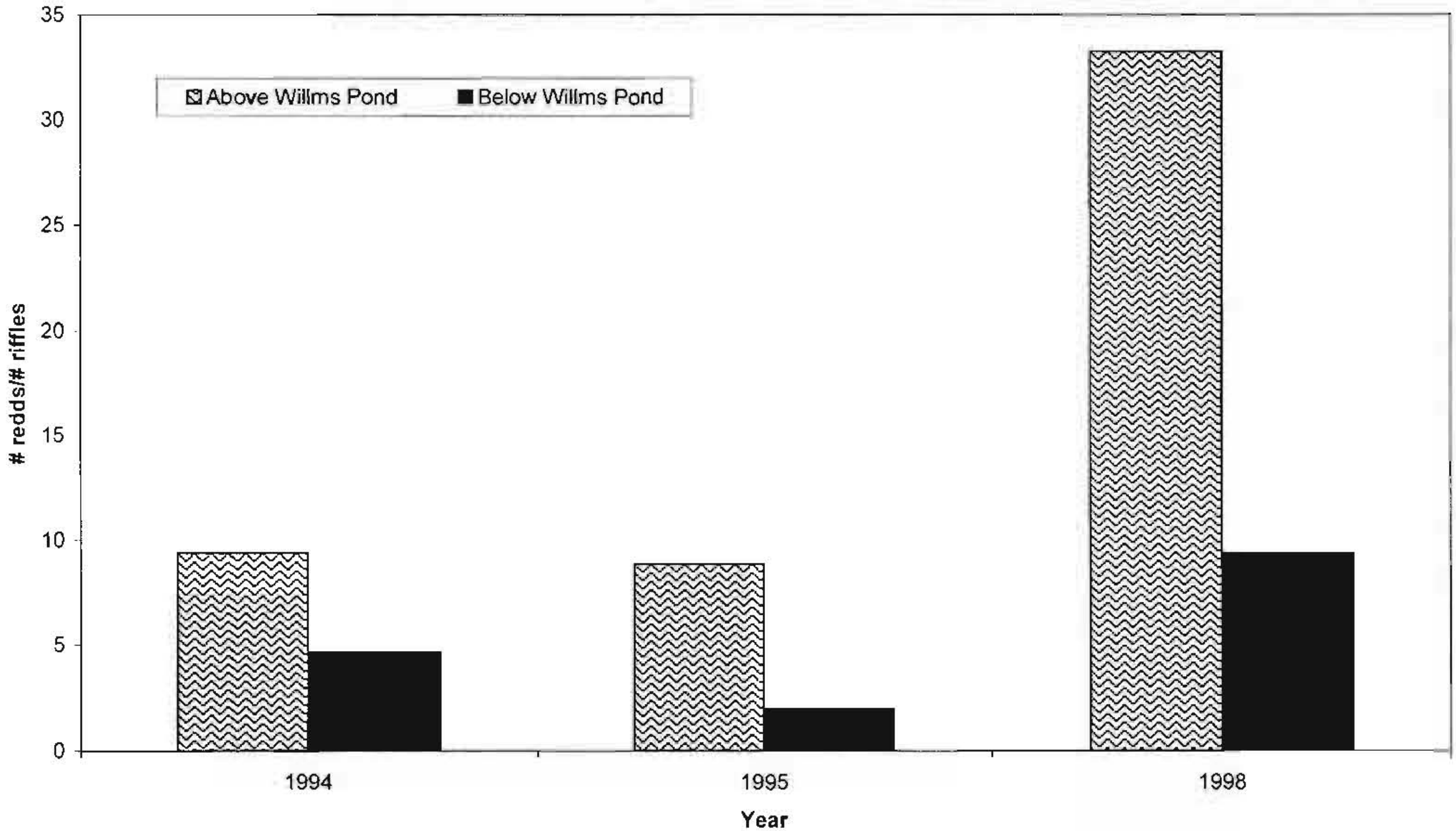


Figure 6.9: Redds per Riffle Above and Below Willms Pond. This figure shows the change concentration of spawning above and below Willms Pond. From 1994 to 1998 more salmon spawned in the reach between Goodwin Dam and Willms Pond. *Data source: CMC 2000*.

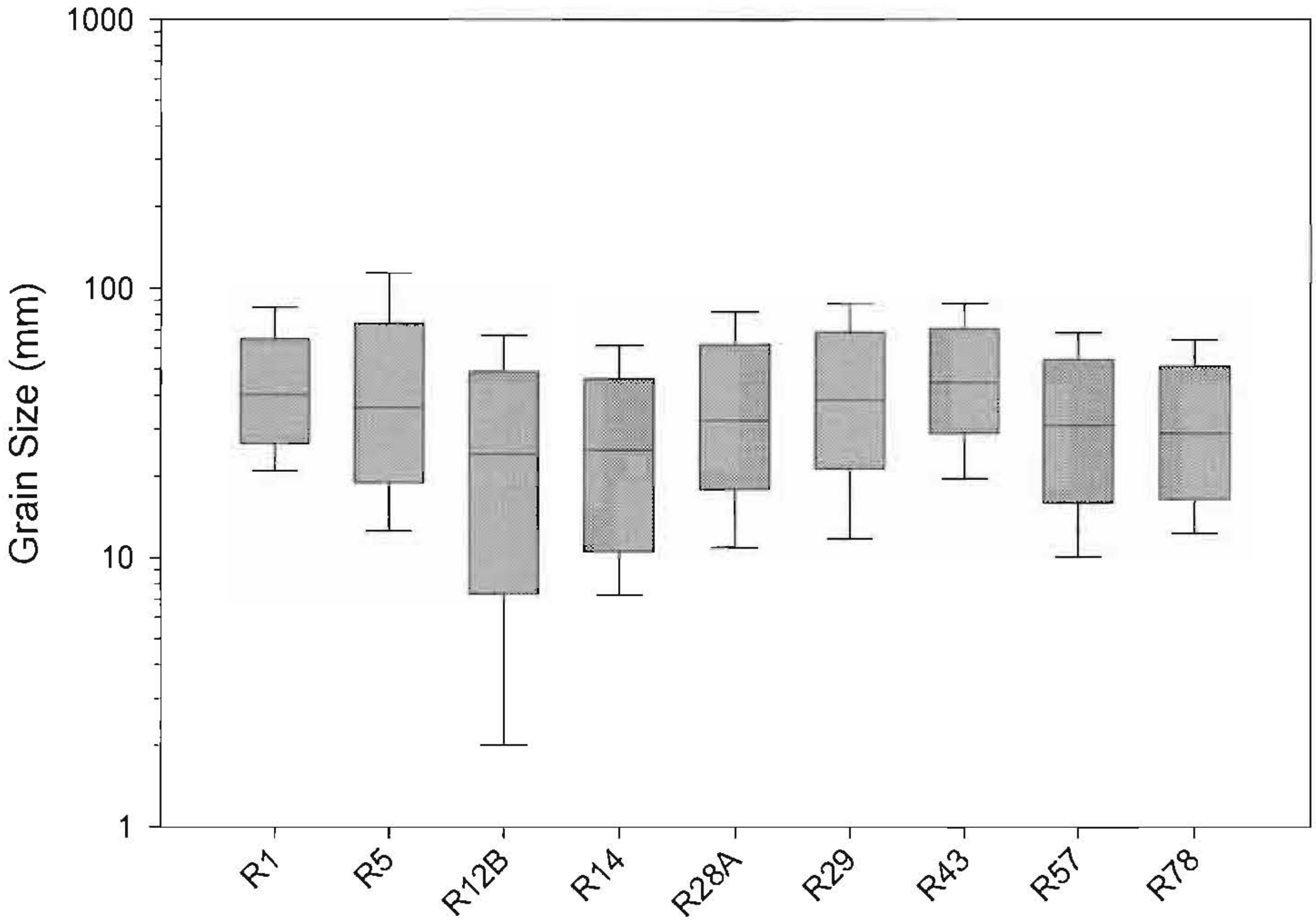


Figure 6.10: Year 2000 Pebble Counts on Riffles Enhanced in 1999. We performed pebble counts on riffles enhanced in 1999 by CMC (2000) riffles to establish a baseline to document future change in the size distribution of the surface layer of gravel. Riffle R12B (**Figure 6.2**) is adjacent to an active gravel mine and has the highest concentration of fine sediment of the CMC (2000) riffles we measured. Note: All grains in the size class <4 mm are plotted at 2 mm.

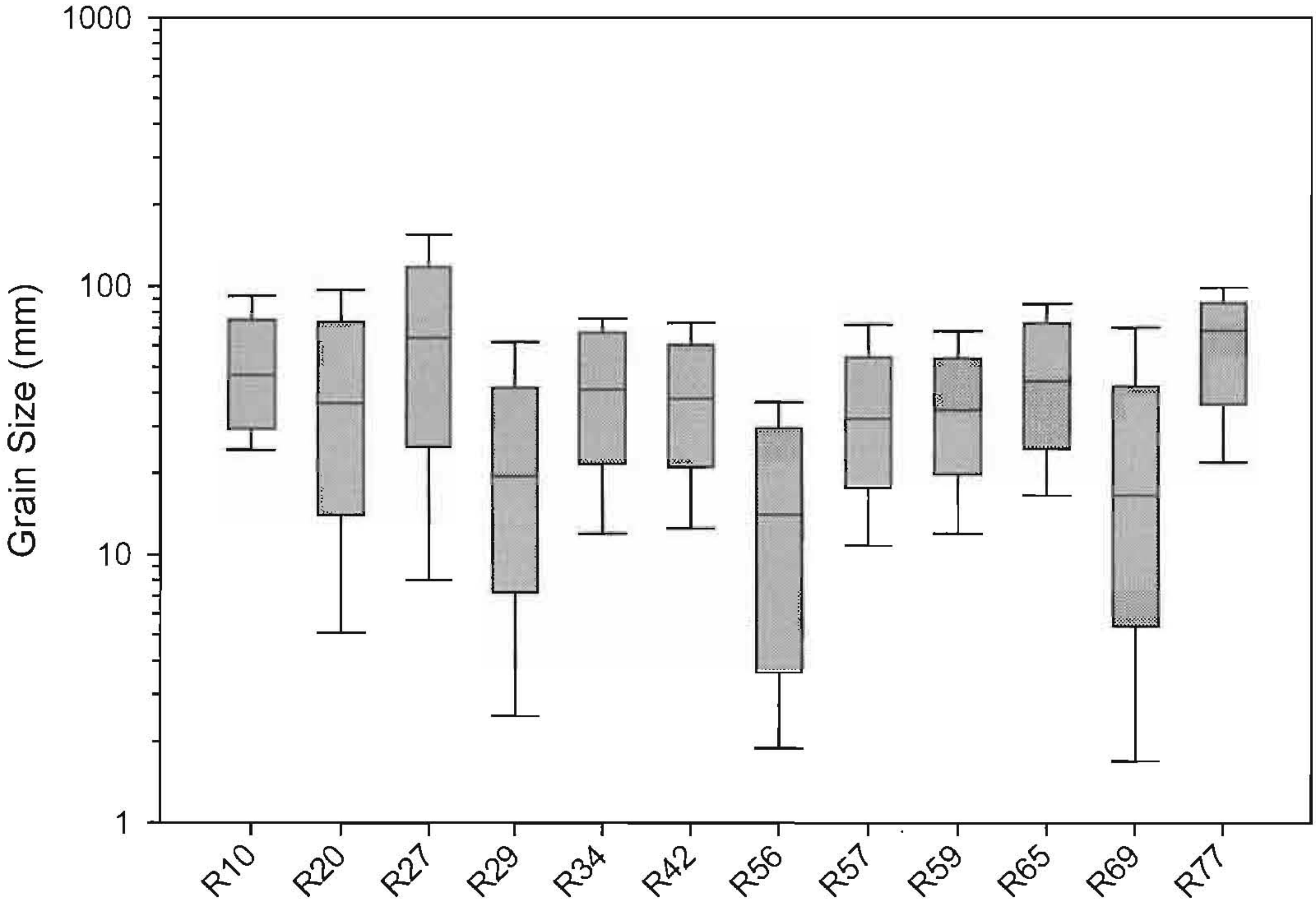


Figure 6.11: DWR 1994 Pebble Counts. We plotted pebble count data from DWR 1994 for all the riffles we relocated. Of the twelve relocated riffles two were enhanced by CMC in 1999 (R29 and R58) and one by CDFG in 1994 (R27), after the DWR 1994 study. Note: All grains in the size class <4 mm are plotted at 2 mm.

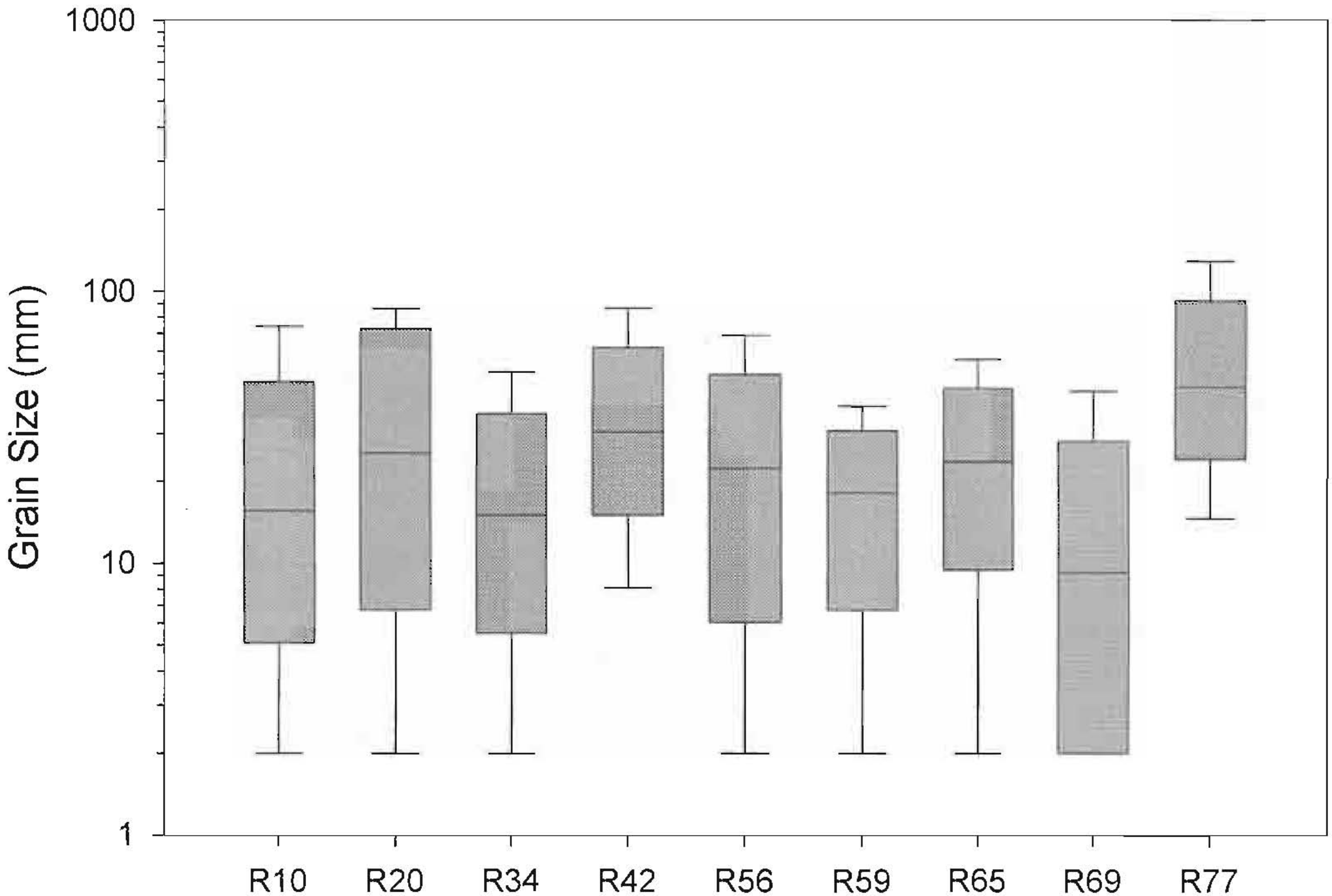


Figure 6.12: Re-visted DWR Riffles Pebble Counts, Non-enhanced. We plotted pebble counts we performed during the summer of 2000 on the re-located DWR 1994 riffles that had not been enhanced by CMC in 1999. Note: All grains in size class < 4 mm are plotted as 2.0 mm.

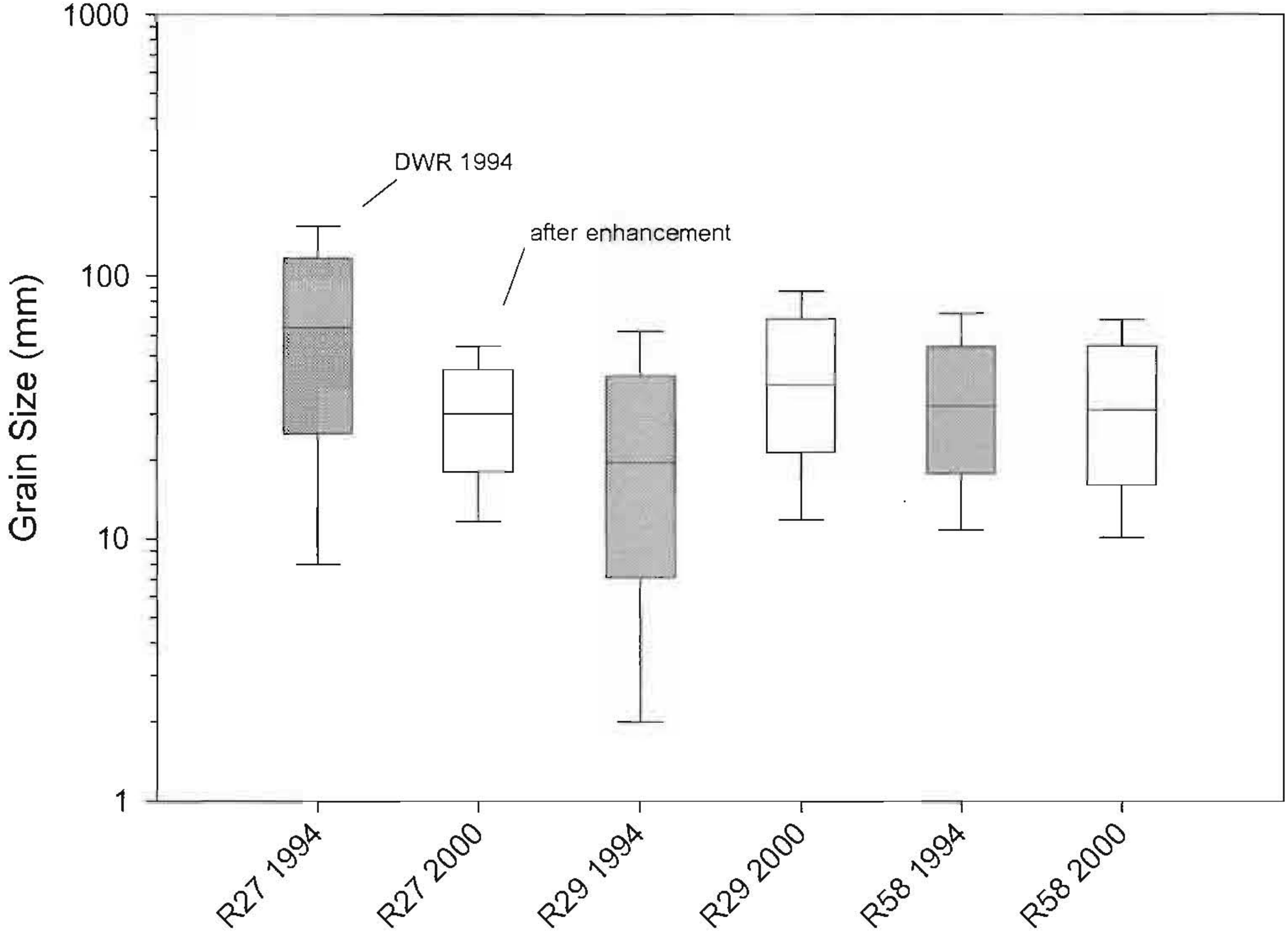


Figure 6.13: Pebble Counts DWR 1994 Riffles Vs. Enhanced Riffles. This figure compares the relocated DWR 1994 riffles with two riffles enhanced by CMC in 1999 (R29 and R58) and one CDFG enhanced riffle at Horseshoe Bend Recreation Area in 1994 (R-27) (**Table 3.2**). Two of the riffles show that the amount of fine sediment decreased after enhancement (R27 and R29). Note: All grains in the < 4 mm size class are plotted at 2 mm.

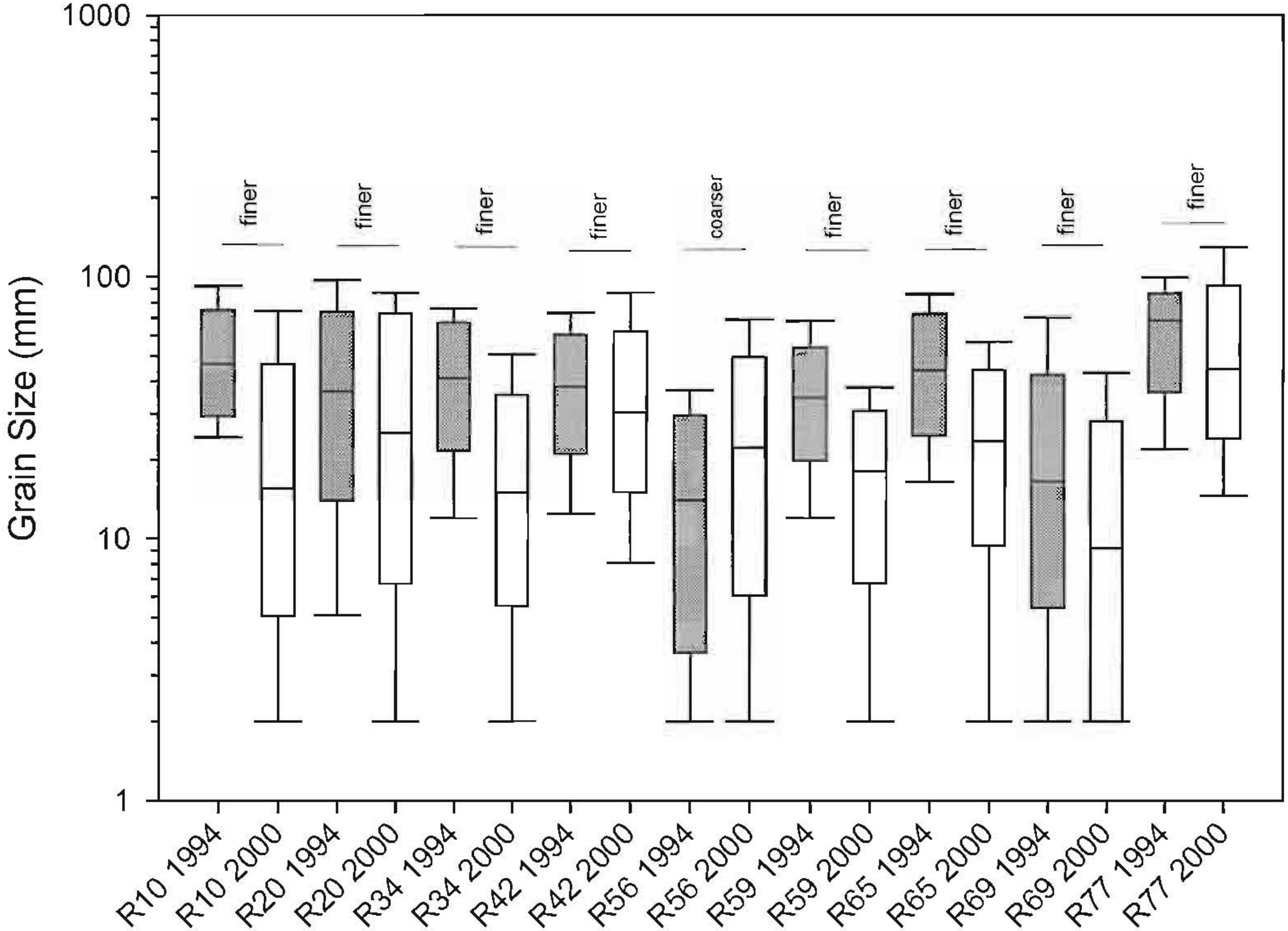


Figure 6.14: Pebble Counts Non-enhanced Riffles 1993 Vs. 2000. This figure compares the DWR 1994 data we plotted from DWR pebble counts in 1993 with the pebble counts we preformed in 2000 for this study. Eight of the nine re-located riffles show an increase in the amount of fine sediment from 1993 to 2000. Note: All grains in the < 4 mm size class are plotted at 2 mm.

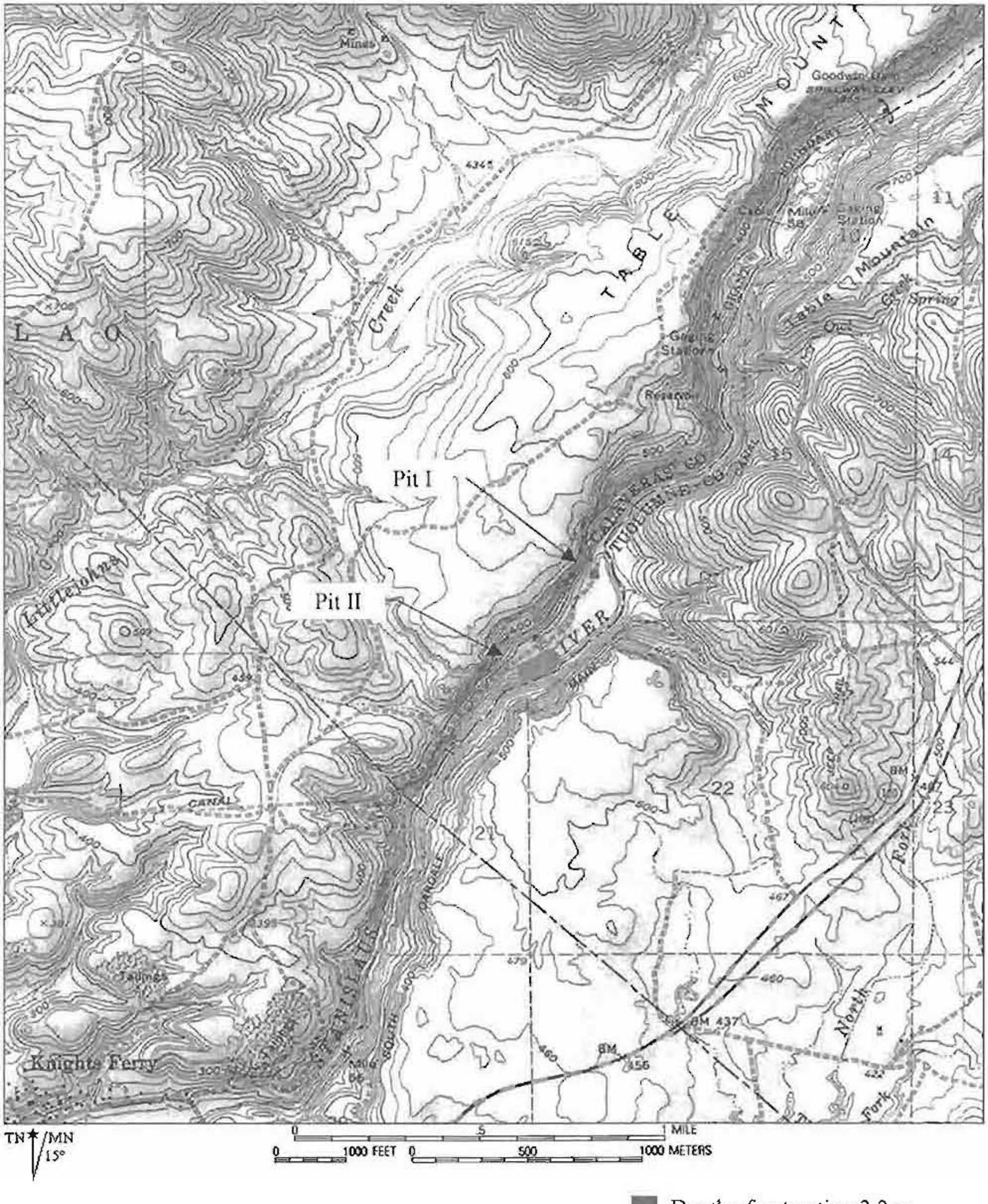


Figure 8.1: Gravel Extraction Location Map: Goodwin Dam to Two Mile Bar. This figure shows the location of gravel extraction we identified from historical aerial photographs and USGS topographic maps from 1949 to 1999.

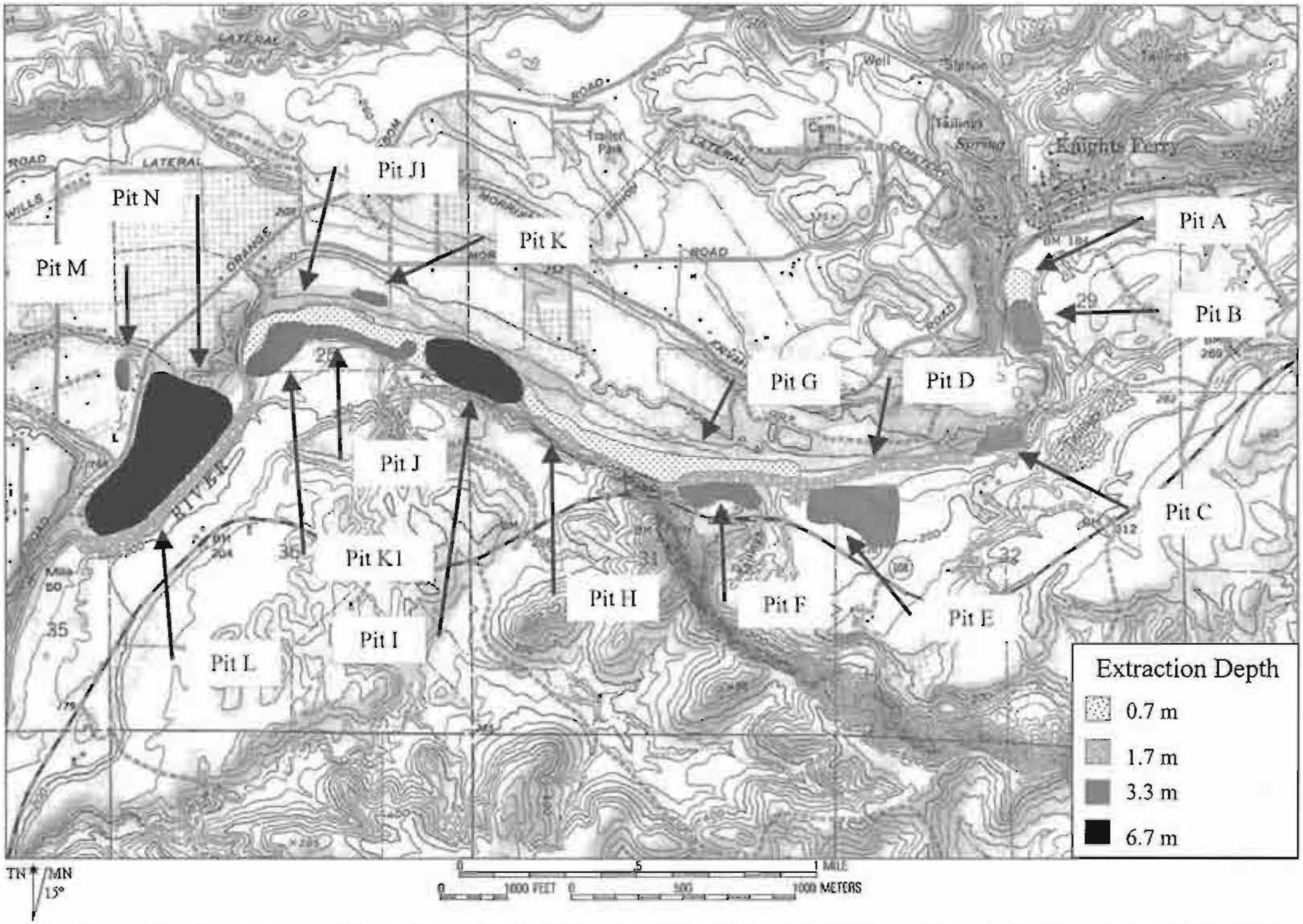


Figure 8.2: Gravel Extraction Location Map: Knight's Ferry to Horseshoe Bend Recreation Area. This figure shows the location of gravel extraction we identified from historical aerial photographs and USGS topographic maps from 1949 to 1999.

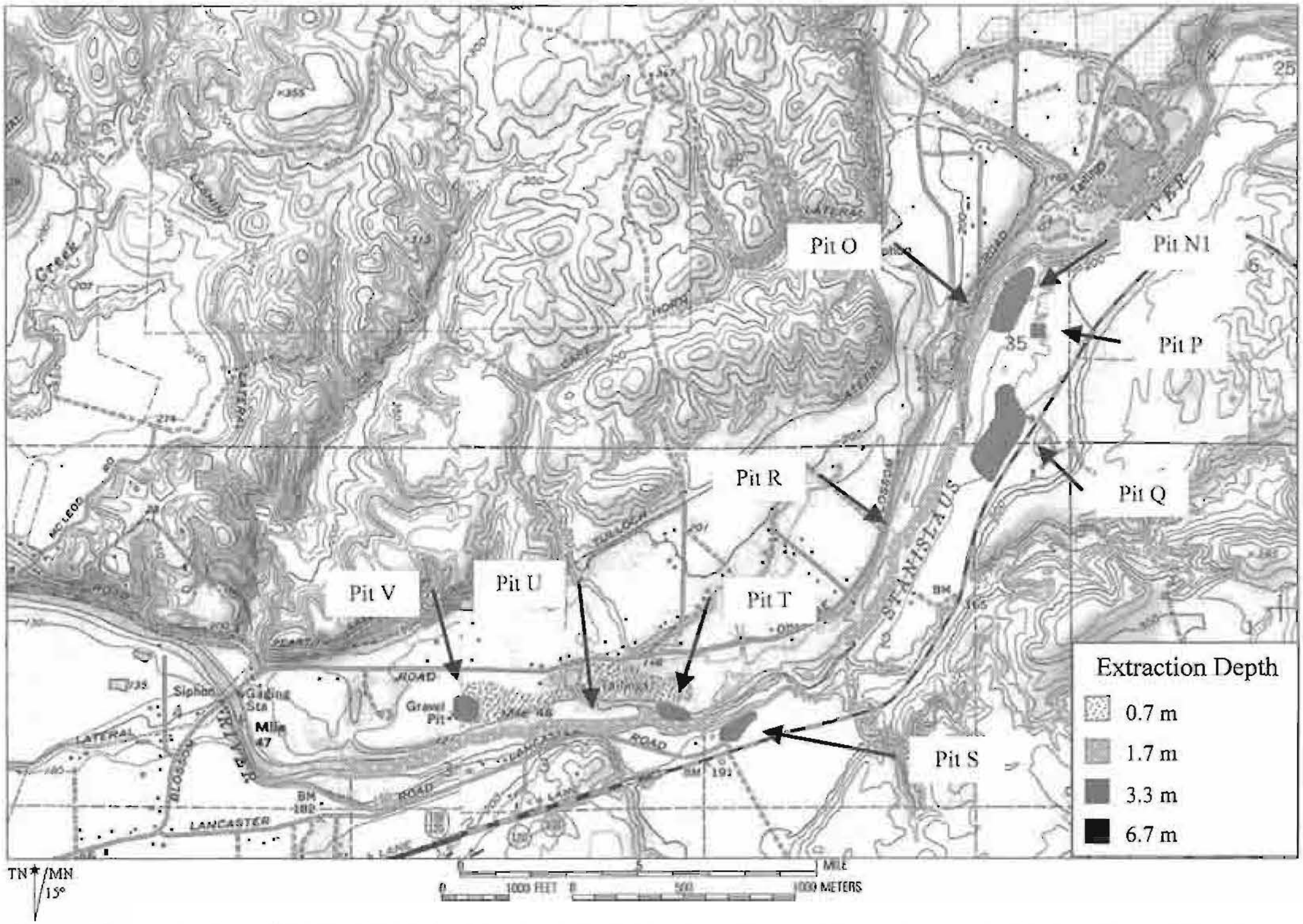


Figure 8.3: Gravel Extraction Location Map: Horseshoe Bend Recreation Area to Orange Blossom Bridge. This figure shows the location of gravel extraction we identified from historical aerial photographs and USGS topographic maps from 1949 to 1999.

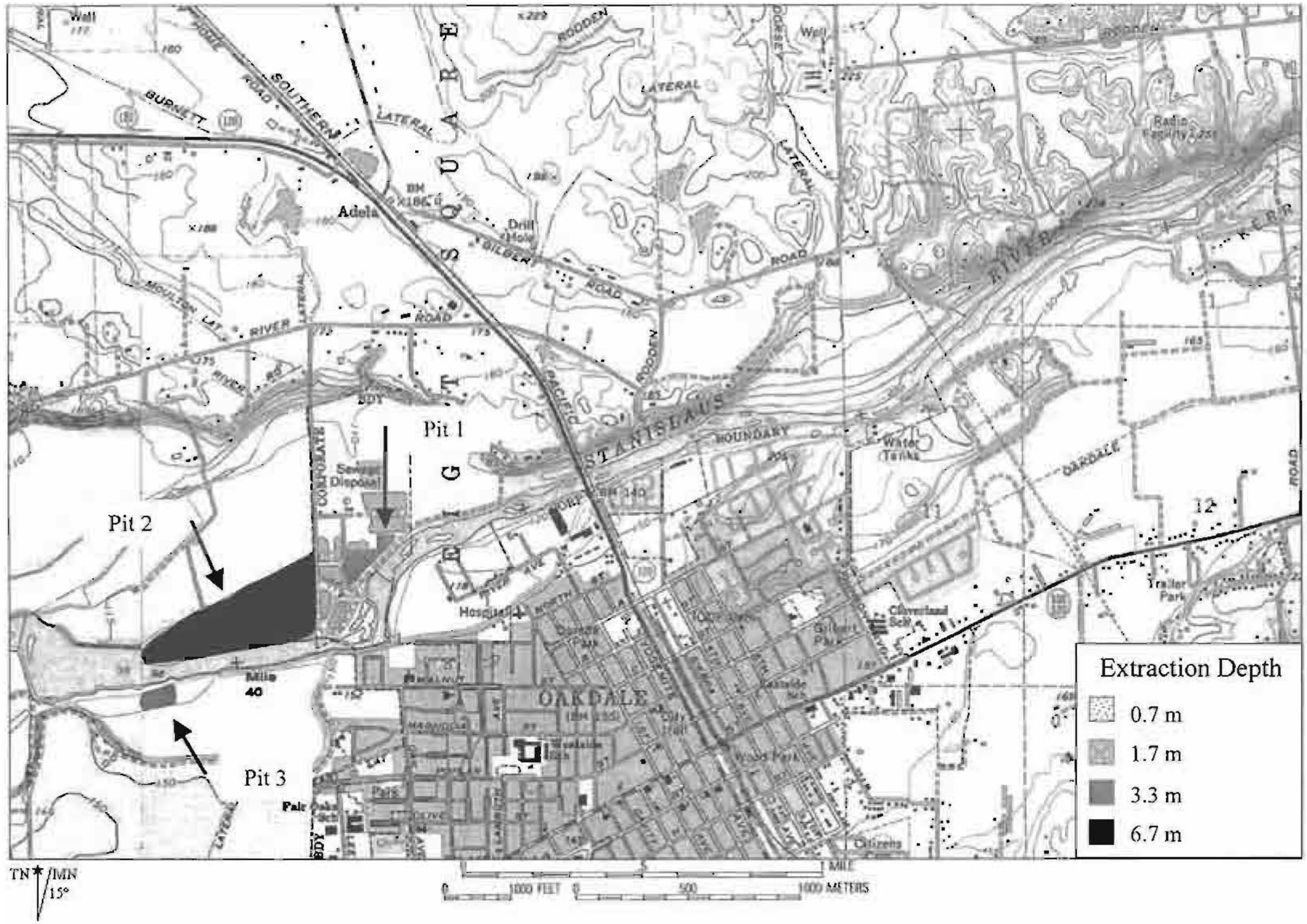


Figure 8.4: Gravel Extraction Location Map: Kerr Park to Oakdale. This figure shows the location of gravel extraction we identified from historical aerial photographs and USGS topographic maps from 1949 to 1999.

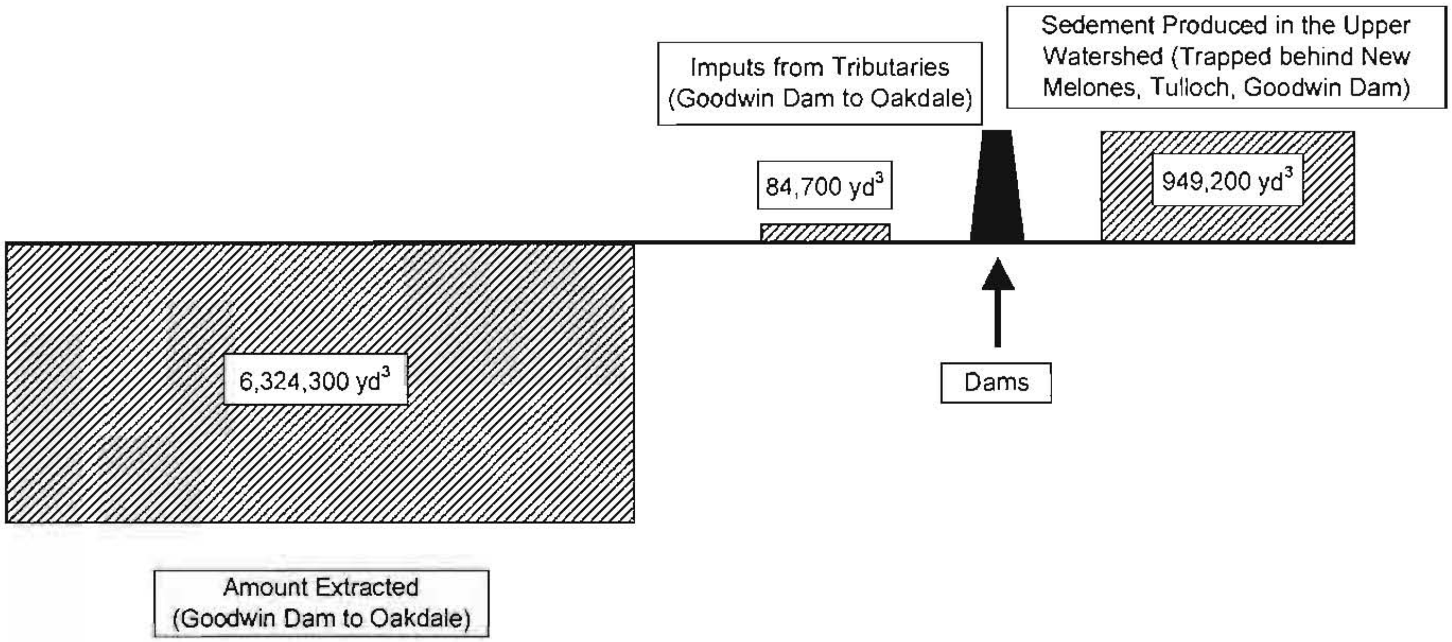


Figure 8.5: Sediment Budget: 1949 to 1999. This figure illustrates the imbalance in the sediment budget for the Stanislaus River over a fifty year period. Extraction for aggregate was 600% greater than the amount of sand and gravel produced in the watershed. When the amount of sand and gravel trapped behind Melones, New Melones, Tulloch, and Goodwin dams is accounted for, the amount of sand and gravel extracted is almost two orders of magnitude greater than the amount produced

STANISLAUS RIVER BASIN DAMS
CUMULATIVE STORAGE CAPACITY
(Expressed as a percentage of average unimpaired runoff) [1]

A	B		C		D	E	F
Year	Dam Name		Stream	Capacity (m3)	Storage Capacity (AF)	Cumulative Storage (AF)	Cum. Storage as % annual unimpaired runoff
1902	Union	NF	N Fork	2,470,000	2,000	2,000	0.2%
1905	Copperopolis	M	Penney Creek	278,000	225	2,225	0.2%
1906	Alpine	NF	Silver Creek	5,670,000	4,596	6,821	0.6%
1908	Stan FB	M	Trib Stan. River	395,000	320	7,141	0.6%
1908	Utica	NF	N Fork	2,960,000	2,399	9,541	0.8%
1910	Relief	MF	Relief Creek	18,700,000	15,158	24,699	2.1%
1912	Goodwin	M	Mainstem	617,000	500	25,199	2.1%
1916	Rodden Lake	M	Lesnini Creek	469,000	380	25,579	2.1%
1916	Main Strawberry	SF	South Fork	22,900,000	18,312	43,891	3.7%
1926	Old Melones [3]	M	Mainstem	139,000,000	112,674	156,566	13.0%
1928	Hunters	NF	Mill Creek	246,000	199	156,765	13.1%
1930	Lyons - PGE	SF	South Fork	7,680,000	6,228	162,993	13.6%
1938	McCarty	M	Trib Johnny Creek	115,000	93	163,086	13.6%
1953	Murphys Afterbay	M	Trib Angels Creek	49,300	40	163,126	13.6%
1953	Murphys Forebay	M	Trib Angels Creek	66,600	54	163,180	13.6%
1953	Fly in Acres	NF	Moran Creek	123,000	100	163,280	13.6%
1957	Beardsley	MF	Middle Fork	120,000,000	77,600	240,880	20.1%
1958	Tulloch	M	Mainstem	84,400,000	68,400	309,280	25.8%
1958	Beardsley Afterbay	MF	Middle Fork	395,000	320	309,600	25.8%
1958	Donnells	MF	Middle Fork	79,600,000	56,893	366,493	30.5%
1965	Reba	NF	Trib Bloods Creek	296,000	240	366,733	30.6%
1970	Utica	NF	No. Fork Stan	2,960,748	2,400	369,133	30.8%
1975	Forest Meadows	M	Angels Creek	133,000	108	369,241	30.8%
1975	Bear Vly Sewage Hldg	NF	Trib Bloods Creek	427,000	346	369,587	30.8%
1976	Holman	M	Trib Angels Creek	308,000	250	369,836	30.8%
1978	Leland Meadows	MF	Leland Creek	97,000	79	369,915	30.8%
1979	New Melones	M	Mainstem	2,960,000,000	2,400,000	2,657,241	221.4%
1980	Murphy's Wastewater	M	Trib Six-Mile Creek	173,000	140	2,657,381	221.4%
1983	Andrew Cademartori	M	Trib Angels Creek	175,000	142	2,657,523	221.5%
1988	North Fork Diversion	NF	No. Fork Stan	148,037	120	2,657,643	221.5%
1988	New Spicer Meadows	NF	Highland Creek	233,000,000	188,871	2,846,514	237.2%
1989	McKays Pt Div	NF	No. Fork Stan	2,590,654	2,100	2,848,614	237.4%
	TOTAL LISTED DAMS:	32			TOTAL CAPACITY:	**2,846,514** AF	
	(including Old Melones)					TOTAL:	**237%**
					avg unimpaired runoff Stan basin:	1,200,000 AF [2]	
					1 m3 =	*0.000810606* AF	

Data source:

[1] Department of Water Resources, Bulletin17-93, Dams Within the Jurisdiction of the State of California, June 1993.

[2] CALFED Bay-Delta Program, ERPP Draft PEIS/EIR Tech. App., Vol. 2 - Ecological Management Zone Visions, 6/99.

[3] Kondolf et al, 1996a, Water Resources Center Rept. 90 (for data on Old Melones Reservoir)

Note -- storage from Old Melones (built in 1926) was subtracted when New Melones was filled (1979).

Table 2.1: Stanislaus River Basin Dams and Cumulative Storage Capacity. Data on the dams within the Stanislaus basin large enought to be regulated by the Division of Safety of Dams (DOSD), including the year the dam was built (col. A), watershed location (C.), and its storage capacity (D). Col. E details the cumulative storage capacity within the basin after the construction of each additional dam. Col. F expresses this cumulative storage as a percentage of total average unimpaired runoff in the basin (1.2 maf, Calfed, 1999). The total dam storage capacity in the Stanislaus basin exceeds 2.8 maf, or almost 240% of average annual unimpaired runoff.

Gauge No. (Name)	*Water Year*	*Drainage Area*	*Data Source*[1]	*Remarks*
# 11302000 ("Stan. River at Knights Ferry")	1903-1914	982 mi^2 *(revised; Meyer, USGS, 4/3/00)*	USGS Water Supply Paper 299 (1903-1912); #361 (1913); #391 (1914).	Established May 19, 1903 until Sept. 14, 1914. Location: downstream of Goodwin Dam, Elev. 157.53 ft. Flows not "unimpaired" due to diversions from S. Fork to Tuolumne Basin, from N. Fork near Murphy and Angels, and numerous mining ditches. Diversions from S.San Joaq. Canal and Oakdale Canal begin 1914. 1903-1908: only gage height data with rating tables available for mean daily flow. Data converted to cfs using rating tables and linear interpolation. 1909-1914: mean daily in cfs. No water flowed over Goodwin Aug. or Sept. 1914. Peak flow data (cfs) 1903-1912 available from USGS website.
#11300000 ("Stan. River near Knights Ferry")	1915-1932	972 mi^2 *(Meyer, USGS, 4/3/00. web says 980 mi^2)*	Hydrosphere CD USGS website	Established Dec. 18, 1915 with full operation 2/1/16. Location: 2 miles upstream of Goodwin dam (300 ft. upstream of current day Tullock dam, filled in 1957). Lat: 37deg53'30"; Long: 120deg36'20" , Elev. 370 ft. (Meyer, USGS, 4/3/00) Mean daily flow and annual peak flow data in cfs
#11299500 ("Stan River below Melones Powerhouse")	1931-1967	905 mi^2 *(web)*	Hydrosphere CD USGS website	Established Feb. 1, 1931. Location: Lat: 37deg56'50", Long: 120deg31'45" Records "good" except during periods of no gage-height record or backwater from Tullock Reservoir, which are "fair." Backwater from Tullock affects record since 11/25/57 (since storage began). Mean daily flow and annual peak flow data in cfs
#11302000 ("Stan River below Goodwin near Knights Ferry")	1957 - present	986 mi^2	Hydrosphere CD USGS website	Established: Feb. 1957. Location: Lat: 37deg51'06", Long: 120deg38'13"; .9 mi downstream Goodwin and 2.9 mi NE Knights Ferry. Elev. 252.83 ft above sea level. Records equivalent to Stan R at KF, 1903-14, and Stan River nr. Knights Ferry, 1915-32, if adjusted for diversions: Stan and SJ Water Co's Canal, and Oakdale (#11301000) and S San Joaquin Canals (#11300500) which divert 1 mile upstream at Goodwin Dam. Records "good."

Table 2.2: Stream Gauges on the Stanislaus River. Flow data from 1903-1929 (pre Old Melones dam) are used to characterize "pre-impact" period, and data following construction of New Melones dam in 1979 characterizes "post-impact." Flood frequency analysis required longer periods of record, so peak flow data preceding construction of New Melones dam (1903-1978) are compared with peak flows following construction of the dam (1979-2000).

[1] Data Sources: 1) USGS website: http://waterdata.usgs.gov/nwis-w/CA/; 2) Hydrosphere CD; 3) USGS Water Supply Papers (Note: WS Paper #299 (1903-1912) updates WS Papers 251, 271, 291, 311, 331); 4) Personal communication with Robert W. Meyer, Surface Water Specialist, USGS, 4/3/00. Meyer provided revised drainage area values and other information from USGS materials including "Compilation of Records of Surface Waters of the United States through Sept. 1950."

Table 2.2: Continued:

Other Data used:				
Gauge No. (Name)	*Water Year*	*Drainage Area*	*Data Source*	*Remarks*
Oct. 1940-current #11303000 ("Ripon")	1940 - present	1075 mi^2	Hydrosphere CD USGS website	Established Oct. 1940. Location: Lat: 37deg43'50", Long: 121deg06'35"; left bank, 1mi SE Ripon. 15 mi upstream mouth. SSJ Canal (#11300500) and Oakdale Canals (#11301000) divert at Goodwin Dam 34 mi upstream. Records "good" Peak flow data from Ripon used in flood frequency to compare data from a single gauge.
#11301000 (Diversion data at Oakdale Canal near Knights Ferry)	1914 - present	n.a.	Hydrosphere CD	Established May 3, 1914. (Operated: 5/3/14-10/31/33; 3/21/34-10/28/34; 7/31/35-10/31/35; 3/1/36-9/30/99). Location: Lat: 37deg51'32", Long: 120deg37'56"; on left bank .3 mi downstream of Goodwin Dam headgate and 3.4 mi NE Knights Ferry (for OID irrigation). Records "good" except for estimated daily discharges, which are poor. Records for Water years 1933-36 incomplete. Monthly and yearly estimates published in WSP 1315-A.
#11300500 (Diversion data at SSJ Canal nr. Knights Ferry)	1914 – present	n.a.	Hydrosphere CD	Established March 1, 1914. Location: Lat: 37deg51'10", Long: 120deg38'15"; left bank .8 mi downstream Goodwin Dam headgate and 3.0 mi NE Knights Ferry. Monthly and yearly discharge only for some periods (in WSP 1315-A) Records "fair." Canal diverts from right bank (?) of Stan at Goodwin Dam (for irrigation in Oakdale and SSJ Irrigation Districts).

Category	----- Pre - Old Melones Dam ----- Year	Unimpaired Flow (maf)	Year Type		----- Post - New Melones Dam ------ Year	Unimpaired Flow (maf)	Year Type
CRIT DRY	**1924**	**0.26**	**crit dry**		**1987**	**0.37**	**crit dry**
					1988	0.38	crit dry
					1994	0.46	crit dry
					1990	0.47	crit dry
					1992	0.49	crit dry
DRY	1913	0.59	dry		1991	0.51	dry
	1912	0.60	dry		1981	0.59	dry
	1926	0.61	dry		1985	0.68	dry
	1908	0.62	dry		**1989**	**0.78**	**dry**
	1920	0.74	dry				
	1919	**0.77**	**dry**				
	1918	0.83	norm/dry				
NORM	1905	0.98	norm				
	1903	1.12	norm		2000	1.16	norm
	1923	1.13	norm		1979	1.16	norm
	1925	1.22	norm				
	1921	1.26	norm				
	1915	1.30	norm				
WET	1917	1.38	wet		1999	1.35	wet
	1910	1.41	wet		1984	1.43	wet
	1922	**1.43**	**wet**		**1996**	**1.49**	**wet**
	1916	1.67	wet		1993	1.56	wet
EXT. WET	1914	1.77	ext. wet		1997	1.76	ext wet
	1909	1.93	ext. wet		1980	1.80	ext wet
	1904	**2.05**	**ext. wet**		1986	1.94	ext wet
	1911	2.36	ext. wet		**1998**	**2.09**	**ext wet**
	1906	2.41	ext. wet		1995	2.34	ext wet
	1907	2.83	ext. wet		1982	2.35	ext wet
					1983	2.95	ext wet

Data source: Unimpaired flow data derived from SNS station, sensor #65 at http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=SNS&sensor_num=65&dur_code=M&start_date=1903&end_date=now

Table 2.3: Stanislaus River Unimpaired Flow for Categorized Year Types. Sorted list of unimpaired flows (maf) for the Pre- Old Melones Dam period (1903-1926) and Post - New Melones Dam period (1979-2000). Unimpaired flow data derived from DWR CDEC website for the SNS station (sensor #65). Water year type determined using McBain and Trush (2000) classification at the adjacent Tuolumne River, with adjustments made based on actual Stanislaus unimpaired flow data. Designated water year type also compared to DWR 60-20-20 classification for the Stanislaus and other nearby rivers. Water years indicated in bold were used for annual hydrograph comparisons discussed in chapter four and graphed in Figures 4.4 to 4.7.

Table 2.4: Aerial Photographs of the Lower Stanislaus River Identified in This Study

Time Period		Year	Date	Scale	Avg. Daily Flow (cfs)	Gauge for Flow #	Gauge for Flow Name	Photo Location	Notes
I. Historical Photographs 1937-1939	X	1937	8/7	1:20,000	1190	11299500	Old Melones	National Archives	
		1939	1/18	alt. 7,500'	854	11299500		USACE	Can #412*
II. Historical Photographs Pre-New Melones 1957-1978	X	1957	3/23; 4/25	*(adjusted)*	592; 1350	11299500	Old Melones	UCD	
		1961	6/8	1:12,000	67	11303000	Ripon	USACE	Can #439
		1972	4/20	1:48,000	142	11303000		USACE	Can #595
		1978	3/24; 3/25	1:12,000	3180; 3170	11303000		USACE	Can #693
III. Post New Melones 1979-2000		1982	6/17	1:9,600	1270	11303000	Ripon		
		1987	8/5	1:3,000	497	11303000			
		1993	5/9	1:40,000		11302000	Goodwin Dam		
	X	1998	8/15	1:40,000	1780	11302000			
Flood/High Water Events		1956	1/17	alt 12,000	11800	1130300	Ripon	USACE	Can #379
		1964	12/31	1:6,000	6580	"	"	USACE	Can #483-4
		1967	3/19	1:6,000	7000	"	"	USACE	Can #513
		1980	1/18	1:6,000	4780	"	"	USACE	Can #726
		1997	1/13	1:12,000	6340	"	"	USACE	Can #991

**: Can #412 could not be located by the COE and is still missing.*

X: photographs used in this analysis

Table 2.5: List of Previous Spawning Studies Reviewed

CDFG (California Department of Fish and Game), 1972. Report to the California State Water Resources Control Board on Effects of the New Melones Project on Fish and Wildlife Resources of the Stanislaus River and Sacramento-San Joaquin Delta, Region 4-Fresno

CMC (Carl Mesick Consultants), 2000. Task 3 Pre-project evaluation report Knight's Ferry Gravel Replenishment Project for CALFED Bay Delta Program

DWR (California Department of Water Resources), 1994. San Joaquin River Tributary Spawning Gravel Assessment. William Rowe, Northern District

Table 2.6: Criteria Compared Between the Three Studies

Study	Criteria (range of preferred Values)				
	Size class (mm)	**Depth (ft)**	**Velocity (cfs)**	**Embeddedness**	**Flows during study (cfs)**
CDFG 1972	26 to 153	0.8 to 2.0	1.5 to 2.5	NA	100 to 250
DWR 1994	14 to 113*	0.75 to 3.5*	1 to 3	Not compacted	200 to 375
This Study	25 to 150	0.5 to 3.5	1 to 5	Movable with foot	350 to 425

* not explicitly stated, inferred from report summary

Table 2.7: Categories of Salmon usage of Redds.

Category	# of Salmon or # of redds	% of crest of rifle used
Not counted	<3	<10
Low	3-5	10-30
Medium	5-8	30-60
High	>8	>60

Table 3.1: Principal Objectives of the New Melones Project
(Source: USACE 1967 General Design).

Objective	*Description*
Flood Protection	Provide a high degree of flood protection to cities and agriculture areas along the Stanislaus river (estimated 35,000 acres in Ripon, Riverbank, and Oakdale areas) and lower San Joaquin River.
Irrigation Water	Provide water for irrigation by storage of surplus water during periods of high runoff for release during periods when irrigation demand are high.
Hydropower	Provide for maximum development of electric hydropower within the limits of flood control and irrigation operations.
Recreation	Provide the opportunity for water oriented recreational activities.
Fisheries	Provide enhancement of reservoir and downstream fisheries.
Water Quality	Provide water quality control in the Stanislaus river below the dam to prevent damage to downstream fishery and to maintain good quality irrigation water in the lower San Joaquin river.

Table 3.2: Gravel Enhancement Projects on the Stanislaus River

Year	Agency/Organization (funding source)	Volume Added (yd^3)	Cost	Reach	Notes:
1994	CDFG, DWR (4-Pumps)	3,070	$194,000	Horseshoe Bend Recreation Area	Excavated the channel bed to removed silt, rock, and cobble at 3 sites (RM 47.4, 50.4, and 50.9); replaced with 0.5 inch to 4 inch washed gravel to 1-1.5 ft depth; 5,680 sq. yds gravel area enhanced. Project washed out by November 1995. [1]
1997	CDFG (salmon stamps)	2,222	$46,620	Goodwin Canyon	Stanislaus Fly Fishermen Inc., contractors for the project, abandoned placement of gravel using a hydraulic delivery system and completed the project using a skip loader. Placed gravel where none existed previously; salmon used site three weeks after completion; received heavy spawning use; half of gravel moved downstream during winter flows. [2]
1997	CDFG (CVPIA)	741	$110,000	Goodwin Canyon	Placed gravel by helicopter; used by salmon almost immediately; gravel washed downstream by 1998. [3]
1998	CDFG (salmon stamp)	4,444	$66,620	Goodwin Canyon	Stanislaus Fly Fisherman Inc., as the contractor, added gravel using a skip loader to the 1997 riffles. Salmon appeared immediately upon completion of addition of gravel; 30 redds; 67% of gravel still in place one year post project completion. [4]
1999	Carl Mesick Consultants (CALFED prop 204)	9,630	$633,000	Goodwin Canyon to the City of Oakdale	Used a skip loader to place gravel at 18 riffles from Goodwin Dam to Oakdale; includes $180,000 monitoring budget for 3 yrs. (17 river miles; Two Mile Bar to City of Oakdale) This project is a field experiment designed to evaluate different riffle construction configuration and gravel types. [5]

Sources:

[1] Kondolf et al. (1996a); S. Spaar, DWR, pers. comm., 10/20/99

[2] Dave Boucher, pers. comm., 1999

[3] Larry Pucket, USFWS, pers. comm., 10/8/99

[4] Dave Boucher, pers. comm., 1999

[5] Carl Mesick, pers. comm., 12/27/99, S. Spaulding USFWS-AFRP pers. comm. 1/10/00

Table 4.1: FLOOD FREQUENCY ANALYSIS
Knights Ferry Combined Gages

*Flood Frequency **Stanislaus River near Knights Ferry Ca**, Tuolumne Co, Upper Stanislaus Basin*
Water Years Retrieved: 1904-1914 (KF1), 1915-1932 (KF2), 1933-1955 (M), 1956-1999 (KF3). Data Source (Peak Flow Data):
*1904-1914: **Stan. River at Knights Ferry ("KF1")**, US Geological Survey, Station # undesignated, Drainage Area: 982 sq. mi.*
*1915-1932: **Stan. River Near Knights Ferry ("KF2")**, US Geological Survey, Station # 11300000, Drainage Area: 972 sq. mi.*
*1933-1955: **Melones Dam ("M")**, US Geological Survey, Station # 11299500, Drainage Area: 905 sq. mi. **
*1956-1999: **Goodwin Dam Near Knights Ferry ("KF3")**, US Geological Survey, Station # 11302000, Drainage Area: 986 sq. mi.*

Pre-New Melones Dam (1904-1978)					No. data points (N)=	75
Water Year	Date	Data Source (gage)	Annual Peak Discharge (cfs)	Rank Order by discharge M	Probability of Occurrence (%) P=(1/T)*100	Return Period (yrs) (Recurrence Interval) T = (N + 1)/M
1907	1907.03.19	KF1	64500	1	1.32	76.00
1956	1955.12.23	KF3	62900	2	2.63	38.00
1911	1911.03.31	KF1	60000	3	3.95	25.33
1909	1909.01.21	KF1	57000	4	5.26	19.00
1951	1950.11.21	M	49500	5	6.58	15.20
1928	1928.03.25	KF2	46000	6	7.89	12.67
1965	1964.12.24	KF3	40200	7	9.21	10.86
1914	1914.01.25	KF1	32200	8	10.53	9.50
1904	1904.02.24	KF1	31800	9	11.84	8.44
1969	1969.01.21	KF3	28600	10	13.16	7.60
1925	1925.02.06	KF1	25200	11	14.47	6.91
1940	1940.03.31	M	22800	12	15.79	6.33
1943	1943.03.10	M	22000	13	17.11	5.85
1906	1906.01.19	KF1	19900	14	18.42	5.43
1936	1936.02.22	M	19300	15	19.74	5.07
1970	1970.01.22	KF3	18000	16	21.05	4.75
1938	1938.02.11	M	17900	17	22.37	4.47
1917	1917.03.21	KF2	17400	18	23.68	4.22
1921	1921.01.18	KF2	16200	19	25.00	4.00
1953	1953.04.27	M	14700	20	26.32	3.80
1918	1918.03.12	KF2	14300	21	27.63	3.62
1916	1916.03.20	KF2	14200	22	28.95	3.45
1941	1941.05.12	M	12600	23	30.26	3.30
1922	1922.05.18	KF2	12500	24	31.58	3.17
1952	1952.05.28	M	12500	25	32.89	3.04
1942	1942.05.23	M	12300	26	34.21	2.92
1958	1958.04.04	KF3	12200	27	35.53	2.81
1963	1963.02.02	KF3	11800	28	36.84	2.71
1923	1923.04.06	KF2	11500	29	38.16	2.62
1935	1935.04.08	M	11500	30	39.47	2.53
1915	1915.05.13	KF2	11100	31	40.79	2.45
1932	1932.05.18	KF2	10600	32	42.11	2.38
1937	1937.05.15	M	10600	33	43.42	2.30
1945	1945.04.30	M	10600	34	44.74	2.24
1949	1949.05.14	M	10600	35	46.05	2.17
1927	1927.05.17	KF2	9840	36	47.37	2.11
1919	1919.05.01	KF2	9700	37	48.68	2.05
1967	1967.05.24	KF3	9430	38	50.00	2.00
1920	1920.05.20	KF2	8860	39	51.32	1.95
1948	1948.05.27	M	8850	40	52.63	1.90
1910	1910.03.20	KF1	8750	41	53.95	1.85
1946	1946.05.06	M	7980	42	55.26	1.81
1950	1950.05.22	M	7780	43	56.58	1.77
1933	1933.05.31	M	7660	44	57.89	1.73
1975	1975.06.02	KF3	7360	45	59.21	1.69
1905	1905.03.19	KF1	7000	46	60.53	1.65
1954	1954.05.09	M	6800	47	61.84	1.62
1912	1912.05.30	KF1	6160	48	63.16	1.58
1944	1944.05.22	M	5840	49	64.47	1.55
1978	1978.05.25	KF3	5470	50	65.79	1.52
1926	1926.04.05	KF2	5330	51	67.11	1.49

Table 4.1: FLOOD FREQUENCY ANALYSIS
Knights Ferry Combined Gages

Water Year	Date	Data Source (gage)	Annual Peak Discharge (cfs)	Rank Order by discharge M	Probability of Occurrence (%) P=(1/T)*100	Return Period (yrs) (Recurrence Interval) T = (N + 1)/M
1929	1929.06.06	KF2	5330	52	68.42	1.46
1930	1930.05.19	KF2	5330	53	69.74	1.43
1955	1955.05.29	M	5310	54	71.05	1.41
1974	1974.04.02	KF3	5300	55	72.37	1.38
1957	1957.05.20	KF3	5140	56	73.68	1.36
1962	1962.06.01	KF3	4970	57	75.00	1.33
1947	1947.05.04	M	4940	58	76.32	1.31
1913	1913.05.19	KF1	4880	59	77.63	1.29
1971	1971.06.27	KF3	4550	60	78.95	1.27
1973	1973.05.16	KF3	4240	61	80.26	1.25
1908	1908.04.21	KF1	3990	62	81.58	1.23
1939	1939.04.08	M	3160	63	82.89	1.21
1934	1934.03.26	M	2940	64	84.21	1.19
1924	1924.05.03	KF2	2100	65	85.53	1.17
1972	1971.12.25	KF3	1770	66	86.84	1.15
1968	1968.04.01	KF3	1730	67	88.16	1.13
1966	1965.12.03	KF3	1710	68	89.47	1.12
1976	1975.10.20	KF3	1590	69	90.79	1.10
1959	1959.02.25	KF3	1480	70	92.11	1.09
1931	1931.05.14	KF2	1250	71	93.42	1.07
1964	1964.01.22	KF3	900	72	94.74	1.06
1960	1960.04.23	KF3	798	73	96.05	1.04
1961	1961.01.08	KF3	219	74	97.37	1.03
1977	1976.12.21	KF3	22	75	98.68	1.01

Post New Melones Dam (1979-1999)					No. data points (N)=	21
Year	Date	Gage	Peak Q (cfs)	M	P=(1/T)*100	T = (N + 1)/M
1997	1/3/97	KF3	7350	1	4.55	22.00
1986	3/15/86	KF3	6620	2	9.09	11.00
1984	1/14/84	KF3	5550	3	13.64	7.33
1983	4/23/83	KF3	5400	4	18.18	5.50
1979	2/21/79	KF3	5170	5	22.73	4.40
1980	1/16/80	KF3	5080	6	27.27	3.67
1998	2/4/98	KF3	4900	7	31.82	3.14
1999	2/12/99	KF3	4340	8	36.36	2.75
1996	3/2/96	KF3	3890	9	40.91	2.44
1982	1/5/82	KF3	3810	10	45.45	2.20
1993	1/17/93	KF3	3070	11	50.00	2.00
1995	3/12/95	KF3	2870	12	54.55	1.83
1985	1/31/85	KF3	2440	13	59.09	1.69
1992	4/23/92	KF3	1900	14	63.64	1.57
1987	3/6/87	KF3	1830	15	68.18	1.47
1991	4/27/91	KF3	1820	16	72.73	1.38
1994	4/26/94	KF3	1640	17	77.27	1.29
1981	4/14/81	KF3	1410	18	81.82	1.22
1988	3/31/88	KF3	1380	19	86.36	1.16
1989	5/3/89	KF3	1330	20	90.91	1.10
1990	5/5/90	KF3	1220	21	95.45	1.05

Methodology: Annual flood peak magnitudes entered and sorted with the largest intensity Q given a rank of M=1.
Probability of Occurrence (P): probability (in percent) that a specified discharge will be equalled or exceeded in a given year. (P=10 means that in any year there is a 10% chance that the value will be exceeded.)
Recurrence Interval/Return Period (T): avg interval (yrs) between events equaling or exceeding a given flow Q.
*: *Data From Melones Gage used as stand in for Knights Ferry, recognizing peak flows will likely be somewhat higher at Melones than Knights Ferry due to reservoir storage capacity at Tulloch and Goodwin Dams.*

Table 4-3: Summary of Annual Hydrograph Comparisons. Summary of total runoff (millions of acre feet, maf), annual peak flows (cubic feet per second, cfs), and average summer flows (cfs) for the water year types used to compare pre- Old Melones Dam and post- New Melones Dam annual hydrographs.
(*Data source: http://cdec.water.ca.gov/cgi*).

Year Type	Water Year	Total Runoff (maf)	Annual Peak Flow (cfs)	(date)	July 1- Sept.30 Average (cfs)	Plotted Hydrograph
Critically Dry	1924	0.26	1,700	May 3	106	Figure 4-4
	1987	0.37	1,360	March 6	409	
Dry	1919	0.77	7,740	May 1	365	Figure 4-5
	1989	0.78	1,270	March 21; May 4	325	
Wet	1922	1.43	10,500	May 18	668	Figure 4-6
	1996	1.49	3,780	March 2	441	
Extremely Wet	1904	2.05	30,400	March 20	533	Figure 4-7
	1996	2.09	4,150	Feb. 9	1,764	

	FLOWS (AF)												
Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	TOTAL
*Pre-dam Flows **:*													
AVG 1901-1926 *:	11,777	18,377	32,542	83,746	108,923	166,938	232,181	318,454	230,462	76,638	16,988	7,296	1,304,323
AVG 1901-1957:	9,711	23,199	46,870	70,297	93,698	140,970	216,955	304,186	203,184	62,223	13,850	5,851	1,190,995
AVG 1901-2000:	10,372	26,041	48,973	85,392	101,490	141,154	203,571	292,266	193,353	61,051	14,032	6,962	1,184,657
Post-dam Flows:													
AVG 1979-1998:	38,737	32,670	49,969	71,851	72,881	97,478	77,369	77,732	55,313	51,479	45,059	38,034	708,573
*Δ post NM/preOM *:*	*329%*	*178%*	*154%*	*86%*	*67%*	*58%*	*33%*	*24%*	*24%*	*67%*	*265%*	*521%*	*54%*

	FLOWS (cfs)												
Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	TOTAL
*Pre-dam Flows **:*													
AVG 1901-1926 *:	192	309	530	1,364	1,965	2,720	3,909	5,188	3,880	1,249	277	123	21,705
Post-dam Flows:													
AVG 1979-1998:	631	550	814	1,171	1,315	1,588	1,303	1,266	931	839	734	640	11,782
*Δ post NM/preOM *:*	*329%*	*178%*	*154%*	*86%*	*67%*	*58%*	*33%*	*24%*	*24%*	*67%*	*265%*	*521%*	*54%*

**: 1901-1926 represents the "Pre - Old Melones" dam flow records and is graphed in Figure 4-9.*

***: Unimpaired flow data from "Full Natural Flow" data, USGS gauge at Stanislaus R-Goodwin (SNS), Sensor #65, Elev. 252'.*

Table 4.4: Average Monthly Flows, Stanislaus River. Comparison of unimpaired flows for various time frames with post New Melones dam regulated flows. The most significant changes have occurred with a shift to lower winter and spring flows and higher late summer and fall flows.

No.	Attribute	*Description*
1.	**Spatially complex channel morphology**	*No single segment of channelbed provides habitat for all species, but he sum of channel segments provides high-quality habitat for native species. A wide range of structurally complex physical environments supports diverse and productive biological communities.*
2.	**Streamflows and water quality are predictably variable**	*Inter-annual and seasonal flow regimes are broadly predictable, but specific flow magnitudes, timing, durations, and frequencies are unpredictable due to runoff patterns produced by storms and droughts. Seasonal water quality characteristics, especially water temperature, turbidity, and suspended sediment concentration, are similar to regional unregulated rivers and fluctuate seasonally. This temporal "predictable unpredictability" is a foundation of river ecosystem integrity.*
3.	**Frequently mobilized channelbed surface**	*In gravel-bedded reaches, channelbed framework particles of coarse alluvial surfaces are mobilized by the bankfull discharge, which on average occurs every 1-2 years. In sand-bedded reaches, bed particles are in transport much of the year, creating migrating channelbed "dunes" and shifting sand bars.*
4.	**Periodic channelbed scour and fill**	*Alternate bars are scoured deeper than their coarse surface layers by floods exceeding 3- to 5-year annual maximum flood recurrences. This scour is typically accompanied by re-deposition, such that net change in channelbed topography following a scouring flood usually is minimal. In gravel-bedded reaches, scour was most likely common in reaches where high flows were confined by valley walls.*
5.	**Balanced fine and coarse sediment budgets**	*River reaches export fine and coarse sediment at rates approximately equal to sediment inputs. The amount and mode of sediment storage within a given river reach fluctuates, but sustains channel morphology in dynamic quasi-equilibrium when averaged over many years. A balanced coarse sediment budget implies bedload continuity: most particle sizes of the channelbed must be transported through the river reach.*
6.	**Periodic channel migration and/or avulsion**	*The channel migrates at variable rates and establishes meander wavelengths consistent with regional rivers with similar flow regimes, valley slopes, confinement, sediment supply, and sediment caliber. In gravel-bedded reaches, channel relocation can also occur by avulsion, where the channel moves from one location to another, leaving much of the abandoned channel morphology intact. In sand-bedded reaches, meanders decrease their radius of curvature over time, and are eventually bisected, leaving oxbows.*
7.	**A functional floodplain**	*On average, floodplains are inundated once annually by high flows equaling or exceeding bankfull stage. Lower terraces are inundated by less frequent floods, with their expected inundation frequencies dependent on norms exhibited by similar, but unregulated river channels. These floods also deposit finer sediment onto the floodplain and low terraces.*
8.	**Infrequent channel resetting floods**	*Single large floods (i.e., >10-yr to 20-yr recurrences) cause channel avulsions, rejuvenate mature riparian stands to early-successional states, form and maintain side channels, and create off channel wetlands (e.g., oxbows). Resetting floods are as essential for creating and maintaining channel complexity as lesser magnitude floods, but occur less frequently.*
9.	**Self-sustaining diverse riparian plant communities**	*Based on species life history strategies and inundation patterns, initiation, maturation, and mortality of native woody riparian plants culminate in early- and late-successional stand structures and species diversities (canopy and understory) characteristic of self-sustaining riparian communities common to regional unregulated river corridors.*
10.	**Naturally-fluctuating groundwater table**	*Groundwater tables within the floodway are hydrologically connected to the river, and fluctuate on an inter-annual and seasonal basis with river flows. Groundwater and soil moisture on floodplain, terraces, sloughs, and adjacent wetlands are supported by this hydrologic connectivity.*

Table 5.1: Attributes of Alluvial River Ecosystem Integrity, from McBain and Trush (2000). McBain and Trush (2000) developed a list of attributes based on historical conditions in the Tuolumne River and literature documentation of natural fluvial processes in other alluvial rivers.

Period	Years	Total Years	% Years Peak over 8,000 cfs	% Years Peak over 16,000 cfs	Max Flow (cfs)	Max Flow (date)
I.	1904-1937	34	68%	32%	64,500	3/19/1907
II.	1938-1957	20	60%	25%	62,900	12/23/1955
III.	1958-1978	21	29%	14%	40,200	12/24/1964
III.	1979-1998	20	0%	0%	7,350	1/03/1997

Table 5.2: Summary of Flows During Sequence of Air Photographs. Table 5.2 summarizes the flow conditions that occurred between the 1937 (period I), 1957 (II), and 1997 (III) air photographs used in our air photo analysis of historical channel and floodplain conditions. Although the photographs from 1937 do not represent "pre-impact" conditions on the Stanislaus (Old Melones dam built in 1926, first dam in basin 1853), they are the earliest photographs available. (*Data source: USGS* National Water Data Storage and Retrieval System: http://waterdata.usgs.gov/).

XS Site	1999 Measured Width LEW-REW (ft)	1999 *Adjusted Width LEW – REW (ft)*	*10/27/99 Hourly Flow (cfs)*	1996 Measured Width LEW–REW (Mesick)	*1996 Hourly Flow (cfs)*	**Estimated Change in Width Low to High (ft)**
TM1	101.3	--	344	99 (2/96)	300	**+ 2.3**
R10	85.90	--	344	80.25 (2/96)	397	**+ 5.65**
R27	89.3	*104.30*	340	91 (2/96)	319	**-1.7 to +13.30**
R58	95.2	*96.60*	344	93.50 (11/96)	421	**+1.7 to +3.10**
R78	95.40	--	347	82.00 (11/96)	421	**+13.4**

Table 5.3: Comparison Channel Width Surveys (Mesick, 1996 vs. Schneider, 1999). Estimated change (low to high) in channel width at TM1, R10, R27, R58, and R78 from Schneider (1999). "1999 Measured Width" data obtained from surveyed distance, left edge to right edge of water. "1999 Adjusted Width" accounts for unusual features, such as overhanging root wads or gravel piles, at the cross sections (see Schneider, 1999). Hourly flow data during the 1996 and 1999 surveys (from OBB gauge, DWR CDEC website) verify similar channel conditions at the time of surveys.

Table 5.4: Contacted Sources for Historical Cross Sections

Agency/ Company	Office	Person Contacted	Historical X Sections	Notes
USACE	Sacramento	Dale Hatch Wilbur Huang Raymond Dennis	No	Very little information exists on the Stanislaus at the Sacramento office. Most information relates to the dam or the area between Old Melones and New Melones. They have HEC-2 runs but no locations for the cross sections. Information on the Stanislaus was lost when the office moved to its new location.
	Oakdale	Jason Anderson	No	Knew of no USACE surveys on the Stanislaus
		Phil Holcomb	No	No survey information on the covered bridge at the Oakdale office.
FEMA	San Francisco	Cynthia McKenzie	No	Have flood photos, Flood Insurance Studies, and Flood Insurance Rate Maps, but they do not have supporting documentation or data.
Michael Baker (FEMA)	Alexandria, VA	Tom Robinson	Yes	Recovered surveyors notes from archives but they are outside of the study reach and the benchmarks aren't re-locatable. Also included HEC-2 runs but no locations for the cross sections were included.
DWR	Sacramento		No	
	Fresno	Kevin Faulkenberry	No	Have information for other rivers, but not the Stanislaus. Could re-create from gauging records at Orange Blossom Bridge.
		Iris Yamagata	No	
USBR	Sacramento	Peggy Manza	No	
Carl Mesick Consultants	El Dorado	Carl Mesick	Yes	Pre and Post gravel enhancement cross sections at enhancement and control sites 1998 to current.
USGS	Sacramento	Pat Shiffer Carole Marlow	No	Could recreate cross sections from gauging records, but most gauges are located at bedrock controls in Goodwin Canyon or outside of the study reach.
		Robert Meyer	Possible	Sending data to plot gauge height vs mean depth. If this shows a relationship measurement notes can be pulled for select years with cross sections.
	Menlo Park			No cross sectional information in the library database nor card catalog

Agency/ Company	Office	Person Contacted	Historical X Sections	Notes
Cal Trans	Sacramento	Nick Burmas Steve Ng Suong Vu	Yes	Bridge cross sections.
Stan. Co. Public Works		Ron Cherry	No	
State Reclamation Board		Sam Brandon	No	
San Joaquin Co. Public Works		Mike Callahan	No	
		John Sanchez	No	Reported that the county gave all information regarding the covered bridge at Knight's Ferry to the USACE.
State Lands Commission		Frank Berry	No	
NRCS	Stockton		No	
Oakdale Irrigation District		Ron Rinitz	No	
SP Cramer		Doug Demko	No	Suggested looking at IFIM reports.
CDFG	Oakdale	Steve Baumgartner	Yes	Only has cross sections for before and after gravel enhancement projects in Goodwin Canyon.
	Sacramento	Rob Titus	No	
EIP Associates		Roy Liety	No	
USFWS	Sacramento	Mark Gard	No	IFIM report on the Stanislaus has cross section but no permanent benchmarks used making re-visiting the cross sections impossible.
NMFS	Sacramento	Dennis Smith	No	Recommended looking at IFIM reports.

Table 6.1: Spawning Gravel Area

		(ft)		(ft^2)	(ft^2)					
Riffles #	RM	Length	Width	Area	CMC converted	Quality	Size Dist.	Fine Sed.	Looseness	Notes
1	54.6	89	100	8,900	3,266	beautiful	med	none	very loose	CMC added 395 yd3 in 1999 Above Knight's Ferry Bridge
2	54.4	175	81	14,175	5,202	beautiful	med	none	loose	below Knight's Ferry Bridge
15	52.5	41	127	5,207	1,911	beautiful	small/med	med	loose	CMC added 610 yd3 in 1999
16	52.48	41	129	5,289	1,941	beautiful	small/med	med	loose	CMC added 240 yd3 in 1999
27	50.8	96	85	8,160	2,995	beautiful	large	low	loose	CMC Control Upper 4-Pumps
29	49.75	96	78	7,488	2,748	beautiful	med	low	loose	CMC added 210 yd3 in 1999 Honolulu Bar Rec Area
58	44.5	173	94	16,262	5,968	beautiful	med	med	med/high	CMC added 465 yd3 in 1999
19A	52.06	75	87	6,525	2,395	beautiful	med	low	loose	CMC added 680 yd3 in 1999
28A	50.2	42	82	3,444	1,264	beautiful	med	low	med	CMC added 250 yd3 in 1999
		828	**863**	**75,450**	**27,690**					
TMA		35	106	3,710	1,966	good	med	low	loose	CMC added 470 yd3 in 1999
TMA		45	50	2,250	1,193	"	"	"	"	
5	53.9	5	49	245	90	good	med	low	loose	CMC added 315 yd3 in 1999
12A	52.82	53	113	5,989	2,198	good	med	low	loose	CMC added 380 yd3 in 1999
12B	52.77	50	92	4,600	1,688	good	med	low	loose	CMC added 470 yd3 in 1999
13	52.8	78	84	6,552	2,405	good	small/med	med	loose	CMC added 860 yd3 in 1999
14	52.6	310	81	25,110	9,215	good	med-large	low	loose	CMC added 1055 yd3 in 1999
19	52.13	248	87	21,576	7,918	good	med	med	loose	CMC added 465 yd3 in 1999
26A	51.1	60	125	7,500	2,753	good	med/large	low	loose	
32	49.4	40	33	1,320	484	good	med	med	loose	
32A	49.3	90	60	5,400	1,982	good	med			
35	48.9	300	120	36,000	13,212	good	med	low	loose	
43	46.9	130	94	12,220	4,485	good	med	med/low	loose	CMC added 315 yd3 in 1999
57new	44.6	80	52	4,160	1,527	good	med	med	med/high	CMC added 645 yd3 in 1999
78	40.2	236	80	18,880	6,929	good	med	med	med-high	CMC added 405 yd3 in 1999
78	40.2	60	40	2,400	881	"	"	"	"	
		1,820	**1,266**	**157,912**	**57,954**					

		(ft)		(ft^2)	(ft^2)					
					CMC					
Riffles #	RM	Length	Width	Area	converted	Quality	Size Dist.	Fine Sed.	Looseness	Notes
TM1		75	95	7,125	3,776	acceptable	large	med	med	
21.5	51.6	100	75	7,500	2,753	acceptable	large	low	med/high	merges into R22
25	51.2	80	50	4,000	1,468	acceptable	med/large	med		
27A	50.7	40	30	1,200	440	acceptable	med			
36A	48.8	40	25	1,000	367	acceptable	med			
60	44	60	40	2,400	881	acceptable	med/large	low/med	loose	
63	43.7	160	75	12,000	4,404	acceptable	med	med	med	
71	41.9	200	29	5,800	2,129	acceptable	med	med	med	
		755	**419**	**41,025**	**15,056**					
		3,403	**2,548**	**274,387**	**100,700**	total of beautiful, good, acceptable				
		NA	**NA**	**95,448**	**37,098**	- CMC ehance riffles (CMC 2000)				
				178,939	**63,602**	total less CMC				

Table 6.2: Relationship between CMC 2000 Riffles and DWR 1994 Riffles

CMC riffle #	CMC RM	CMC enhanced/ control	DWR RM	Comparable pebble counts this study & DWR 1994	Notes
TMA	56.8	enhanced		no	
TM1	56.6	control		no	
			2MI	no	DWR no RM can't tell which of the 3 riffles it is
R1	54.55	enhanced			
R5	53.9	enhanced			
R10	53.5	control	53.4	yes	
			53.4	no	Couldn't locate, too many riffles close together
R12	53.3	control			
R12A	52.82	enhanced			
R12B	52.77	enhanced			
R13	52.73	enhanced			
R14	52.6	enhanced	52.5	no	
R14A	52.57	enhanced			
R15	52.51	enhanced			
R16	52.48	enhanced			
R19	52.13	enhanced			
R19A	52.06	enhanced			
R20	51.8	control	51.9	yes	
R24	51.3		51.4		Couldn't re-locate, this entire reach has become a run
R27	50.8	control	50.9	yes	Site of 4 pumps riffle project 1994
R28A	50.2	enhanced			
R29	49.75	enhanced	49.7	no	
R32	49.4		49.4	no	Has become a run
R34	49.2		49.2	yes	
R35	48.9		48.8	no	R36 (fadded red tag on tree) has become a run, R35 is suitable, too close to tell
R40	47.3		47.3	no	Not measured because washed out in center
R42	47		47.0	no	
R43	46.9	enhanced			
R56	45.1		45.2	yes	
R57	44.6	enhanced	44.7	no	
R58	44.5	enhanced		no	
R59	44.4	control	44.2	yes	
R65	43.2		43.2	yes	
R69	42.3		42.2	yes	
R76	40.35	control			
R78	40.2	enhanced	40.2	no	
			38	no	Outside study reach
			36	no	Outside study reach
			34.15	no	Outside study reach

Table 6.3: Riffle Usage by Spawning Salmon

Degree of Spawning Usage	# of riffles within each reach (# of enhanced riffles)	
	Goodwin Dam to Willms Pond	Willms Pond to Valley Oak Park
High	14 (10)	0
Medium	7 (4)	0
Low	9 (0)	5 (2)
Total	30 (14)	5 (2)

Table 6.4: Summary Statistics Comparing Pebble Counts From 1993 (DWR 1994) to 2000 (this study)

Riffle #	River Mile	Year of Study	Size (mm) D10	D16	D25	D50	D75	D84	D90	dg [1]	sg [2]
R10	53.4	1993	24.5	28.0	31.0	46.5	69.0	80.0	92.0	47.33	1.69
		2000	<4	4.4	6.1	15.6	37.4	56.5	74.4	15.82	3.57
Difference			--	-23.6	-24.9	-30.9	-31.6	-23.5	-17.6	-31.5	1.9
R20	51.9	1993	5.1	8.9	17.0	36.5	66.0	79.0	97.0	26.52	2.98
		2000	<4	5.5	8.3	25.4	68.0	79.1	86.6	20.85	3.80
Difference			--	-3.4	-8.7	-11.1	2.0	0.1	-10.4	-5.7	0.8
R34	49.2	1993	12.0	18.5	25.0	41.0	64.0	59.0	76.0	30.04	1.79
		2000	<4	4.7	6.7	15.0	30.5	41.4	50.7	13.95	2.97
Difference			--	-13.8	-18.3	-26.0	-33.5	-17.6	-25.3	-16.1	1.2
R42	47	1993	12.5	18.0	24.0	38.0	56.0	66.0	73.0	34.47	1.91
		2000	8.1	12.2	17.3	30.4	54.2	67.6	86.8	28.74	2.35
Difference			-4.4	-5.8	-6.7	-7.6	-1.8	1.6	13.8	-5.7	0.4
R56	45.2	1993	<4	<4	4.2	14.0	27.0	33.5	37.0	--	--
		2000	<4	<4	7.4	22.3	43.1	56.4	68.9	--	--
Difference			--	--	3.2	8.3	16.1	22.9	31.9	--	--
R59	44.2	1993	12.0	17.5	22.5	34.5	49.0	59.0	68.0	32.13	1.84
		2000	<4	<4	8.3	18.1	28.4	32.0	37.9	--	--
Difference			--	--	-14.2	-16.4	-20.6	-27.0	-30.1	--	--
R65	43.2	1993	16.5	21.5	27.5	44.0	68.0	76.0	86.0	40.42	1.88
		2000	<4	4.3	11.9	23.6	39.9	47.6	56.4	--	--
Difference			--	-17.2	-15.6	-20.4	-28.1	-28.4	-29.6	--	--

Riffle #	River Mile	Year of Study	Size (mm) D10	D16	D25	D50	D75	D84	D90	dg [1]	sg [2]
R69	42.2	1993	<4	4.0	6.6	16.5	33.0	50.0	70.0	14.05	3.56
		2000	<4	<4	<4	9.2	23.1	33.1	43.0	--	--
Difference			–	–	–	-7.3	-9.9	-16.9	-27.0	–	–
R77	40.2	1993	22.0	30.0	41.0	68.0	82.0	88.0	99.0	51.38	1.71
		2000	14.6	19.9	27.3	44.5	80.1	104.2	129.2	45.54	2.29
Difference			-7.4	-10.1	-13.7	-23.5	-1.9	16.2	30.2	-5.8	0.6

Footnotes

[1] Geometric mean, $dg = (D16*D84)^{0.5}$ (mm)

[2] Sorting index, $sg = (D84/D16)^{0.5}$, dimensionless

Note: sg, skewness, was not included because the pebble count method doesn't fully capture the smaller size categories that may significantly affect the skewness of the distribution.

Table 6.5: Comparison of Bulk Samples from DWR (1994) and CMC (2000)

Surface, Subsurface and Combined Samples

CMC Riffle #	DWR RM	Sample Type	Report	Year Sampled	D25	D50	D75
R10	53.4	Surface	DWR	1993	29.83	60.27	82.31
			CMC	1999	14.16	40.16	78.60
		Subsurface	DWR	1993	13.64	31.33	58.06
			CMC	1999	4.73	17.78	53.84
		Combined	DWR	1993	16.26	33.48	61.08
			CMC	1999	7.65	28.11	62.99
R20	51.9	Surface	DWR	1993	19.15	48.18	87.91
			CMC	1999	28.11	50.31	96.59
		Subsurface	DWR	1993	13.15	36.51	77.01
			CMC	1999	25.84	49.29	96.57
		Combined	DWR	1993	14.72	39.90	80.65
			CMC	1999	27.38	50.03	96.59
R27	50.9	Surface	DWR	1993	17.15	37.92	84.44
			CMC	1999	22.82	41.10	58.89
		Subsurface	DWR	1993	5.81	27.38	61.20
			CMC	1999	6.37	20.97	37.97
		Combined	DWR	1993	8.33	31.31	68.01
			CMC	1999	16.15	31.43	51.70
R58	44.7	Surface	DWR	1993	3.95	15.11	31.43
			CMC	1999	2.31	12.45	24.04
		Subsurface	DWR	1993	0.71	4.28	21.23
			CMC	1999	<0.85	6.50	19.63
		Combined	DWR	1993	0.78	6.91	23.43
			CMC	1999	0.99	9.41	22.25
R59	44.2	Surface	DWR	1993	15.14	36.55	60.84
			CMC	1999	0.88	9.22	27.55
		Subsurface	DWR	1993	4.07	18.69	37.52
			CMC	1999	<0.85	7.65	24.25
		Combined	DWR	1993	6.42	22.93	45.84
			CMC	1999	0.86	8.53	26.00

DWR = Department of Water Resources Report 1994
CMC = Carl Mesick Consultants Report 2000
RM = River Mile

Table 6.6: Comparison Among Studies in Spawning Gravel Area and Length

Comparison Among Studies in Spawning Gravel Area

Study	Reach of study (# of riffles)	Area (ft^2)	Reach of study (# of riffles)	Area (ft^2)	Reach of study (# of riffles)	Area (ft^2)
CDFG 1972	Goodwin to Knight's Ferry (3)	15,900			Knight's Ferry to Riverbank (86)	376,700
DWR 1994	Goodwin to Knight's Ferry (1)	5,500	Knight's Ferry to Oakdale (48)	92,885	Knight's Ferry to Riverbank (64)	226,620
This Study 2000	Goodwin to Knight's Ferry including enhancements, adjusted based on CMC criteria (2)	6,935	Knight's Ferry to Oakdale including enhancements, adjusted based on CMC criteria (29)	93,765		
	Goodwin to Knight's Ferry excluding enhancements, adjusted based on CMC criteria (2)	4,694	Knight's Ferry to Oakdale excluding enhancements, adjusted based on CMC criteria (29)	58,908		

Comparisons Among Studies in Length of Spawning Riffles

Study	Reach of study (# of riffles)	Length (ft)	Reach of study (# of riffles)	Length (ft)	Reach of study (# of riffles)	Length (ft)
CDFG 1972	Goodwin to Knight's Ferry (3)	505	Knight's Ferry to Orange Blossom Bridge (29)	5,097	Orange Blossom Bridge to Oakdale Bridge (27)	3,775
DWR 1994	Goodwin to Knight's Ferry (1)	NA	Knight's Ferry to Orange Blossom Bridge (25)	NA	Orange Blossom Bridge to Oakdale Bridge (23)	NA
This Study 2000	Goodwin to Knight's Ferry (2)	155	Knight's Ferry to Orange Blossom Bridge including enhancements (24)	2,621	Orange Blossom Bridge to Oakdale Bridge including enhancements (5)	603
			Knight's Ferry to Orange Blossom Bridge excluding enhancements (11)	1,493	Orange Blossom Bridge to Oakdale Bridge excluding enhancements (2)	220

I, A&B. SHIELD'S EQN for Critical Shear Stress (T_c) to mobilize gravel

Solve for depth to attain T_c *(Using slope from 1:24,000 topo map)*

ρ_w = 1000 kg/m³ $T_{ci} = T^*_{ci}(\rho_s - \rho_w)g(d_i)$ *[I. A.]*

ρ_s = 2650 kg/m³ $R = T_d/(\rho_f g S_2)$ *[I. B.]*

g = 9.81 m/s²

T^*_{ci} = 0.047

II. B, C, D: Calc. area inundated at D_T, using XS plots

Avg V with Manning's Eqn

$V=1.49(R^{.67}S^{.5})/n$

Discharge Q w/ Flow Eqn

Q=VA

XS Site	Ptx size %ile	Ptx Size FIELD (mm)	Critic Shear St T_c (N/m²)	Shear Stress T_d (N/m²)	S_1 (1:24K topo map slope)	Hydr. Rad $R = T_d/(\rho g S_1)$ (m)	assume R=D D_i (ft)	Note	Area A: @D_i (ft²)	n back calcul'd	V back-calc (ft/s)	Q Q=VA (w/ map n) (cfs)	Estim. Return Period Pre NM Dam (FFA)	Estim. Return Period Post NM Dam (FFA)
TM1	50	*35.00*	26.63	26.63	0.004444	0.61	2.00		145	0.077	2.05	**297**	**~1**	**<1**
	84	*100.00*	76.08	76.08	0.004444	1.74	5.72		580	0.077	4.12	**2,389**	**~1.2**	**~1.65**
R1	50	40.20	30.58	30.58	0.001176	2.65	8.69		1060	0.035	6.17	**6,544**	**~1.6**	**10+**
	84	70.00	53.25	53.25	0.001176	4.61	*15.13*	*	–	*0.035*	*8.94*	–	--	–
R5	50	36.10	27.46	27.46	0.001176	2.38	7.81		898	0.028	7.24	**6,502**	**~1.6**	**10+**
	84	85.40	64.97	64.97	0.001176	5.63	*18.46*	*	--	*0.028*	*12.86*	–	--	--
R28A	50	32.30	24.57	24.57	0.000952	2.83	8.63	*	--	0.034	5.62	–	–	--
	84	68.50	52.11	52.11	0.000952	5.58	*18.30*	*	–	*0.034*	*9.28*	--	--	--
R78	50	28.90	21.99	21.99	0.000714	3.14	10.29		1065	0.035	5.40	**5,749**	**~1.5**	**8+**
	84	57.30	43.59	43.59	0.000714	6.22	*20.41*	*	--	*0.035*	*8.52*	--	--	--

II. A. FLOW AND MANNINGS EQNS (to back-calculate n) Q= VA, $V=1.49(R^{.67}S^{.5})/n$

calculated value

XS Site	(1) Q (cfs)	(2) A (ft2) Nov.98 survey data	(3) WP (ft)	(1)/(2) V (ft/s) V=Q/A	(2)/(3) R (ft) R=A/WP	Slope S_1 (topo)	n (map)
TM1	1800	557	140	3.23	3.98	0.00444	0.077
R1	1800	486	120	3.70	4.04	0.00118	0.035
R5	1800	533	214	3.38	2.49	0.00118	0.028
R28A	1800	536	135	3.36	3.98	0.00095	0.034
R78	1800	543	110	3.31	4.95	0.00071	0.035

Notes: ** Indicates XS's where estimated mobilizing depths exceed bankfull conditions, so no discharge could be calculated*

D_{50} and D_{84} particle size from pebble counts (Falzone, summer 2000) except at TM1, where restoration gravel size (Mesick, 1998) is used (in italic).

Areas in IIA computed by counting squares of plotted cross sections (Mesick, Nov. 1998), using 1800 cfs as "bankfull."

Areas in IIB computed by graphing the estimated mobilizing depth and counting squares in Mesick (Nov. 1998) surveys (attached).

Wetted perimeter determined via trigonometric calculations for each plotted cross section (Mesick, Nov. 1998).

The topographic map slope is used for slope estimates, with surveys (Nov. 2000) resulting in a slope at R1 or 0.0021 and R28A or 0.000473.

Table 7.1: Bed Mobility Calculations – 5 Sites. The following table summarizes the flows needed to mobilize gravels at five different study sites (all nine sites studied in Appendix C) on the Lower Stanislaus River. Bed mobility thresholds are modeled using basic basic shear stress, velocity and flow equations. D_{84} mobilizing depths exceeded the cross sectional survey data for all sites except for TM1, and the D_{50} mobilizing depths exceeded survey data at R28A, thereby limiting an estimate of mobilizing flows. We recommend more extensive surveys to address this problem *(Data Source: Mesick, Nov. 1998 surveys)*.

Riffle	RM	Advantages	Disadvantages
TM1	56.6	✓ Bed mobility analysis results in flow estimates for mobilizing both the D_{50} (280cfs) and the D_{84} (2,400 cfs).	✓ A general value for the D_{50} and D_{84} based on the size of restoration gravels had to be used due to a lack of pre-project pebble count data at TM1. Thus, the imported gravels are unusually mobile and would probably wash out in high flow releases. ✓ Site conditions at TM1, with a slope four times as steep as other sites, do not necessarily best reflect the conditions at most of the spawning sites in the study reach. Bed mobility equations are highly sensitive to the steep slope, resulting in potential underestimated mobilizing flows.
R1	54.55	✓ Existing cross section data allows for an estimate of D_{50} mobilizing flow (6,450cfs). ✓ R1 is covered in our aerial photograph analysis. ✓ Field slope data collected Nov. 2000 are equivalent to topographic slopes.	✓ Existing cross section data does not allow for an estimate of D_{84} mobilizing flow due to the very deep mobilizing depth (over 15 ft) and limited cross section data.
R5	53.9	✓ Existing cross section data allows for an estimate of D_{50} mobilizing flow (6,500cfs). ✓ R5 is covered in our aerial photograph analysis. ✓ Estimate of changes in floodplain inundation (chapter 5) are performed at R5.	✓ Existing cross section data does not allow for an estimate of D_{84} mobilizing flow due to the very deep mobilizing depth (over 18 ft) and limited cross section data.
R28A	50.2	✓ Estimate of changes in floodplain inundation (chapter 5) are performed at R28A. ✓ R28A is representative of four of nine total sites in which estimates of D_{50} and D_{84} bed mobility flows could not be estimated due either to limited cross section data and/or an indication that flows in far excess of 5,000-8,000 cfs are needed for bed mobilization.	✓ Existing cross section data does not allow for an estimate of either D_{50} or D_{84} mobilizing flows as even just 8.6 feet depth exceeds the cross section data. ✓ Field slope data collected Nov. 2000 (not used in calculations) indicates a slope that is half as steep as the topographic slope, indicating even larger flows are necessary to mobilize gravels.
R78	40.2	✓ Existing cross section data allows for an estimate of D_{50} mobilizing flow (5,750cfs).	✓ This site, which is downstream of Oakdale, is at the very bottom of our study reach and is not covered in air photo analysis.

Table 7.2: Selected Bed Mobility Riffle Sites. A summary of the sites selected in the bed mobility analysis summarized in table 7-1, as well as notes regarding advantages and disadvantages in using these sites to characterize bed mobility flows for the Lower Stanislaus River. Plotted cross sections with mobilizing depths indicated for each of these five sites is found in Appendix C. Bed Mobilization calculations from all nine riffle sites studies is found in Appendix C. See figures 6.1 to 6.5 for map identifying the location of each site.

Table 8.1: Maps Used in Sediment Budget Analysis

Map Title	Publisher	Year	Scale	Notes
Oakdale	USGS	1994	1:100,000	
Oakdale	USGS	1987	1:24,000	Photo revised from 1968 USGS map
Oakdale	USGS	1968	1:24,000	
Oakdale	USGS	1953	1:24,000	
Oakdale	USGS	1915	1:31,680	
Knight's Ferry	USGS	1987	1:24,000	Photo revised 1962 USGS map
Knight's Ferry	USGS	1962	1:24,000	
Copperopolis	USGS	1916	1:62,500	Original Knight's Ferry map at smaller scale

Table 8.2: Estimated Gravel Mining Area and Volume

Reach	Pit #	Method of Extraction	Floodplain/ In Channel	Measured Area (yd^2)	Estimated Depth (yd)	Volume (yd^3)	Source/Notes
Goodwin Canyon							
	I	Pit	Floodplain	11,852	3.3	39,506	1978 air photos
	II	Pit	Floodplain	19,753	3.3	65,843	1999 air photos
		Total extracted	**Floodplain**	**31,605**		**105,349**	
			In Channel	**0**		**0**	
			Total	**31,605**		**105,349**	
Goodwin to Orange Blossom Bridge							
	A	Skim	Floodplain	27,654	0.7	18,436	1978 air photos
	B	Pit	Floodplain	45,432	3.3	151,440	1978 airphotos
	C	Pit	Floodplain	25,679	3.3	85,596	CMC map
	D	Dredge	In Channel	69,136	1.7	115,226	CMC map
	E	Pit	Floodplain	124,444	3.3	414,813	1999 air photos
	F	Pit	Floodplain	49,383	3.3	164,608	1978 air photos
	G	Skim	Floodplain	138,271	0.7	92,181	1978 air photos/CMC map
	H	Dredge	In Channel	27,654	1.7	46,090	CMC map
	I	Pit	In Channel	94,814	6.7	632,096	all air photos and maps
	J	Pit	Floodplain	25,679	3.3	85,596	1956 air photo
	J1	Skim	In Channel	63,210	0.7	42,140	1956, 1957 air photo
	K	Pit	Floodplain	19,753	3.3	65,843	1964 air photo
	K1	Pit	Floodplain	43,457	3.3	144,855	1957 & 1999 air photo
	L	Skim	In Channel	69,136	0.7	46,090	1964 air photo
	M	Pit	Floodplain	7,901	3.3	26,337	1956 air photo
	N	Pit	Floodplain	266,666	6.7	1,777,770	all air photos and maps
	N1	Pit	Floodplain	33,580	3.3	111,934	1937 air photo
	O	Dredge	In Channel	19,753	1.7	32,922	CMC map
	P	Pit	Floodplain	7,901	3.3	26,337	1937 air photo
	Q	Pit	Floodplain	67,160	3.3	223,867	1997 air photo
	R	Skim	In Channel	65,185	0.7	43,457	1956 air photo

Reach	Pit #	Method of Extraction	Floodplain/ In Channel	Area (yd^2)	Depth (yd)	Volumne (yd^3)	Source/Notes
	S	Pit	Floodplain	19,753	3.3	65,843	1957 air photo
	T	Pit	Floodplain	17,778	3.3	59,259	1956 air photo
	U	Skim	In Channel	110,617	0.7	73,745	1956 air photo
	W	Pit	Floodplain	9,877	3.3	32,922	1953 USGS map
		Total extracted	**Floodplain**	**930,366**		**3,547,639**	
			In Channel	**519,504**		**1,031,765**	
			Total	**1,449,870**		**4,579,404**	
Orange Blossom Bridge to Oakdale							
	1	Pit	Floodplain	21,728	3.3	72,428	1964 air photo
	2	Pit	Floodplain	229,135	6.7	1,527,565	all photos, 1953 USGS map,
	3	Pit	Floodplain	11,852	3.3	39,506	1964 air photo
		Total extracted	**Floodplain**	**262,715**		**1,639,499**	
			In Channel	**0**		**0**	
			Total	**262,715**		**1,639,499**	
		Total for all reaches	**Floodplain**	**1,224,686**		**5,292,487**	
			In Channel	**519,504**		**1,031,765**	
			Total	**1,744,190**		**6,324,252**	

Table 8.3 Estimated Depths of Different Methods of Gravel Extraction.

Method of Extraction	Estimated Depth of Extraction (ft)
Pit: Shallow	10
Pit: Deep	20
Skim	2
Dredging	5

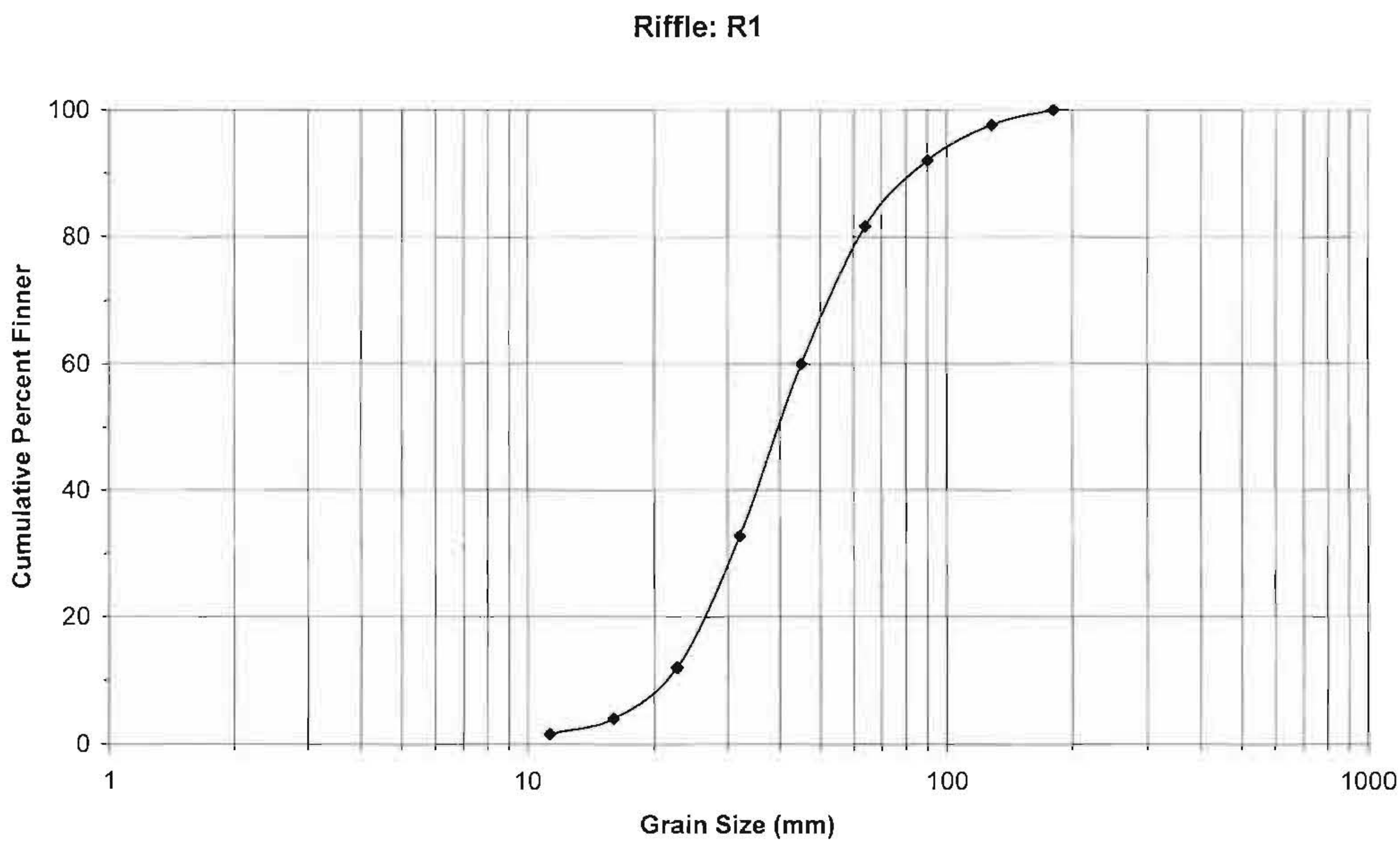
Appendix A, Table 1

Summary Statistics of Pebble Counts Completed in 2000 and Interpreted from 1994 DWR Report

		Size (mm)								
Riffle #	RM	D10	D16	D25	D50	D75	D84	D90	dg	sg
Field data collected Summer 2000										
R1	54.55	21.0	24.4	28.5	40.2	58.2	70.0	85.0	41.33	1.69
R5	53.9	12.6	15.4	21.1	36.1	60.8	85.4	113.8	36.27	2.35
RTB		8.2	11.4	15.4	34.7	58.5	73.5	87.2	28.94	2.54
R10	53.5	<4	4.4	6.1	15.6	37.4	56.5	74.4	15.82	3.57
R12	53.3	<4	5.8	7.9	20.4	46.6	57.4	66.2	18.32	3.13
R12B	52.77	<4	<4	9.1	24.2	43.1	55.9	66.9	–	--
R14	52.6	7.3	9.0	11.6	25.1	41.2	50.3	61.2	21.27	2.36
R20	51.8	<4	5.5	8.3	25.4	68.0	79.1	86.6	20.85	3.80
R20II		4.8	6.6	9.8	27.0	46.1	59.4	72.4	19.79	3.00
R27	50.8	11.6	14.9	20.1	30.1	40.8	44.8	54.4	25.79	1.74
R28A	50.2	10.9	14.7	20.3	32.3	55.3	68.5	81.8	31.71	2.16
R29	49.75	11.8	17.7	24.6	38.5	62.6	77.3	87.6	36.99	2.09
R34		<4	4.7	6.7	15.0	30.5	41.4	50.7	13.95	2.97
R42		8.1	12.2	17.3	30.4	54.2	67.6	86.8	28.74	2.35
R43	46.9	19.7	24.8	32.1	44.8	65.1	78.7	87.8	44.18	1.78
R56		<4	<4	7.4	22.3	43.1	56.4	68.9	--	--
R58(newR57)	44.6	10.1	13.4	18.0	30.9	49.7	59.2	68.3	28.11	2.11
R59	44.4	<4	<4	8.3	18.1	28.4	32.0	37.9	--	--
R65		<4	4.3	11.9	23.6	39.9	47.6	56.4	--	--
R69		<4	<4	<4	9.2	23.1	33.1	43.0	--	--
R77		14.6	19.9	27.3	44.5	80.1	104.2	129.2	45.54	2.29
R78	40.2	12.3	14.7	17.9	28.9	47.1	57.3	64.4	29.02	1.97

Riffle #	RM	Size (mm) D10	D16	D25	D50	D75	D84	D90	dg	sg
DWR Riffles 1994 (data interpolated from Wolman plots)										
R10	53.4	24.5	28.0	31.0	46.5	69.0	80.0	92.0	47.33	1.69
R20	51.9	5.1	8.9	17.0	36.5	66.0	79.0	97.0	26.52	2.98
R27	50.9	8.0	20.0	31.0	64.0	105.0	135.0	155.0	51.96	2.60
R29	49.7	<4	4.0	8.8	19.5	35.0	47.0	62.0	13.71	3.43
R34	49.2	12.0	18.5	25.0	41.0	64.0	59.0	76.0	33.04	1.79
R42	47	12.5	18.0	24.0	38.0	56.0	66.0	73.0	34.47	1.91
R56	45.2	<4	<4	4.2	14.0	27.0	33.5	37.0	--	--
R58(newR57)	44.7	10.8	16.5	20.0	32.0	48.0	58.0	72.0	30.94	1.87
R59	44.2	12.0	17.5	22.5	34.5	49.0	59.0	68.0	32.13	1.84
R65	43.2	16.5	21.5	27.5	44.0	68.0	76.0	86.0	40.42	1.88
R69	42.2	<4	4.0	6.6	16.5	33.0	5.0	70.0	4.44	1.13
R77	40.2	22.0	30.0	41.0	68.0	82.0	88.0	99.0	51.38	1.71

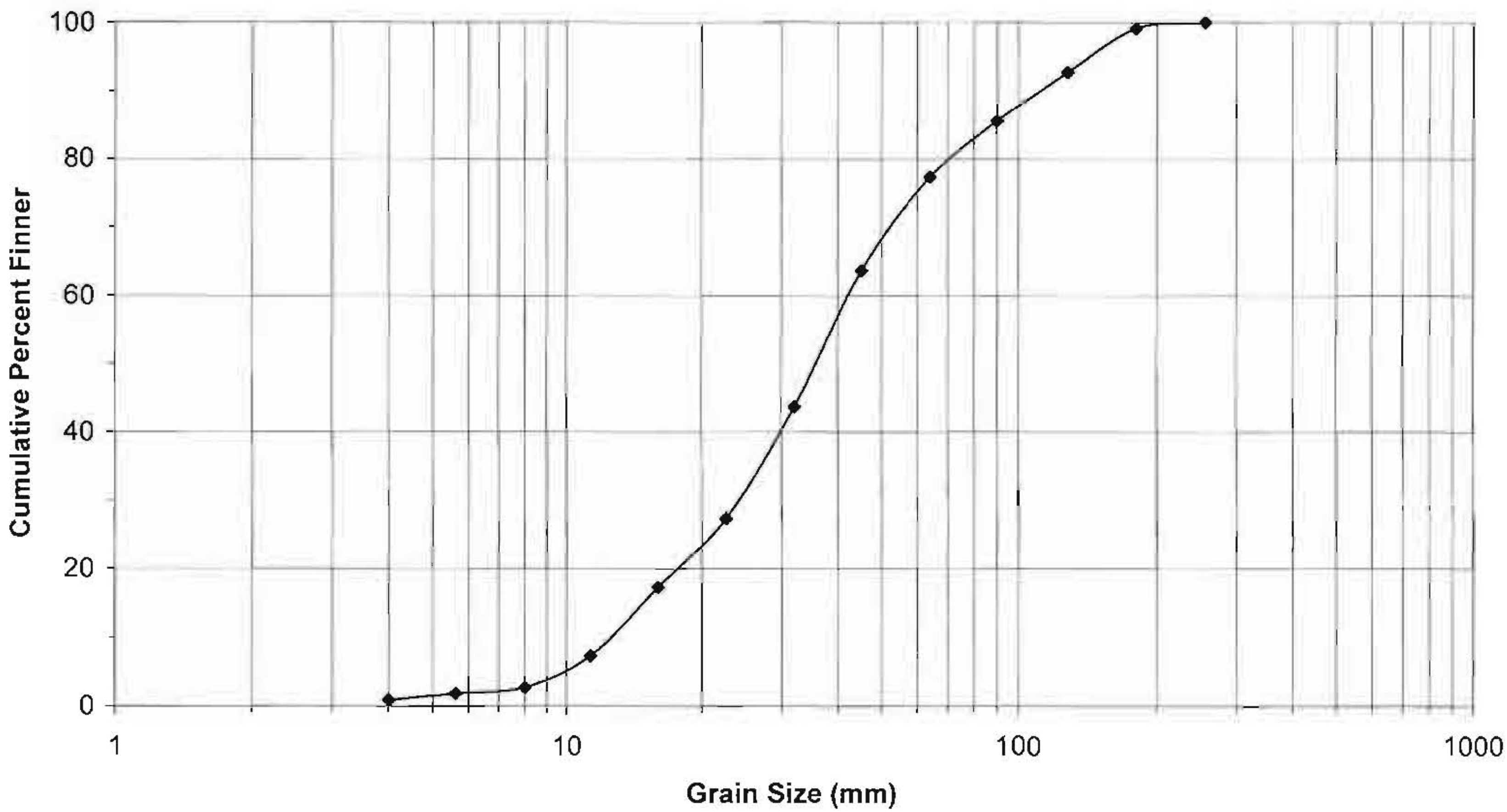
RM = river mile
dg = $(D16*D84)^{0.5}$ (mm)
sg = $(D84/D16)^{0.5}$, dimesionless
note: sg, skewness, was not included because the pebble count method doesn't fully capture the smaller size categories that may significantly affect the skewness of the distribution.



D16=21.0 D50=40.2 D84=70.0

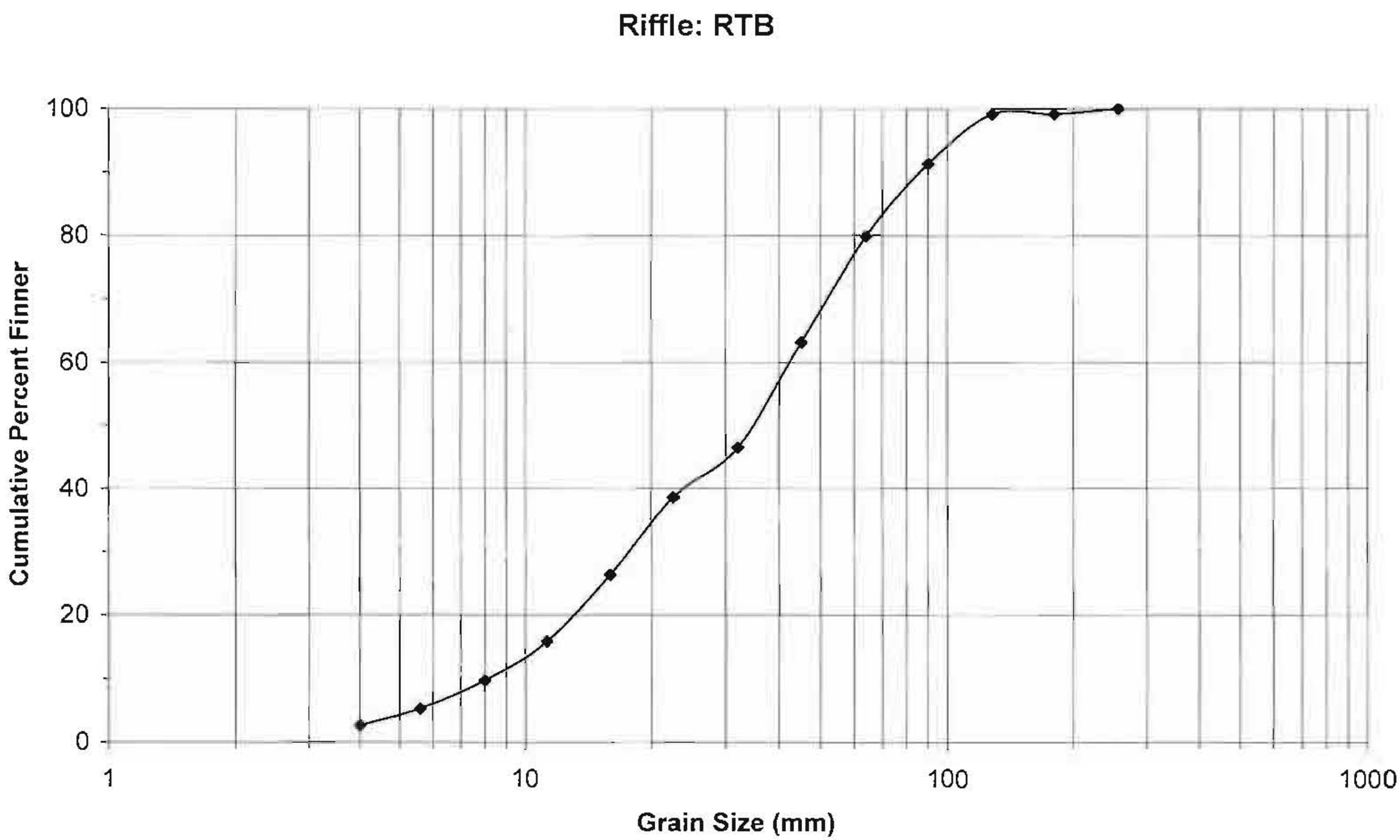
Appendix A, Figure 1

Riffle: R5



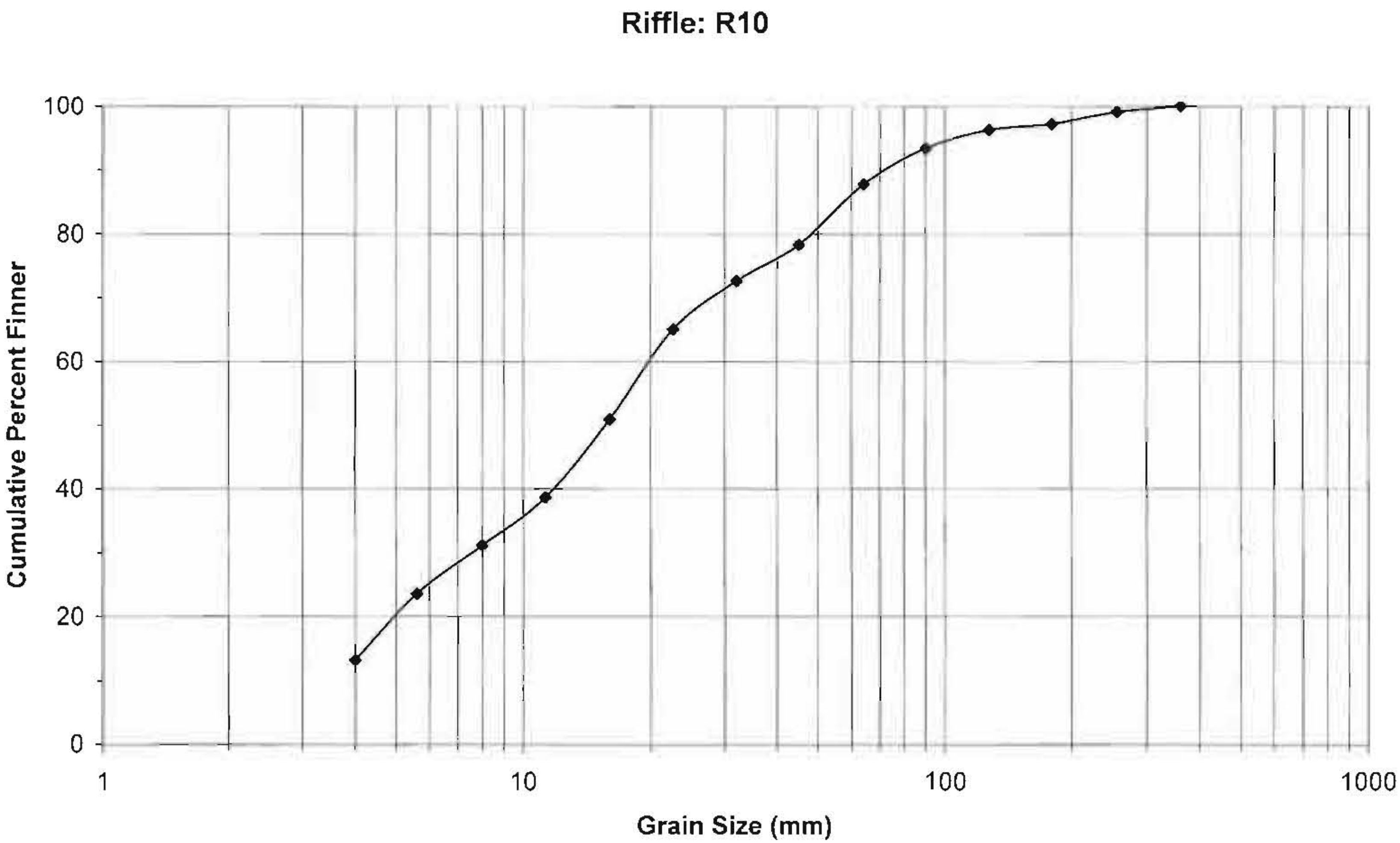
D16=15.4 D50=36.1 D84=85.4

Appendix A, Figure 2



D16=11.4 D50=34.7 D84=73.5

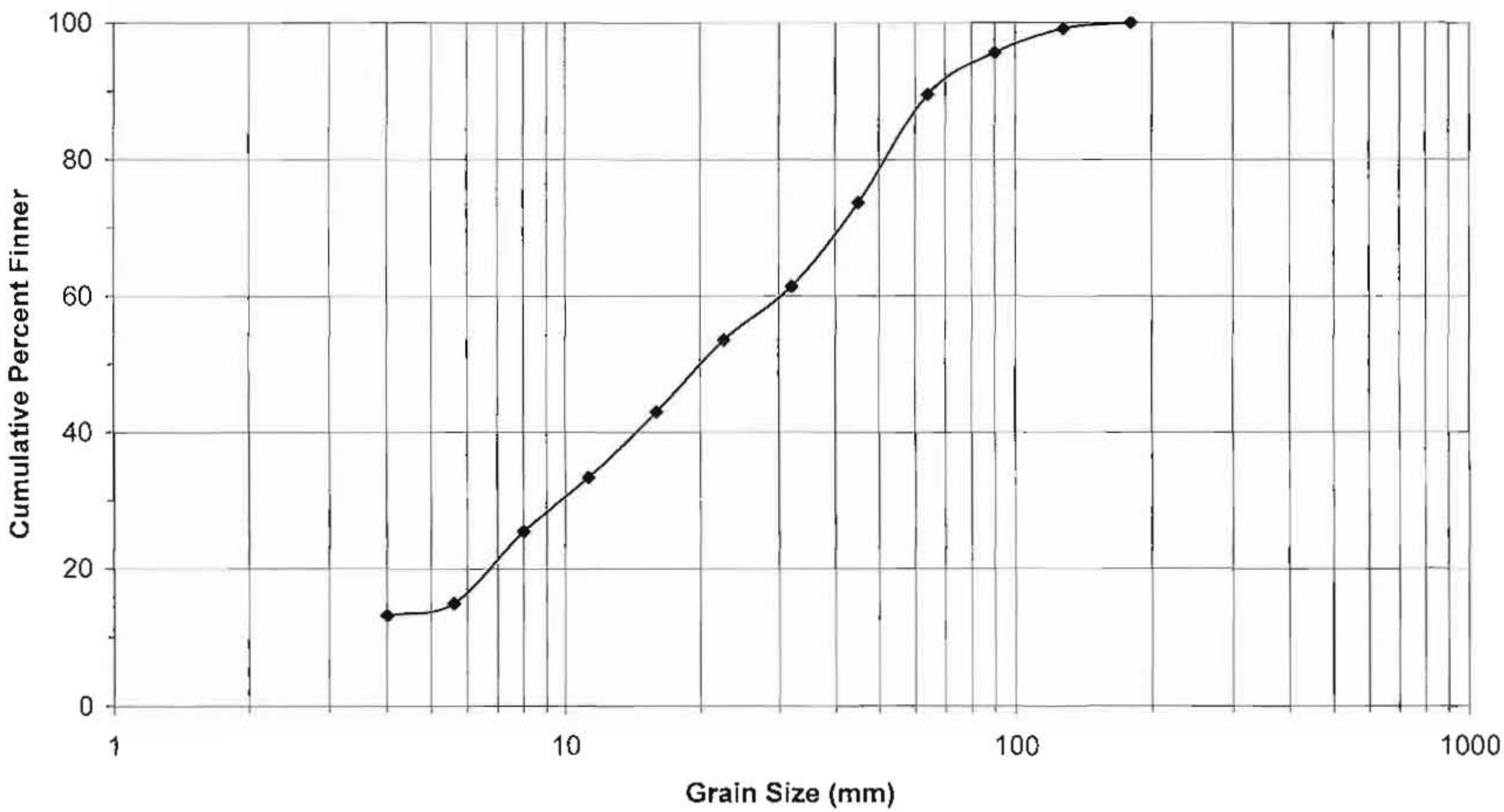
Appendix A, Figure 3



D16=4.4 D50=15.6 D84=56.5

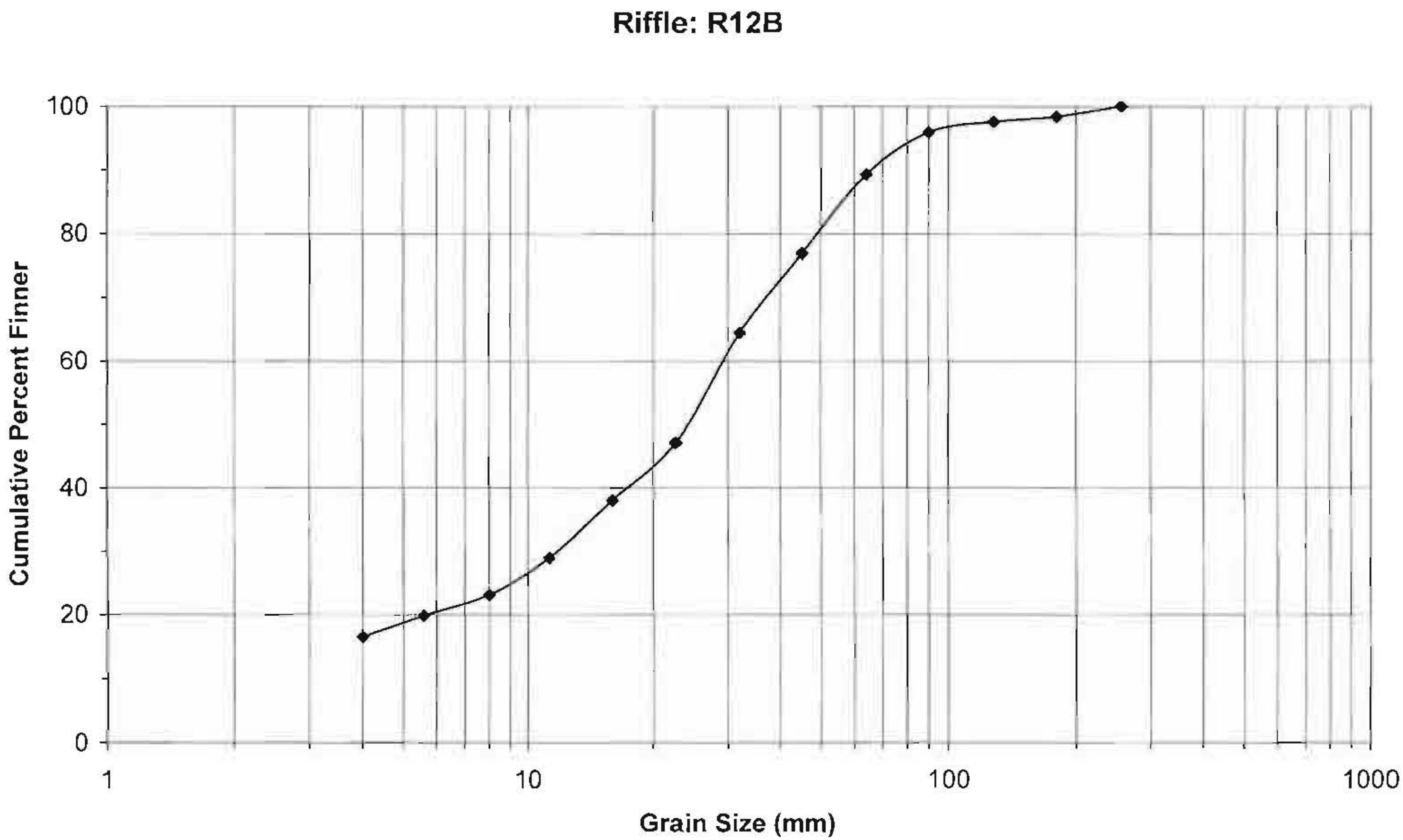
Appendix A, Figure 4

Riffle: R12



D16=5.8 D50=20.4 D84=57.4

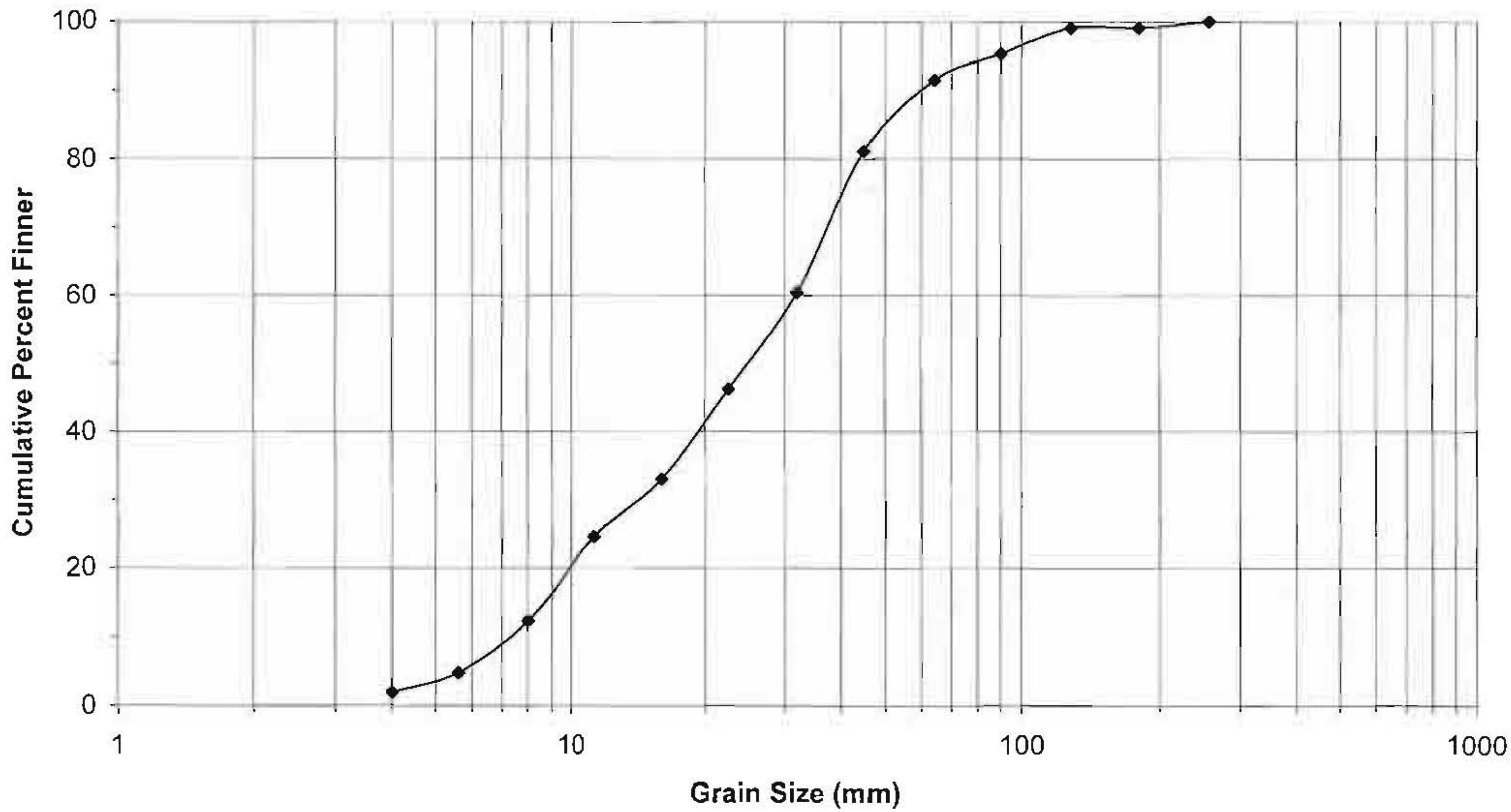
Appendix A, Figure 5



D16=<4 D50=24.2 D84=55.9

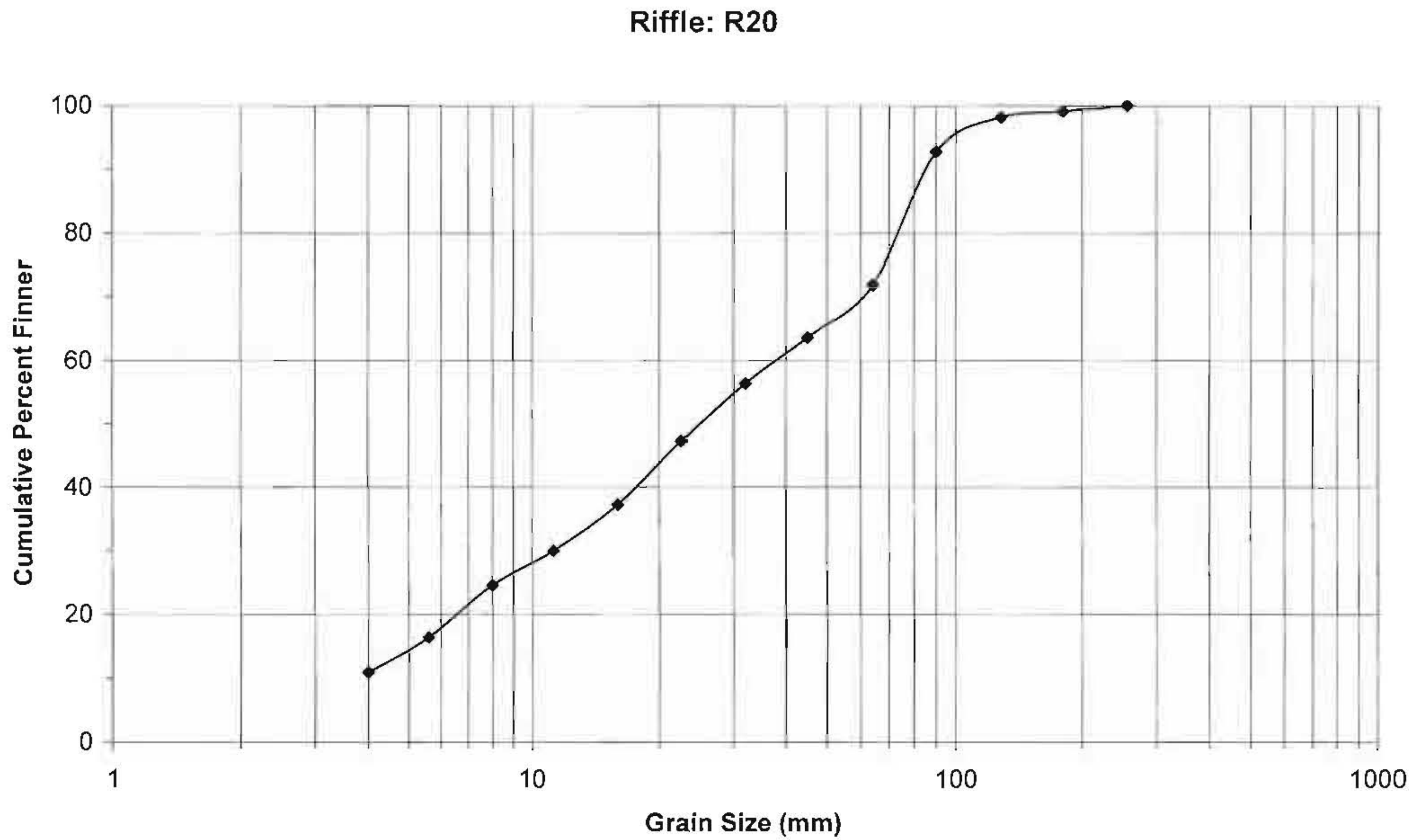
Appendix A, Figure 6

Riffle: R14



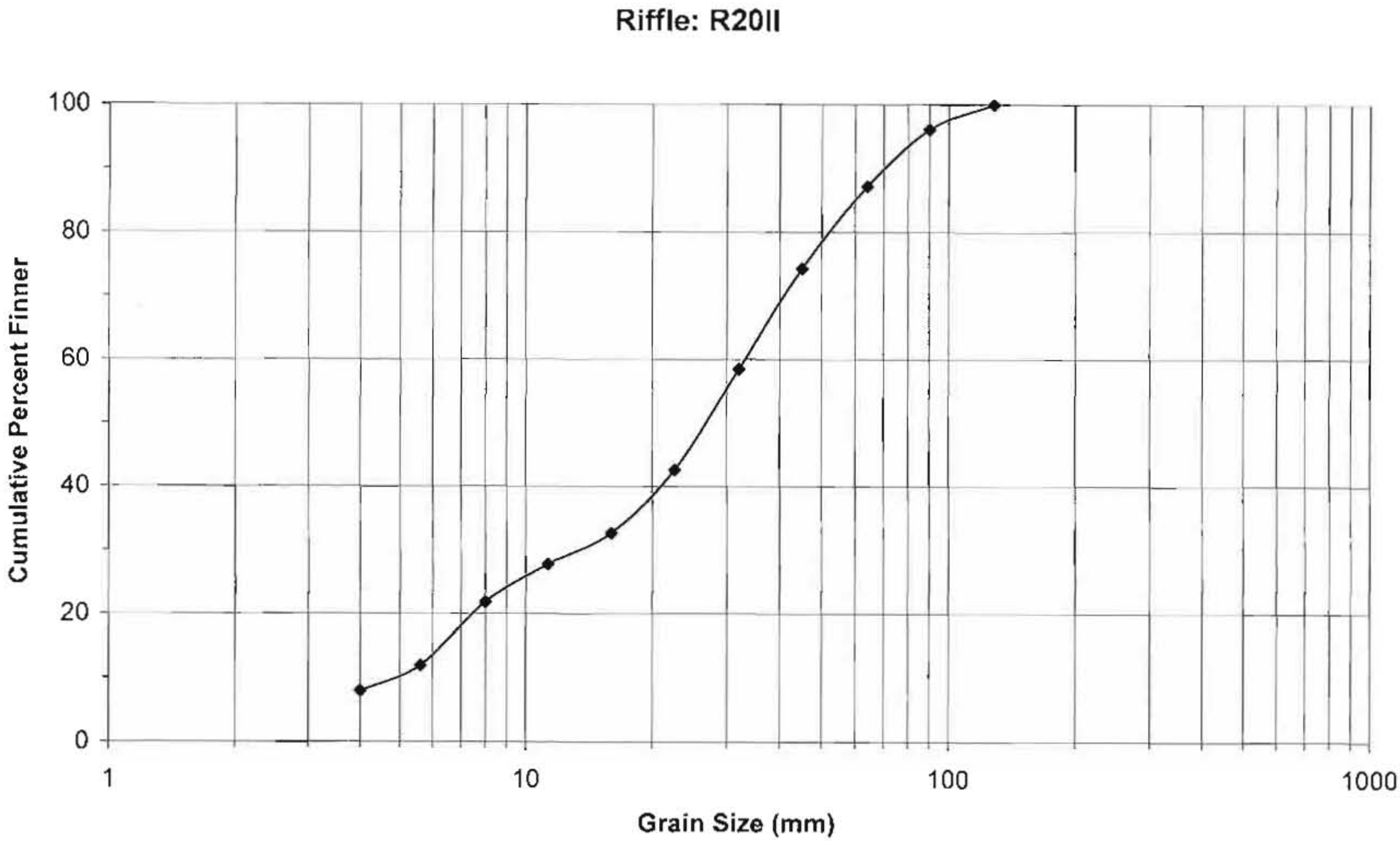
D16=9.0 D50=25.1 D84=50.3

Appendix A, Figure 7



D16=5.5 D50=25.4 D84=79.1

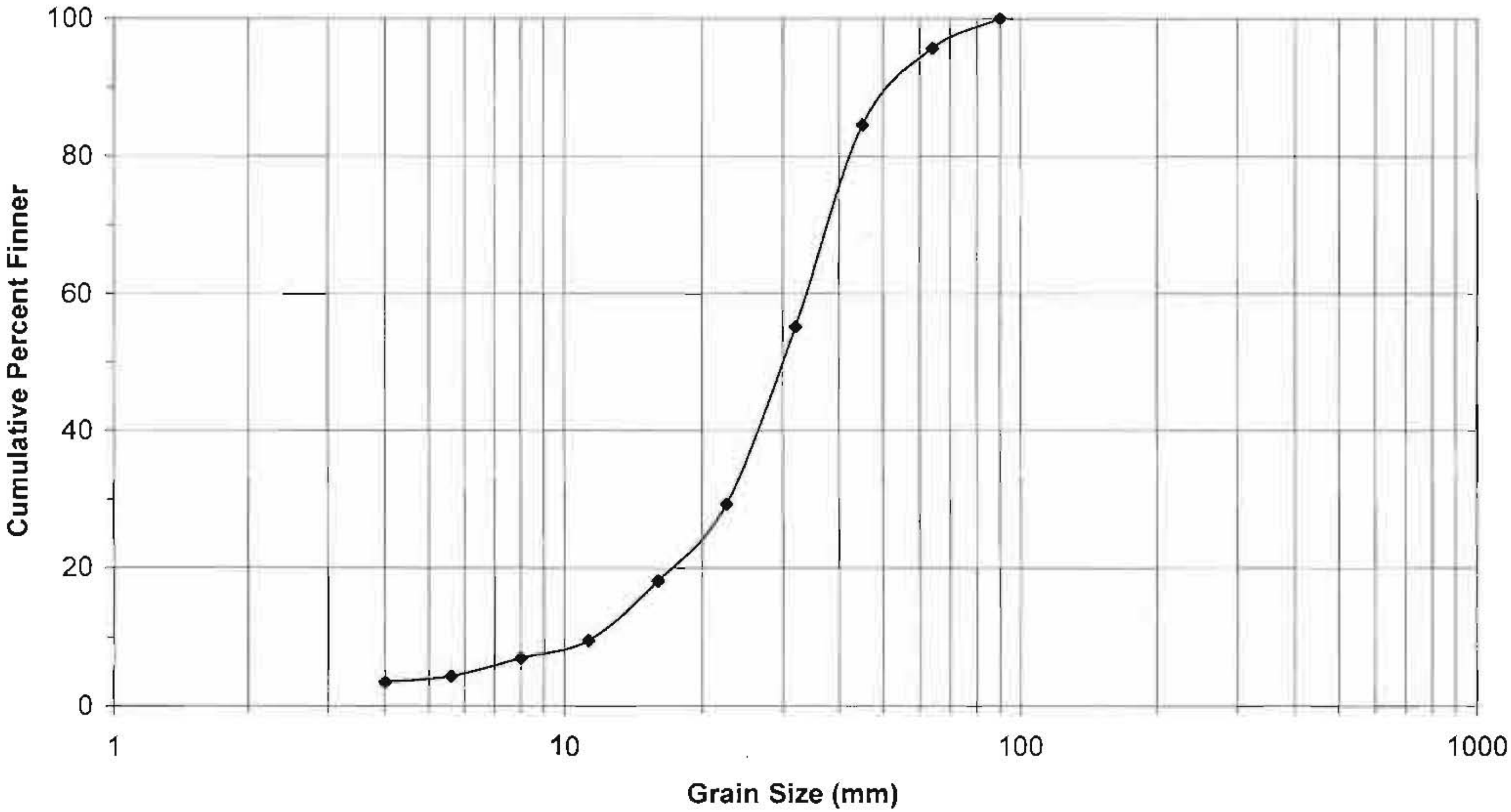
Appendix A, Figure 8



D16=6.6 D50=27.0 D84=59.4

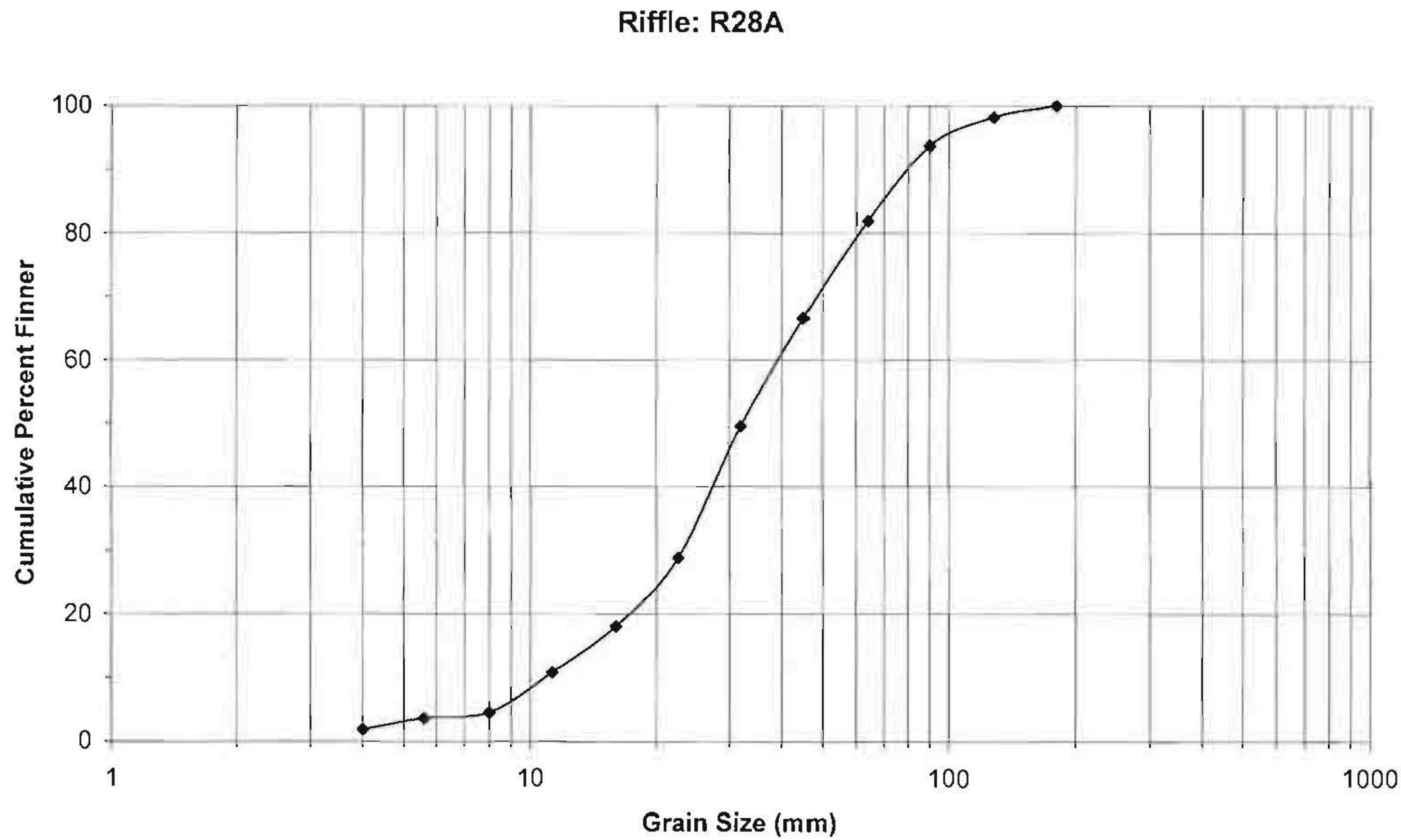
Appendix A, Figure 9

Riffle: R27



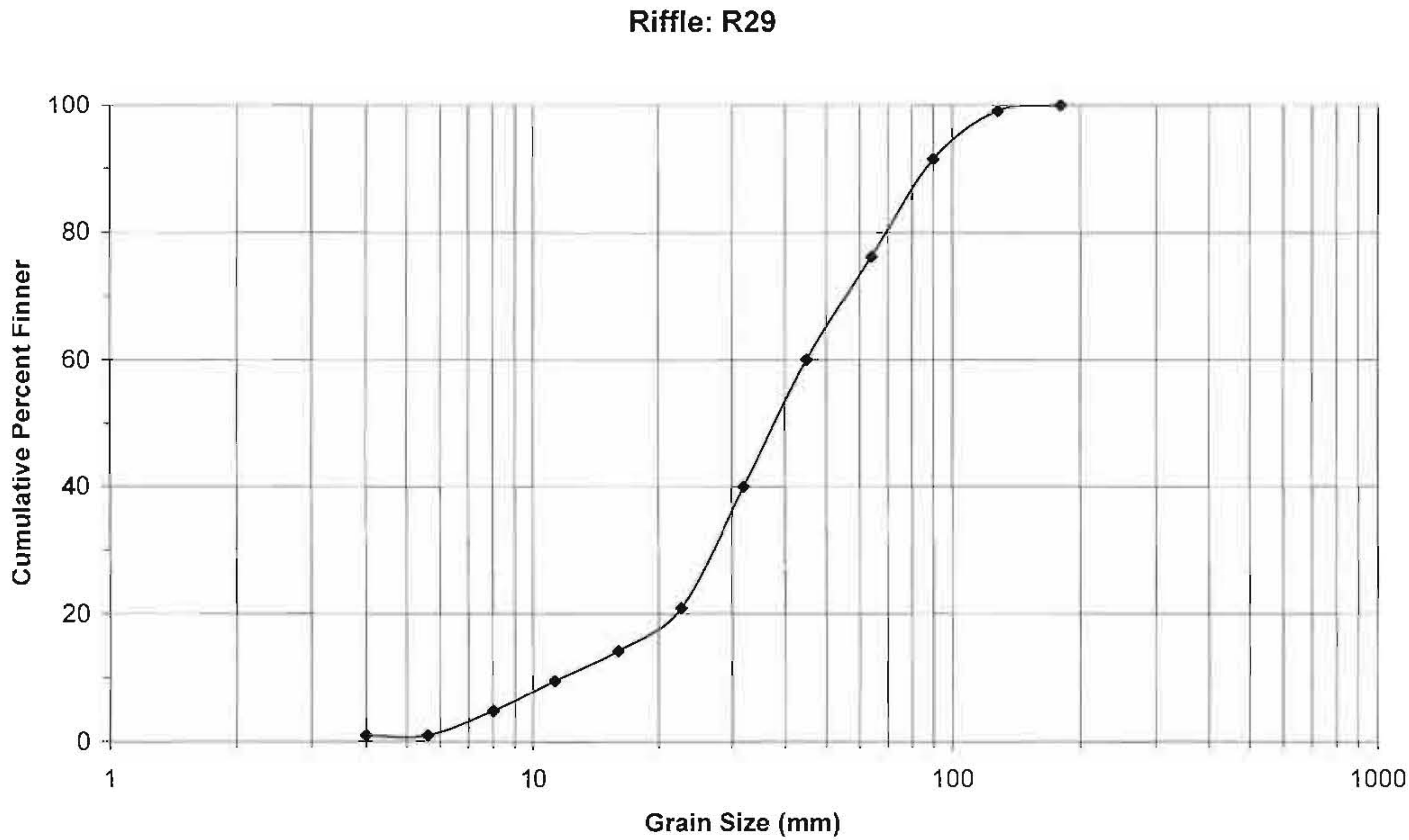
D16=14.9 D50=30.1 D84=44.8

Appendix A, Figure 10



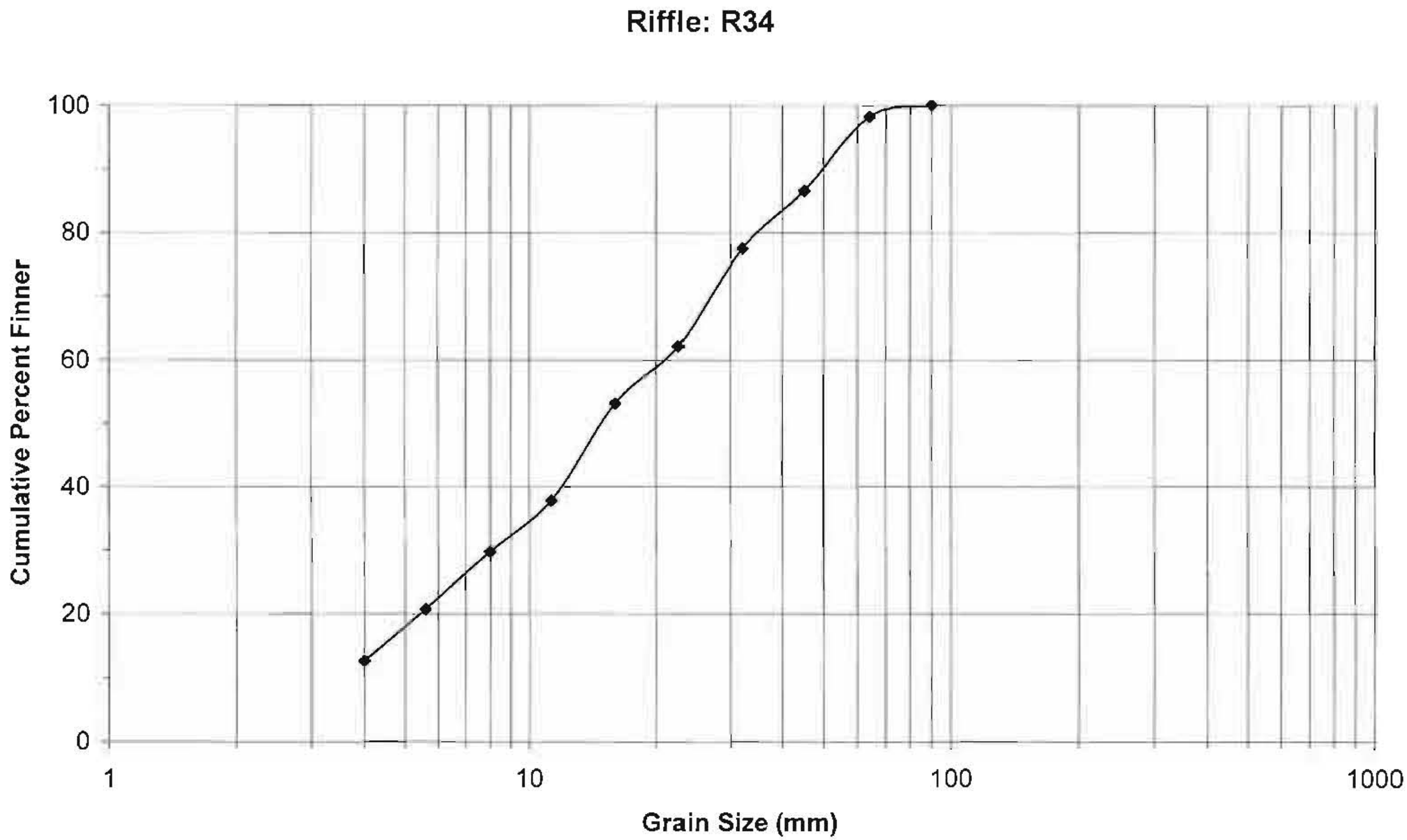
D16=14.7 D50=32.3 D84=68.5

Appendix A, Figure 11



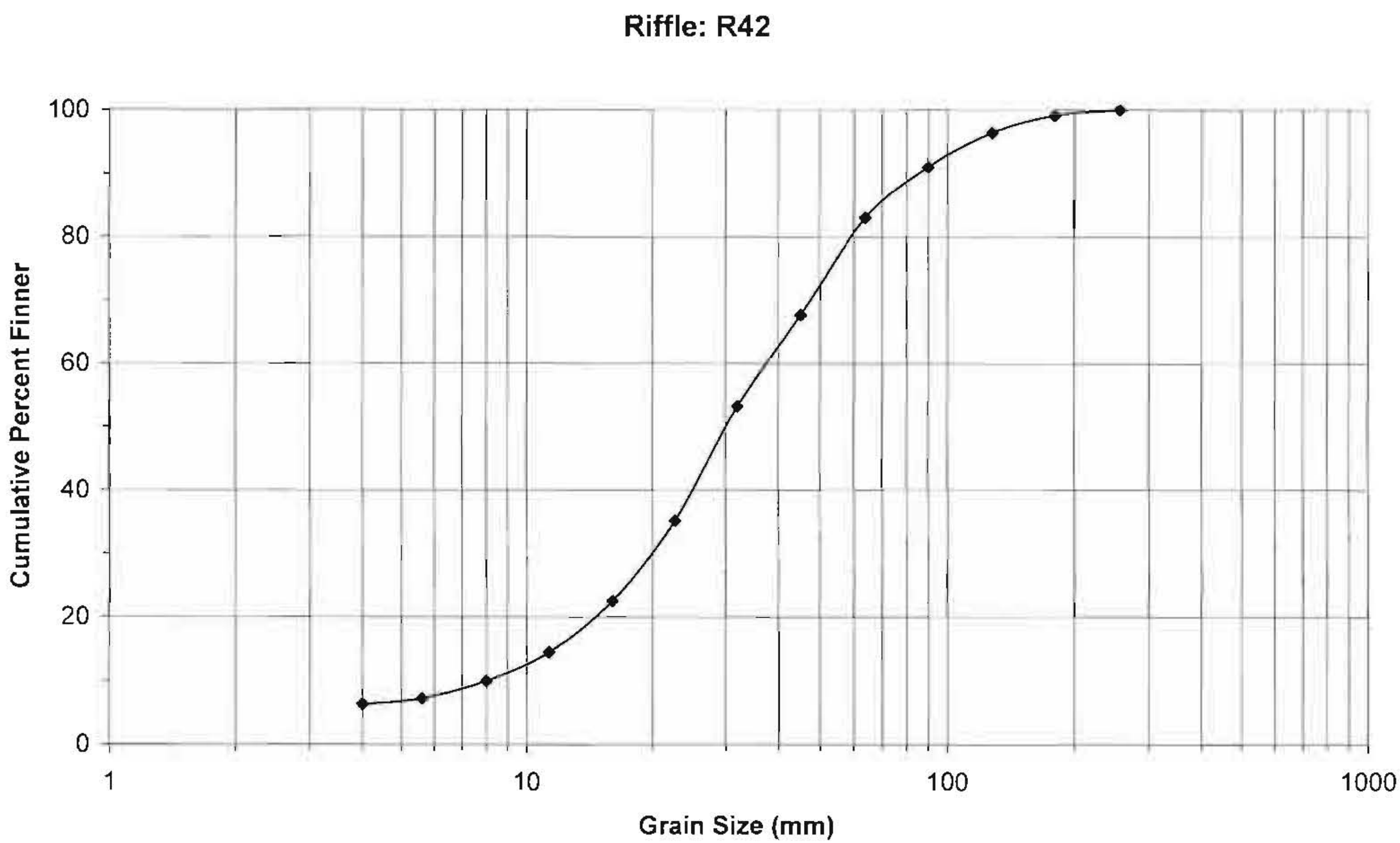
D16=17.7 D50=38.5 D84=77.3

Appendix A, Figure 12



D16= D50= D84=

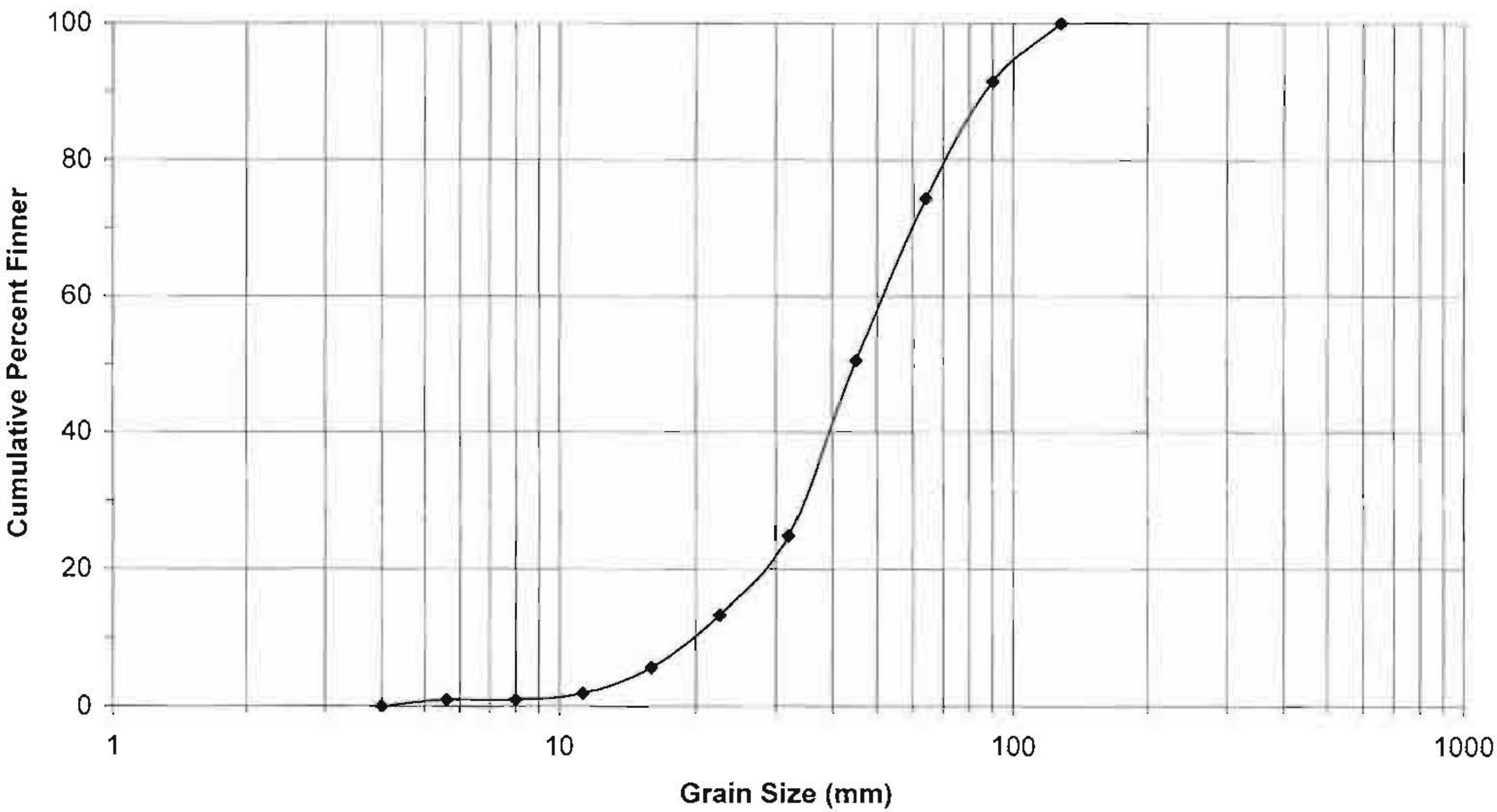
Appendix A, Figure 13



D16=12.2 D50=30.4 D84=67.6

Appendix A, Figure 14

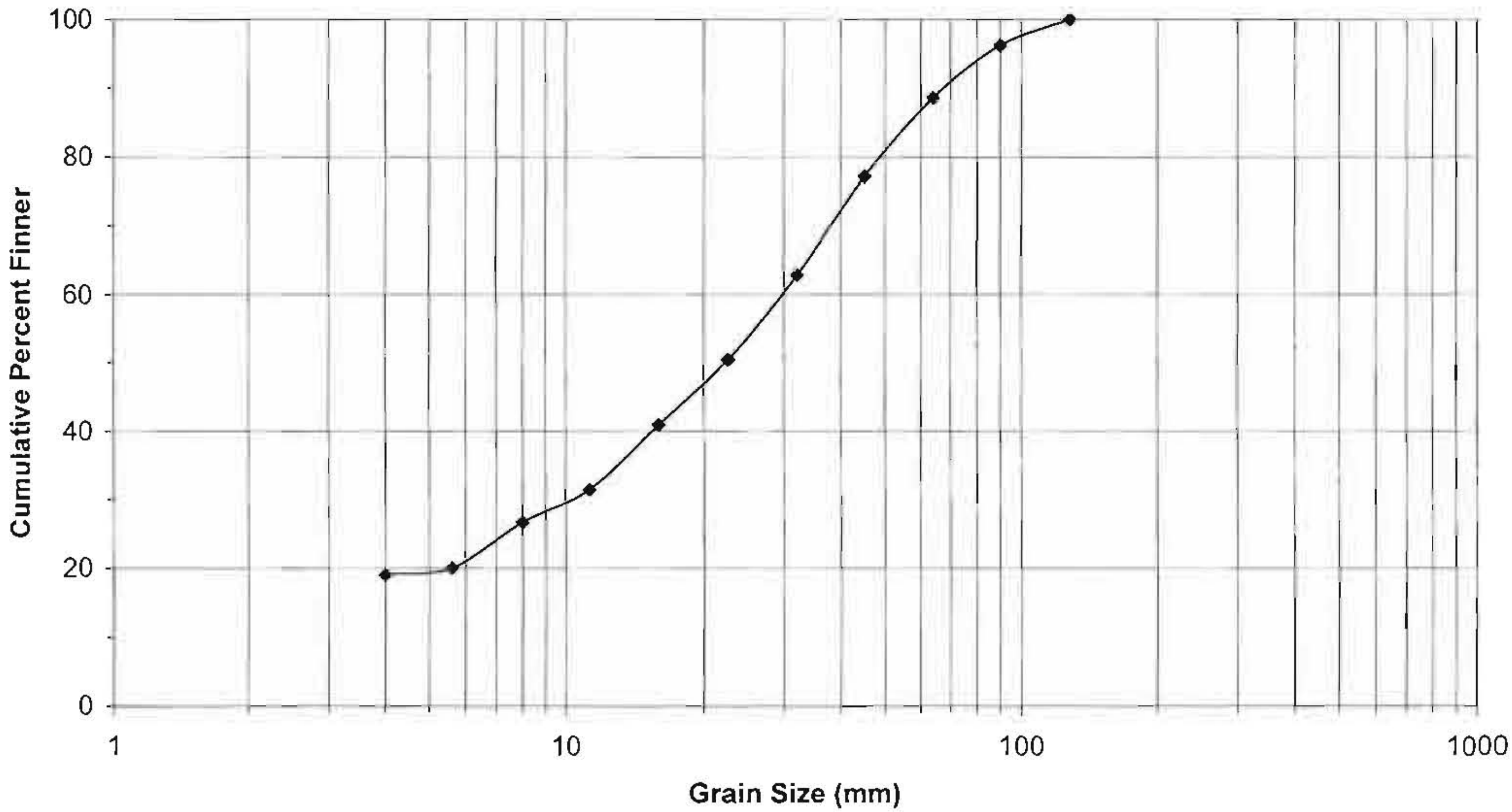
Riffle: R43



D16=24.8 D50=44.8 D84=78.7

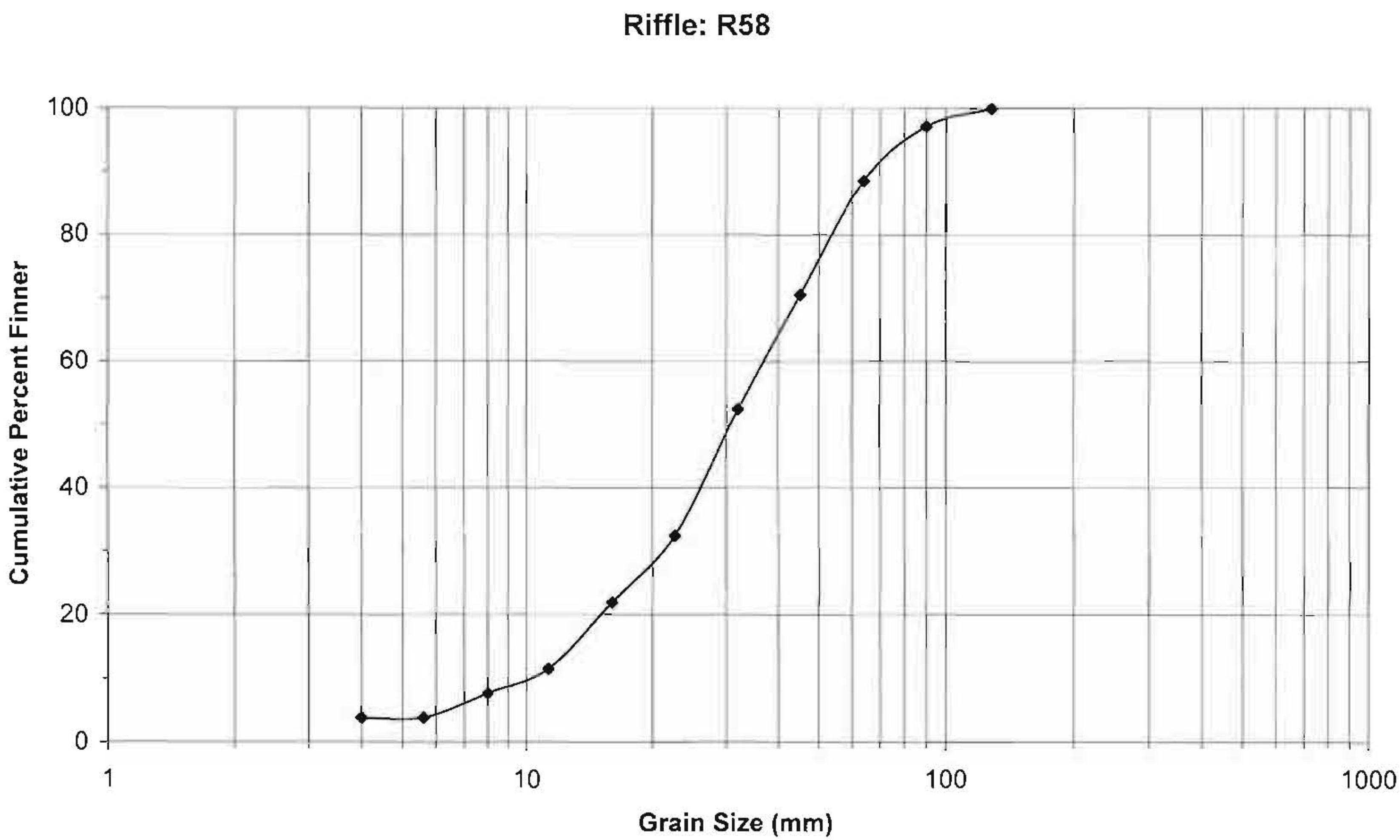
Appendix A, Figure 15

Riffle: R56



D16=<4 D50=22.3 D84=56.4

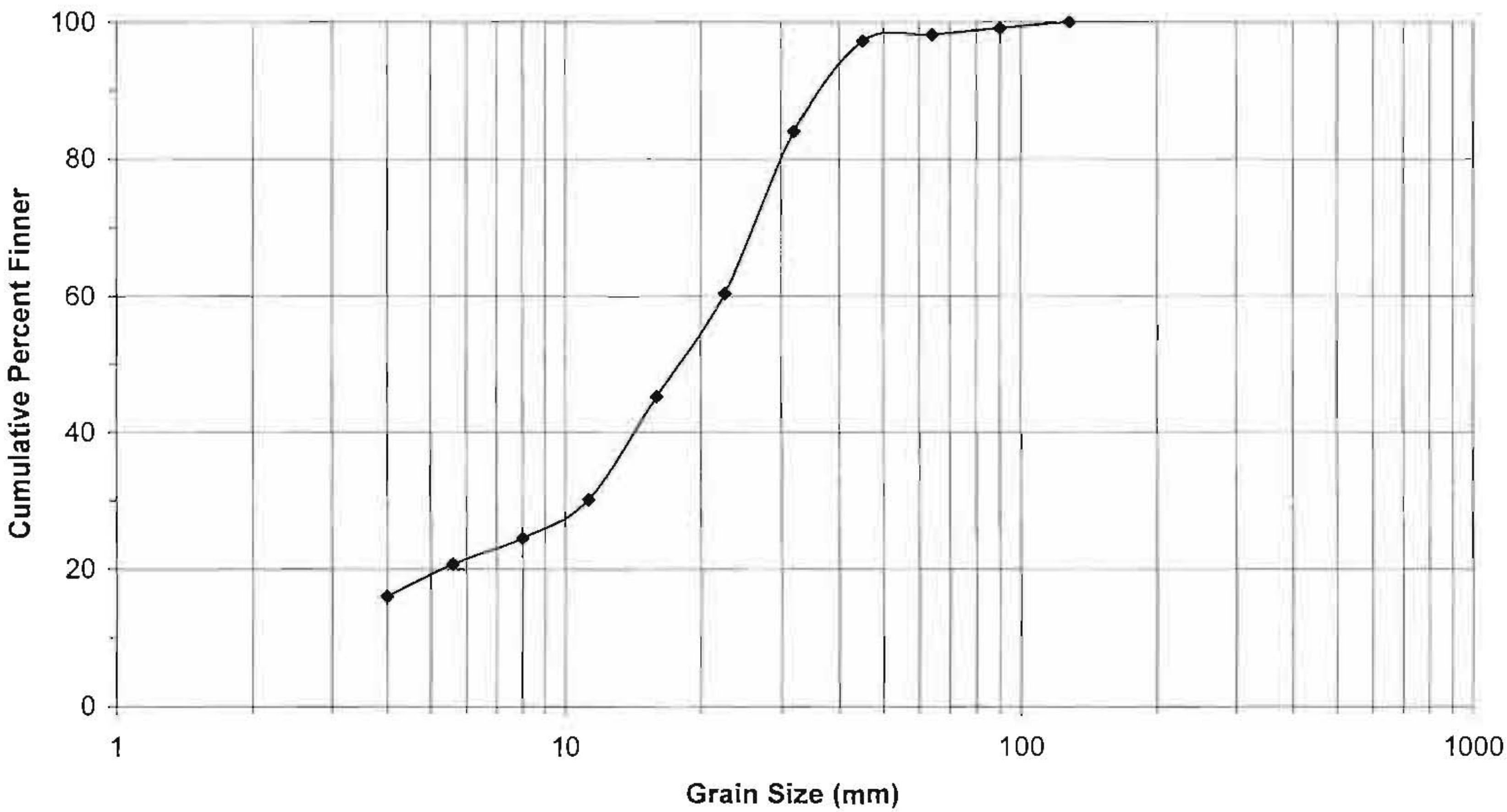
Appendix A, Figure 16



D16=13.4 D50=30.9 D84=59.2

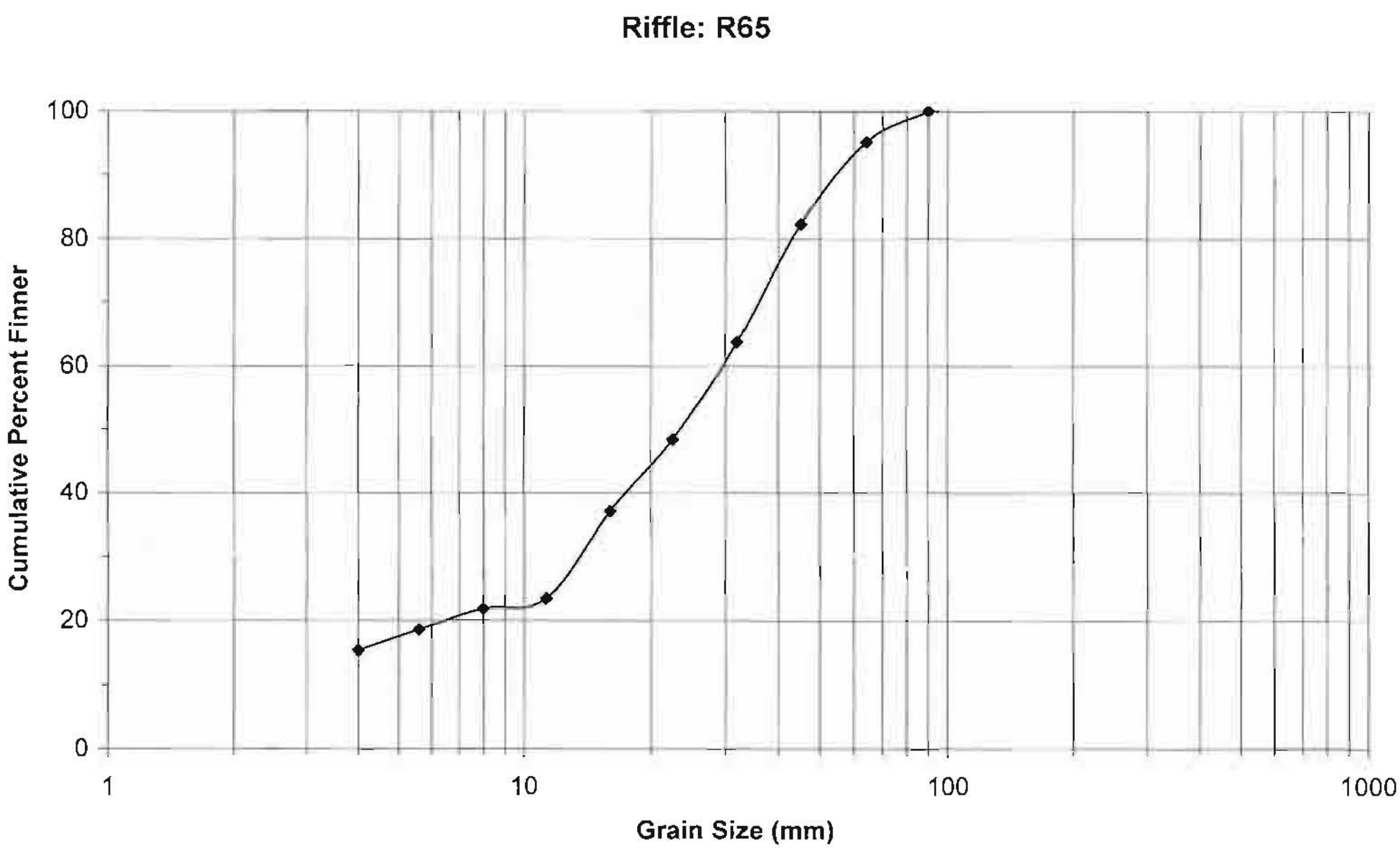
Appendix A, Figure 17

Riffle: R59



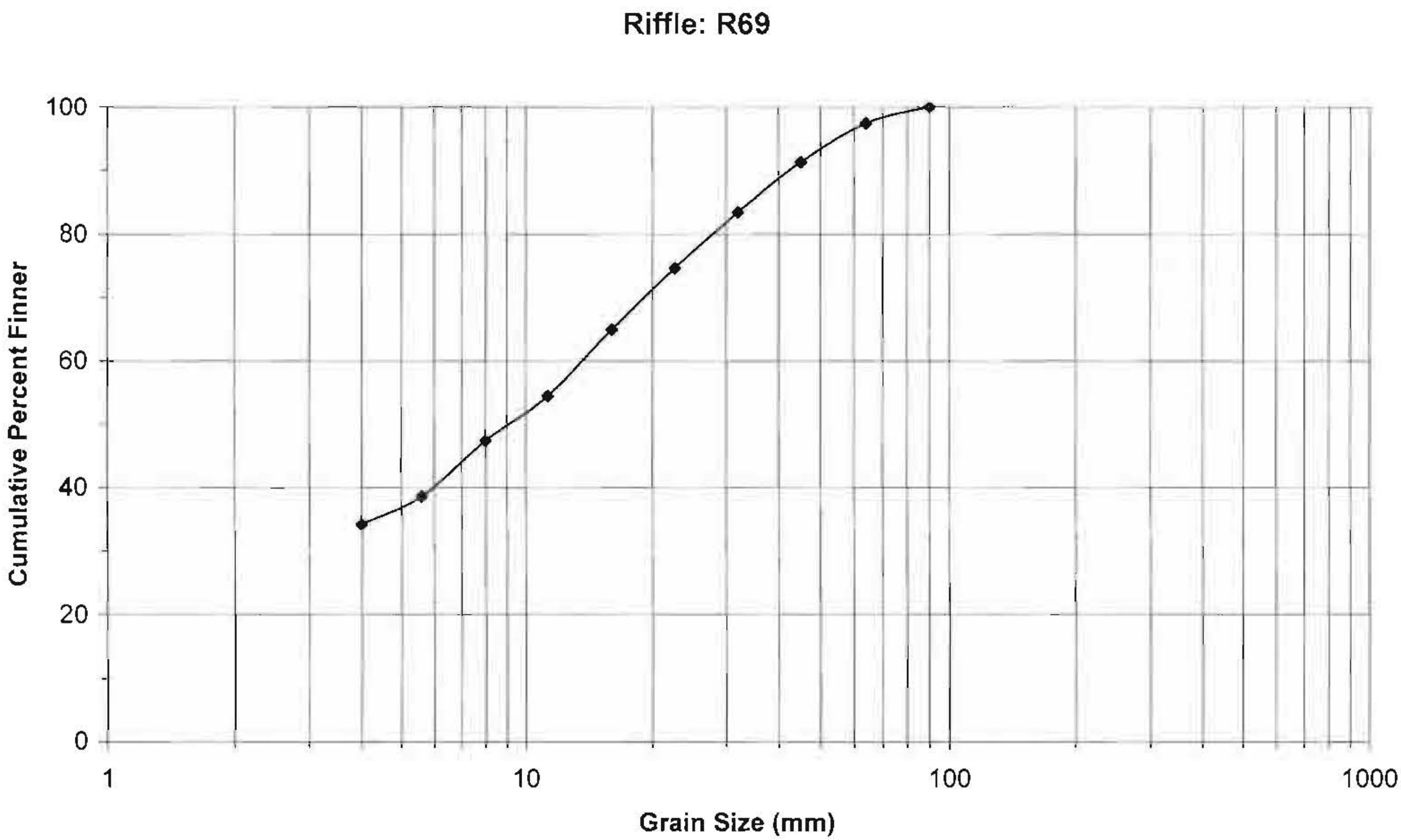
D16=<4 D50=18.1 D84=32.0

Appendix A, Figure 18



D16=4.3 D50=23.6 D84=47.6

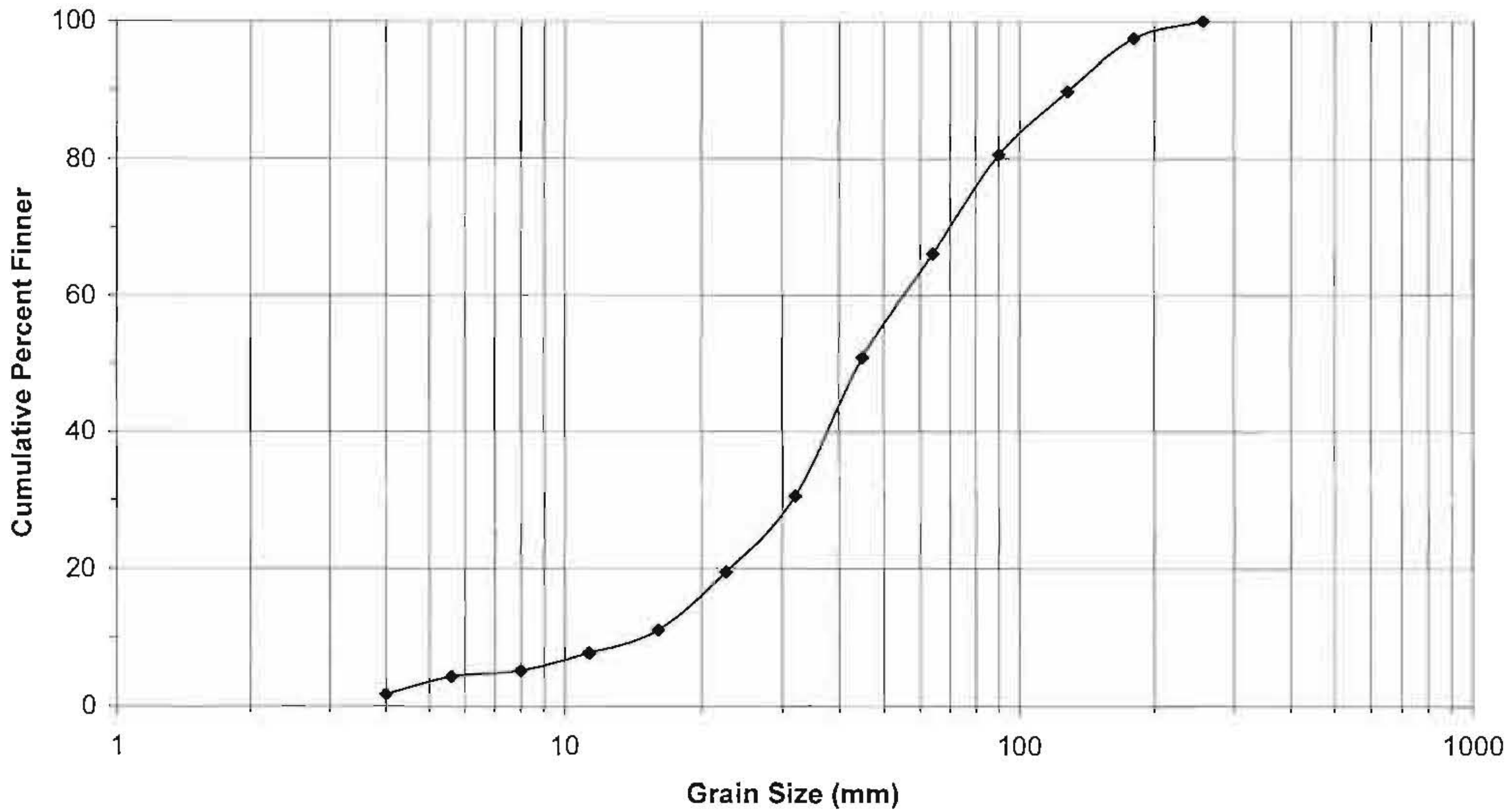
Appendix A, Figure 19



D16=<4 D50=9.2 D84=33.1

Appendix A, Figure 20

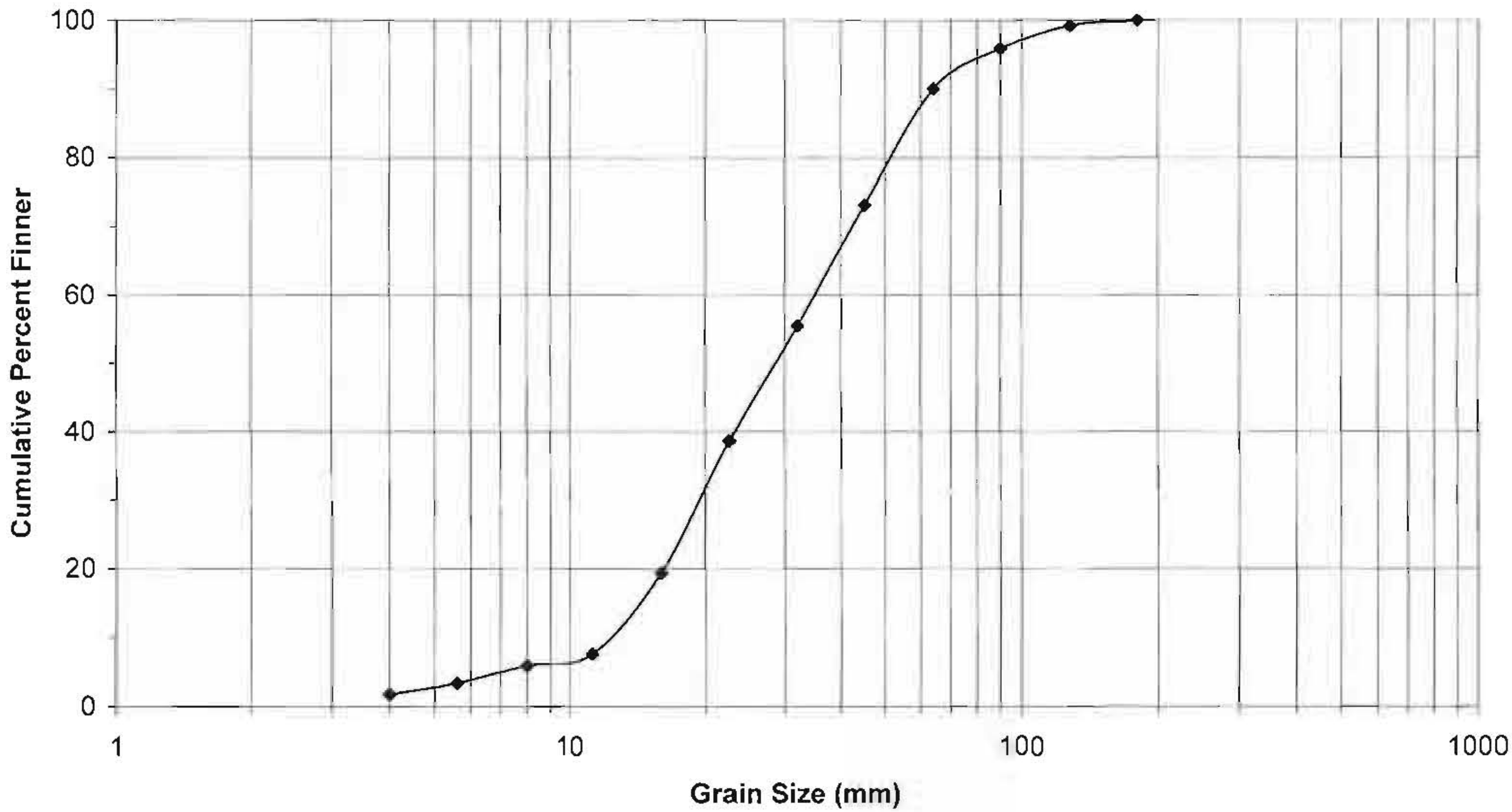
Riffle: R77



D16=19.9 D50=44.5 D84=104.2

Appendix A, Figure 21

Riffle: R78



D16=14.7 D50=28.9 D84=57.3

Appendix A, Figure 22

Appendix B, Table 1

Summary Statistics of Bulk Samples from 1994 DWR Report and CMC Report
Combined, Surface and Subsurface

CMC Riffle #	DWR RM	Location in bed	D5	D10	D16	D20	D25	D50	D75	D84	D90	D95	dg	sg	sk
			Size (mm)												
DWR Bulk Samples															
R10	53.4	Surface	7.74	12.07	17.84	22.22	29.83	60.27	82.31	87.46	90.60	93.22	39.50	2.21	-0.5317
		Subsurface	0.74	1.92	5.78	9.42	13.64	31.33	58.06	70.24	80.58	94.26	20.15	3.49	-0.3535
		Combined	0.94	2.69	8.08	11.78	16.26	33.48	61.08	72.57	83.82	95.89	24.22	3.00	-0.2953
R20	51.9	Surface	2.43	6.64	11.63	14.96	19.15	48.18	87.91	111.13	126.60	139.50	35.94	3.09	-0.2596
		Subsurface	1.44	4.11	7.45	9.67	13.15	36.51	77.01	104.15	122.25	137.32	27.86	3.74	-0.2052
		Combined	1.70	4.70	8.37	11.06	14.72	39.90	80.65	106.48	123.70	138.05	29.85	3.57	-0.2282
R27	50.9	Surface	0.84	2.03	6.54	10.84	17.15	37.92	84.44	108.90	125.21	138.81	26.69	4.08	-0.2496
		Subsurface	0.47	0.90	1.78	2.97	5.81	27.38	61.20	77.46	105.57	128.98	11.74	6.60	-0.4487
		Combined	0.54	1.07	2.31	4.57	8.33	31.31	68.01	92.22	114.79	133.59	14.60	6.32	-0.4139
R58	44.7	Surface	0.33	0.49	0.85	1.56	3.95	15.11	31.43	38.87	52.87	64.53	5.74	6.77	-0.5063
		Subsurface	0.25	0.36	0.49	0.57	0.71	4.28	21.23	28.67	33.62	37.75	3.75	7.65	-0.0652
		Combined	0.26	0.38	0.52	0.61	0.78	6.91	23.43	30.76	35.64	48.91	3.99	7.71	-0.2693
R59	44.2	Surface	1.19	3.82	8.27	11.35	15.14	36.55	60.84	69.64	75.52	93.82	24.01	2.90	-0.3947
		Subsurface	0.56	0.83	1.13	1.87	4.07	18.69	37.52	51.04	60.48	68.34	7.59	6.72	-0.4725
		Combined	0.62	0.94	1.77	3.43	6.42	22.93	45.84	57.99	66.10	72.85	10.14	5.72	-0.4678
CMC Bulk Samples															
R10	53.4	Surface	<0.85	2.39	6.24	9.47	14.16	40.16	78.60	115.10	139.44	159.72	26.81	4.29	-0.2774
		Subsurface	<0.85	0.94	2.00	3.14	4.73	17.78	53.84	89.91	123.69	151.85	13.41	6.70	-0.1481
		Combined	<0.85	1.40	3.32	5.11	7.65	28.11	62.99	105.11	133.19	156.60	18.68	5.63	-0.2365
R20	51.9	Surface	8.09	13.96	19.66	23.08	28.11	50.31	96.59	126.62	146.64	163.32	49.90	2.54	-0.0088
		Subsurface	9.60	14.38	19.14	22.07	25.84	49.29	96.57	126.60	146.63	163.31	49.23	2.57	-0.0012
		Combined	8.54	14.10	19.49	22.76	27.38	50.03	96.59	126.61	146.63	163.32	49.68	2.55	-0.0074
R27	50.9	Surface	1.31	10.28	17.34	19.78	22.82	41.10	58.89	82.59	119.12	149.56	37.84	2.18	-0.1058
		Subsurface	<0.85	<0.85	1.70	3.20	6.37	20.97	37.97	46.98	52.99	57.99	8.94	5.26	-0.5139
		Combined	<0.85	1.70	7.24	11.56	16.15	31.43	51.70	59.00	74.30	127.15	20.67	2.85	-0.3997

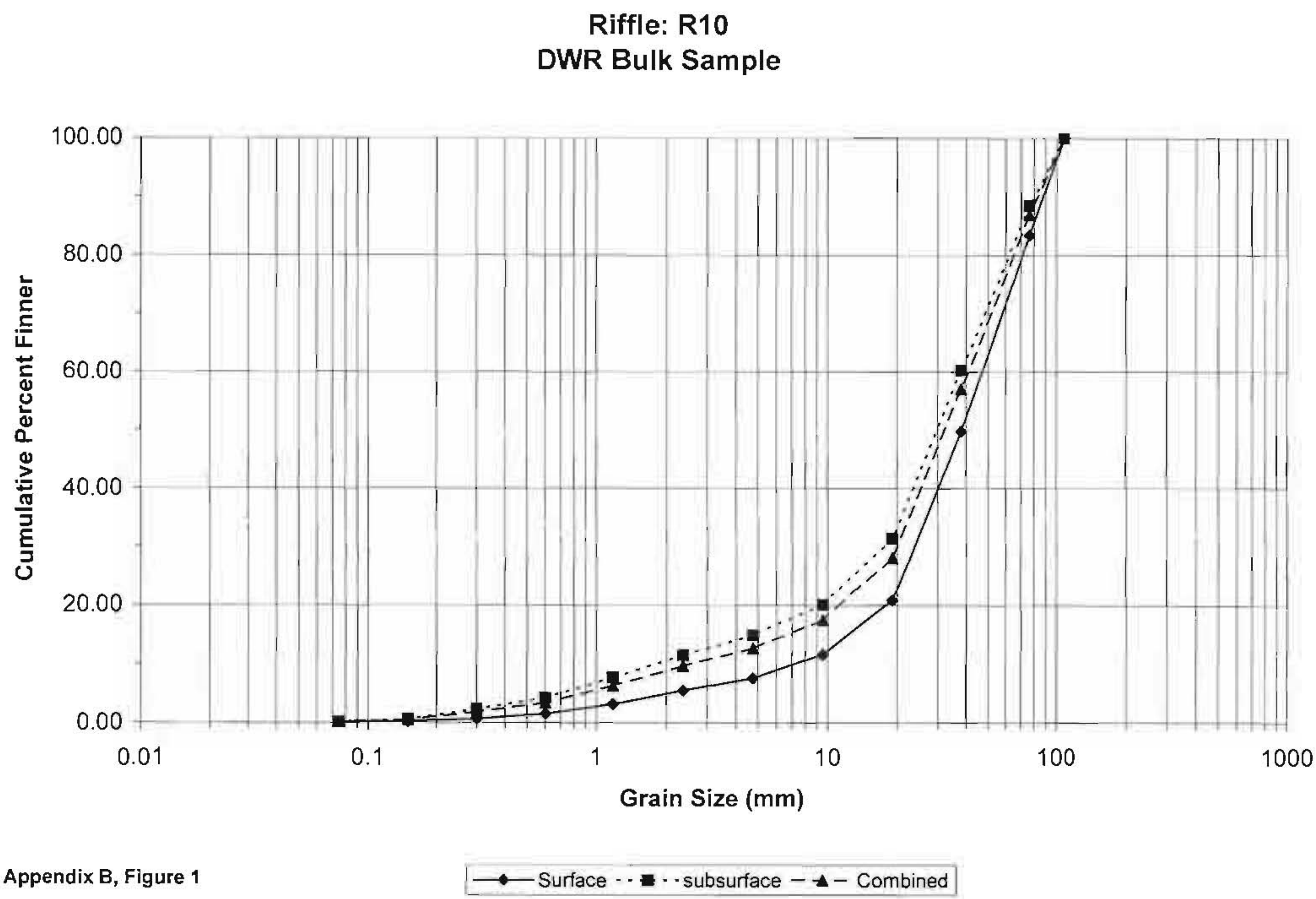
CMC Riffle #	DWR RM	Location in bed	Size (mm)												
			D5	D10	D16	D20	D25	D50	D75	D84	D90	D95	dg	sg	sk
R58	44.7	Surface	<0.85	<0.85	<0.85	1.17	2.31	12.45	24.04	29.47	38.64	50.82	--	--	--
		Subsurface	<0.85	<0.85	<0.85	<0.85	<0.85	6.50	19.63	26.10	32.67	47.83	--	--	--
		Combined	<0.85	<0.85	<0.85	<0.85	0.99	9.41	22.25	28.10	35.99	49.50	--	--	--
R59	44.2	Surface	<0.85	<0.85	<0.85	<0.85	0.88	9.22	27.55	43.93	57.28	101.28	--	--	--
		Subsurface	<0.85	<0.85	<0.85	<0.85	<0.85	7.65	24.25	35.18	45.61	54.31	--	--	--
		Combined	<0.85	<0.85	<0.85	<0.85	0.86	8.53	26.00	39.84	51.82	61.81	--	--	--

RM = river mile

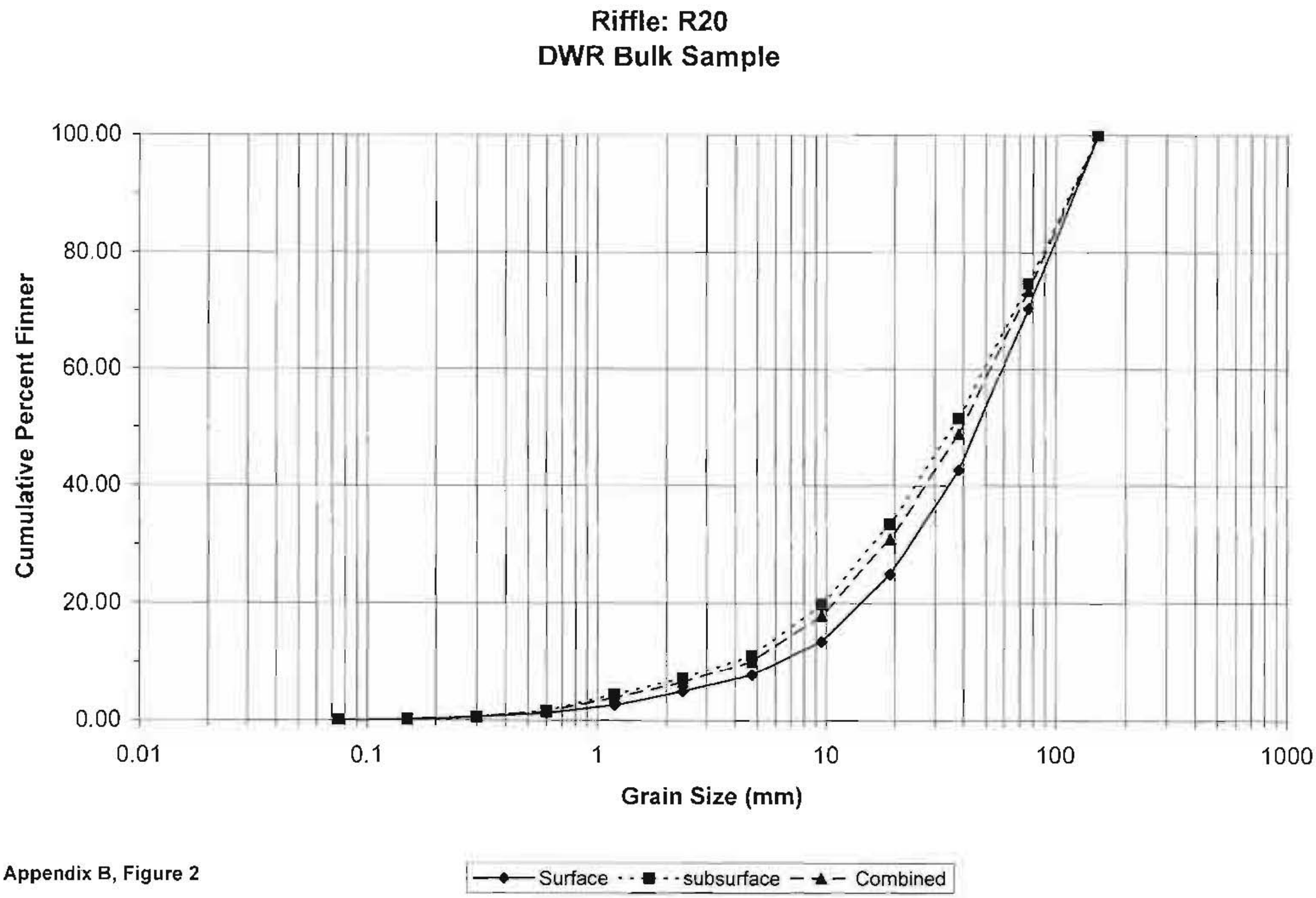
dg = $(D16*D84)^{0.5}$ (mm)

sg = $(D84/D16)^{0.5}$, dimensionless

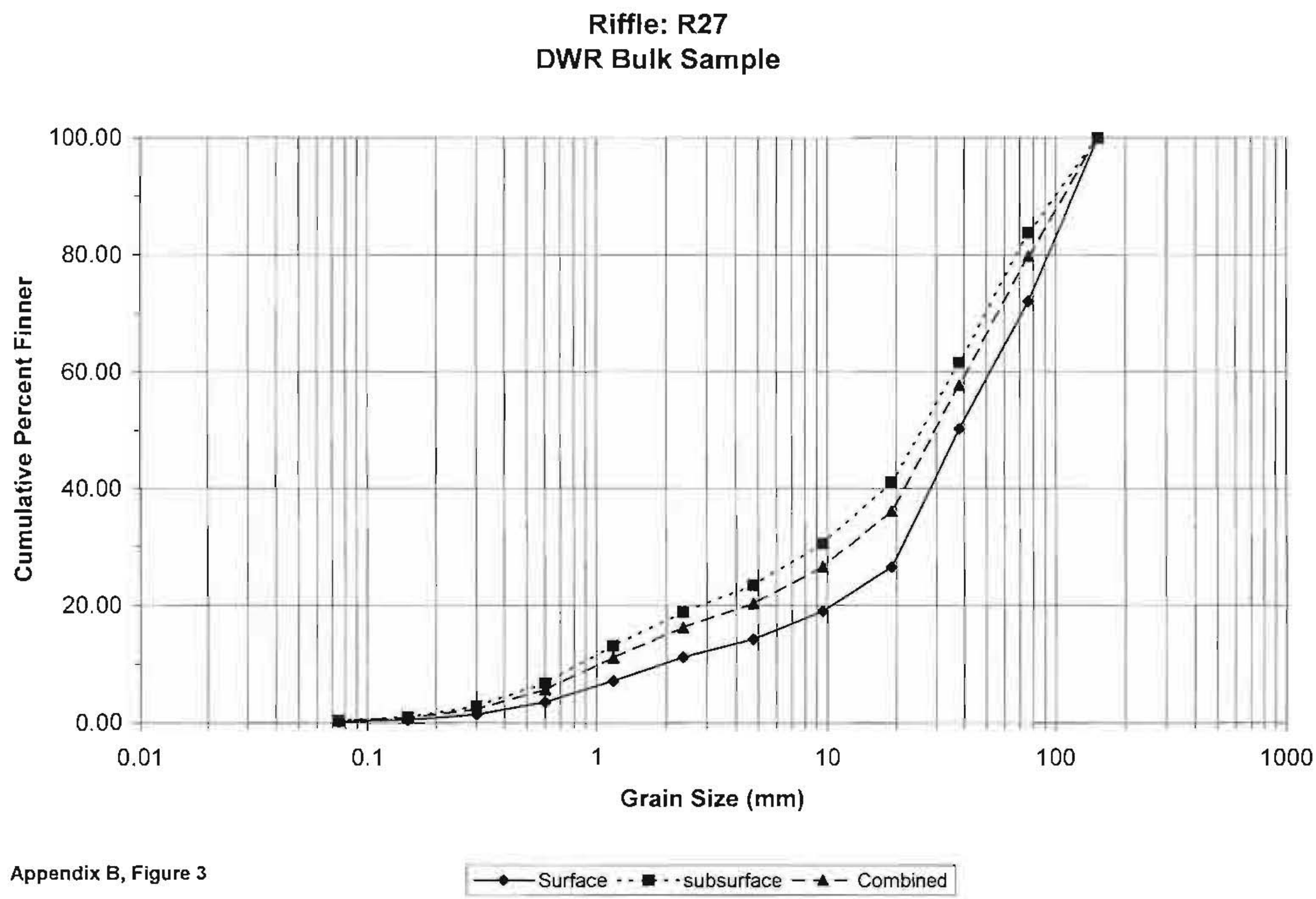
sk = log(dg/D50)/log(sg) , dimensionless



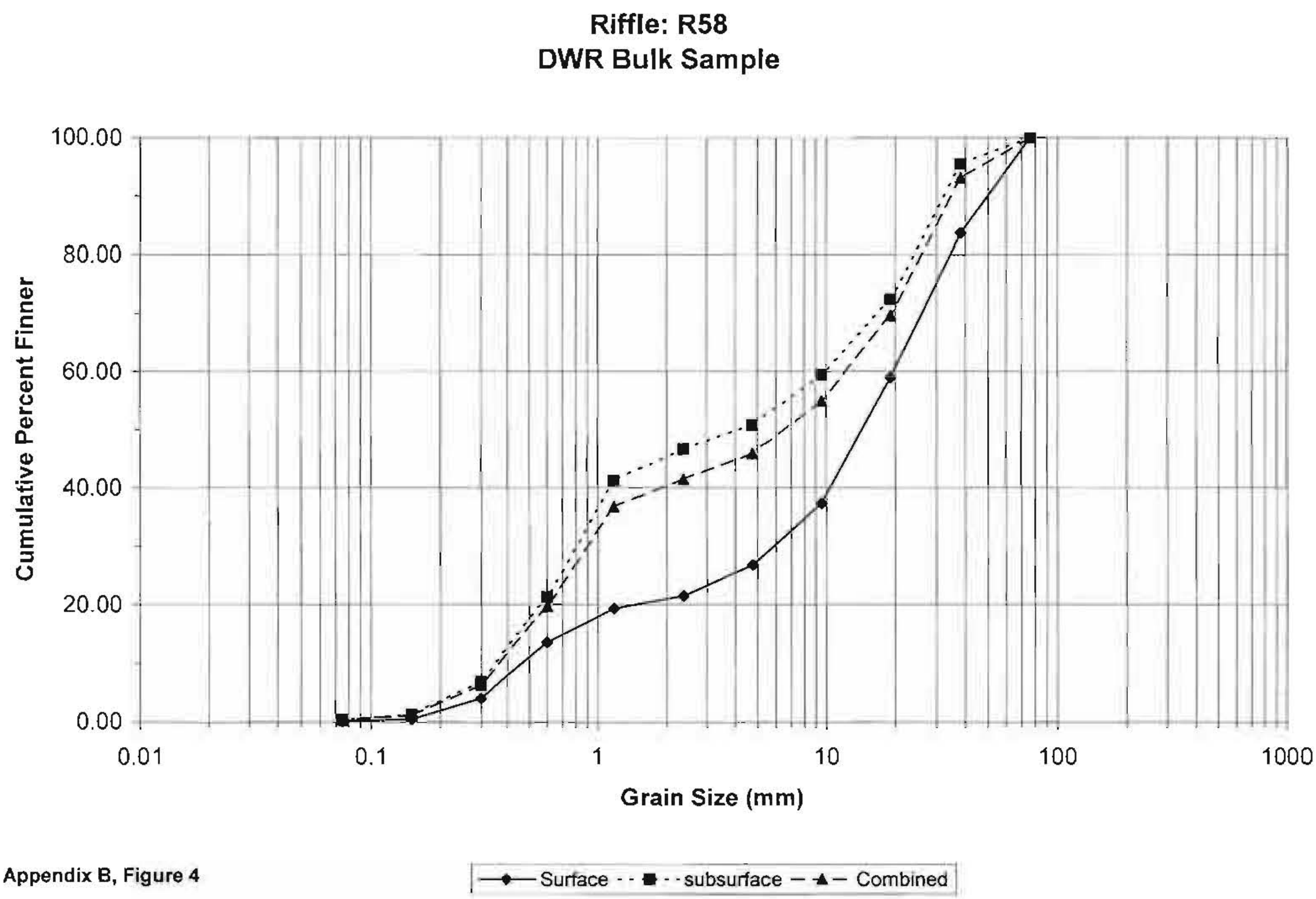
Appendix B, Figure 1



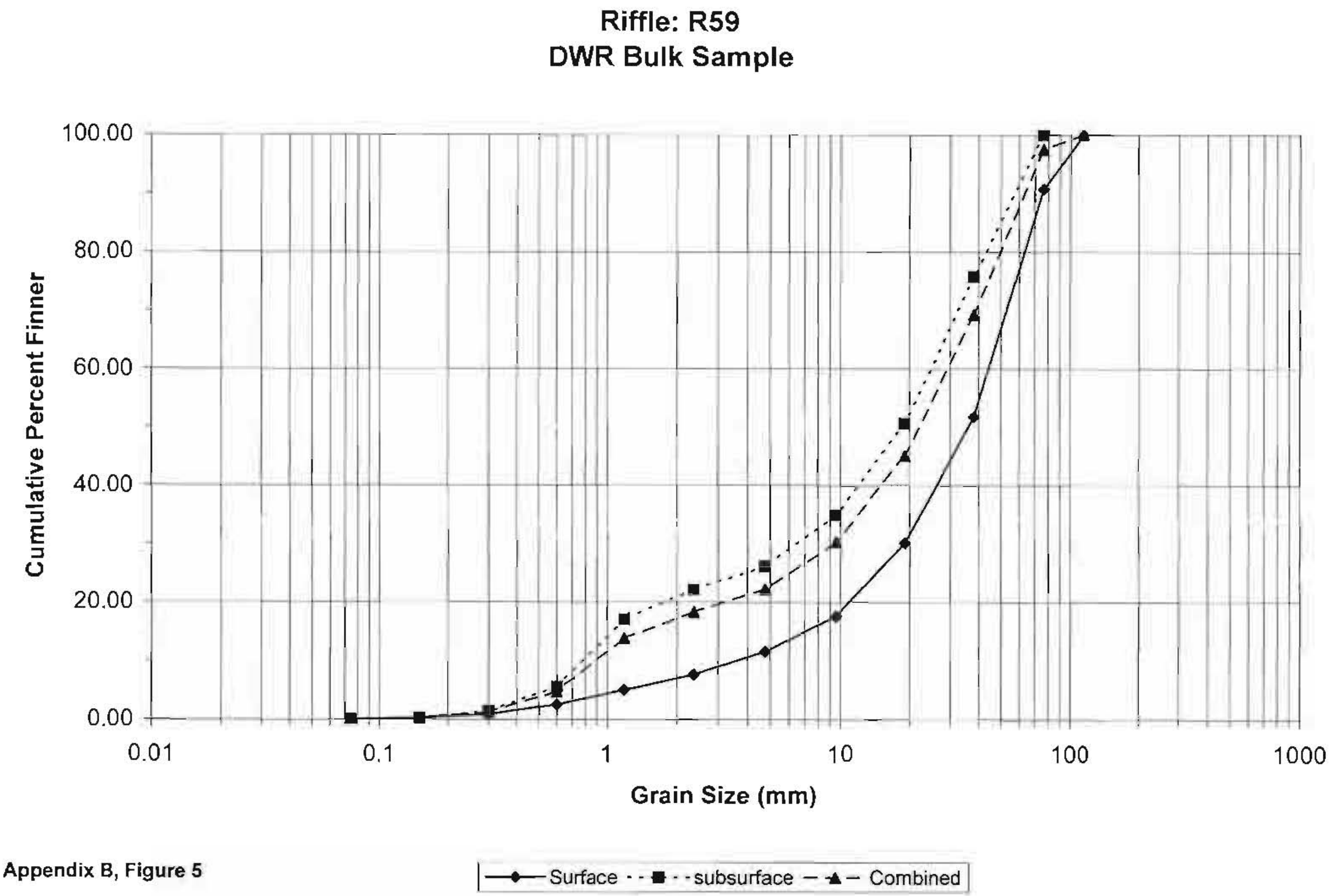
Appendix B, Figure 2



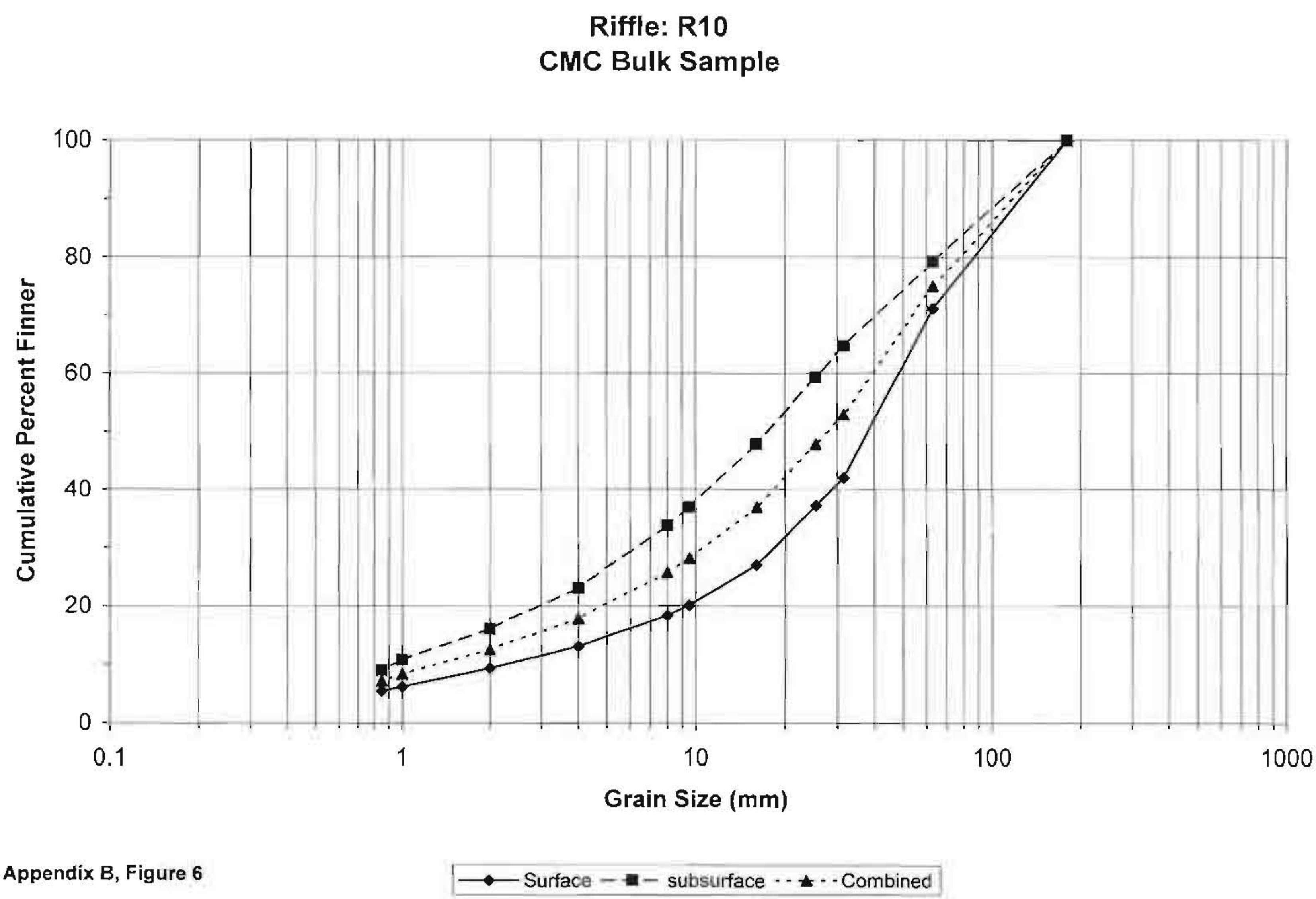
Appendix B, Figure 3



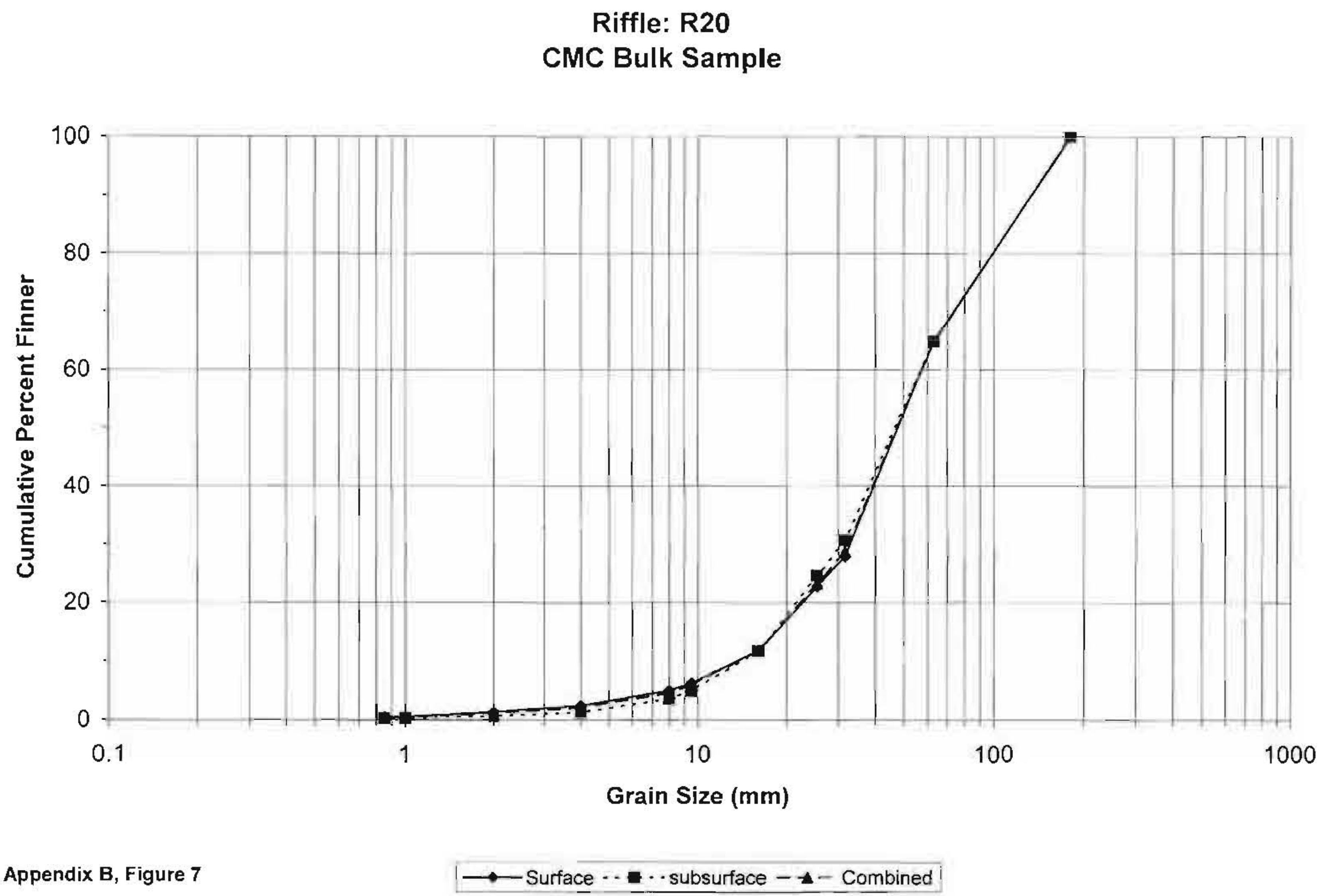
Appendix B, Figure 4



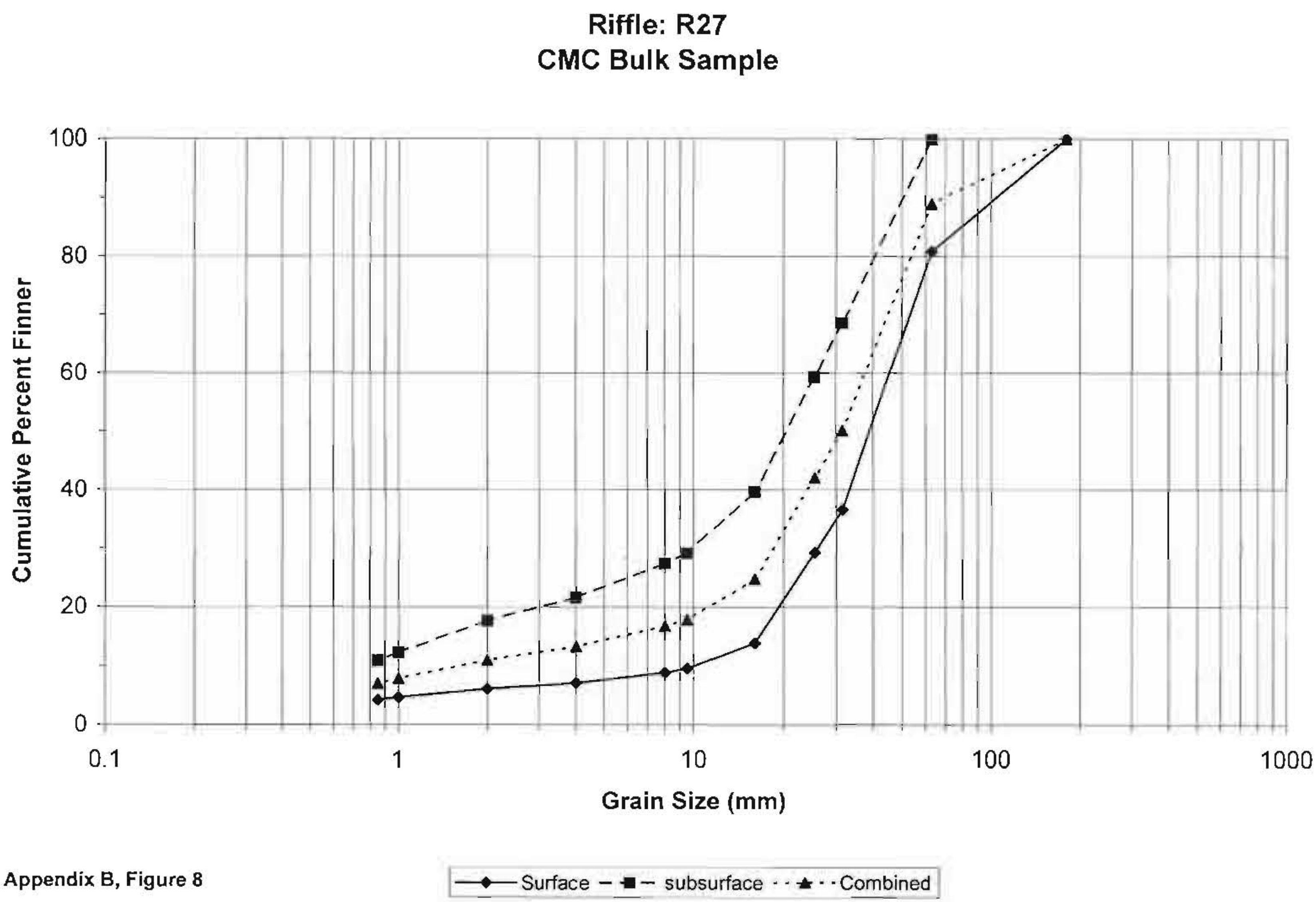
Appendix B, Figure 5



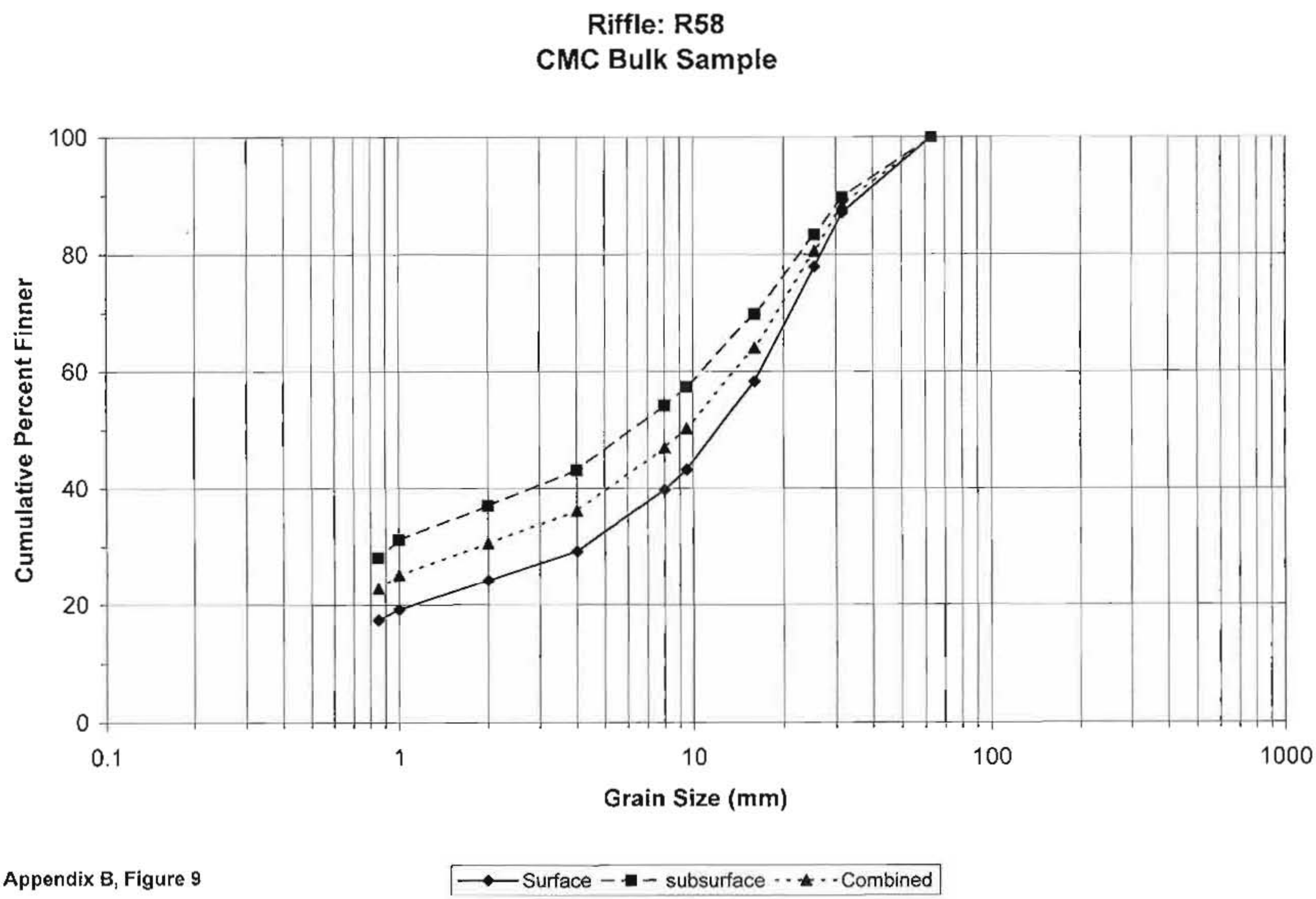
Appendix B, Figure 6



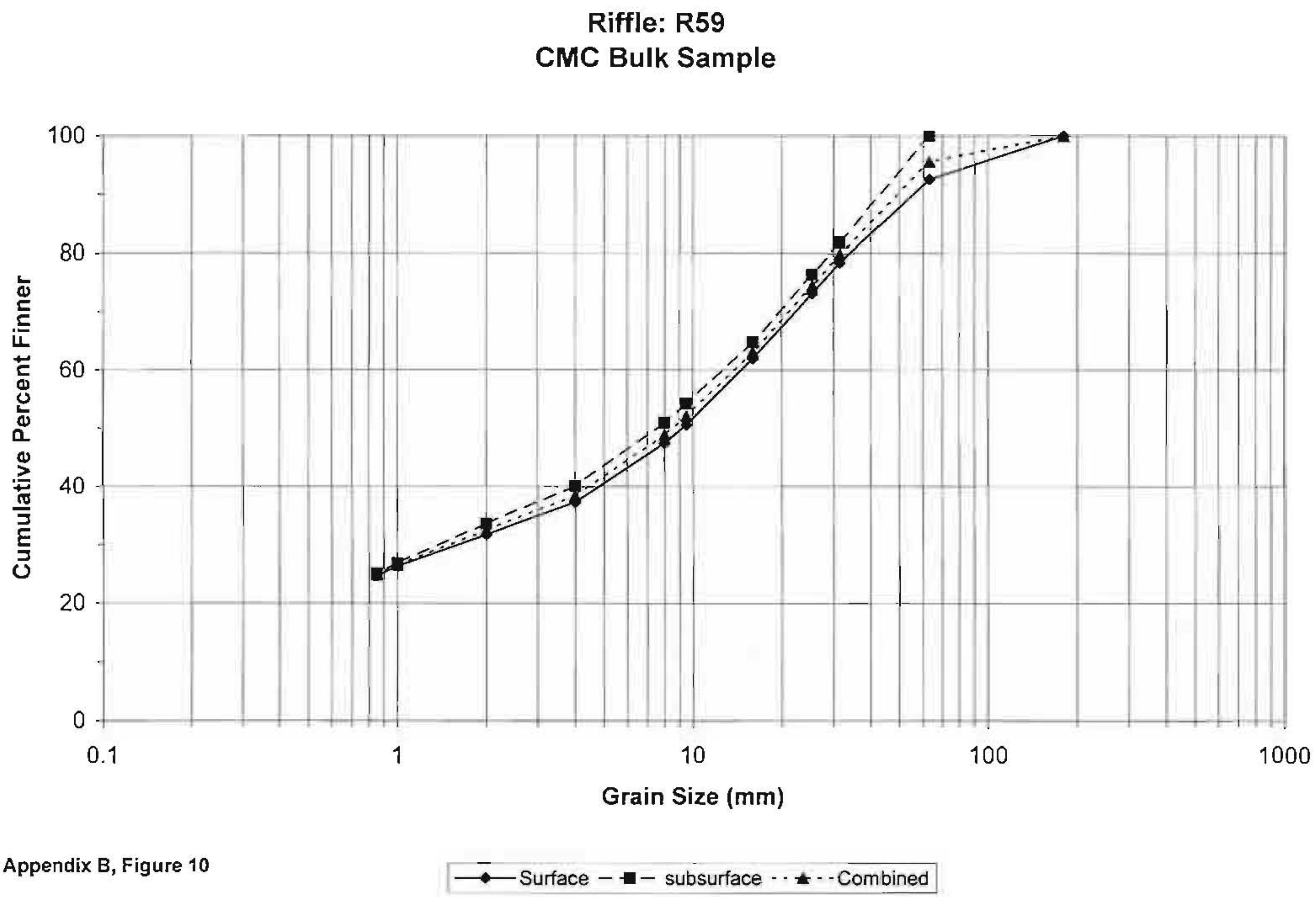
Appendix B, Figure 7



Appendix B, Figure 8



Appendix B, Figure 9



Appendix B, Figure 10

Table 7.1: Bed Mobility Calculations -- 5 Sites. The following table summarizes the flows needed to mobilize gravels at five different study sites (all nine sites studied in Appendix C) on the Lower Stanislaus River. Bed mobility thresholds are modeled using basic basic shear stress, velocity and flow equations. D_{84} mobilizing depths exceeded the cross sectional survey data for all sites except for TM1, and the D_{50} mobilizing depths exceeded survey data at R28A, thereby limiting an estimate of mobilizing flows. We recommend more extensive surveys to address this problem *(Data Source: Mesick, Nov. 1998 surveys)*.

I. A&B. SHIELD'S EQN for Critical Shear Stress (T_c) to mobilize gravel

Solve for depth to attain T_c *(Using slope from 1:24,000 topo map)*

ρ_w = 1000 kg/m^3

ρ_s = 2650 kg/m^3

g = 9.81 m/s^2

T^*_{ci} = 0.047

$T_{ci} = T^*_{ci}(\rho_s-\rho_w)g(d_i)$ *[I. A.]*

$R = T_d/(\rho_f g S_2)$ *[I. B.]*

II. B, C, D: Calc. area inundated at D_T, using XS plots

Avg V with Manning's Eqn

$V=1.49(R^{.67}S^{.5})/n$

Discharge Q w/ Flow Eqn

Q=VA

XS Site	Ptx size %ile	Ptx Size FIELD (mm)	Critic Shear St T_c (N/m^2)	Shear Stress T_e (N/m^2)	S_t (1:24K topo map slope)	Hydr. Rad $R=T_d/(\rho g S_2)$ (m)	assume R=D D_t (ft)	Note	Area A @D_t (ft^2)	n back calc'd	V back-calc (ft/s)	Q Q=VA (w/ map n) (cfs)	Estim. Return Period Pre NM Dam (FFA)	Estim. Return Period Post NM Dam (FFA)
TM1	50	*35.00*	26.63	26.63	0.004444	0.61	2.00		145	0.077	2.05	297	~1	<1
	84	*100.00*	76.08	76.08	0.004444	1.74	5.72		580	0.077	4.12	2,389	~1.2	~1.65
R1	50	40.20	30.58	30.58	0.001176	2.65	8.69		1060	0.035	6.17	6,544	~1.6	10+
	84	70.00	53.25	53.25	0.001176	4.61	*15.13*	*	--	*0.035*	*8.94*	--	--	--
R5	50	36.10	27.46	27.46	0.001176	2.38	7.81		898	0.028	7.24	6,502	~1.6	10+
	84	85.40	64.97	64.97	0.001176	5.63	*18.46*	*	--	*0.028*	*12.86*	--	--	--
R28A	50	32.30	24.57	24.57	0.000952	2.63	8.63	*	--	0.034	5.62	--	--	--
	84	68.50	52.11	52.11	0.000952	5.58	*18.30*	*	--	*0.034*	*9.28*	--	--	--
R78	50	28.90	21.99	21.99	0.000714	3.14	10.29		1065	0.035	5.40	5,749	~1.5	8+
	84	57.30	43.59	43.59	0.000714	6.22	*20.41*	*	--	*0.035*	*8.52*	--	--	--

II. A. FLOW AND MANNINGS EQNS (to back-calculate n) $Q= VA$, $V=1.49(R^{.67}S^{.5})/n$

XS Site	[1] Q (cfs)	[2] A (ft2)	[3] WP (ft)	[1]/[2] V (ft/s) V=Q/A	[2]/[3] R (ft) R=A/WP	Slope S_t (topo)	n (map)
		Nov 98 survey data					
TM1	1800	557	140	3.23	3.98	0.00444	0.077
R1	1800	486	120	3.70	4.04	0.00118	0.035
R5	1800	533	214	3.38	2.49	0.00118	0.028
R28A	1800	536	135	3.36	3.98	0.00095	0.034
R78	1800	543	110	3.31	4.95	0.00071	0.035

(shaded) calculated value

Notes:

** Indicates XS's where estimated mobilizing depths exceed bankfull conditions, so no discharge could be calculated*

D_{50} and D_{84} particle size from pebble counts (Falzone, summer 2000) except at TM1, where restoration gravel size (Mesick, 1998) is used (in italic).

Areas in IIA computed by counting squares of plotted cross sections (Mesick, Nov. 1998), using 1800 cfs as "bankfull."

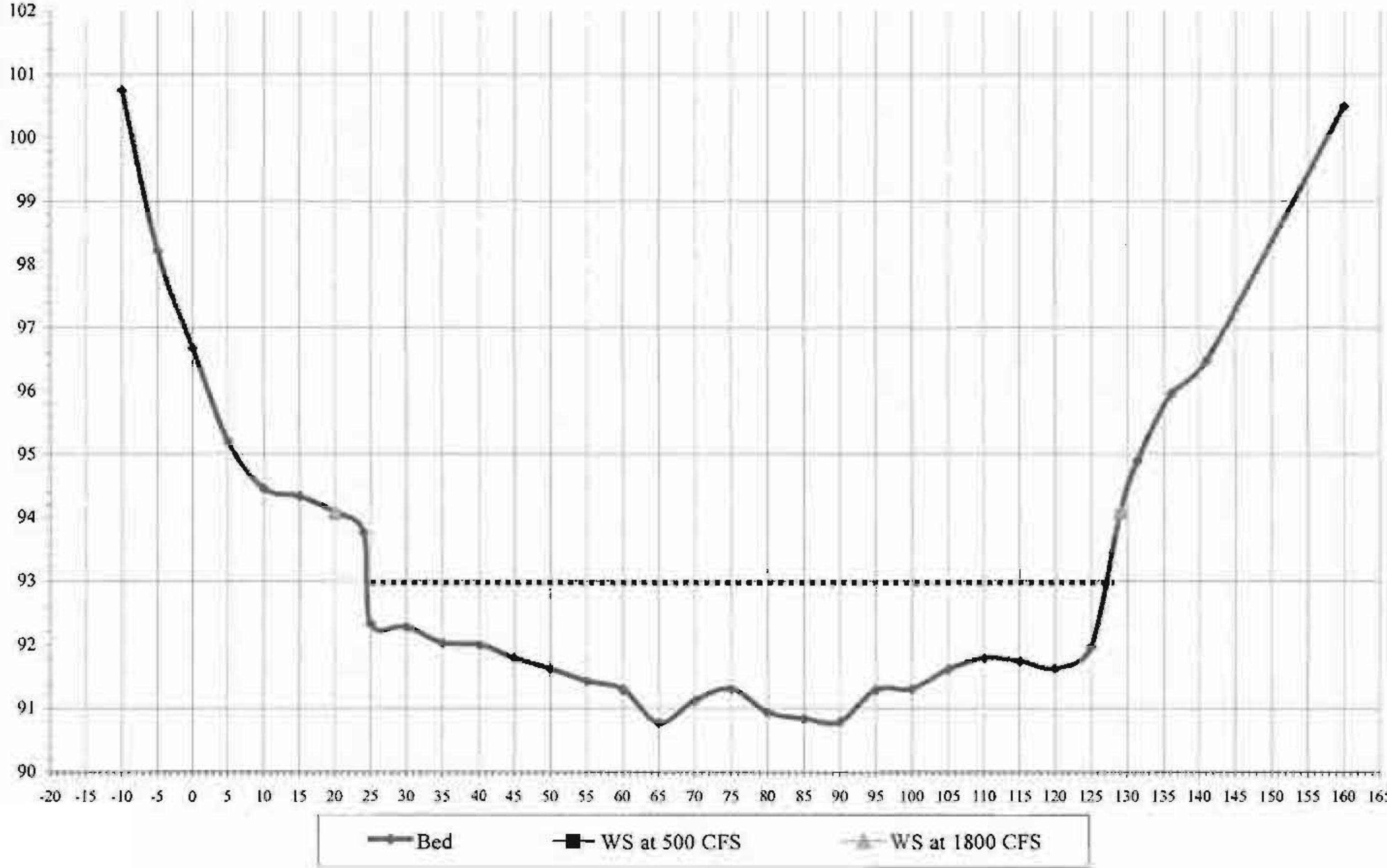
Areas in IIB computed by graphing the estimated mobilizing depth and counting squares in Mesick (Nov. 1998) surveys (attached).

Wetted perimeter determined via trigonometric calculations for each plotted cross section (Mesick, Nov. 1998).

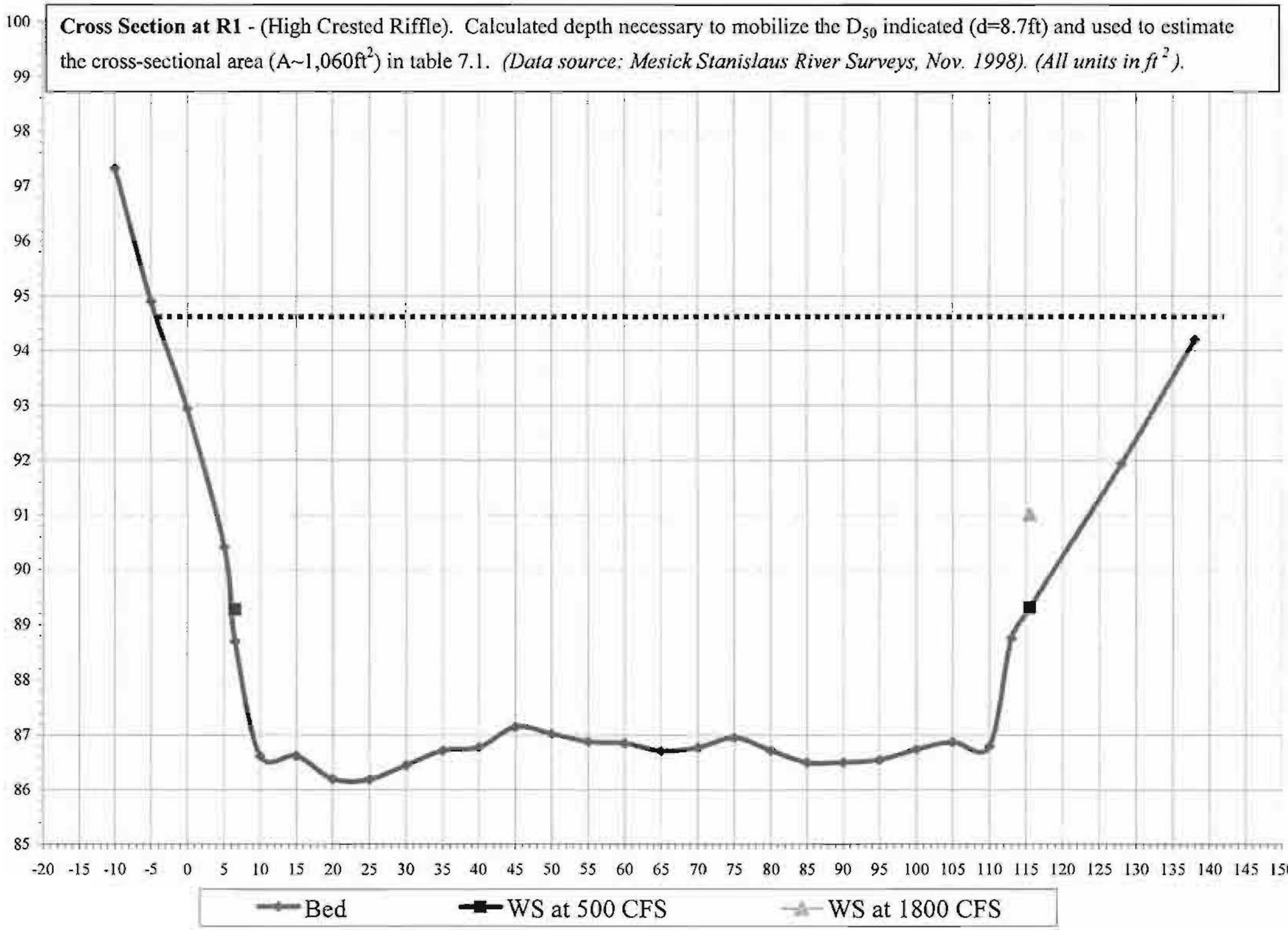
The topographic map slope is used for slope estimates, with surveys (Nov. 2000) resulting in a slope at R1 or 0.0021 and R28A or 0.000473.

Appendix 3, figure 1

Cross Section at TM1. (High Crested Riffle). Calculated depth necessary to mobilize the D_{50} indicated (d =2 ft) and used to estimate the cross-sectional area (A~145ft2) in table 7.1. *(Data source: Mesick Stanislaus River Surveys, Nov. 1998). (All units in ft^2).*



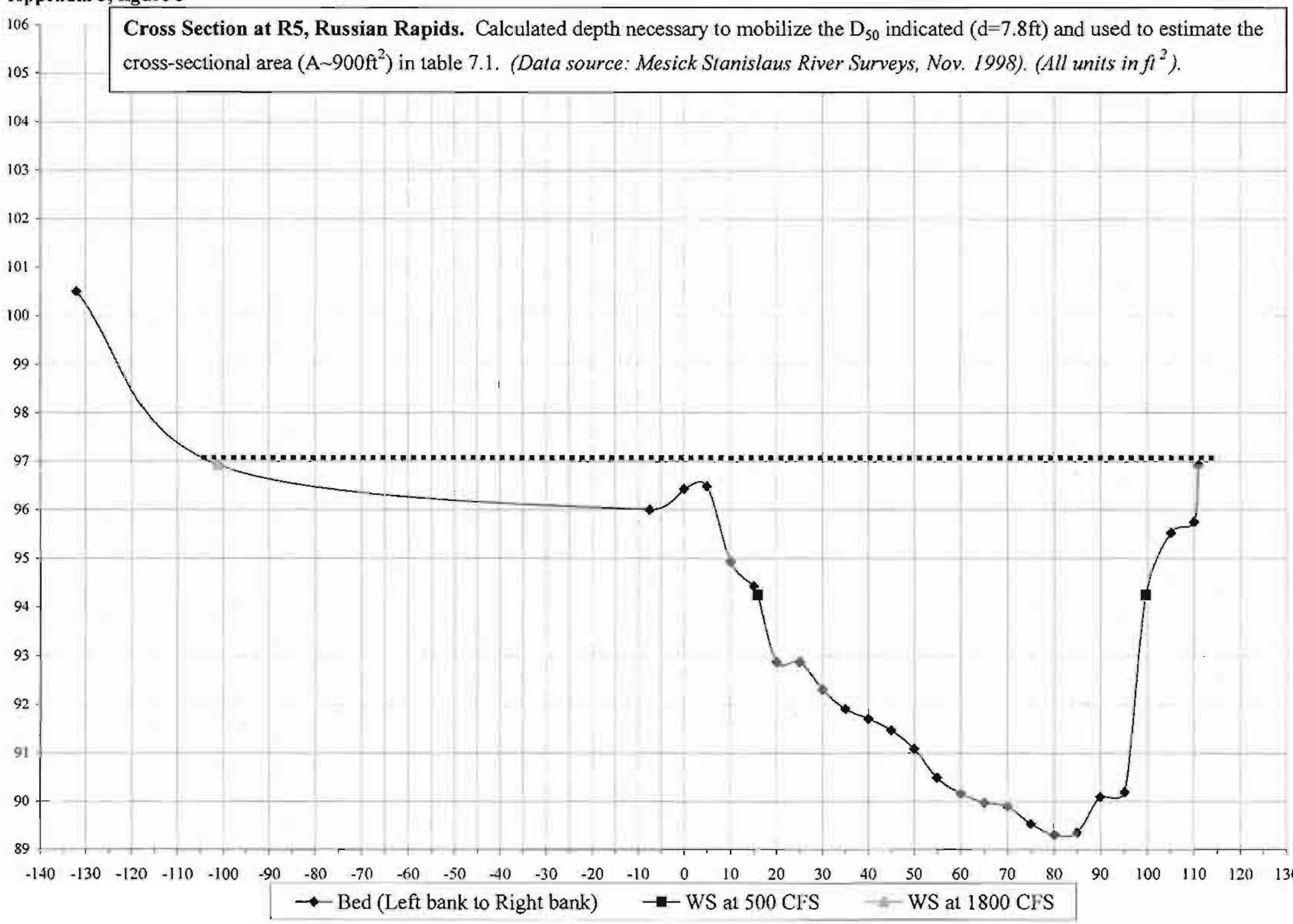
Appendix 3, figure 2



Cross Section at R1 - (High Crested Riffle). Calculated depth necessary to mobilize the D_{50} indicated (d=8.7ft) and used to estimate the cross-sectional area (A~1,060ft^2) in table 7.1. *(Data source: Mesick Stanislaus River Surveys, Nov. 1998). (All units in ft^2).*

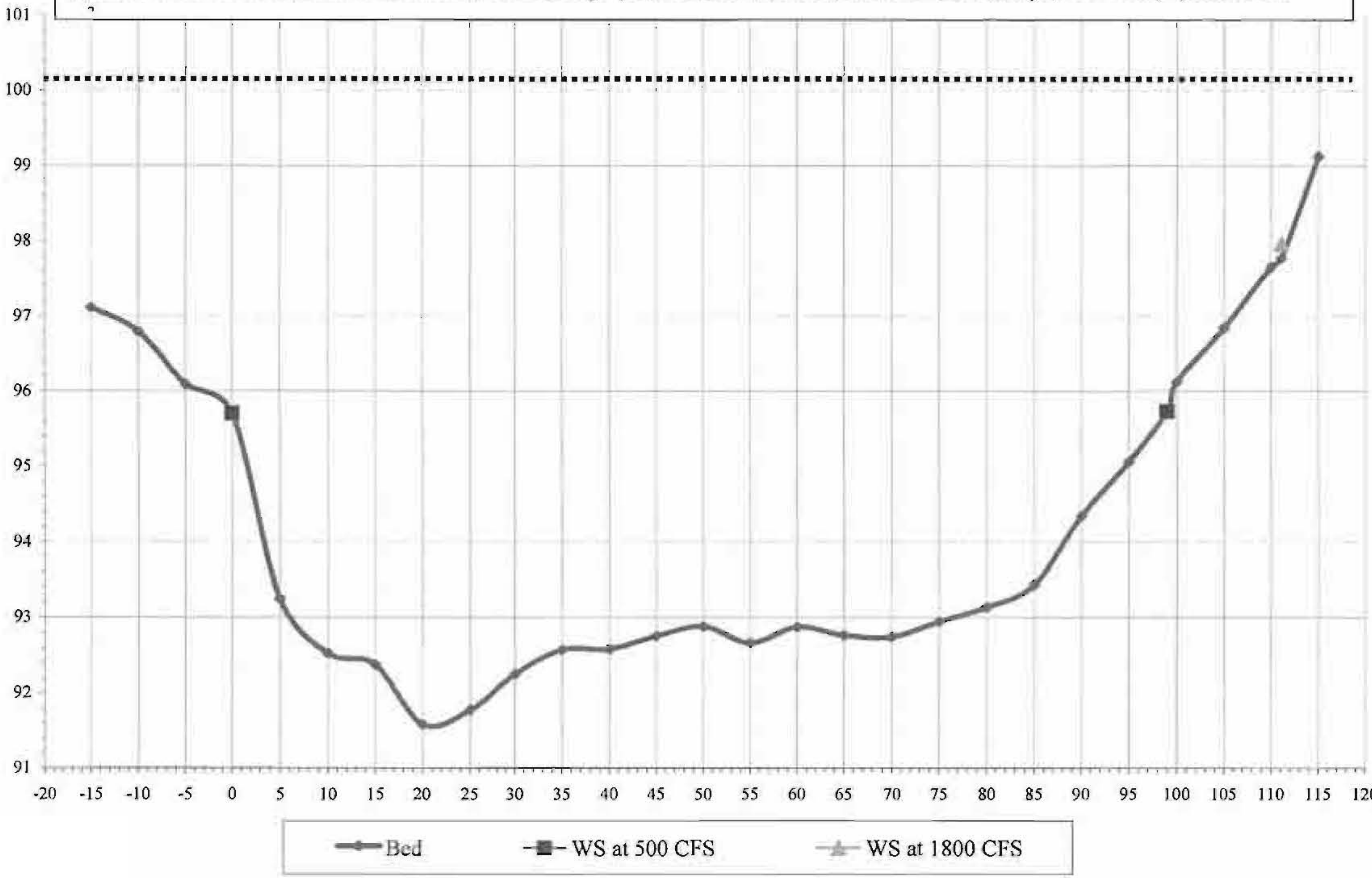
Appendix 3, figure 3

Cross Section at R5, Russian Rapids. Calculated depth necessary to mobilize the D_{50} indicated (d=7.8ft) and used to estimate the cross-sectional area (A~900ft^2) in table 7.1. *(Data source: Mesick Stanislaus River Surveys, Nov. 1998). (All units in ft^2).*



Appendix 3, figure 4

Cross Section at R28A. (High Crested Riffle). Calculated depth necessary to mobilize the D_{50} indicated (d~8.6ft) could not be used to estimate the cross-sectional area as it exceeded the survey. *(Data source: Mesick Stanislaus River Surveys, Nov. 1998). (All units in*



Appendix 3, figure 5

Cross Section at R78 - (Moderate Crested Riffle). Calculated depth necessary to mobilize the D_{50} indicated (d=10.3ft) and used to estimate the cross-sectional area (A~1,065ft^2) in table 7.1. *(Data source: Mesick Stanislaus River Surveys, Nov. 1998). (All units in ft^2).*