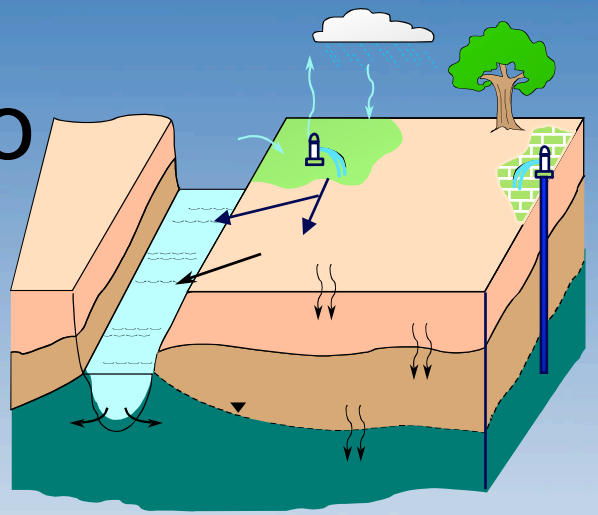
Integrated Modeling - An Analytical Tool for IRWMP Development – Application to Kings Basin



By:

Reza Namvar

Elias Tijerina

Ali Taghavi

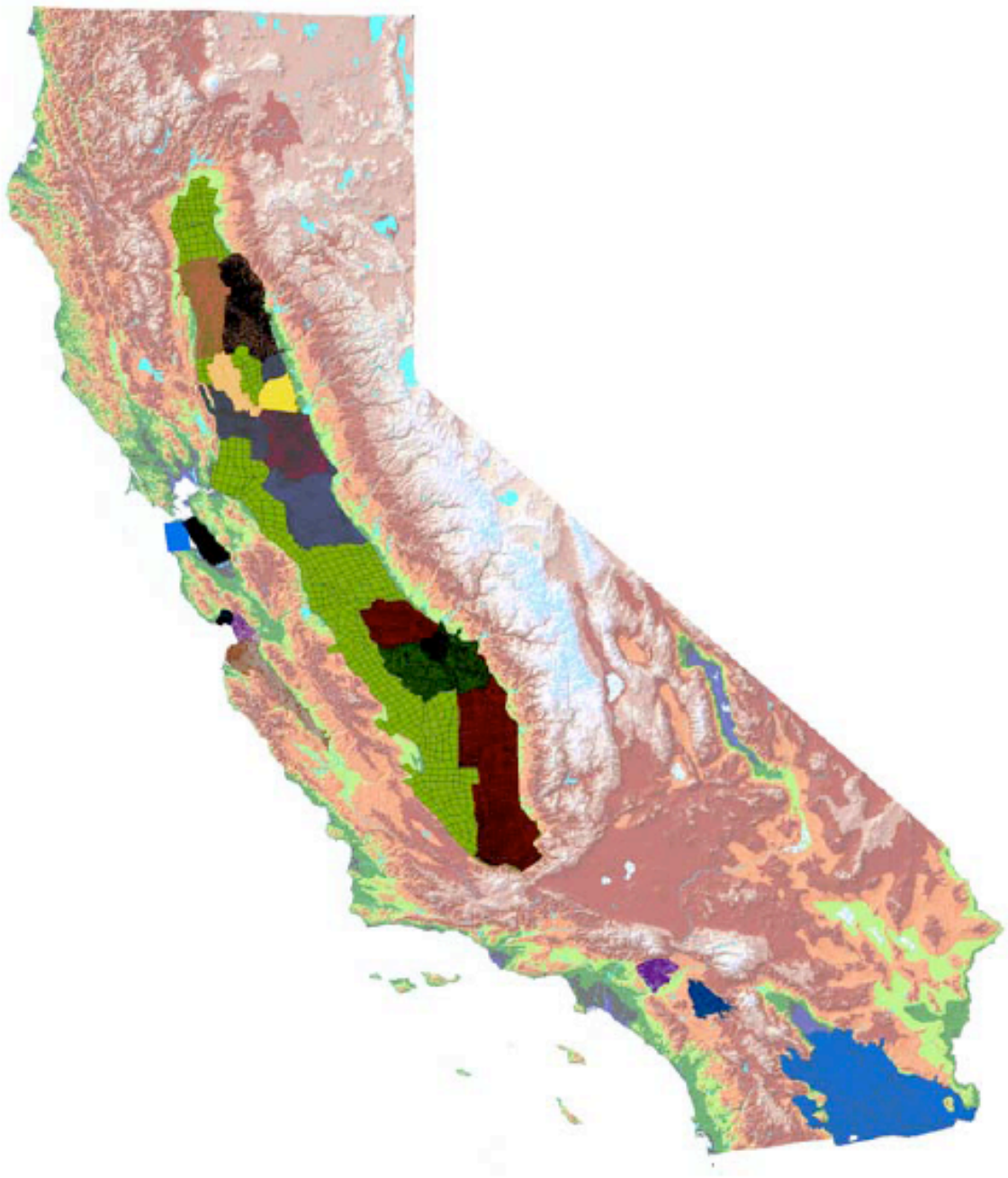
WRIME Water Resources & Information Management Engineering, Inc.

July 11, 2008

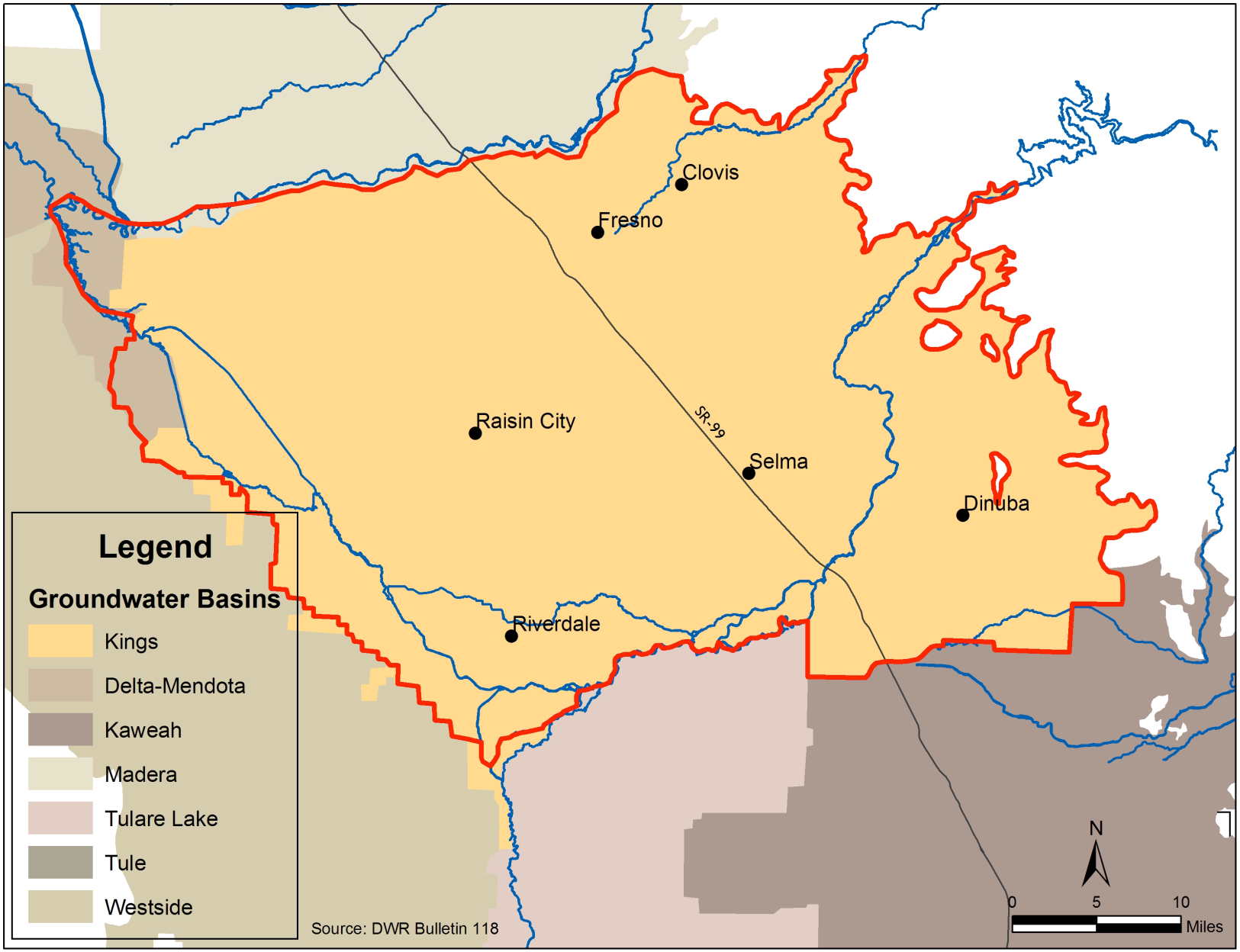
Presentation Outline

- Kings Basin
- Kings Basin IRWMP
  - Need for Analytical Tool
  - Selected Model
- Development of the Model
- Application of the Model

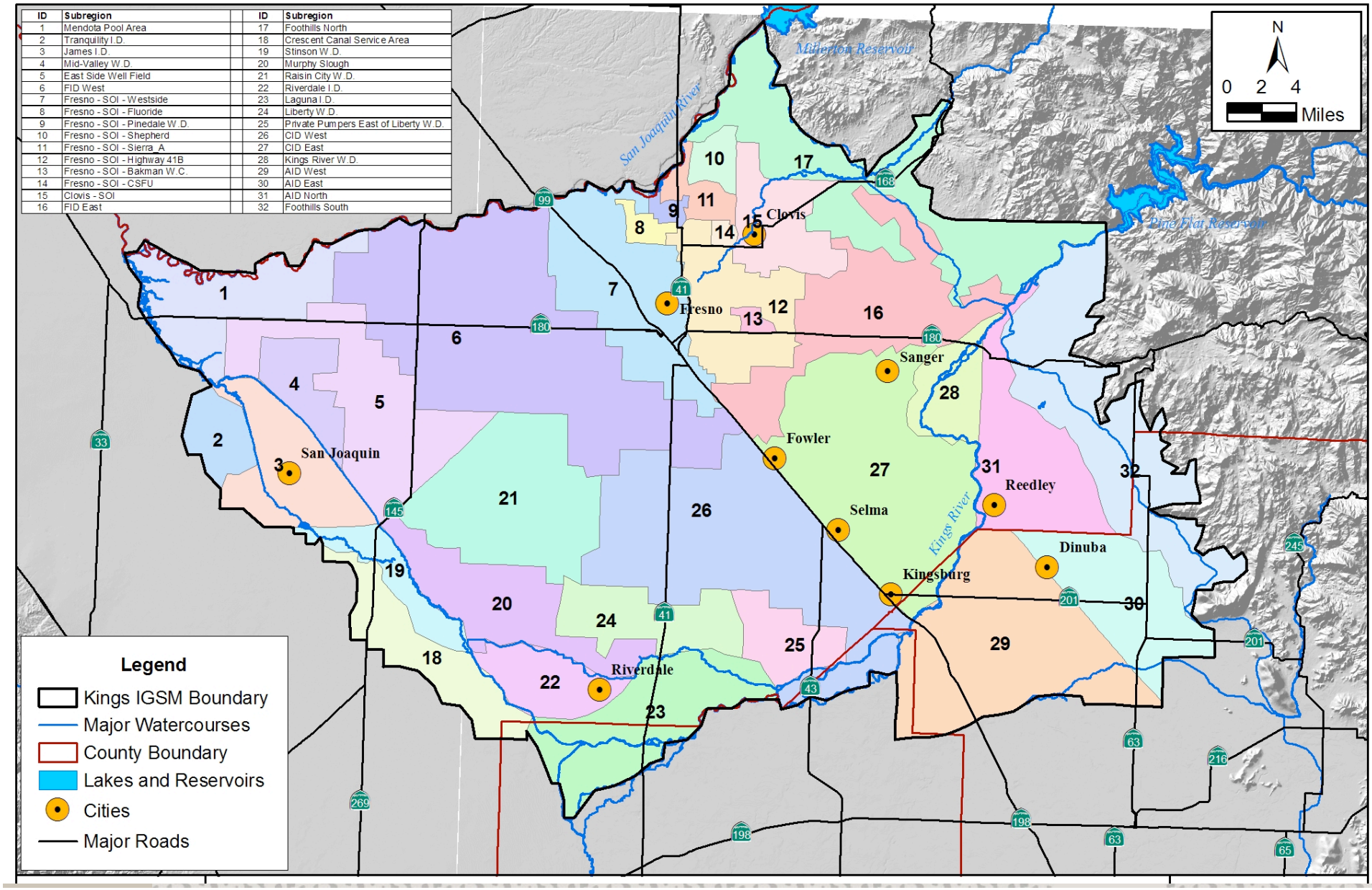
KINGS BASIN

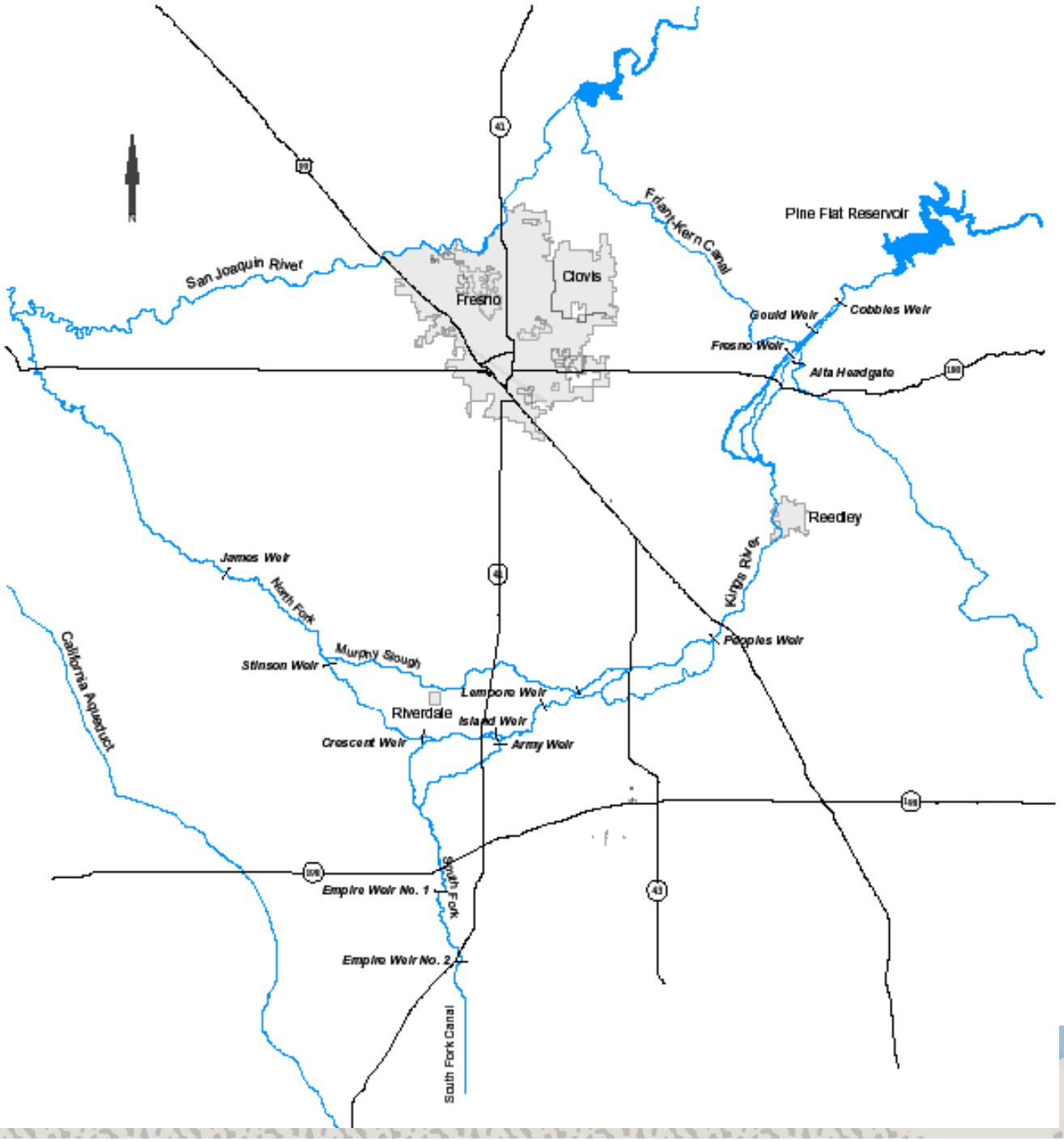


Kings Basin

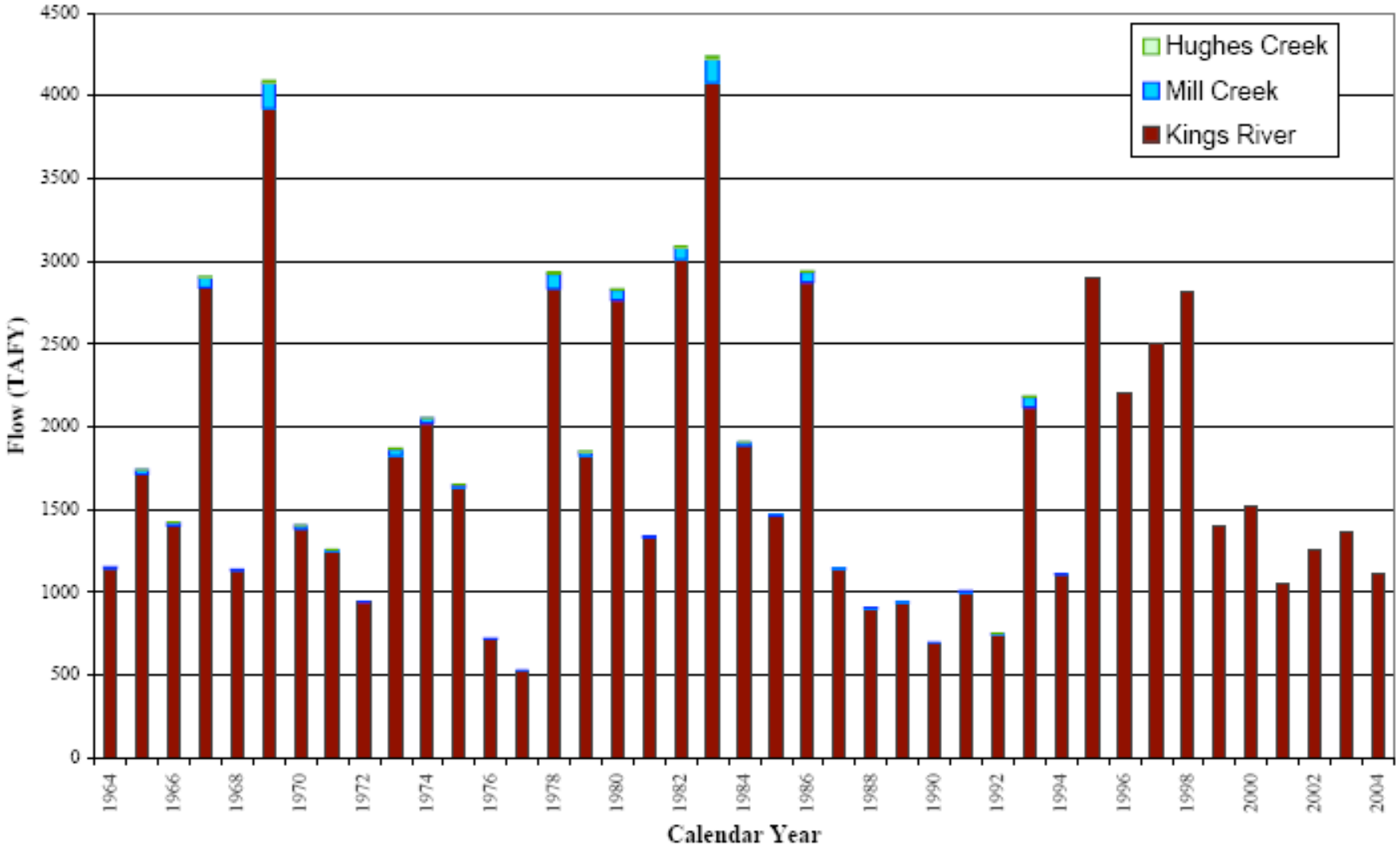

Clovis
Fresno
Raisin City
SR-99
Selma
Dinuba
Riverdale
Legend
Groundwater Basins
Kings
Delta-Mendota
Kaweah
Madera
Tulare Lake
Tule
Westside
Source: DWR Bulletin 118
N
0
5
10
Miles

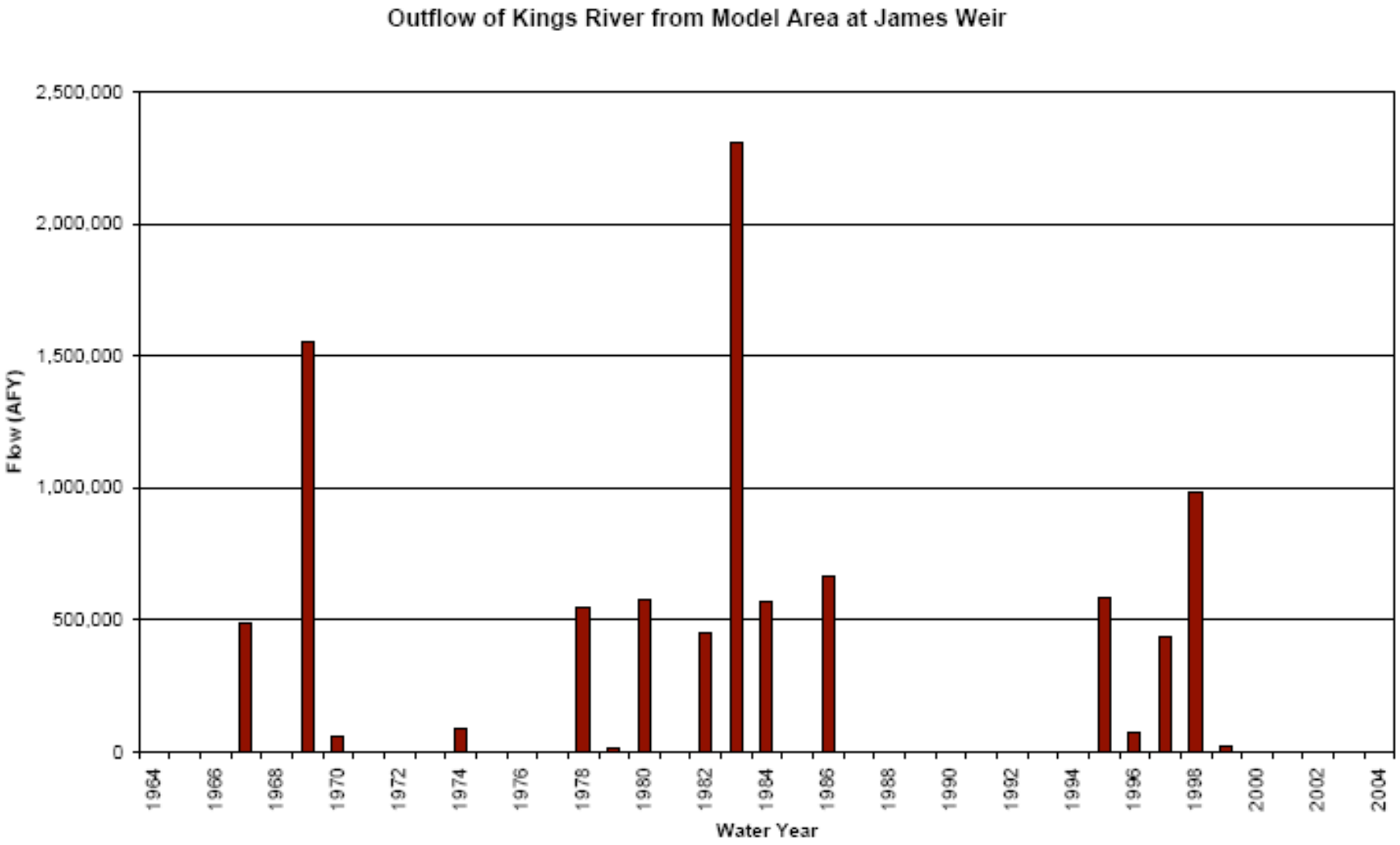
Water Agencies

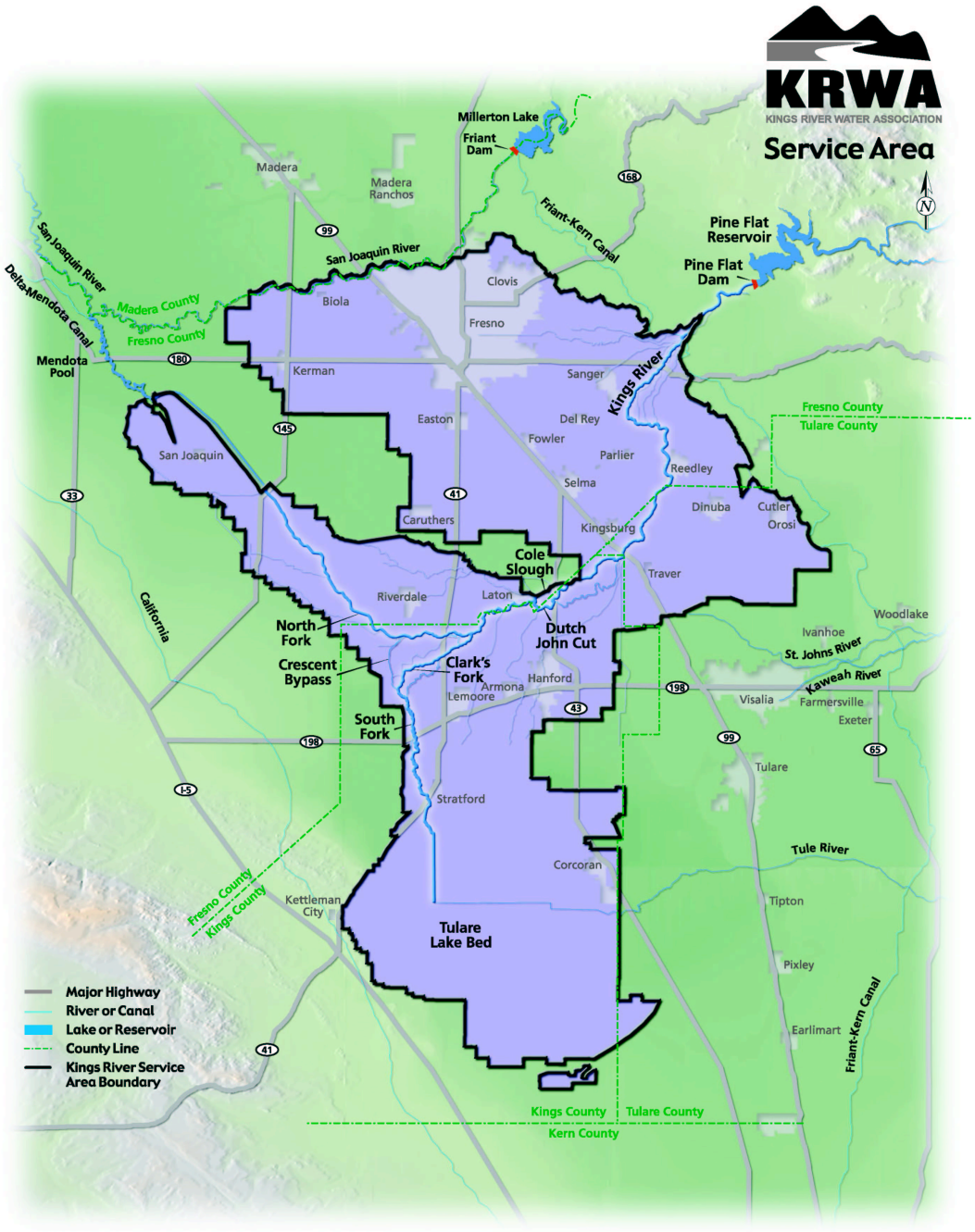


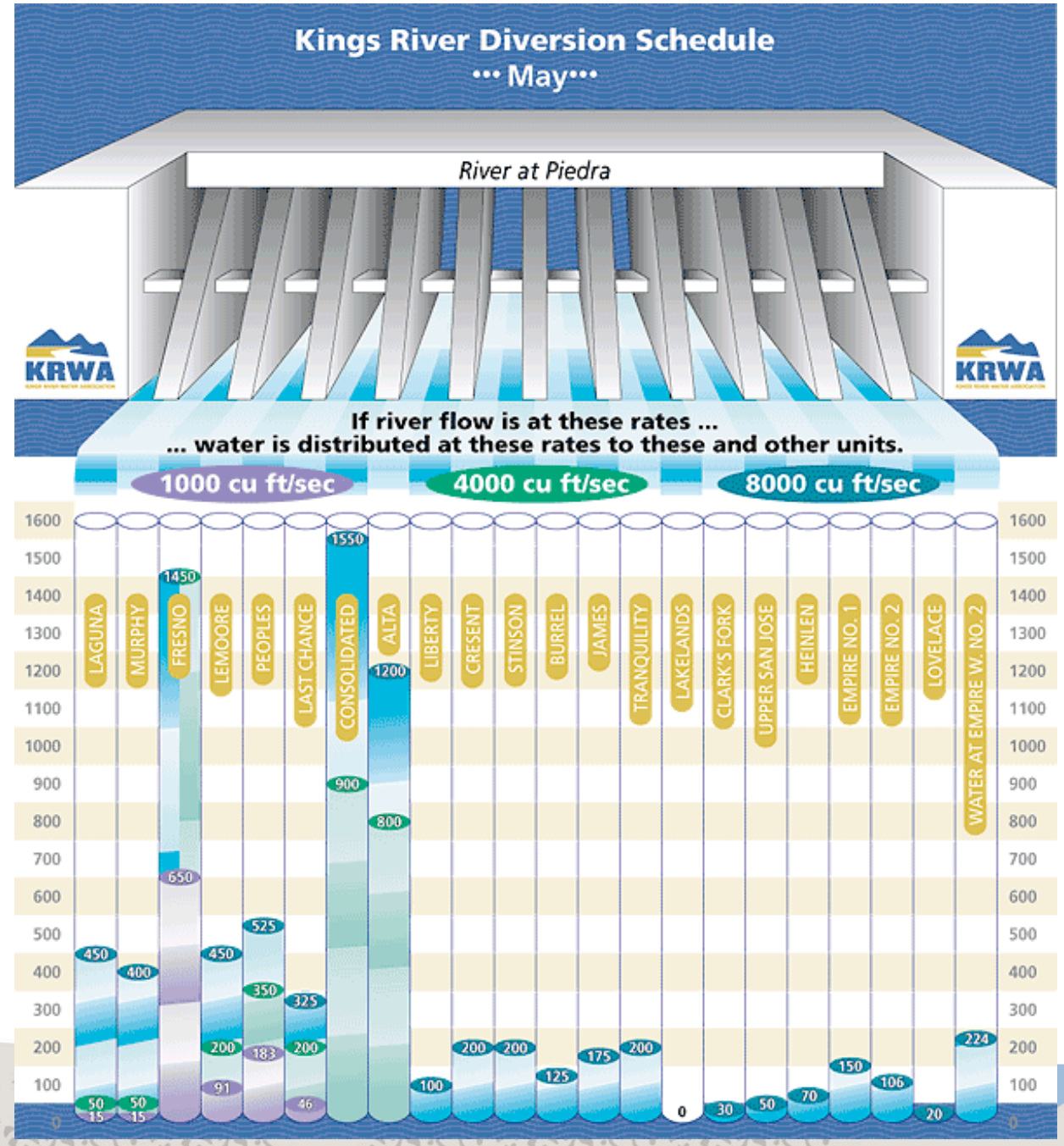

Pine Flat Reservoir
Friant-Kern Canal
San Joaquin River
Fresno
Clovis
Gould Weir
Cobbles Weir
Fresno Weir
Alta Headgate
Reedley
Kings River
James Weir
North Fork
Murphy Slough
Stinson Weir
Peoples Weir
Lemoore Weir
Riverdale
Island Weir
Crescent Weir
Army Weir
California Aqueduct
Empire Weir No. 1
South Fork
Empire Weir No. 2
South Fork Canal

Inflow of Kings River, Mill Creek, and Hughes Creek into Model Area

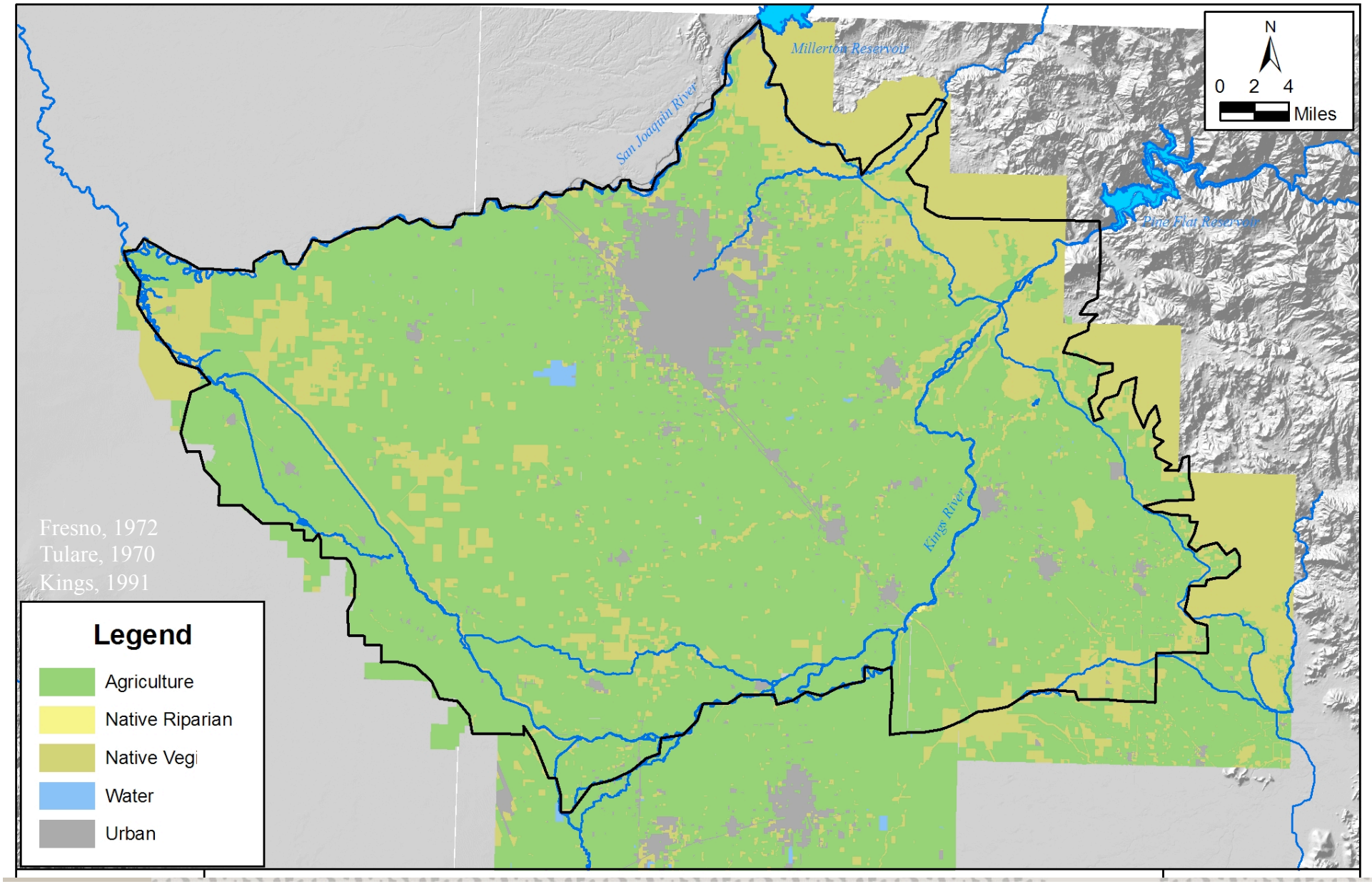



Outflow of Kings River from Model Area at James Weir
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Flow (AFY)
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Water Year

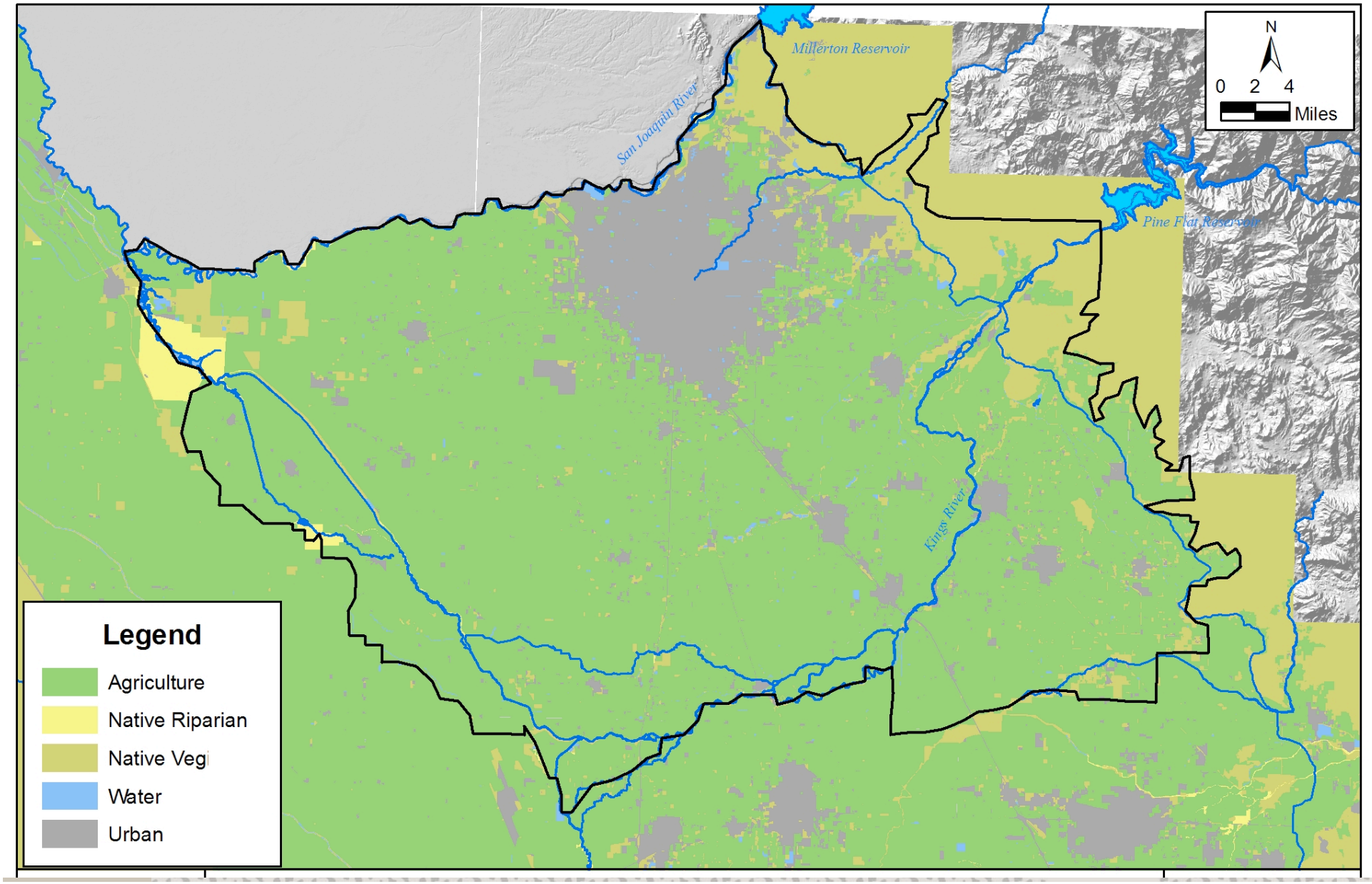

KRWA
KINGS RIVER WATER ASSOCIATION
Service Area
Millerton Lake
Friant Dam
Friant-Kern Canal
Pine Flat Reservoir
Pine Flat Dam
San Joaquin River
Delta-Mendota Canal
Madera County
Fresno County
Mendota Pool
Madera
Madera Ranchos
Biola
Clovis
Fresno
Kerman
Sanger
Kings River
Fresno County
Tulare County
Easton
Del Rey
Fowler
Parlier
Reedley
San Joaquin
Selma
Dinuba
Cutler
Orosi
Caruthers
Kingsburg
Cole Slough
Traver
Riverdale
Laton
Woodlake
Ivanhoe
St. Johns River
Kaweah River
North Fork
Dutch John Cut
Crescent Bypass
Clark's Fork
Armona
Hanford
Lemoore
Visalia
Farmersville
Exeter
South Fork
Tulare
Stratford
Tule River
Corcoran
Kettleman City
Fresno County
Kings County
Tulare Lake Bed
Tipton
Pixley
Earlimart
Friant-Kern Canal
Major Highway
River or Canal
Lake or Reservoir
County Line
Kings River Service Area Boundary
Kings County
Tulare County
Kern County
California


Kings River Diversion Schedule
••• May•••
River at Piedra
KRWA
KRWA
If river flow is at these rates ...
... water is distributed at these rates to these and other units.
1000 cu ft/sec
4000 cu ft/sec
8000 cu ft/sec
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
LAGUNA
MURPHY
FRESNO
LEMOORE
PEOPLES
LAST CHANCE
CONSOLIDATED
ALTA
LIBERTY
CRESENT
STINSON
BURREL
JAMES
TRANQUILITY
LAKELANDS
CLARK'S FORK
UPPER SAN JOSE
HEINLEN
EMPIRE NO. 1
EMPIRE NO. 2
LOVELACE
WATER AT EMPIRE W. NO. 2
450
400
1450
650
450
525
350
200
183
325
200
46
1550
900
1200
800
100
200
200
125
175
200
0
30
50
70
150
106
20
224
50
15
50
15
91

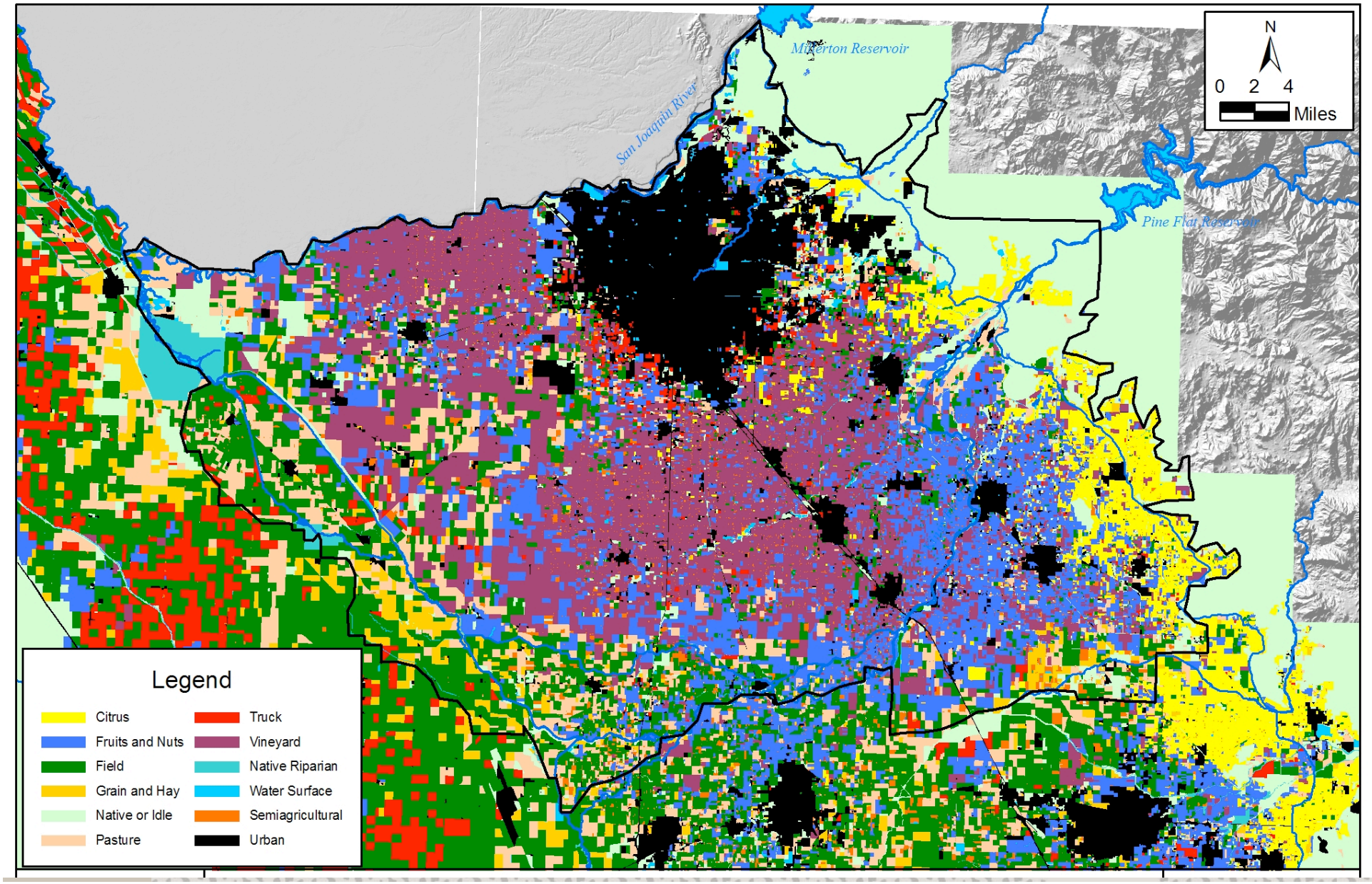
Land Use 1970



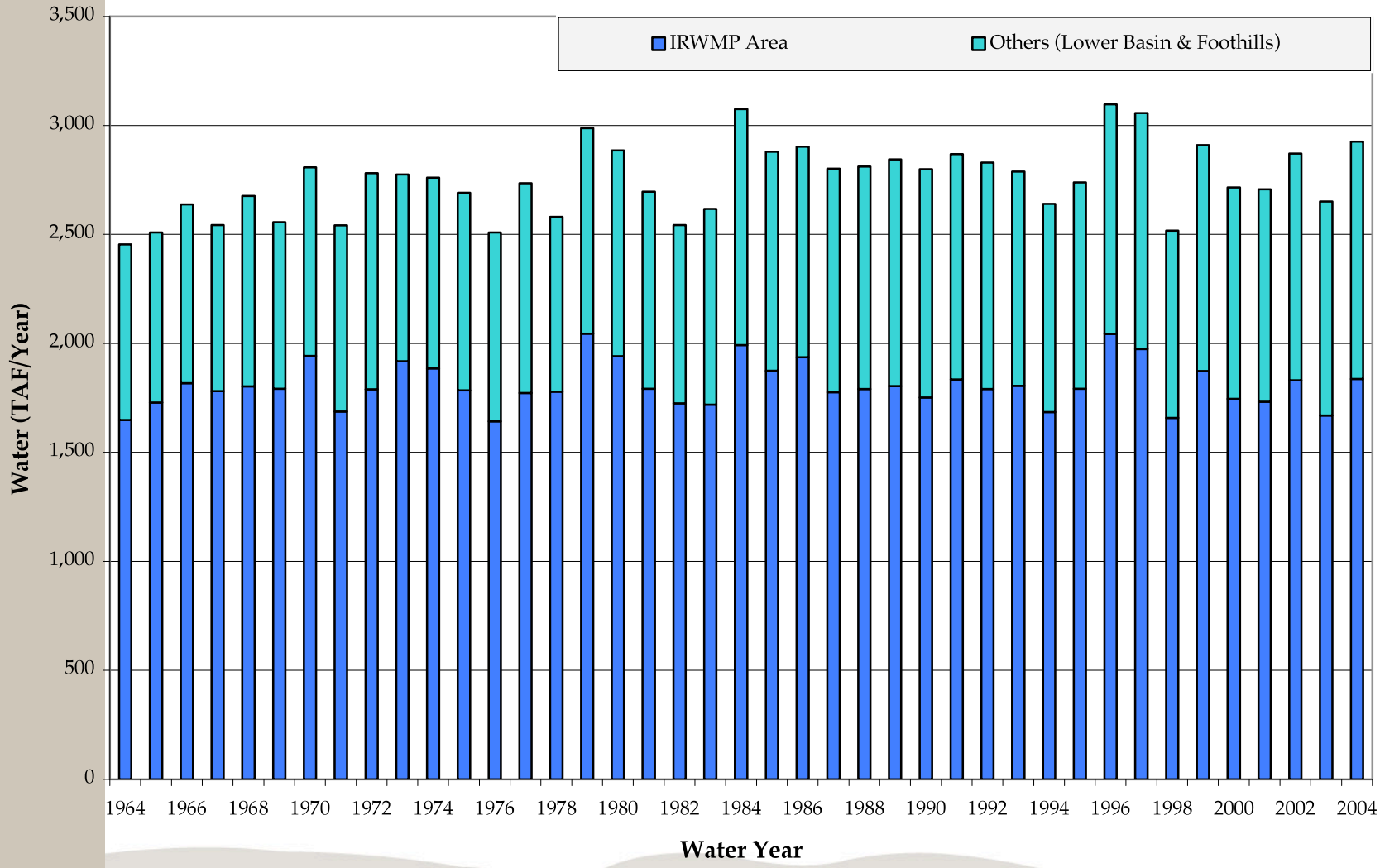
Land Use 2000



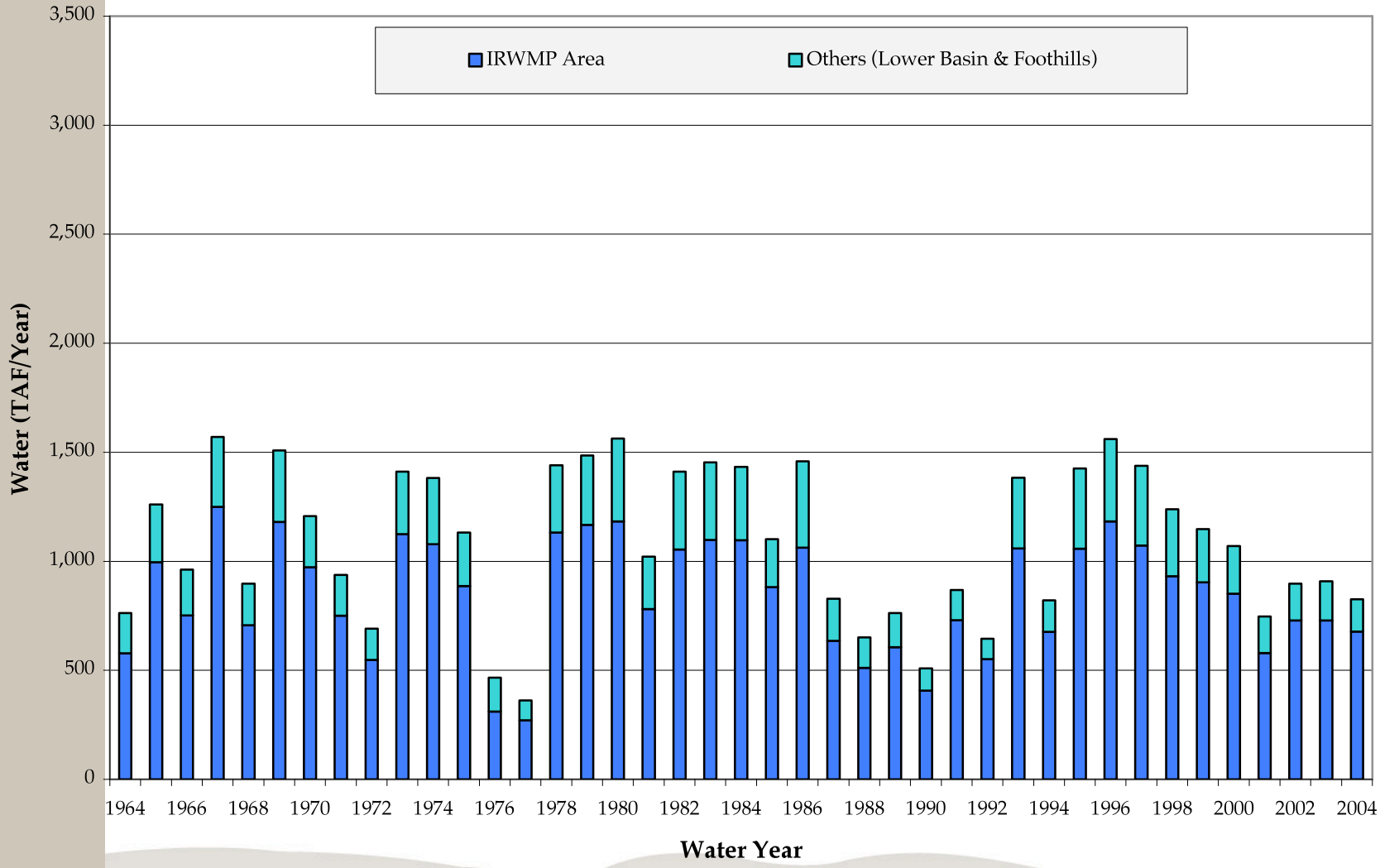
Crop Mix 2000



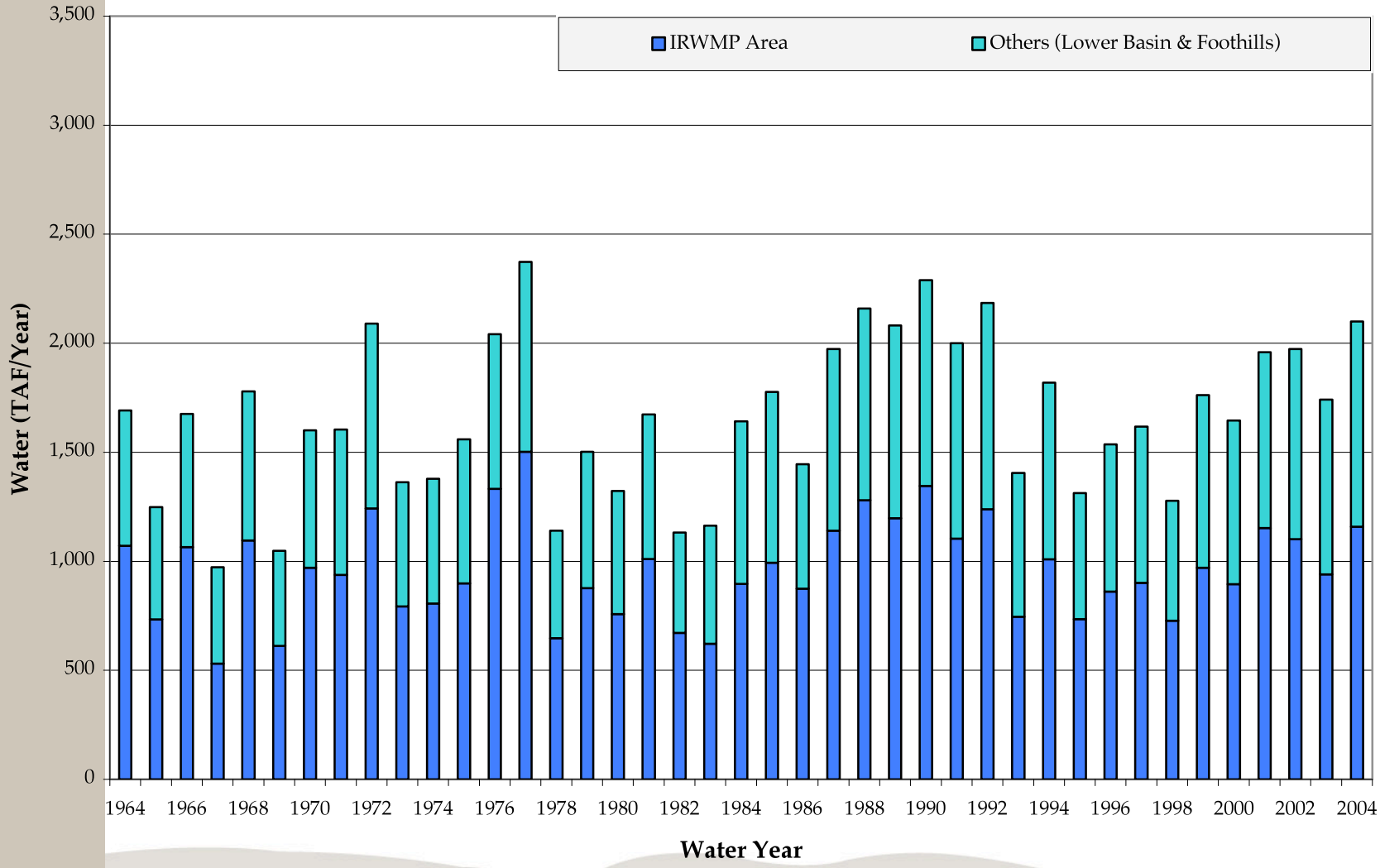
Annual Agricultural Water Use



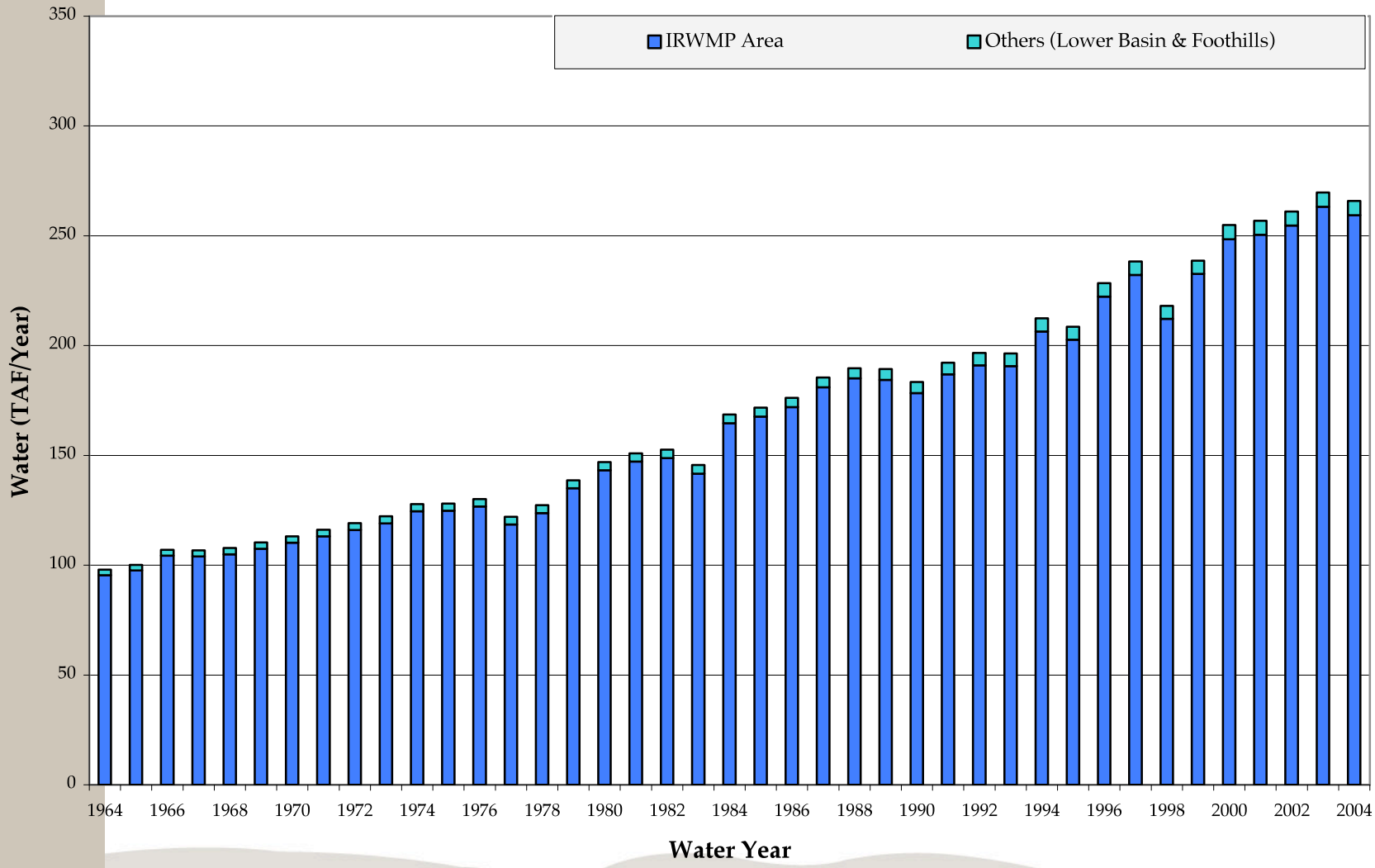
Annual Surface Water Delivery



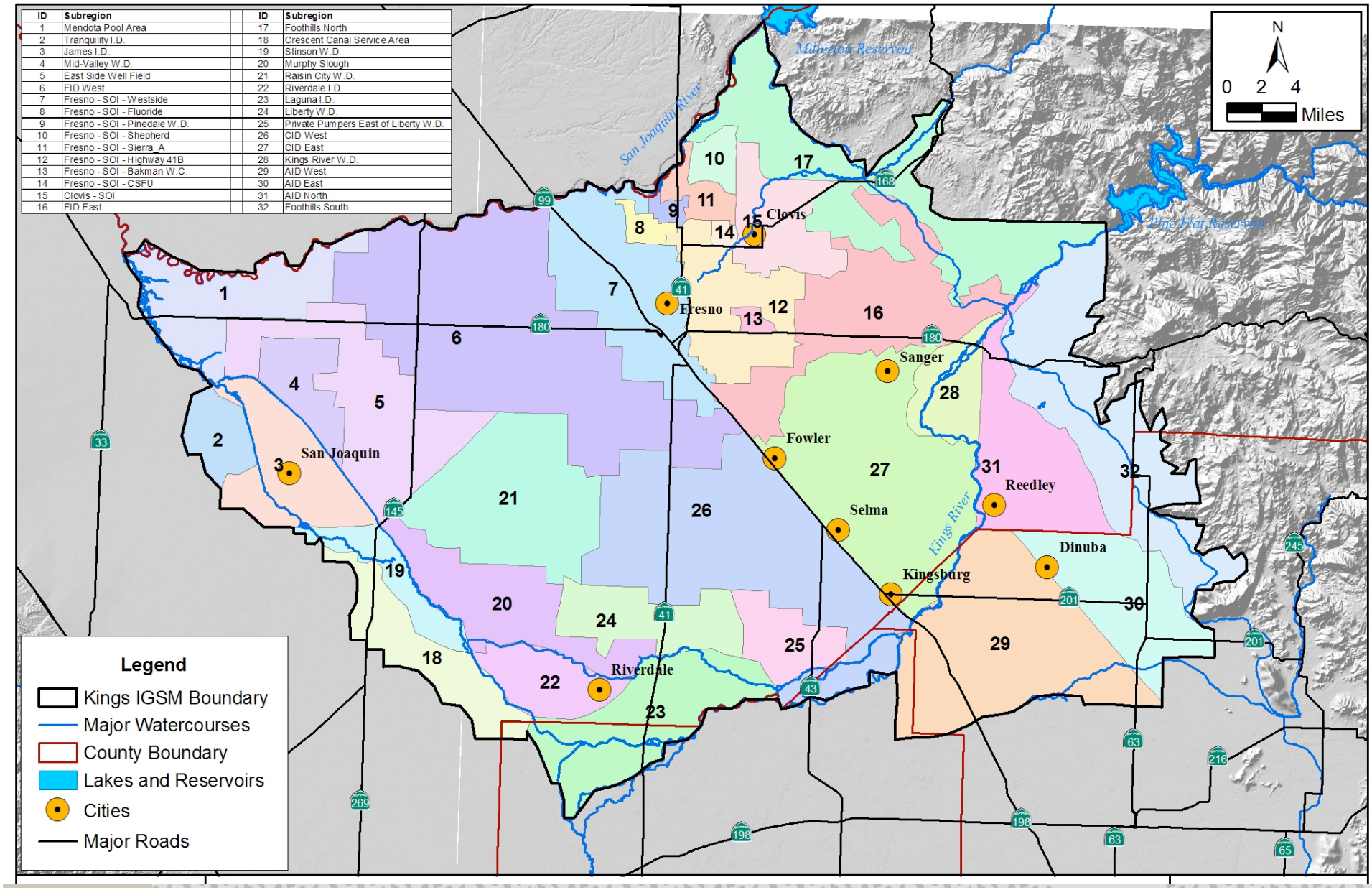
Annual Agricultural Groundwater Pumping



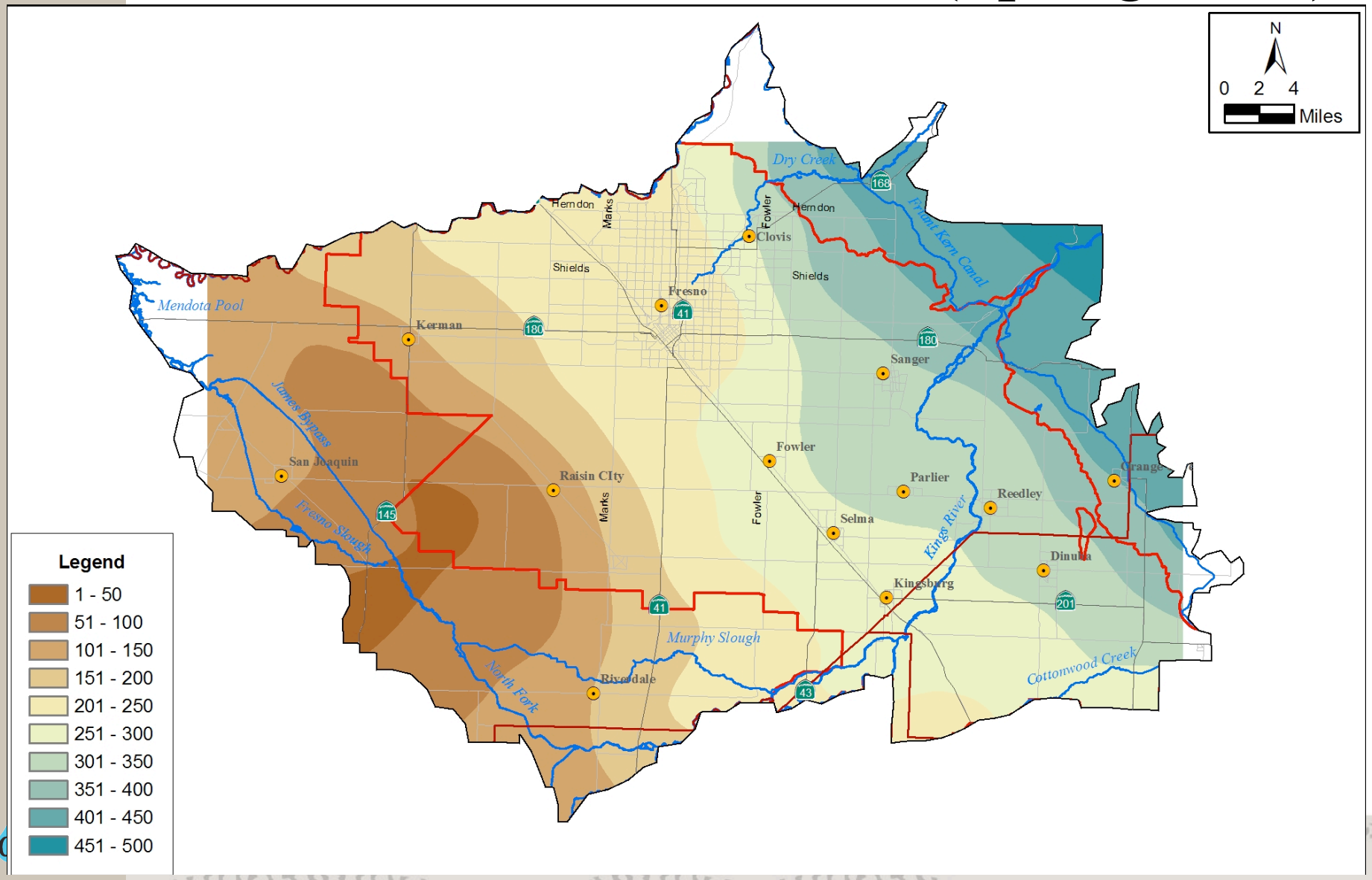
Annual Urban Water Use



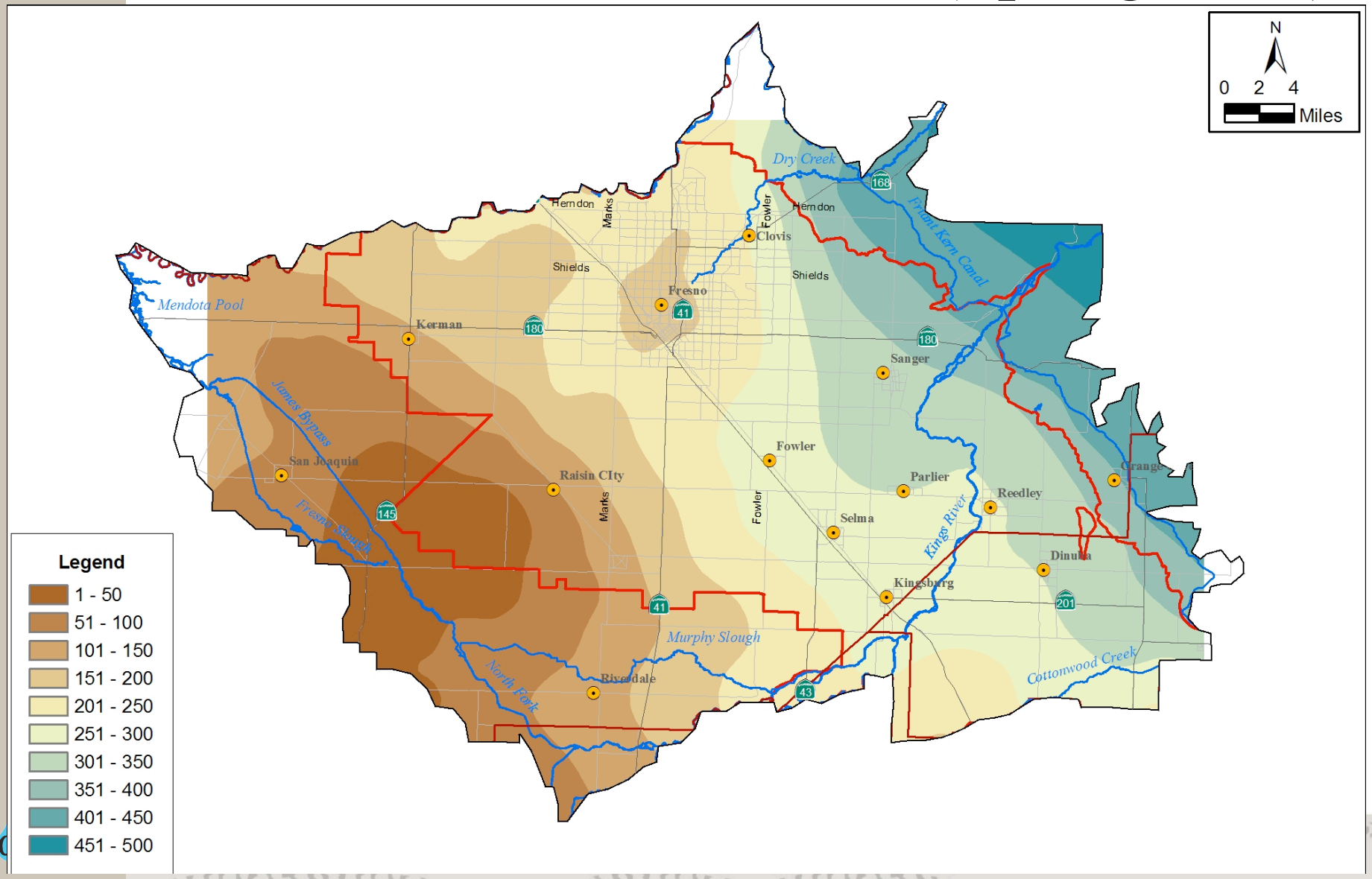
Water Agencies



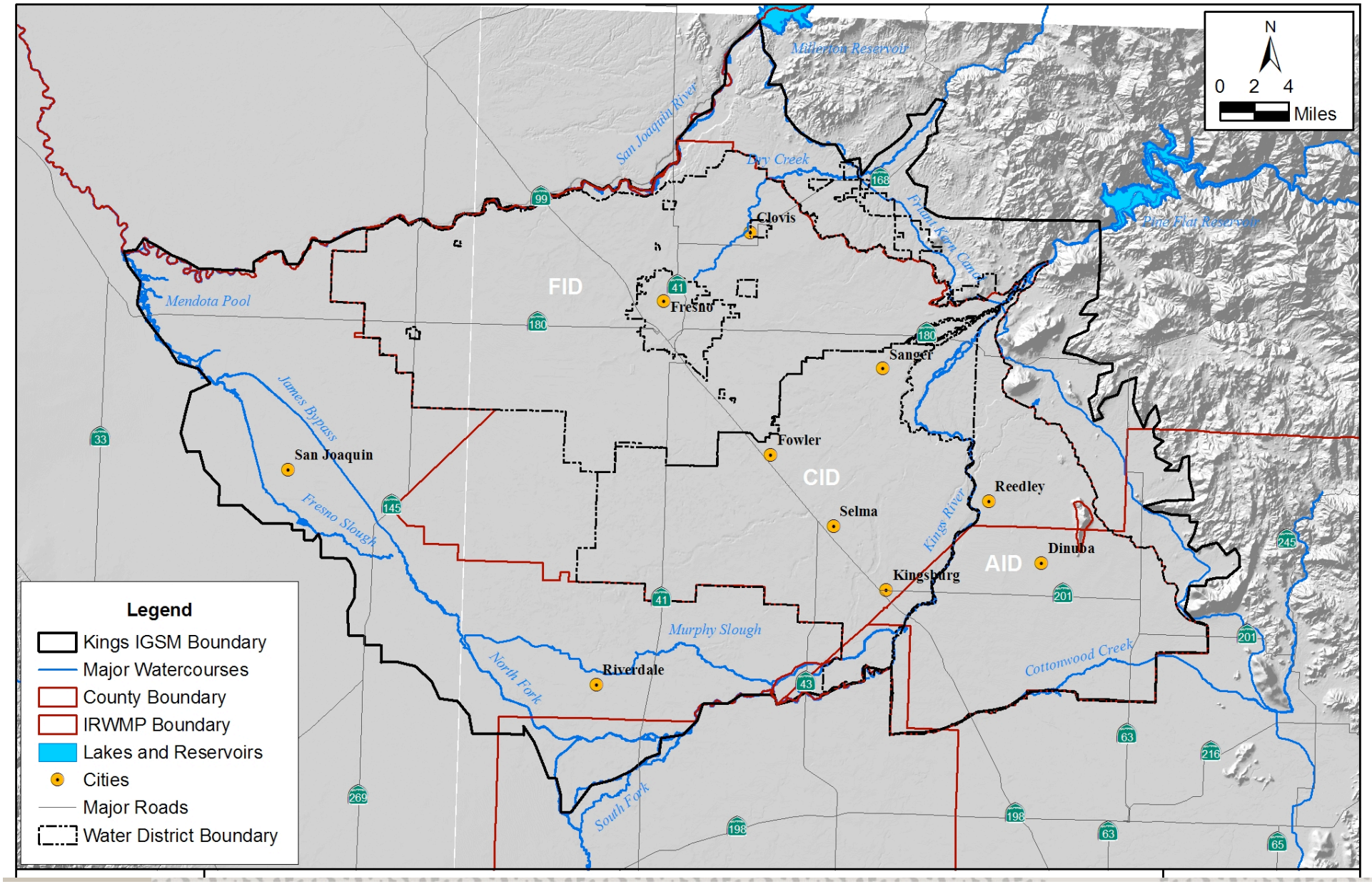
Observed Groundwater Levels (Spring 1984)



Observed Groundwater Levels (Spring 2000)



Upper Kings Basin IRWMP Area



NEED FOR
AN ANALYTICAL TOOL

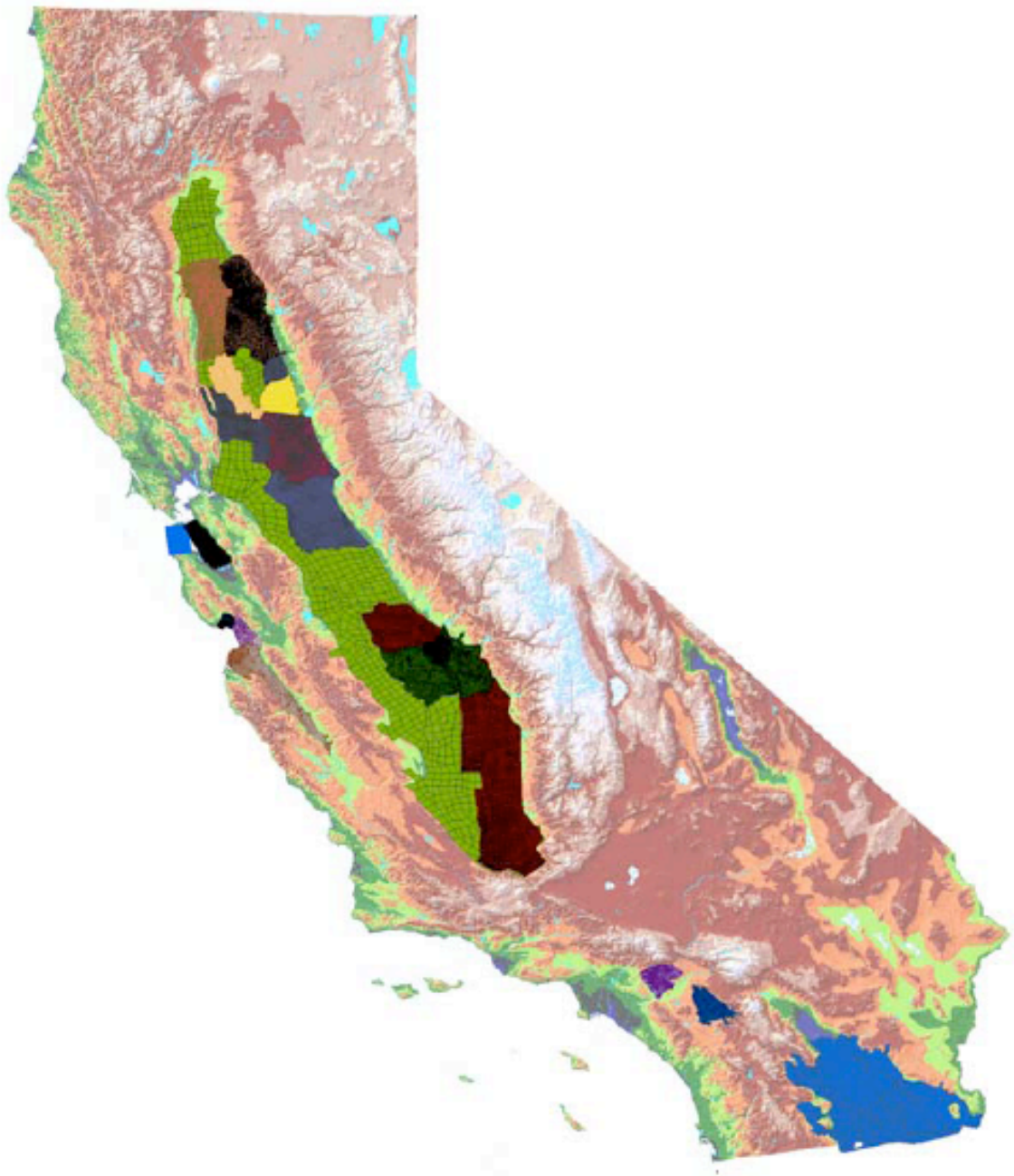
Need for Kings Basin Model

- To develop an analytical tool to assist in:
  - Better understanding the basin hydrology/hydrogeology and its interaction with surface water resources
  - Evaluation of project benefits and impacts on the GW & SW resources
  - Development of IRWMP
  - Analysis of environmental impacts for EIR/EIS permitting
  - Estimation of cost shares for regional projects based on benefits/impact levels
  - Analysis of benefits/impacts on water quality conditions, when WQ model is developed

SELECTED ANALYTICAL TOOL

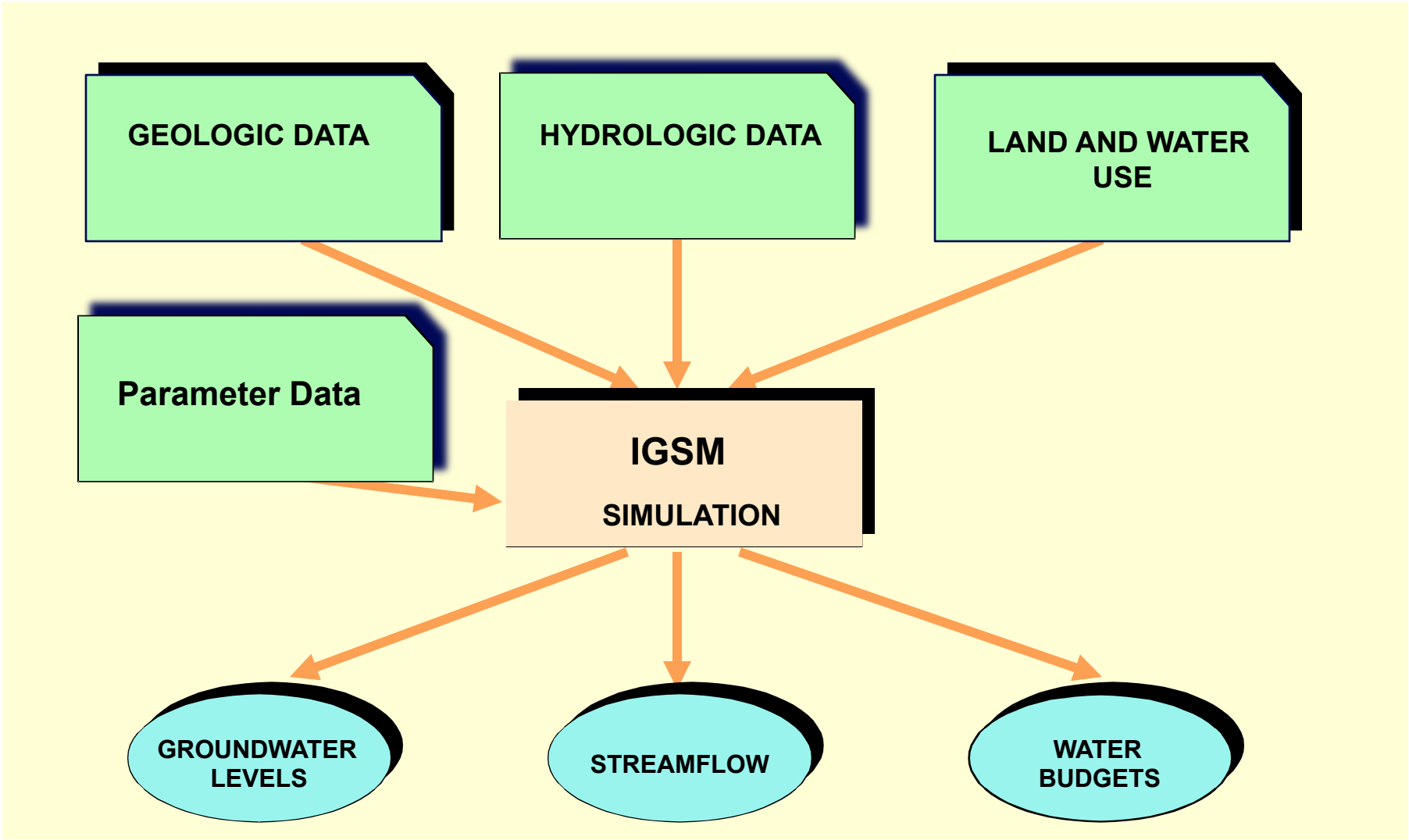
The Selected Model Code: IGSM

- Capable of simulating both the surface water and groundwater systems and their interactions;
- Capable of providing quantitative information for assessment of management strategies consistent with the IRWMP goals and objectives;
- Easily modified to accommodate relevant features that may be needed for the IRWMP; and
- A non-proprietary model.



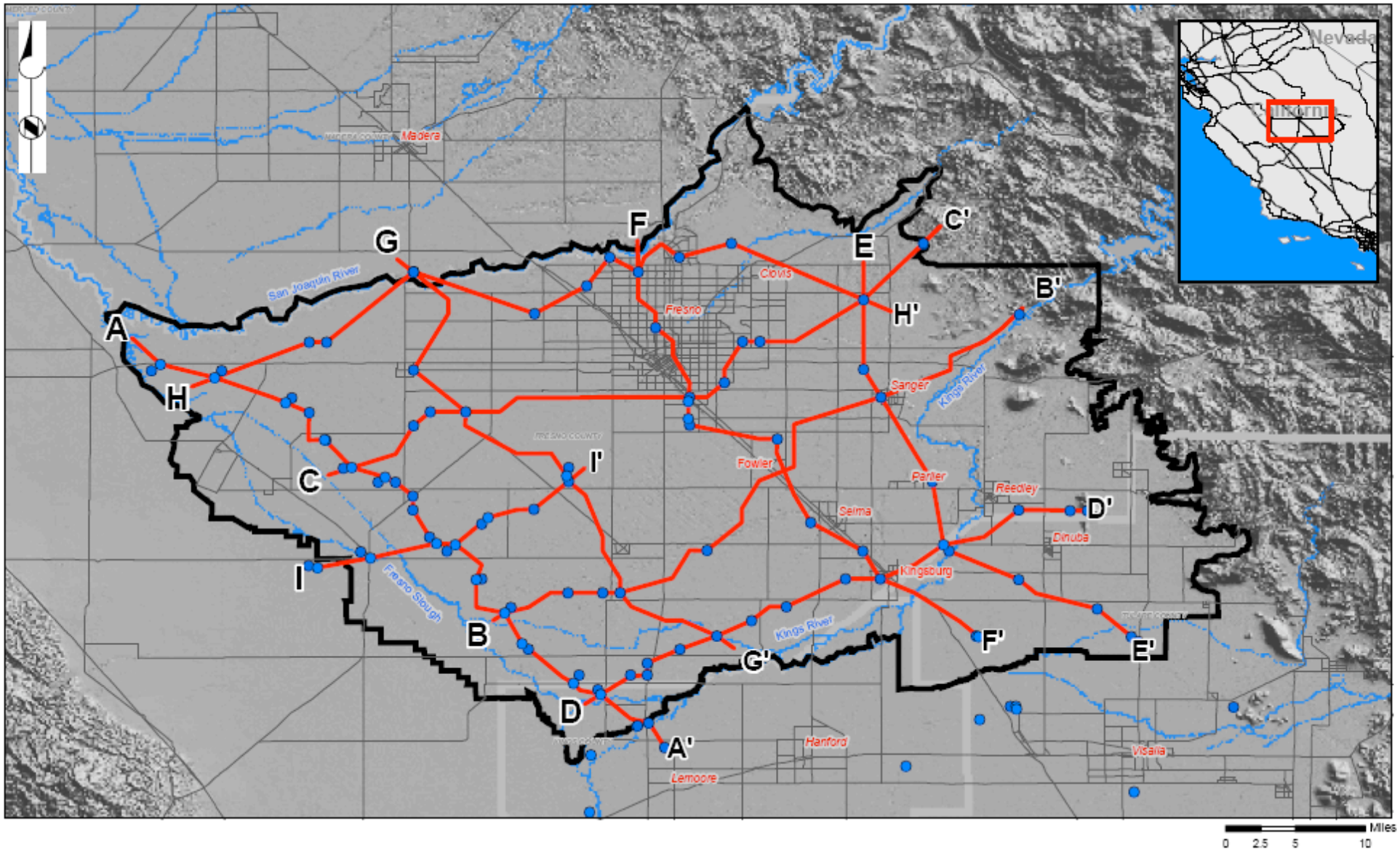
MODEL DEVELOPMENT

Model Data


GEOLOGIC DATA
HYDROLOGIC DATA
LAND AND WATER USE
Parameter Data
IGSM
SIMULATION
GROUNDWATER LEVELS
STREAMFLOW
WATER BUDGETS

Technical Studies Supporting Model Development

1. Modeling Goals and Objectives
2. Hydrogeologic Investigations
3. Water Demand Analysis
4. Water Supply Analysis

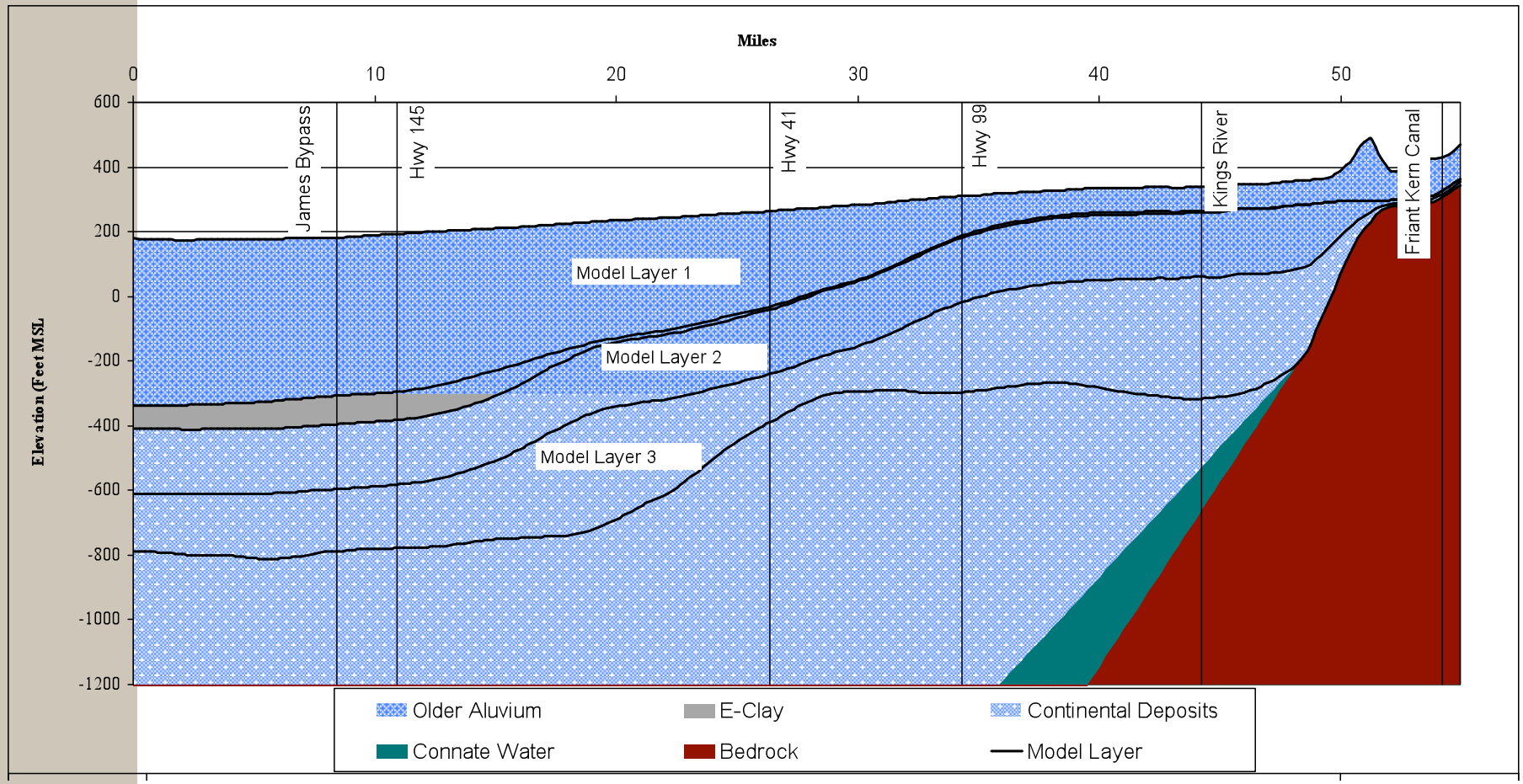


EXPLANATION

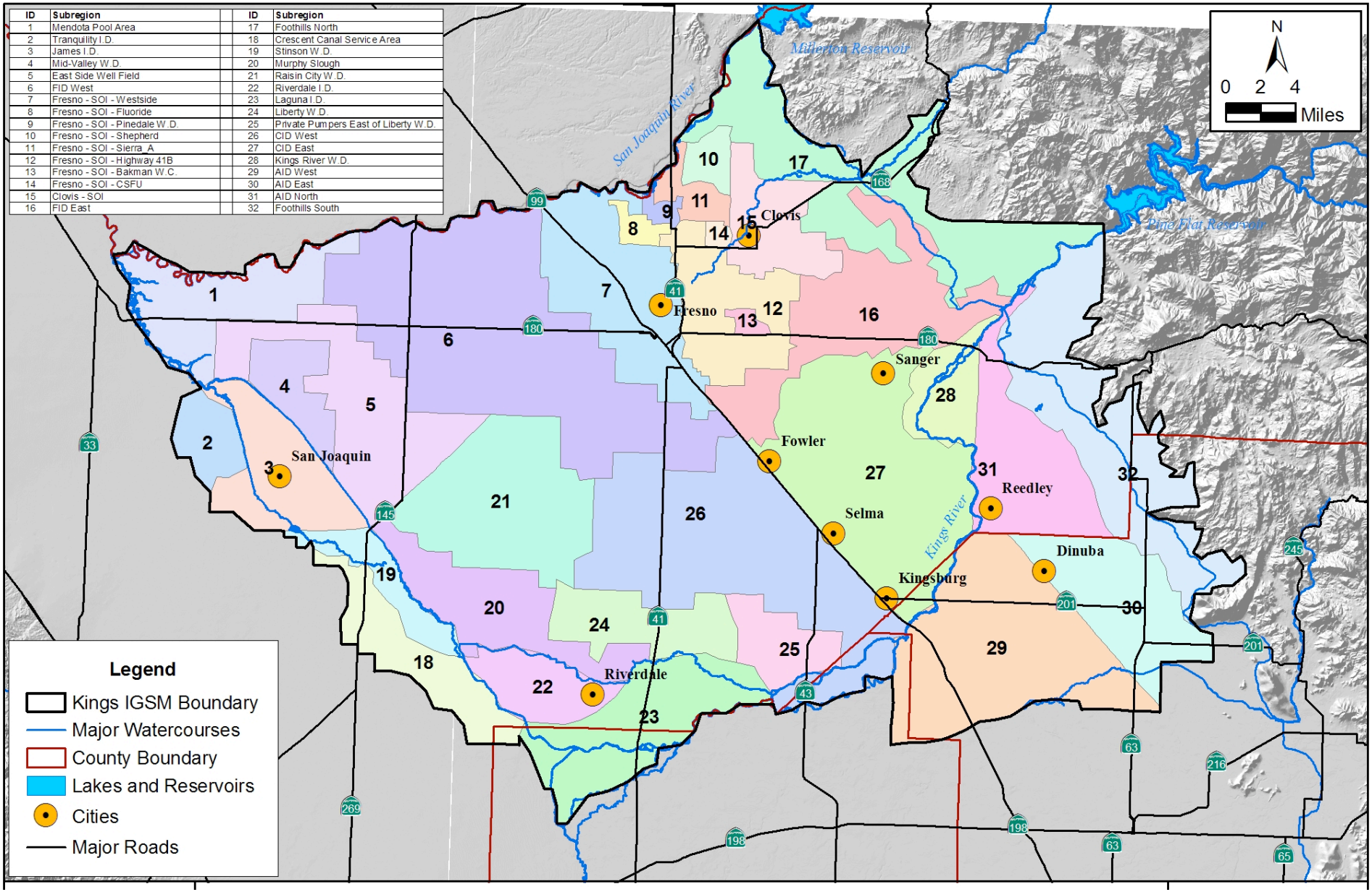
- Wells
- Model Boundary
- Cross Section Location

Figure 5
LOCATIONS OF DETAILED HYDROGEOLOGIC CROSS-SECTIONS
KINGS BASIN
SAN JOAQUIN VALLEY, CALIFORNIA

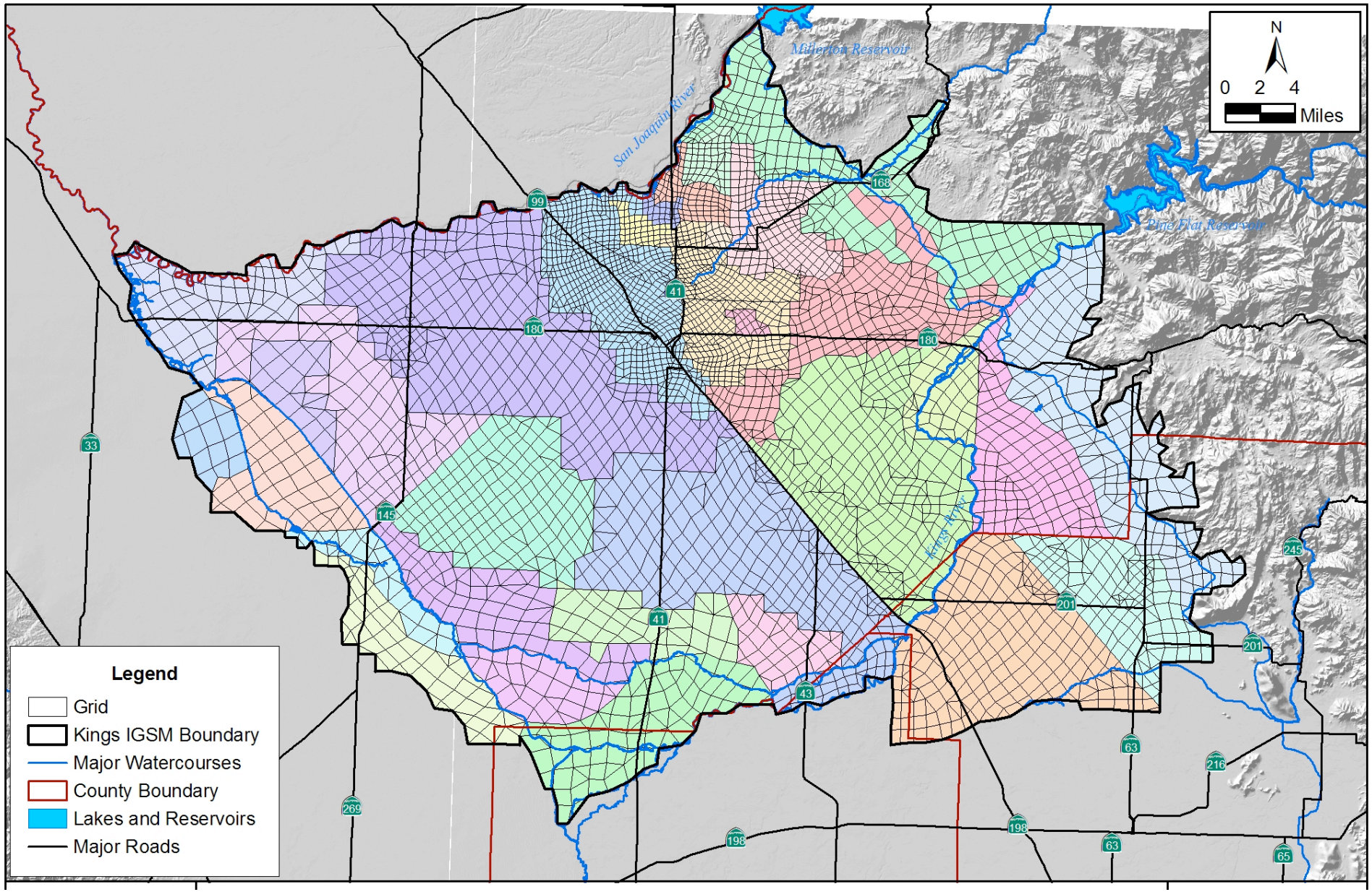
BROWN AND CALDWELL


Miles
0
10
20
30
40
50
600
400
200
0
-200
-400
-600
-800
-1000
-1200
Elevation (Feet MSL
James Bypass
Hwy 145
Hwy 41
Hwy 99
Kings River
Friant Kern Canal
Model Layer 1
Model Layer 2
Model Layer 3
Older Aluvium
E-Clay
Continental Deposits
Connate Water
Bedrock
Model Layer

Model Subregions



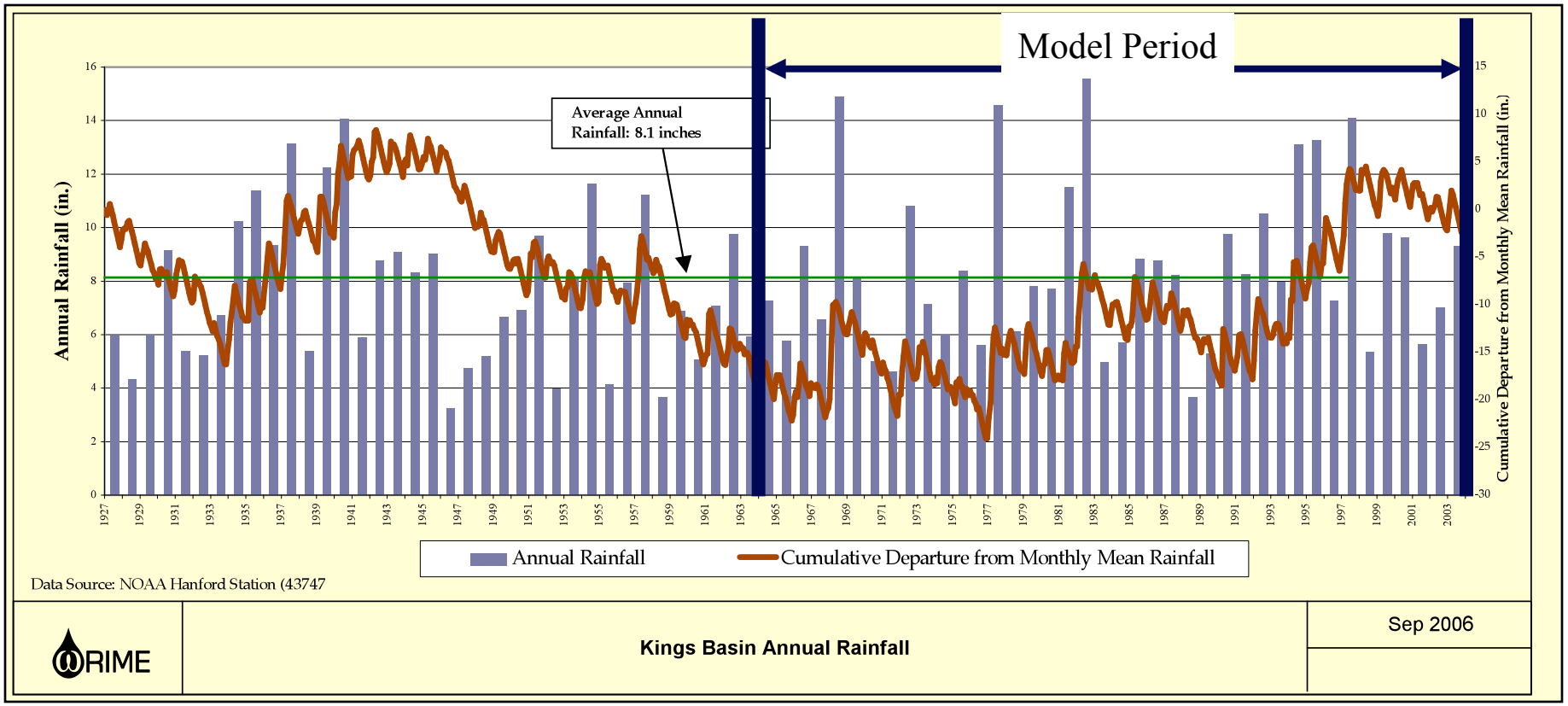
Model Grid Map



Model Grid Statistics

No. of Nodes	4,266
No. of Elements	4,689
No. of Layers	3
Min. Element Size (acres)	9
Max. Element Size (acres)	965
Avg Element Size (acres)	222
Model Area (sq. miles)	1,627

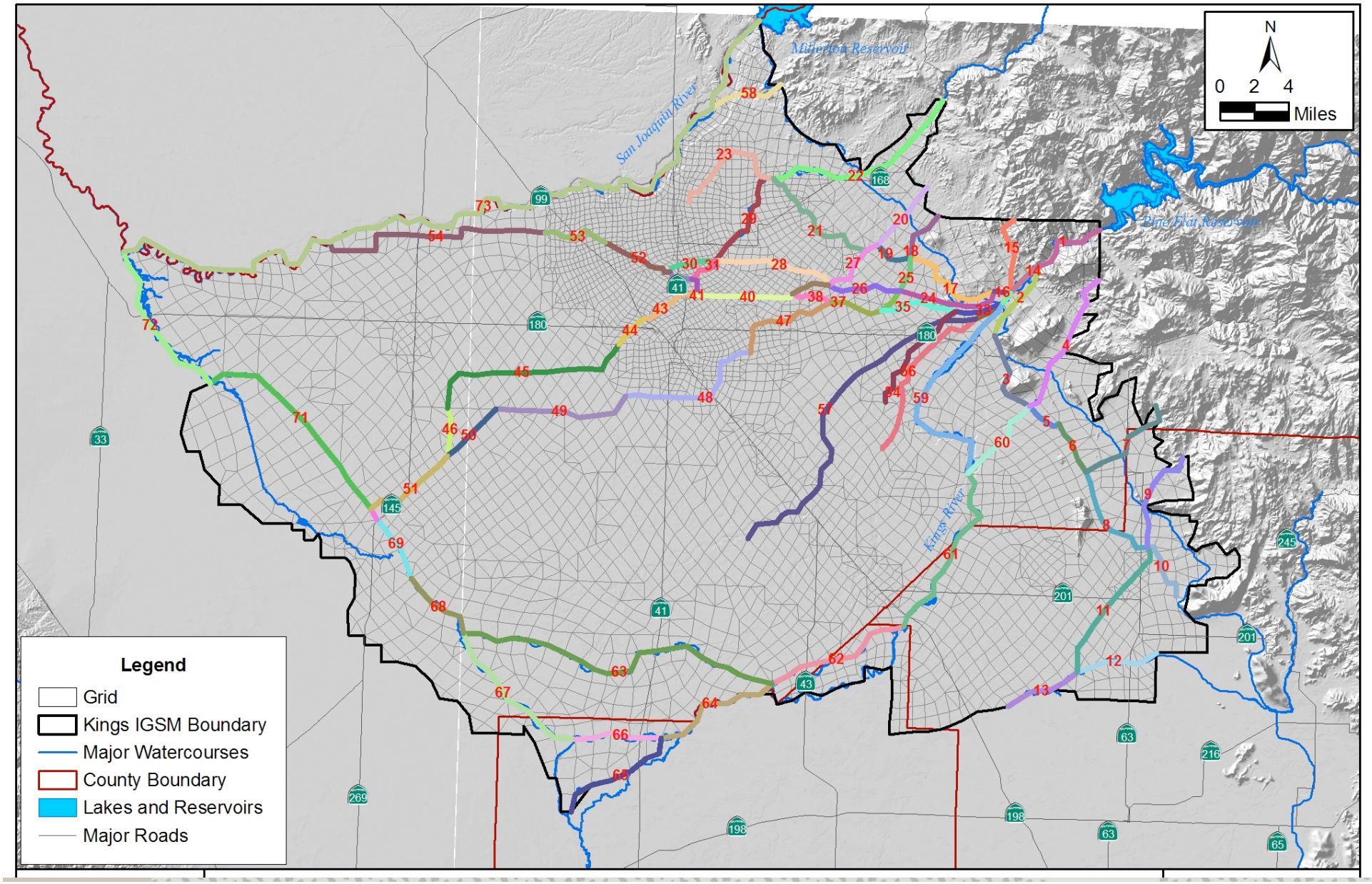
Annual Precipitation

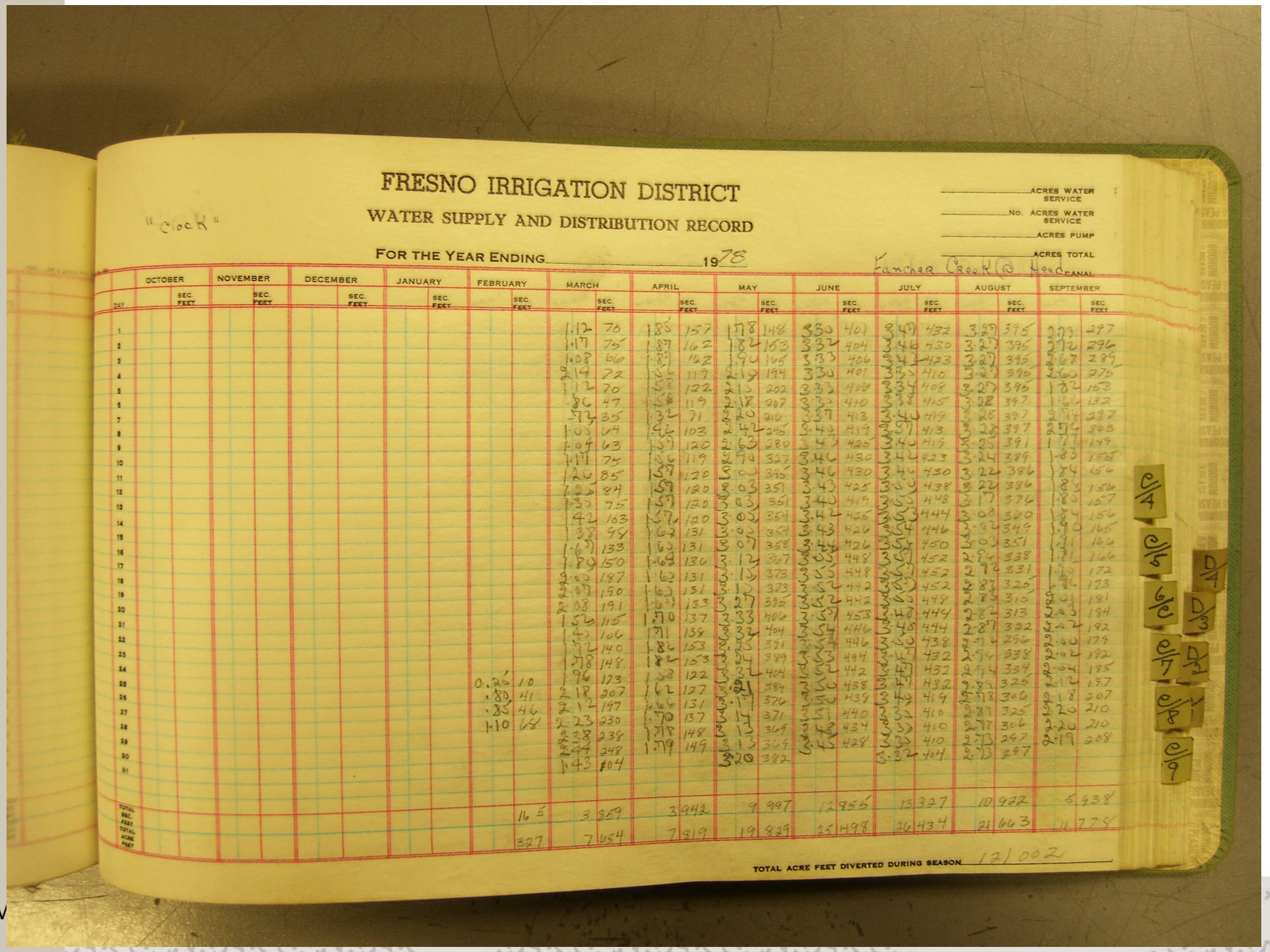


Hydrologic Periods

- Long-term Average
  1964-2004
- Short Dry Period 1976-1977
- Extended Dry Period 1987-1992
- Short Wet Period 1982-1983
- Extended Wet Period 1995-1998

Surface Water System in Kings IGSM





FRESNO IRRIGATION DISTRICT

WATER SUPPLY AND DISTRIBUTION RECORD

"Clock"

FOR THE YEAR ENDING 1978

Fancher Creek @ Head

_____ ACRES WATER SERVICE

_____ No. ACRES WATER SERVICE

_____ ACRES PUMP

_____ ACRES TOTAL

CANAL

DAY	OCTOBER SEC. FEET	NOVEMBER SEC. FEET	DECEMBER SEC. FEET	JANUARY SEC. FEET	FEBRUARY SEC. FEET	MARCH SEC. FEET	APRIL SEC. FEET	MAY SEC. FEET	JUNE SEC. FEET	JULY SEC. FEET	AUGUST SEC. FEET	SEPTEMBER SEC. FEET
1						1.12 78	1.85 157	1.78 148	8.30 401	8.40 432	3.27 395	2.73 297
2						1.17 75	1.87 162	1.82 153	8.32 404	8.46 430	3.27 396	2.72 296
3						1.08 66	1.87 162	1.90 165	8.33 406	8.43 423	3.27 396	2.67 289
4						2.19 72	1.56 119	2.19 194	8.30 401	8.37 410	3.23 396	2.60 276
5						1.12 70	1.58 122	2.13 202	8.33 406	8.37 408	3.27 395	1.82 153
6						.86 47	1.58 119	2.18 207	8.33 410	8.38 415	3.28 397	1.66 132
7						.57 35	1.32 71	2.20 210	8.37 413	8.38 419	3.28 397	3.95 297
8						1.05 64	1.96 103	3.42 345	8.43 417	8.37 413	3.28 397	2.76 308
9						1.09 63	1.57 120	2.63 280	8.43 425	8.40 419	3.25 391	1.71 149
10						1.11 75	1.46 119	3.27 330	8.46 430	8.42 423	3.24 389	1.83 155
11						1.26 85	1.57 120	3.40 346	8.46 430	8.46 430	3.22 386	1.84 156
12						1.23 84	1.57 120	3.03 351	8.43 425	8.38 438	3.22 386	1.86 156
13						1.30 95	1.57 120	3.03 351	8.40 419	8.48 448	3.17 376	1.86 157
14						1.42 103	1.57 120	3.02 354	8.42 426	8.44 444	3.08 360	1.84 156
15						1.38 98	1.67 131	3.02 358	8.43 426	8.46 446	2.92 349	1.80 166
16						1.65 133	1.60 131	3.07 358	8.43 426	8.50 450	2.93 351	1.71 164
17						1.89 150	1.62 136	3.07 367	8.54 448	8.52 452	2.84 338	1.91 166
18						2.02 187	1.62 131	3.13 373	8.54 448	8.52 452	2.78 331	1.80 172
19						2.07 190	1.63 131	3.23 384	8.52 442	8.52 452	2.88 325	1.96 173
20						2.08 191	1.63 133	3.27 395	8.52 442	8.48 448	2.78 315	2.01 181
21						1.56 115	1.70 137	3.33 406	8.57 453	8.44 444	2.82 313	2.03 184
22						1.43 106	1.71 138	3.37 404	8.54 446	8.44 444	2.87 322	2.04 182
23						1.52 140	1.86 153	3.31 391	8.46 446	8.38 438	2.94 296	2.00 179
24						1.78 148	1.82 153	3.24 389	8.44 444	8.32 432	2.94 338	2.02 182
25					0.26 10	1.96 173	1.58 122	3.32 404	8.42 442	8.32 432	2.94 339	2.04 185
26					.80 41	2.18 207	1.62 127	3.21 384	8.38 438	8.32 432	2.88 325	2.12 197
27					.82 46	2.12 197	1.66 131	3.17 376	8.38 438	8.19 419	2.78 306	1.8 207
28					1.10 68	2.23 230	1.70 137	3.17 371	8.40 440	8.32 410	2.87 325	2.0 210
29						2.38 238	1.78 148	3.09 369	8.34 434	8.28 410	2.78 306	2.2 210
30						2.47 248	1.79 149	3.09 369	8.28 428	8.32 410	2.73 297	2.19 208
31						1.43 104		3.20 382		8.32 404	2.73 297	
TOTAL SEC. FEET					16 5	3 869	3 943	9 997	12 956	13 327	10 922	6 938
TOTAL ACRE FEET					327	7 654	7 819	19 829	25 698	26 434	21 663	14 778

TOTAL ACRE FEET DIVERTED DURING SEASON 121002

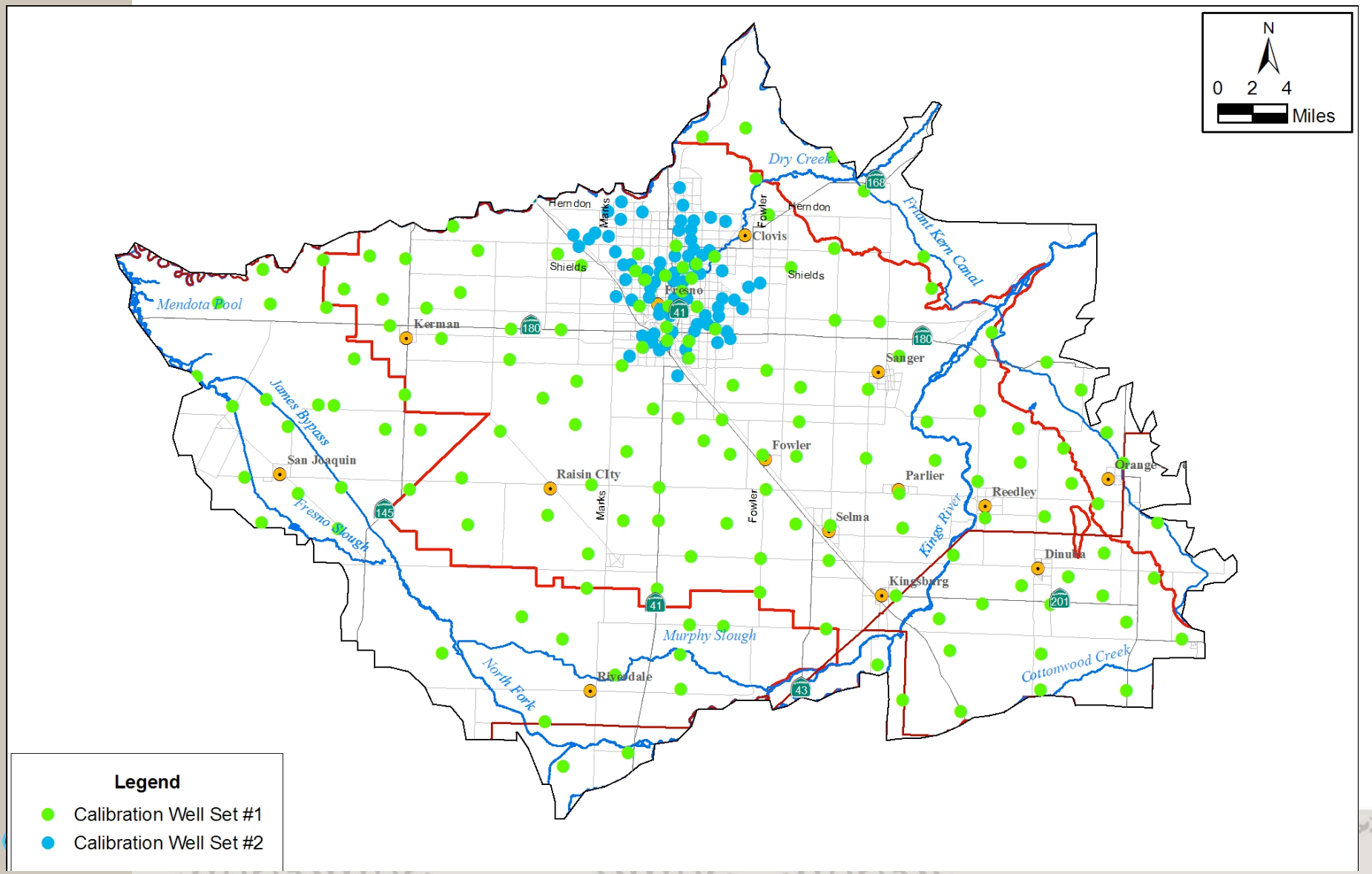
e/4 e/5 6/6 e/7 e/8 e/9 D4 D3 D2 D1

MODEL CALIBRATION

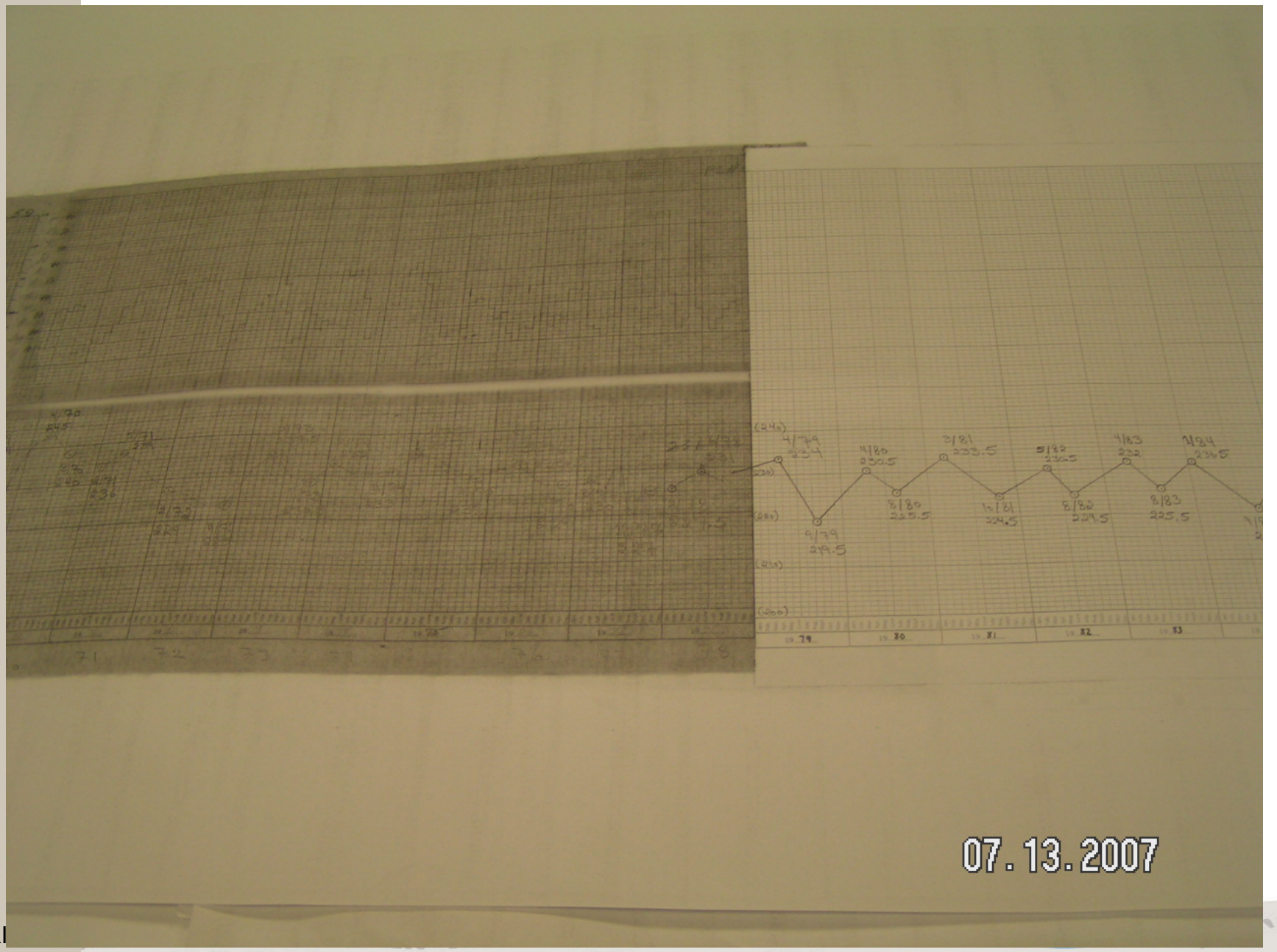
Calibration Components

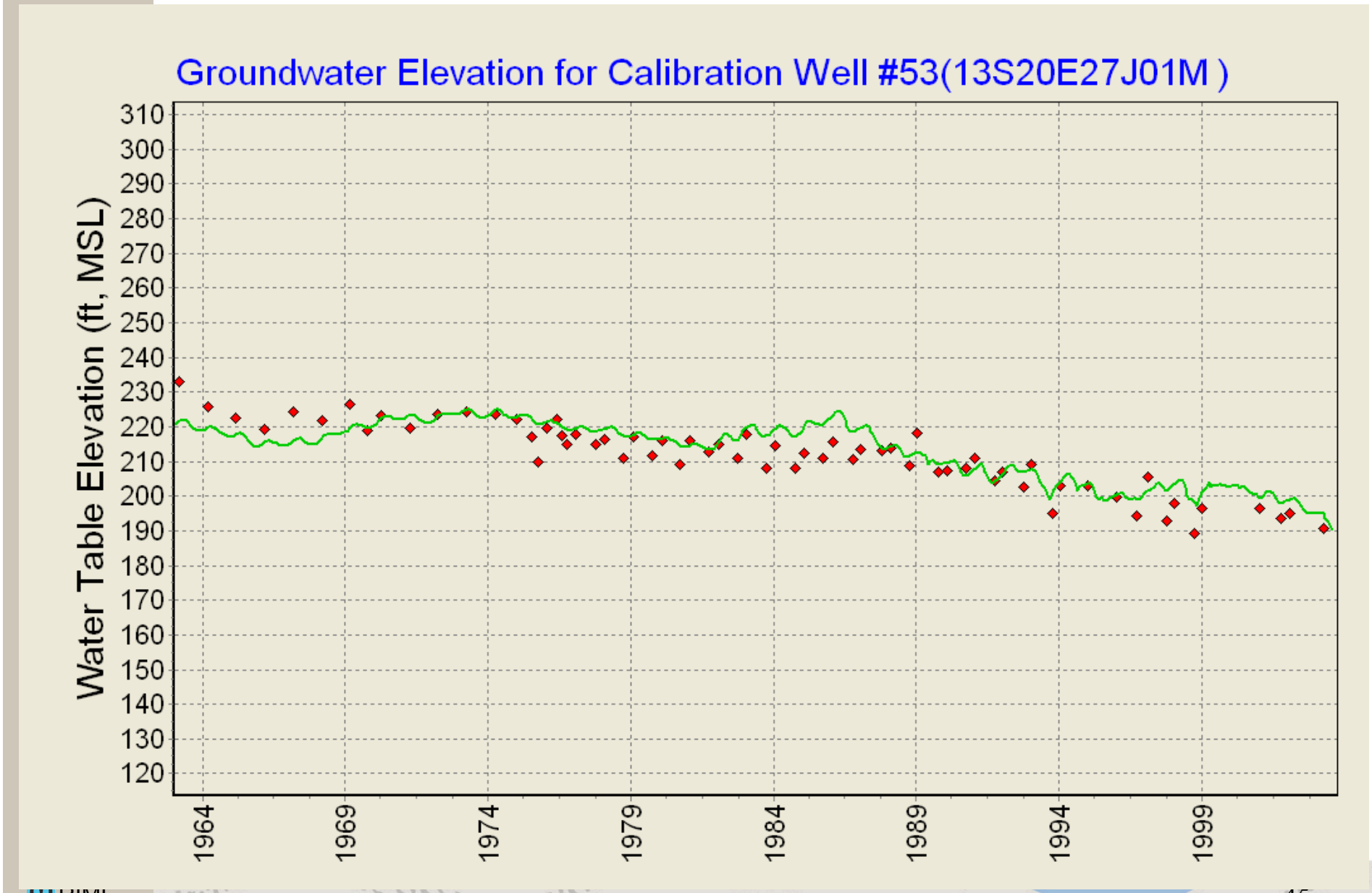
- Model Water Budgets
- Agricultural Water Use & GW Pumping
- GW Levels
- Streamflows

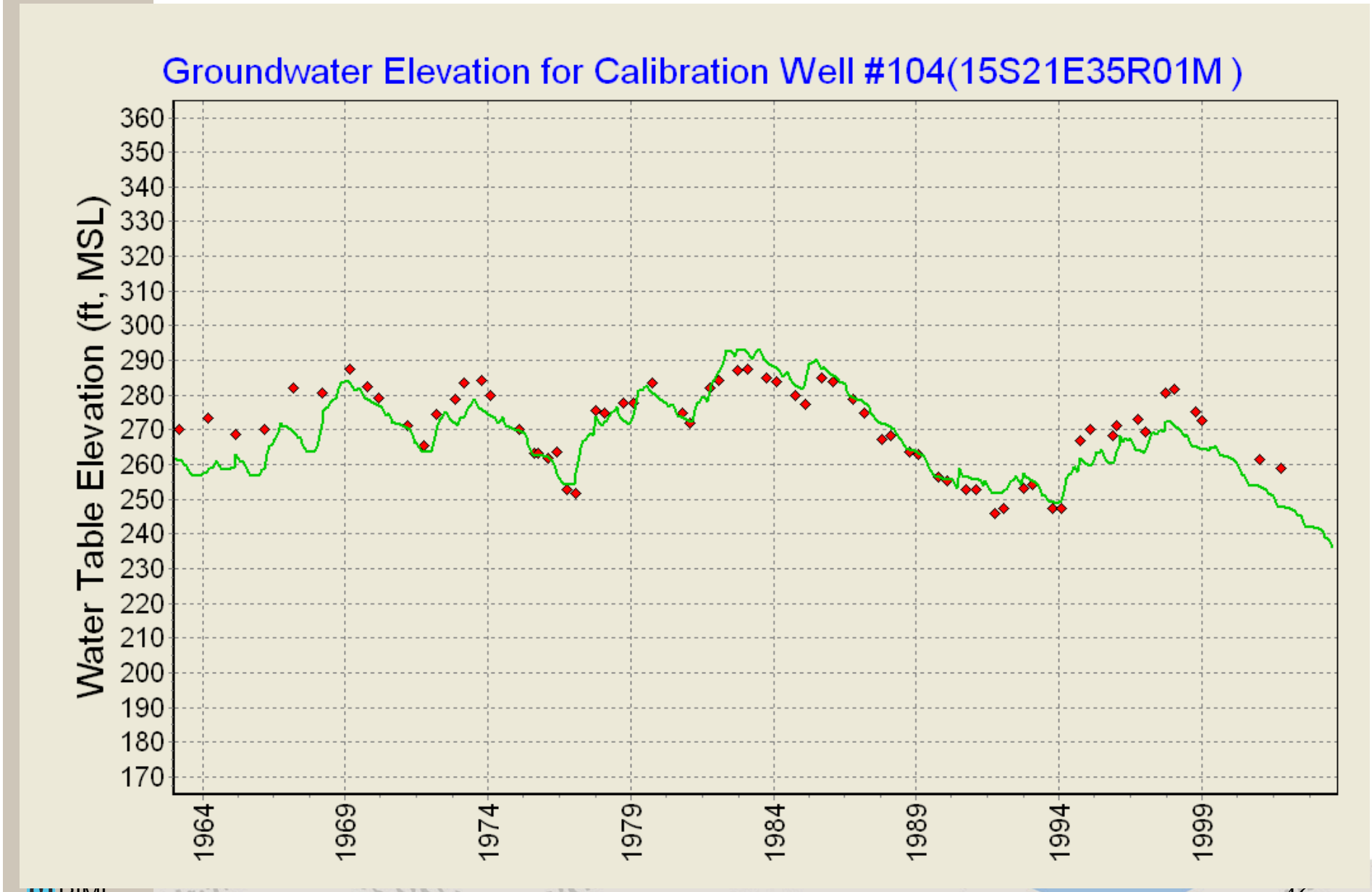
Calibration Wells




07.13.2007


4/79
9/79
4/80
8/80
3/81
10/81
5/82
8/82
4/83
8/83
1/84
19 79
19 80
19 81
19 82
19 83
07. 13. 2007


Groundwater Elevation for Calibration Well #53(13S20E27J01M)
Water Table Elevation (ft, MSL)
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
1964
1969
1974
1979
1984
1989
1994
1999

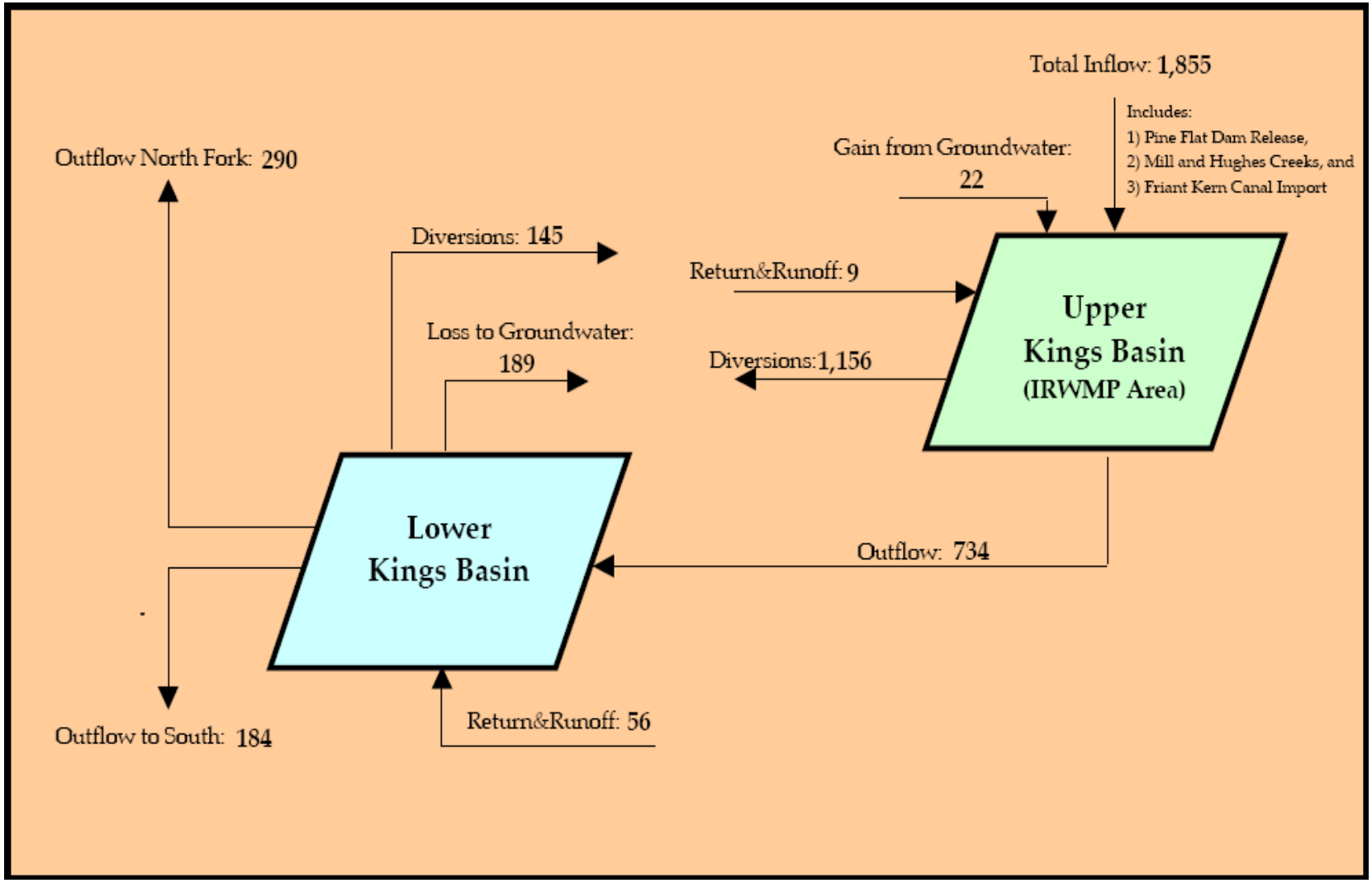

Groundwater Elevation for Calibration Well #104(15S21E35R01M)
Water Table Elevation (ft, MSL)
360
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
1964
1969
1974
1979
1984
1989
1994
1999

MODEL APPLICATION

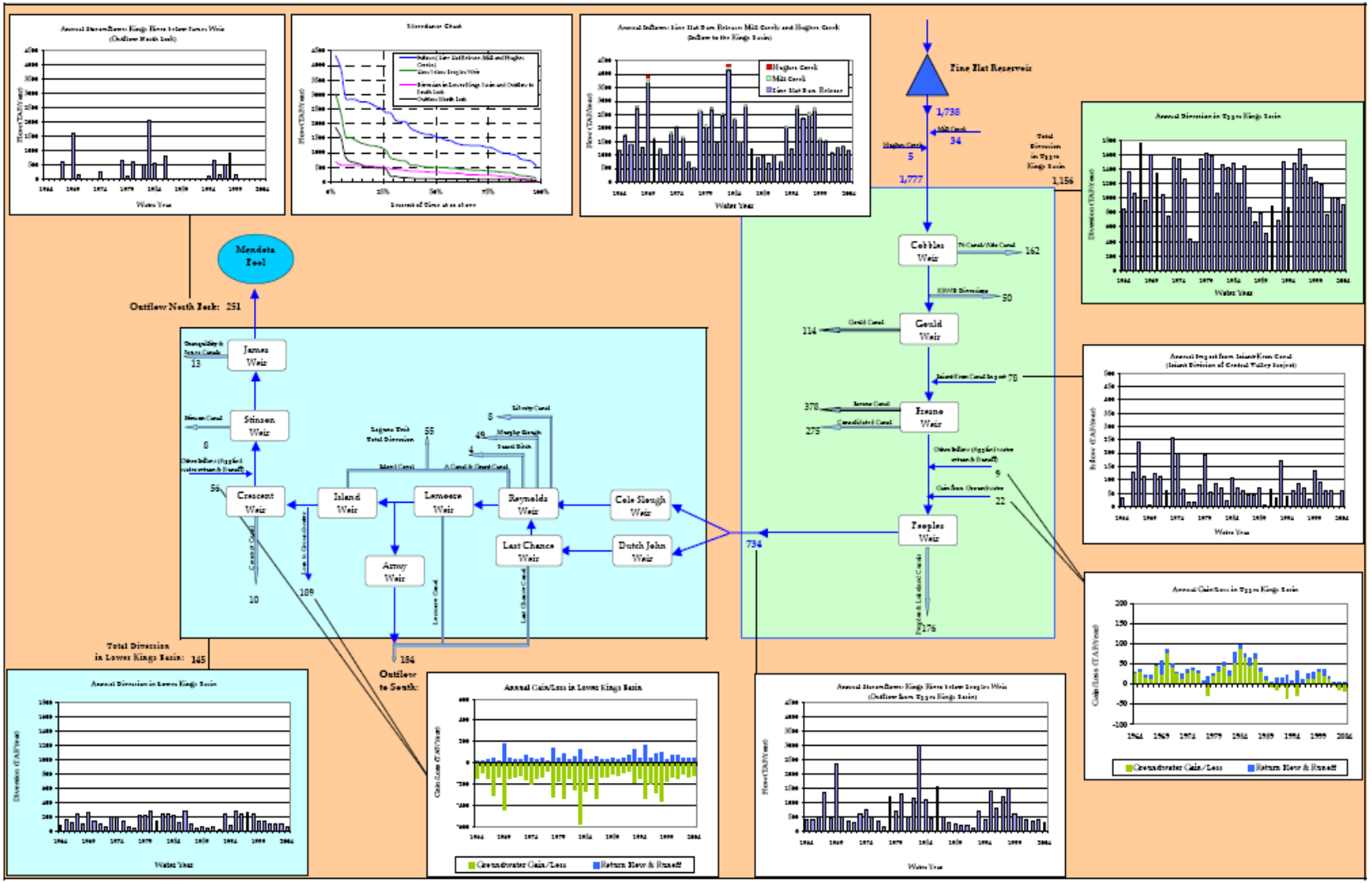
Alternatives Analysis

- Regional Groundwater Recharge Projects
  - Direct Recharge
  - In-lieu Recharge
- Reclamation and Reuse
- Regional/Inter-Regional Groundwater Banking
- Non-Structural/Water Conservation

Kings River System Summary



Kings River System Details



THE END!