

## Stephen Maurano - NOAA Federal

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**From:** Stephen Maurano - NOAA Federal  
**Sent:** Thursday, April 18, 2019 11:19 AM  
**To:** Evan Sawyer - NOAA Federal  
**Cc:** Kate Spear - NOAA Federal; Cathy Marcinkevage - NOAA Federal  
**Subject:** Re: [EXTERNAL] Inimpaired Flow Hydrograph  
**Attachments:** SacramentoRiver\_UnimpairedFlow\_4NOAA20190418.xlsx

Hi Evan,

We looked briefly at the data. At some point we'd need to confirm that the data sets Derek stitched together are fully consistent, specifically the flow (CDEC full natural flow = DWR unimpaired flow?) and station (DWR UF 6 Sacramento River near Red Bluff = CDEC SHA station Sensor 8 - esp. b/c of Paynes Creek flow additions in the former). Assuming those are consistent, below are some quick visualizations of the data. We haven't converted to cfs yet, just quickly averaged and looked at patterns -- which are pretty unremarkable (wet vs dry season & various water year types).

| WY   | OCT | NOV  | DEC  | JAN  | FEB  | MAR  | APR  | MAY  | JUN | JUL | AUG | SEP |
|------|-----|------|------|------|------|------|------|------|-----|-----|-----|-----|
| 1921 | 226 | 1236 | 1557 | 2123 | 1576 | 1583 | 931  | 792  | 541 | 369 | 281 | 261 |
| 1922 | 242 | 289  | 542  | 432  | 967  | 880  | 1067 | 896  | 511 | 338 | 263 | 239 |
| 1923 | 256 | 339  | 646  | 678  | 446  | 422  | 884  | 431  | 398 | 314 | 240 | 233 |
| 1924 | 232 | 250  | 269  | 306  | 517  | 286  | 269  | 263  | 266 | 246 | 199 | 191 |
| 1925 | 211 | 439  | 445  | 463  | 2508 | 789  | 1275 | 700  | 466 | 299 | 246 | 237 |
| 1926 | 220 | 274  | 343  | 437  | 1598 | 548  | 832  | 431  | 314 | 266 | 212 | 199 |
| 1927 | 206 | 858  | 1167 | 1205 | 2589 | 1345 | 1505 | 781  | 490 | 337 | 249 | 239 |
| 1928 | 221 | 633  | 550  | 722  | 1059 | 1585 | 1194 | 538  | 359 | 306 | 236 | 231 |
| 1929 | 215 | 338  | 381  | 369  | 647  | 482  | 526  | 432  | 350 | 257 | 200 | 202 |
| 1930 | 196 | 219  | 973  | 662  | 881  | 1106 | 575  | 487  | 324 | 258 | 198 | 217 |
| 1931 | 219 | 232  | 235  | 470  | 385  | 461  | 300  | 243  | 214 | 186 | 177 | 174 |
| 1932 | 204 | 213  | 781  | 548  | 420  | 845  | 556  | 608  | 310 | 215 | 198 | 184 |
| 1933 | 180 | 201  | 246  | 390  | 319  | 1117 | 644  | 552  | 356 | 218 | 188 | 180 |
| 1934 | 193 | 200  | 505  | 738  | 728  | 609  | 438  | 324  | 232 | 192 | 176 | 167 |
| 1935 | 197 | 483  | 400  | 986  | 732  | 965  | 1895 | 822  | 371 | 248 | 204 | 190 |
| 1936 | 219 | 209  | 282  | 1571 | 1779 | 780  | 724  | 482  | 401 | 247 | 195 | 186 |
| 1937 | 200 | 196  | 224  | 262  | 682  | 1441 | 1194 | 731  | 425 | 250 | 186 | 188 |
| 1938 | 250 | 1165 | 1908 | 950  | 2614 | 3185 | 1769 | 1286 | 632 | 375 | 282 | 261 |
| 1939 | 305 | 326  | 466  | 426  | 406  | 750  | 454  | 339  | 249 | 225 | 209 | 215 |
| 1940 | 207 | 212  | 443  | 1729 | 2577 | 2188 | 1458 | 581  | 346 | 275 | 231 | 246 |
| 1941 | 270 | 320  | 1881 | 2528 | 2339 | 2111 | 2048 | 1124 | 650 | 413 | 325 | 305 |
| 1942 | 311 | 321  | 1655 | 1733 | 2540 | 751  | 1340 | 990  | 658 | 382 | 300 | 280 |
| 1943 | 305 | 364  | 628  | 1687 | 1077 | 1408 | 1002 | 668  | 490 | 331 | 275 | 262 |
| 1944 | 290 | 291  | 295  | 387  | 694  | 696  | 485  | 463  | 378 | 274 | 229 | 221 |
| 1945 | 268 | 527  | 723  | 495  | 1416 | 794  | 629  | 672  | 453 | 268 | 235 | 219 |
| 1946 | 332 | 619  | 2161 | 1249 | 556  | 755  | 767  | 598  | 356 | 283 | 257 | 236 |
| 1947 | 256 | 354  | 421  | 275  | 624  | 995  | 618  | 342  | 480 | 259 | 228 | 221 |
| 1948 | 370 | 302  | 288  | 1031 | 343  | 821  | 1720 | 1151 | 745 | 338 | 268 | 273 |
| 1949 | 274 | 286  | 350  | 277  | 504  | 1937 | 811  | 584  | 332 | 234 | 226 | 217 |
| 1950 | 243 | 243  | 250  | 750  | 962  | 883  | 816  | 542  | 333 | 244 | 225 | 227 |
| 1951 | 665 | 768  | 1517 | 1263 | 1517 | 922  | 654  | 702  | 345 | 252 | 244 | 235 |
| 1952 | 295 | 520  | 1765 | 1463 | 1753 | 1429 | 1621 | 1111 | 575 | 404 | 305 | 302 |

|      |     |      |      |      |      |      |      |      |      |     |     |     |
|------|-----|------|------|------|------|------|------|------|------|-----|-----|-----|
| 1953 | 283 | 300  | 1271 | 2746 | 687  | 897  | 861  | 913  | 734  | 388 | 295 | 293 |
| 1954 | 308 | 490  | 442  | 1487 | 1625 | 1474 | 1445 | 650  | 437  | 318 | 308 | 298 |
| 1955 | 302 | 516  | 789  | 566  | 447  | 473  | 767  | 682  | 335  | 278 | 250 | 257 |
| 1956 | 256 | 414  | 2898 | 3226 | 1849 | 1200 | 951  | 1009 | 542  | 361 | 311 | 290 |
| 1957 | 371 | 325  | 321  | 423  | 1115 | 1446 | 817  | 968  | 459  | 316 | 278 | 330 |
| 1958 | 584 | 527  | 913  | 1482 | 4414 | 2085 | 2149 | 1069 | 731  | 458 | 362 | 346 |
| 1959 | 355 | 326  | 361  | 1308 | 1283 | 789  | 631  | 476  | 343  | 284 | 257 | 326 |
| 1960 | 288 | 265  | 300  | 546  | 1431 | 1216 | 622  | 615  | 403  | 270 | 248 | 254 |
| 1961 | 281 | 423  | 965  | 576  | 1344 | 1043 | 691  | 627  | 418  | 283 | 259 | 256 |
| 1962 | 283 | 425  | 830  | 477  | 1861 | 1100 | 772  | 564  | 382  | 274 | 251 | 245 |
| 1963 | 898 | 400  | 918  | 558  | 1360 | 913  | 2402 | 1033 | 476  | 347 | 309 | 286 |
| 1964 | 353 | 699  | 400  | 850  | 473  | 451  | 470  | 415  | 404  | 246 | 223 | 232 |
| 1965 | 263 | 498  | 2500 | 2089 | 803  | 593  | 1632 | 682  | 406  | 330 | 297 | 267 |
| 1966 | 283 | 725  | 485  | 1121 | 950  | 1186 | 913  | 490  | 337  | 275 | 254 | 259 |
| 1967 | 253 | 691  | 1279 | 1405 | 1083 | 1338 | 1544 | 1273 | 714  | 375 | 294 | 261 |
| 1968 | 303 | 302  | 437  | 764  | 1668 | 1061 | 597  | 500  | 343  | 306 | 327 | 301 |
| 1969 | 321 | 356  | 980  | 2549 | 2209 | 1307 | 1482 | 1072 | 539  | 361 | 293 | 329 |
| 1970 | 356 | 330  | 1486 | 4536 | 1369 | 1233 | 561  | 514  | 411  | 323 | 306 | 288 |
| 1971 | 343 | 1032 | 1705 | 1648 | 766  | 1493 | 1110 | 957  | 674  | 421 | 313 | 322 |
| 1972 | 370 | 360  | 512  | 731  | 760  | 1236 | 872  | 525  | 376  | 297 | 277 | 289 |
| 1973 | 381 | 655  | 818  | 1818 | 1746 | 1436 | 802  | 677  | 397  | 324 | 292 | 295 |
| 1974 | 407 | 2107 | 1846 | 3355 | 1054 | 2579 | 1849 | 911  | 595  | 458 | 362 | 354 |
| 1975 | 345 | 380  | 503  | 507  | 1452 | 2307 | 1177 | 1044 | 634  | 379 | 327 | 332 |
| 1976 | 435 | 379  | 402  | 371  | 443  | 625  | 554  | 391  | 304  | 258 | 304 | 295 |
| 1977 | 298 | 272  | 275  | 303  | 282  | 313  | 255  | 338  | 271  | 242 | 245 | 318 |
| 1978 | 282 | 320  | 969  | 3115 | 1632 | 2074 | 1459 | 801  | 441  | 336 | 281 | 314 |
| 1979 | 271 | 264  | 270  | 474  | 945  | 1010 | 667  | 706  | 271  | 267 | 232 | 240 |
| 1980 | 379 | 479  | 690  | 1776 | 2262 | 1520 | 783  | 592  | 362  | 309 | 257 | 309 |
| 1981 | 299 | 278  | 509  | 969  | 908  | 1227 | 661  | 468  | 312  | 273 | 243 | 244 |
| 1982 | 324 | 1546 | 2104 | 1293 | 1737 | 1687 | 2208 | 929  | 534  | 290 | 313 | 310 |
| 1983 | 383 | 542  | 1367 | 1915 | 2925 | 4677 | 1817 | 1530 | 853  | 475 | 341 | 356 |
| 1984 | 377 | 987  | 2569 | 1029 | 824  | 1069 | 726  | 615  | 441  | 314 | 277 | 293 |
| 1985 | 372 | 963  | 661  | 428  | 497  | 554  | 555  | 338  | 329  | 252 | 245 | 312 |
| 1986 | 330 | 343  | 551  | 1100 | 3671 | 2288 | 764  | 623  | 361  | 338 | 260 | 318 |
| 1987 | 323 | 275  | 330  | 463  | 751  | 1337 | 455  | 371  | 245  | 270 | 219 | 239 |
| 1988 | 250 | 279  | 1015 | 1045 | 473  | 419  | 426  | 492  | 354  | 247 | 201 | 210 |
| 1989 | 231 | 537  | 397  | 470  | 384  | 2242 | 903  | 455  | 288  | 229 | 223 | 264 |
| 1990 | 414 | 262  | 250  | 680  | 370  | 616  | 327  | 663  | 477  | 257 | 215 | 208 |
| 1991 | 241 | 244  | 225  | 247  | 269  | 981  | 516  | 439  | 263  | 208 | 189 | 191 |
| 1992 | 238 | 226  | 269  | 336  | 1268 | 921  | 635  | 353  | 265  | 244 | 190 | 212 |
| 1993 | 259 | 244  | 650  | 1573 | 1410 | 2167 | 1339 | 914  | 808  | 319 | 260 | 249 |
| 1994 | 311 | 256  | 447  | 458  | 653  | 537  | 382  | 374  | 244  | 185 | 159 | 220 |
| 1995 | 229 | 267  | 396  | 3867 | 1431 | 3904 | 1744 | 1513 | 693  | 416 | 333 | 354 |
| 1996 | 307 | 274  | 786  | 1046 | 2277 | 1527 | 967  | 1053 | 481  | 307 | 284 | 282 |
| 1997 | 330 | 495  | 2299 | 3075 | 1032 | 708  | 621  | 464  | 359  | 276 | 276 | 296 |
| 1998 | 375 | 614  | 667  | 2621 | 3960 | 2100 | 1541 | 1650 | 1322 | 562 | 384 | 381 |
| 1999 | 426 | 768  | 942  | 953  | 1741 | 1590 | 1113 | 799  | 513  | 354 | 321 | 335 |
| 2000 | 373 | 426  | 413  | 1186 | 2500 | 1793 | 1027 | 662  | 439  | 305 | 299 | 347 |
| 2001 | 375 | 337  | 408  | 533  | 924  | 1067 | 585  | 461  | 316  | 273 | 273 | 276 |
| 2002 | 292 | 558  | 1507 | 1477 | 810  | 829  | 650  | 507  | 331  | 272 | 280 | 280 |
| 2003 | 286 | 335  | 1920 | 1845 | 746  | 1015 | 1225 | 1214 | 490  | 321 | 283 | 286 |
| 2004 | 213 | 266  | 672  | 661  | 1372 | 779  | 516  | 391  | 265  | 229 | 188 | 180 |
| 2005 | 245 | 211  | 477  | 600  | 499  | 790  | 600  | 1101 | 441  | 267 | 215 | 202 |
| 2006 | 214 | 290  | 1207 | 1414 | 825  | 1379 | 1752 | 933  | 436  | 299 | 254 | 229 |
| 2007 | 240 | 288  | 479  | 325  | 633  | 517  | 346  | 299  | 212  | 209 | 189 | 191 |

|      |     |     |     |      |      |      |      |     |     |     |     |     |
|------|-----|-----|-----|------|------|------|------|-----|-----|-----|-----|-----|
| 2008 | 235 | 209 | 334 | 576  | 610  | 525  | 369  | 390 | 240 | 184 | 165 | 178 |
| 2009 | 199 | 249 | 244 | 246  | 664  | 1041 | 469  | 613 | 266 | 220 | 177 | 160 |
| 2010 | 263 | 213 | 292 | 928  | 836  | 637  | 734  | 580 | 485 | 254 | 215 | 194 |
| 2011 | 236 | 262 | 826 | 462  | 489  | 1488 | 942  | 725 | 565 | 297 | 222 | 209 |
| 2012 | 228 | 231 | 220 | 298  | 259  | 832  | 773  | 401 | 234 | 186 | 168 | 157 |
| 2013 | 171 | 382 | 918 | 392  | 338  | 415  | 413  | 245 | 213 | 165 | 166 | 164 |
| 2014 | 169 | 171 | 177 | 178  | 284  | 588  | 357  | 203 | 154 | 145 | 143 | 145 |
| 2015 | 179 | 185 | 942 | 314  | 720  | 273  | 219  | 189 | 159 | 146 | 141 | 138 |
| 2016 | 143 | 149 | 308 | 1032 | 562  | 1647 | 484  | 324 | 222 | 176 | 155 | 142 |
| 2017 | 322 | 408 | 758 | 1458 | 2712 | 1251 | 1256 | 626 | 346 | 263 | 222 | 207 |

|              | OCT | NOV | DEC  | JAN  | FEB  | MAR  | APR  | MAY | JUN | JUL | AUG | SEP |
|--------------|-----|-----|------|------|------|------|------|-----|-----|-----|-----|-----|
| Wet          | 338 | 599 | 1372 | 1859 | 1848 | 1719 | 1395 | 962 | 581 | 367 | 300 | 296 |
| Above Normal | 318 | 473 | 808  | 1435 | 1516 | 1491 | 1057 | 792 | 455 | 311 | 266 | 274 |
| Below Normal | 267 | 343 | 520  | 823  | 967  | 952  | 866  | 577 | 374 | 263 | 230 | 227 |
| Dry          | 271 | 389 | 570  | 539  | 821  | 956  | 628  | 479 | 330 | 251 | 226 | 230 |
| Critical     | 254 | 247 | 398  | 452  | 531  | 584  | 414  | 376 | 277 | 214 | 193 | 202 |

On Wed, Apr 17, 2019 at 11:34 AM Evan Sawyer - NOAA Federal <[evan.sawyer@noaa.gov](mailto:evan.sawyer@noaa.gov)> wrote:

Hey Stephen, Kate,

Attached is an excel file of unimpaired, average monthly flow at Red Bluff. Also included is a DWR report in which those flows were calculated.

I'm not totally sure how best to summarize this information (there are limitations given the format but I'm open to suggestions or ideas!) but what I'd like to describe is, generally what un-managed flows are like in the Sac River. This way I can describe how the life history adaptations are (may be) incongruent with water operations. Not sure if including [WYT](#) would be helpful or not. Also if units could be converted to cfs that would be helpful.

Take a look and let's talk,  
Evan

----- Forwarded message -----

From: **Hilts, Derek** <[derek\\_hilts@fws.gov](mailto:derek_hilts@fws.gov)>

Date: Wed, Apr 17, 2019 at 8:53 AM

Subject: Re: [EXTERNAL] Inimpaired Flow Hydrograph

To: Cathy Marcinkevage - NOAA Federal <[cathy.marcinkevage@noaa.gov](mailto:cathy.marcinkevage@noaa.gov)>, <[Evan.Sawyer@noaa.gov](mailto:Evan.Sawyer@noaa.gov)>

Hi Cathy,

Here (attached) is a report DWR put out around 10 years ago with unimpaired flow estimates for WY1922-WY2003.

I pulled out the table for the Sac River near Red Bluff and added more recent years' data per documentation in the attached workbook.

I'll leave it to Evan to decide how he wants to chart the data.

Derek

Derek Hilts M.S., P.E.  
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On Tue, Apr 16, 2019 at 2:33 PM Cathy Marcinkevage - NOAA Federal <[cathy.marcinkevage@noaa.gov](mailto:cathy.marcinkevage@noaa.gov)> wrote:

Hey Derek --

Have you seen, or do yo have an idea of the difficulty in generating, a hydrograph of average unimpaired flow ("full natural flow"?) for the upper Sac, say below Keswick? Evan could find that to be useful so I'm poking to find one.

Thanks -  
Cathy

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