San Joaquin River Restoration Program

Stream Temperature Monitoring Study

Water Year 2012 Annual Report

Final Draft: October 18, 2013

California Department of Fish and Wildlife

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Fresno, CA 93710

INTRODUCTION

Water temperature is likely a limiting factor for each life history stage of Chinook salmon in the San Joaquin River, particularly in the warmest and driest years. Adult salmon need appropriate temperatures for upstream migration, holding, and spawning. Hyporheic water temperatures during egg incubation and pre-emergence rearing are critical to survival. Stream temperatures must also be adequate during juvenile rearing, smoltification, and outmigration. Furthermore, water temperatures in sections of the Restoration Area may present thermal barriers to successful fish migration, resulting in stranding and/or increased mortality. Understanding the longitudinal distribution of temperatures in relation to factors such as stream flow, air temperature, Friant Dam release temperature, and other influences is critical to our ability to successfully manage the San Joaquin River for restoration of Chinook salmon.

The goals of the Study are to monitor and understand the water temperature conditions likely to be experienced by each life stage of spring- and fall-run Chinook salmon in the Restoration Area, and to inform management actions to address temperature concerns in the Restoration Area. The study also provides data for a number of other field and computer modeling studies. Study objectives were developed to address questions about the suitability of current conditions to meet the needs of fish and to test hypotheses related to the influence of external factors on stream temperatures.

The objectives of the study are to:

1. Collect reliable water temperature data at time and space intervals that sufficiently document thermal response of stream temperatures to Interim and Restoration Flows, local meteorological conditions, and restoration actions;

2. Evaluate the temporal and spatial suitability of stream temperatures to support all life stages of spring- and fall-run Chinook salmon in the Restoration Area;

3. Determine the effects on instream temperatures of releases from Millerton Reservoir, tributary flows, agricultural returns, riparian shading, and/or channel morphology;

4. Identify warm- and cold-water inputs that affect temperature conditions in the SJR; and

5. Assess the influence of instream and off-stream pools and mining pits on stream temperatures.

This report presents the results of monitoring during Water Year 2012 (WY 2012), which began October 1, 2011 and ended September 30, 2012. The water year was designated as Dry and the Interim Flow hydrograph was developed by the Restoration Administrator based on Exhibit B of the Settlement and current flow constraints in the river. There were no flood releases or spills from Friant Dam during the year. Actual flow in the river at monitoring sites was dependent on releases from Friant Dam, seepage constraints, rainfall, riparian diversions, water deliveries, and agricultural returns. These factors and their effect on instream flows are discussed in more detail by reach under Results.

SITE DESCRIPTION

During WY 2012, channel capacity restrictions limited flows through Reach 2 to 810 cubic feet per second (cfs), and no Restoration Flows were released below Sack Dam due to concerns of rising groundwater causing seepage of adjacent farmland in Reach 4. In general, Restoration Flows were conveyed through Reaches 1 and 2 and captured in Mendota Pool. Flows in Reach 3, between Mendota Pool and Sack Dam, were deliveries to Arroyo Canal, which varied between 0 and 695 cfs. Flows between Sack Dam and the confluence with the Merced River were caused solely by storm runoff, agricultural returns, and other inflow from sloughs and tributaries.

Fifty-two temperature monitoring sites between Friant Dam and the Merced River confluence were in operation during WY 2012. Of these sites, twenty-seven are located in Reach 1 (twenty in the river and seven in abandoned gravel mining pits connected to the river), four are located in Reach 2, two are located in Reach 3, three are located in Reach 4, seven are located in Reach 5, five are located in the bypass system, and four are located in sloughs and tributaries to the SJR. Although sites are not maintained by California Department of Fish and Wildlife (CDFW), data from an additional five telemetered temperature monitoring locations associated with stream gaging stations were also considered as part of the study. Site information, including site codes, River Mile (RM), location description, and GPS coordinates, is shown in **Table 1**, and a map of study sites is provided in **Figure 1**.

METHODS

Thermographs (HOBO® U22 Water Temp Pro v2) are programmed to record temperature hourly at temperature monitoring sites throughout the Restoration Area. Where possible, thermographs are located within the thalweg of the stream in an area with adequate year-round flow to keep the thermograph submerged. Most thermographs are cabled to trees, root wads, or permanent structures to record temperature approximately 6 inches from the bed along the right or left banks of runs, riffles, and glides. Thermographs deployed in gravel mining pit sites are located in the center of each pit, with two thermographs (one approximately one foot below the water surface and one approximately 18 inches from the bed) on a vertical profiling stringer with weight and buoy.

Field personnel download data from most thermographs monthly or quarterly, depending on the site, when river conditions and staff availability allow. This frequency allows identification and remedy of any problems, such as malfunctioning equipment or missing/vandalized thermographs. Thermographs in areas more prone to vandalism are downloaded more frequently. Some thermographs, particularly in the lower reaches of the river, are only accessible under certain river conditions and may be downloaded less frequently.

A detailed description of procedures and study methods, including equipment calibration and data management procedures, is available in the study Standard Operating Procedures manual (CDFW, 2013).

RESULTS

Study results are presented in this report as figures that interpret the data as it relates to temperature objectives for the San Joaquin River, as outlined in Table 3-1 in Exhibit A of the Fisheries Management Plan (SJRRP, 2010) and reproduced in **Figure 2**, and analysis focuses around the study objectives outlined above. Hourly temperature data for the water year is also available for download by interested parties on the Program web site (www.restoresjr.net).

For each monitoring location, daily average temperature was plotted and compared to fisheries management objectives for the San Joaquin River (See **Figures 3** through **52)**. The "Target Water Temperature" in the plot represents relevant "optimal" temperature objectives described in the Fisheries Management Plan (SJRRP, 2010), based on the life stages expected to be present in the reach during each month of year. The graphs also include daily average streamflow and air temperature at the nearest California Data Exchange Center (CDEC) monitoring station, allowing assessment of the effects of these factors on instream temperatures.

Temperature objectives in Reach 1 are dependent on time of year and life history stage, and include keeping temperatures below management targets for adult migration, adult holding (spring-run), spawning, incubation and emergence, and juvenile rearing and outmigration. Temperature objectives in Reaches 2 through 5 include targets for adult migration and juvenile rearing and outmigration. In general, sites nearer to Friant Dam maintained temperatures below objectives for more of the year than sites further downstream.

Figure 53 shows the number of days during the expected spawning period (August through December, 2011) that daily average stream temperature at Reach 1 sites was below objectives for incubation and emergence. In general, the nearer a site is to Friant Dam, the more days temperatures were below critical (14.4 °C) and lethal (15.6 °C) temperature thresholds. However, the trend was opposite when compared to objectives for optimal (≤13 °C) incubation temperatures; the River Bend (RM 259.9) and Gravelly Ford (RM 231.2) sites had "optimal" temperatures for the greatest number of days. This was largely due to water releases from Friant Dam being greater than 13 °C, but water cooling as it moves downstream in the winter when air temperatures are low.

Figure 54 shows the number of days during the spring-run migration period (March through June) that temperatures were below objectives for adult migration at monitoring sites in Reaches 1-5, and **Figure 55** shows the number of days during the juvenile outmigration period (January through June) that temperatures were below objectives for juvenile outmigration. In general, sites in Reaches 4 and 5 becoming limiting for adult and juvenile migration sooner in the year than in Reaches 1 and 2, as shown by fewer days meeting temperature management objectives in the lower reaches.

Streamflow had a notable effect on water temperatures in Reaches 1 and 2 during WY 2012. The spring pulse flow in early May 2012 increased streamflow from 350 cfs to 1100 cfs for two weeks decreased instream temperatures in the river between about Lost Lake and San Mateo crossing. This temperature decrease extended the duration of optimal temperatures for adult migration in Reach 1 between the Willow Unit (RM 260.9) and Donny Bridge (RM 240.6). Instream temperature at sites upstream of Lost Lake was similar to Friant Dam release temperatures and showed little variation due to changes in flow. By the time pulse flows reached San Mateo Crossing, flows were limited to around 750 cfs due to attenuation, seepage into groundwater, and riparian diversions. This, as well as backwater effects of Mendota Pool, caused temperatures downstream of San Mateo crossing to not be notably reduced by the increased flows. Similarly, a decrease in Friant Dam releases from 350 cfs to 185 cfs in September showed a spike in water temperatures through Reaches 1 and 2.

Figure 56 shows the longitudinal distribution of monthly average stream temperatures as water flows downstream from Friant Dam to the Merced River confluence. For each site, monthly average temperatures are plotted for the period of record at each site; therefore, some points represent more years of data than others. The graph displays variation between sites and times of year, shows differences in the rate of change in temperature as water moves downstream during each month, and allows the identification of warm- and cold-water inputs. Monthly temperature variation is lowest near Friant Dam and increases rapidly as water flows downstream. Notable variations in water temperature likely due to tributary or groundwater inflow are evident at Lost Lake, near Skaggs Park, and at Salt and Mud sloughs. Thermal effects of backwater areas, including substantial warming during summer months, can be seen through the gravel pits in Reach 1 and at Mendota Pool. The same data is shown in **Figure 57** with increased resolution through the gravel pits (RM 250 through RM 257) to further demonstrate the effects of these backwater areas on instream temperatures.

Comparing average water temperature at the upstream- and downstream-most sites of each reach shows that most temperature change occurs in Reach 1 of the Restoration Area. As water flows through Reach 1 between Friant Pool (RM 267.2) and Gravelly Ford (RM 231.2), average monthly change in temperature varies from -0.05 °C per RM in December to +0.42 °C per RM in August, with an average of +0.19 °C per RM for all months. Through Reach 2 between Gravelly Ford (RM 231.2) and Mendota Pool (RM 204.5), average monthly change in temperature varies from -0.09 °C per RM in December to +0.06 °C per RM increase in August, with an average of 0.00 °C per RM for all months. Temperature change trends in Reaches 3 through 5 showed increases or decreases of less than 0.1 °C per RM for all months.

In comparison to all of Reach 1, temperature differences between monitoring sites upstream (Sportsmen's Club, RM 256.4) and downstream (Sycamore Island, RM 251.0) of the gravel pits varied from -0.02 °C per RM in January to +0.90 °C per RM in September, with an average of +0.35 °C per RM. Additionally, although Reach 5 showed little temperature variation between upstream- and downstream-most sites, monitoring sites upstream and downstream of Salt and Mud sloughs showed effects of tributary inflows, typically a localized decrease in instream temperature. Temperature change between Above Salt Slough (RM 131.0) and Below Salt Slough (RM 130) varied between -4.02 °C per RM in December to +0.01 °C per RM in January, with an average of -1.20 °C per RM. Temperature change between sites above (Above Mud Slough, RM 125) and below (Newman Wasteway, RM 121) varied from -2.98 °C per RM in June to +1.30 °C per RM increase in November, with an average change of -0.41 °C per RM.

DISCUSSION

It is difficult to use the results of WY 2012 temperature monitoring downstream of Reach 2 to predict future temperatures in a restored river, due to no passage of Restoration flows around Mendota Pool and zero flow releases below Sack Dam. However, temperatures measured in Reach 1 and 2 are likely typical of what might be experienced in a Dry year type after restoration, albeit with a reduced spring pulse flow (1,100 cfs peak flow compared to a Settlement hydrograph peak of 1,500 cfs).

CDFW intends to continue temperature monitoring through the Interim Flow period and after full Restoration Flows commence. This long-term dataset will provide information on the effects of restoration, channel improvements, and habitat enhancements on instream temperature throughout the Restoration Area, and will allow for development and/or calibration of water temperature and ecological models.

Table 1: Temperature monitoring sites in the SJRRP Restoration Area during WY 2012

Site ID	Site Name	Site Type	Reach	River Mile	Latitude	Longitude	Notes from WY 2012
FWQ	San Joaquin River at Friant Dam	Stream	1	267.4	36.999300	-119.706100	Data from CDEC; site operated by USBR
SJRFP	SJR Friant Pool	Stream	1	267.2	36.997014	-119.707928	
SJRCC	SJR Cottonwood Creek	Stream	1	267.0	36.997626	-119.707626	Data lost 10/1/2011 - 12/28/2011 due to vandalism and 7/6/2012 - 9/12/2012 due to equipment malfunction
SJRFB	SJR Friant Bridge	Stream	1	266.6	36.990005	-119.715041	Data lost 7/6/2012 - 8/19/2012 due to equipment malfunction
SJRLL	SJR Lost Lake	Stream	1	264.7	36.968959	-119.740406	
SJRBRB	SJR Ball Ranch Bridge	Stream	1	262.2	36.944150	-119.738780	Thermograph out of water 6/21/2012 - 8/7/2012
SJRWU	SJR Willow Unit	Stream	1	260.9	36.929038	-119.750988	
SJRRB	SJR River Bend	Stream	1	259.5	36.919794	-119.759333	
SJRRI	SJR Rank Island	Stream	1	259.5	36.916964	-119.755812	Data lost 10/1/2011 - 3/1/2012 due to equipment malfunction
SJRV2	SJR Vulcan	Stream	1	258.0	36.910087	-119.774741	Data lost 7/6/2012 - 9/12/2012 due to equipment malfunction.
SJRSC	SJR Sportsman Club	Stream	1	256.4	36.887079	-119.787061	
SJRGPA, 1&2	SJR Gravel Pit A, 1 (Surface) and 2 (Depth)	Gravel Pit	1	254.1	36.866189	-119.802889	
SJRGPB, 1&2	SJR Gravel Pit B, 1 (Surface) and 2 (Depth)	Gravel Pit	1	254.1	36.866953	-119.807592	Data missing 12/19/2011 - 1/5/2012 due to equipment malfunction
SJRGPAB	SJR Gravel Pit AB	Stream	1	254.0	36.865447	-119.807222	Data lost 12/20/2011 - 1/4/2012 due to equipment malfunction
SJRGPC, 1&2	SJR Gravel Pit C, 1 (Surface) and 2 (Depth)	Gravel Pit	1	253.5	36.861394	-119.812208	C2 installed 1/5/12; formerly one logger mid-depth. Data lost 5/31/12-9/19/12 due to vandalism
SJRGPCD	SJR Gravel Pit CD	Stream	1	253.5	36.861250	-119.809897	Data lost 12/20/2011 - 1/4/2012 due to equipment malfunction
SJRGPD, 1&2	SJR Gravel Pit D, 1 (Surface) and 2 (Depth)	Gravel Pit	1	253.5	36.860939	-119.808197	No data prior to 9/19/2012 due to vandalism
SJRGPE, 1&2	SJR Gravel Pit E, 1 (Surface) and 2 (Depth)	Gravel Pit	1	253.2	36.855669	-119.807275	Data lost 12/16/2011 - 1/5/2012 due to equipment malfunction
SJRGPDE	SJR Gravel Pit DE	Stream	1	253.1	36.857500	-119.807836	Data lost 12/20/2011 - 1/4/2012 due to equipment malfunction
SJRGPF-US, 1&2	SJR Gravel Pit F-upstream, 1 (Surface) and 2 (Depth)	Gravel Pit	1	252.5	36.850678	-119.818169	Data lost 12/20/2011 - 1/4/2012 due to equipment malfunction and 7/16/2012 - 9/30/2012 due to vandalism
SJRGPF-DS, 1&2	SJR Gravel Pit F-downstream 1 (Surface) and 2 (Depth)	Gravel Pit	1	252.4	36.850622	-119.821075	Site established 1/5/2012. Data lost 2/27/2012 - 7/16/2012 and 8/15/2012-9/19/0212 due to equipment malfunction
SJRGPF Outlet	SJR Gravel Pit F River Outlet	Stream	1	252.4	36.848956	-119.821114	Data lost 12/20/2011 - 1/4/2012 due to equipment malfunction
SJRSIDS	SJR Downstream Sycamore Island	Stream	1	251.0	36.854950	-119.836533	Site established 1/5/2012
SJRSCI	SJR Scout Island	Stream	1	249.9	36.858283	-119.838700	
SJRMU	SJR Milburn Unit	Stream	1	247.5	36.856795	-119.879497	
SJRCP	SJR Camp Pashayan	Stream	1	243.1	36.843890	-119.932460	
DNB	San Joaquin River at Donny Bridge	Stream	1	240.6	36.833500	-119.965800	Data from CDEC; site operated by USBR
SJRSP	SJR Skaggs Park	Stream	1	234.0	36.821487	-120.060451	Data lost 1/3/2012 - 9/11/2012 due to vandalism
SJRGF	SJR Gravely Ford	Stream	1	231.2	36.817392	-120.096427	
GRF	San Joaquin River at Gravelly Ford	Stream	1	227.5	36.798000	-120.160000	Data from CDEC; site operated by USBR
SJRTHOMAS	SJR Thomas	Stream	2	229.1	36.809300	-120.136000	Site managed by contractors of USBR
SJRDSALISO	SJR Aliso Canal	Stream	2	222.1	36.786500	-120.221400	Site managed by contractors of USBR
SJRDSBIFUR	SJR Bifurcation	Stream	2	215.7	36.773361	-120.283481	Site managed by contractors of USBR
SJRSM	SJR San Mateo	Stream	2	211.9	36.781504	-120.311895	
MWA	Mendota Wildlife Area (Fresno Slough)	Slough	NA	NA	36.732747	-120.342753	
SJRDSM	SJR Downstream Mendota	Stream	3	203.5	36.810458	-120.369211	Thermograph out of water 5/6/2012 - 5/19/2012
CBAVE12	Chowchilla Bypass @ Ave 12	Bypass	NA	NA	36.872048	-120.318497	No flow in WY 2012
CBAVE14	Chowchilla Bypass @ Ave 14	Bypass	NA	NA	36.952549	-120.350575	No flow in WY 2012
SJRFIRE	SJR at Firebaugh Bridge	Stream	3	195.1	36.858058	-120.449094	Site managed by contractors of USBR
SDP	San Joaquin River near Dos Palos (Sack Dam)	Stream	4	181.2	36.994000	-120.501500	Data from CDEC; site operated by DWR

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Table 1: Temperature monitoring sites in the SJRRP Restoration Area during WY 2012 (contd.)

Site ID	Site Name	Site Type	Reach	River Mile	Latitude	Longitude	Notes from WY 2012
SJRUSHWY152	SJR Highway 152	Stream	4	174.0	37.055186	-120.548156	Site managed by contractors of USBR
ESB	Eastside Bypass	Bypass	NA	NA	37.205741	-120.698007	No flow in WY 2012
ESBWB	Eastside Bypass at Washington Bridge	Bypass	NA	NA	37.113267	-120.562547	No flow in WY 2012
SJRSS	SJR Sand Slough Control Structure	Stream	4	168.3	37.113446	-120.587681	No WY 2012 data prior to 12/22/2011
MB	Mariposa Bypass	Bypass	NA	NA	37.201893	-120.705739	No flow in WY 2012
SJRUSCBC	Bear Creek Confluence	Stream	4	136.4	37.274992	-120.827567	Site managed by contractors of USBR
BCCSJR	Bear Creek	Tributary	NA	NA	37.277936	-120.824086	Site managed by contractors of USBR
SJRSTV	SJR Stevenson Bridge (Hwy 165)	Stream	5	132.8	37.295378	-120.851287	Data lost 1/19/2010 - 3/2/2012 due to bridge replacement
SJRASALT	SJR Above Salt Slough	Stream	5	131.0	37.294694	-120.894833	Data lost 2/19/2012 - 3/1/2012 due to equipment malfunction
SALTS	Salt Slough	Slough	NA	NA	37.294045	-120.898787	Data lost 1/31/2012 - 3/2/2012 due to equipment malfunction
SJRBSALT	SJR Below Salt Slough	Stream	5	130.0	37.294056	-120.898806	Data lost 1/31/2012 - 3/2/2012 due to equipment malfunction
SJRFFB	Ford Fremont Bridge (Hwy 140)	Stream	5	127.0	37.318500	-120.934861	Data lost 1/31/2012 - 3/2/2012 due to equipment malfunction
SJRAMUD	Above Mud Slough	Stream	5	125.0	37.331583	-120.949806	Data lost 2/18/2012 - 5/15/2012 and 6/2/2012 - 12/20/2012 due to equipment malfunction
MUDSL	Mud Slough	Slough	NA	NA	37.294045	-120.898787	
SJRNW	SJR Newman Wasteway	Stream	5	121.0	37.333917	-120.952550	Data lost 1/31/2012 - 3/2/2012 due to equipment malfunction
SJRHF	SJR Hills Ferry	Stream	5	118.5	37.346950	-120.976110	Site managed by LaGrange CDFW staff
SMN	San Joaquin at Newman	Stream	5	118.4	37.347214	-120.976181	Data from CDEC, site operated by USGS

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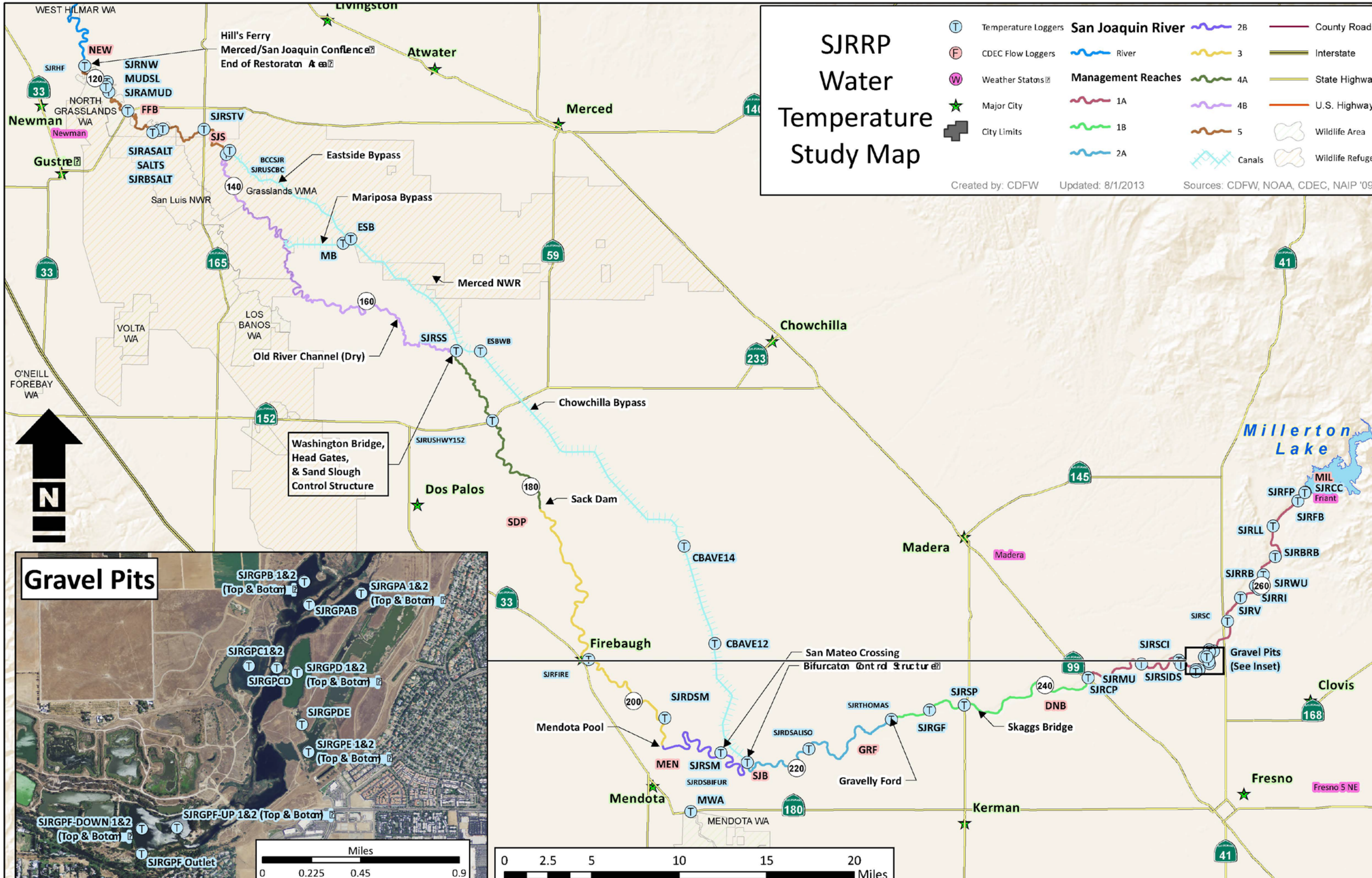

Figure 1: Locations of temperature monitoring sites in the SJRRP Restoration Area

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<table>
<tr><th colspan="13">Spring-Run and Fall-Run Chinook Salmon</th></tr>
<tr><th>Life Stage</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>June</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Adult Migration</td><td></td><td></td><td colspan="4">Optimal: <u><</u> 59°F (15°C)
Critical: 62.6 – 68°F (17 – 20°C)
Lethal: >68°F (20°C)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Adult Holding (Spring-Run Only)</td><td></td><td></td><td></td><td colspan="6">Optimal: <u><</u>55°F (13°C)
Critical: 62.6 – 68°F (17 – 20°C)
Lethal: >68°F (20°C)</td><td></td><td></td><td></td></tr>
<tr><td>Spawning</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Optimal: <u><</u> 57°F (13.9°C)
Critical: 60 – 62.6°F (15.5 – 17°C)
Lethal: 62.6°F or greater (17°C)</td><td></td><td></td></tr>
<tr><td>Incubation and Emergence</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="5">Optimal: <u><</u>55°F (13°C)
Critical: 58 – 60°F (14.4 – 15.6°C)
Lethal: >60°F (15.6°C)</td></tr>
<tr><td>In-River Fry/Juvenile</td><td colspan="12">Optimal: <u><</u>60°F (15.6°C), young of year rearing; <u><</u>62.6°F (18°C), late season rearing (primarily spring-run)
Critical: 64.4 – 70°F (18-21.1°C)
Lethal: >75 °F (23.9°C), prolonged exposure</td></tr>
<tr><td>Floodplain Rearing*</td><td colspan="12">Optimal: 55 – 68°F (13 – 20°C), unlimited food supply</td></tr>
<tr><td>Outmigration</td><td colspan="6">Optimal: <u><</u>60°F (15.6°C)
Critical: 64.4 – 70°F (18 – 21.1°C)
Lethal: >75°F (23.9°C), prolonged exposure</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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Sources: EPA 2003, Rich 2007, Pagliughi 2008, Gordus 2009.

Figure 2: Monthly Water Temperature Objectives for the San Joaquin River Restoration Program (from SJRRP 2010)

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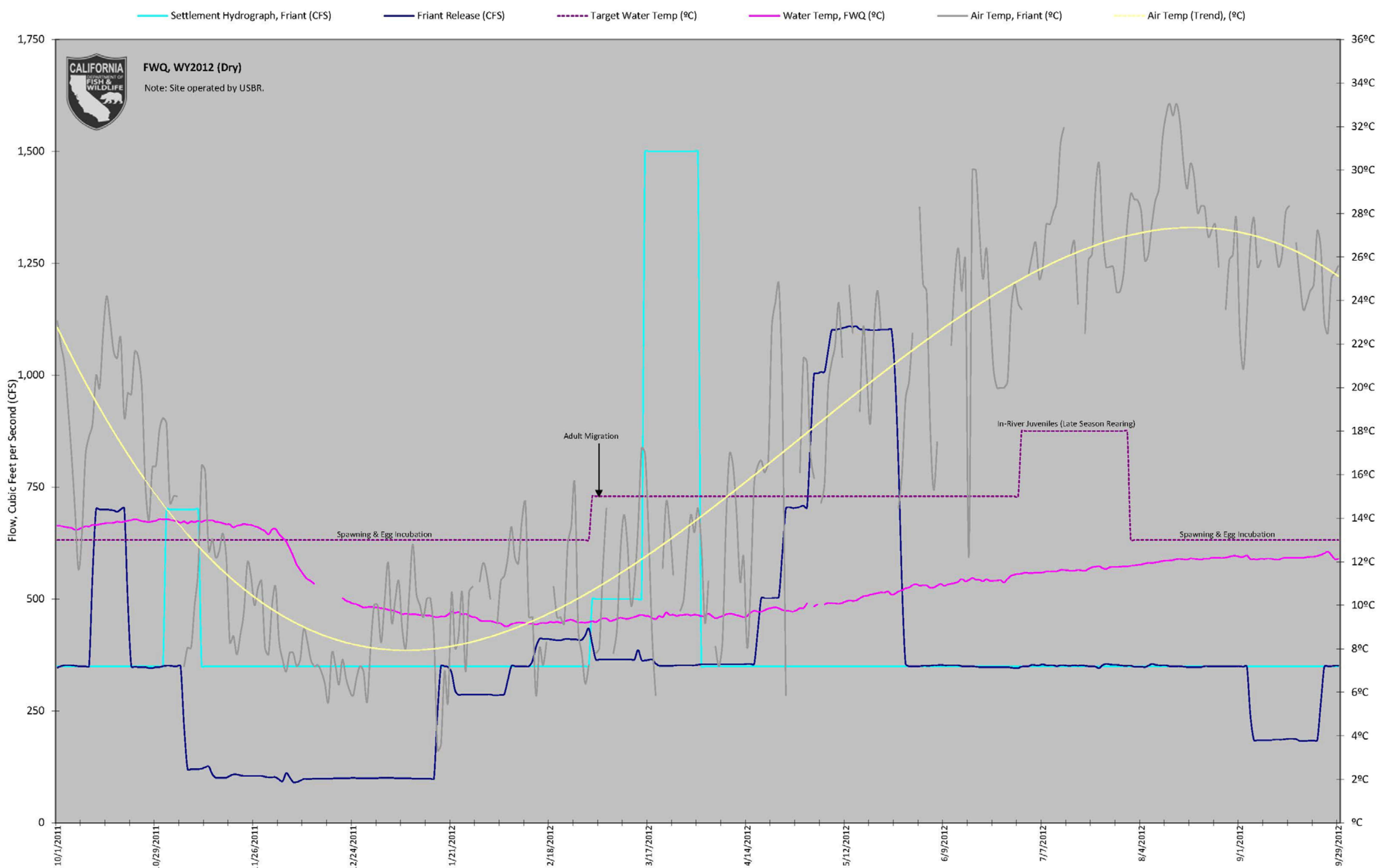

Figure 3: Daily average temperature at Friant Water Quality (Friant Dam Release Temperature) compared with to stream flow and air temperature

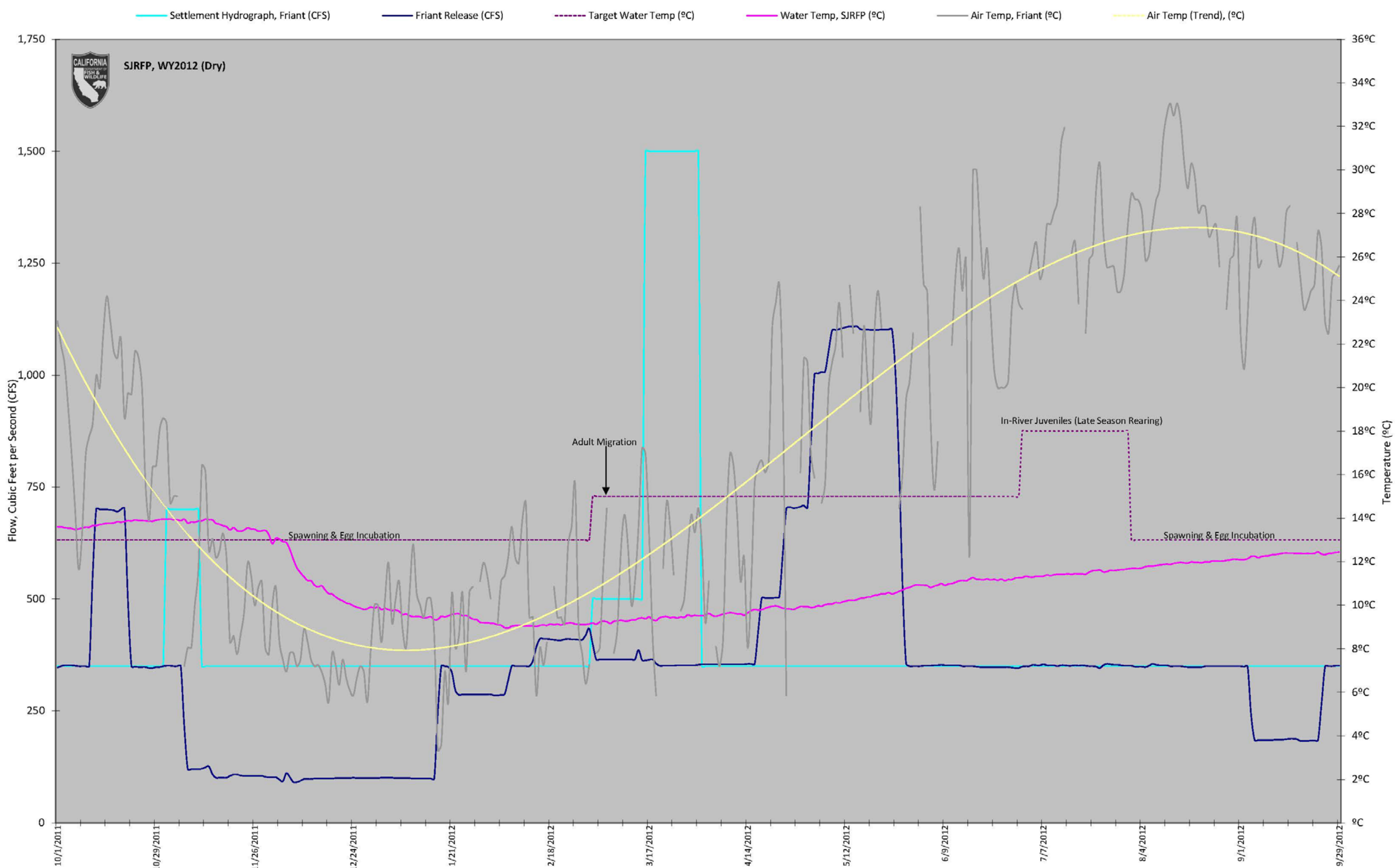

Figure 4: Daily average temperature at the San Joaquin River at Friant Pool (River Mile 267.2) compared with stream flow and air temperature

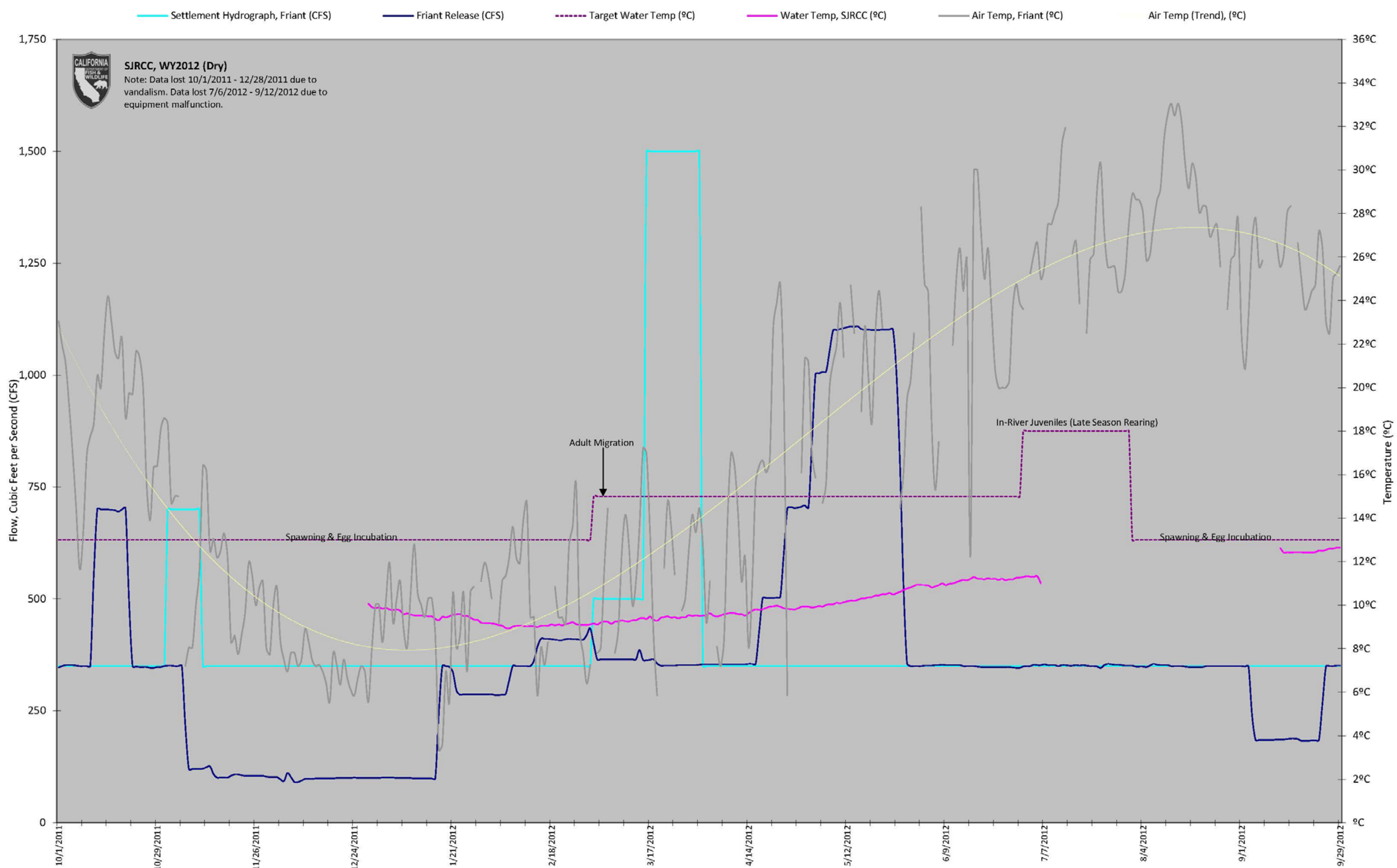

Figure 5: Daily average temperature at the San Joaquin River at the confluence with Cottonwood Creek (River Mile 267.0) compared with stream flow and air temperature

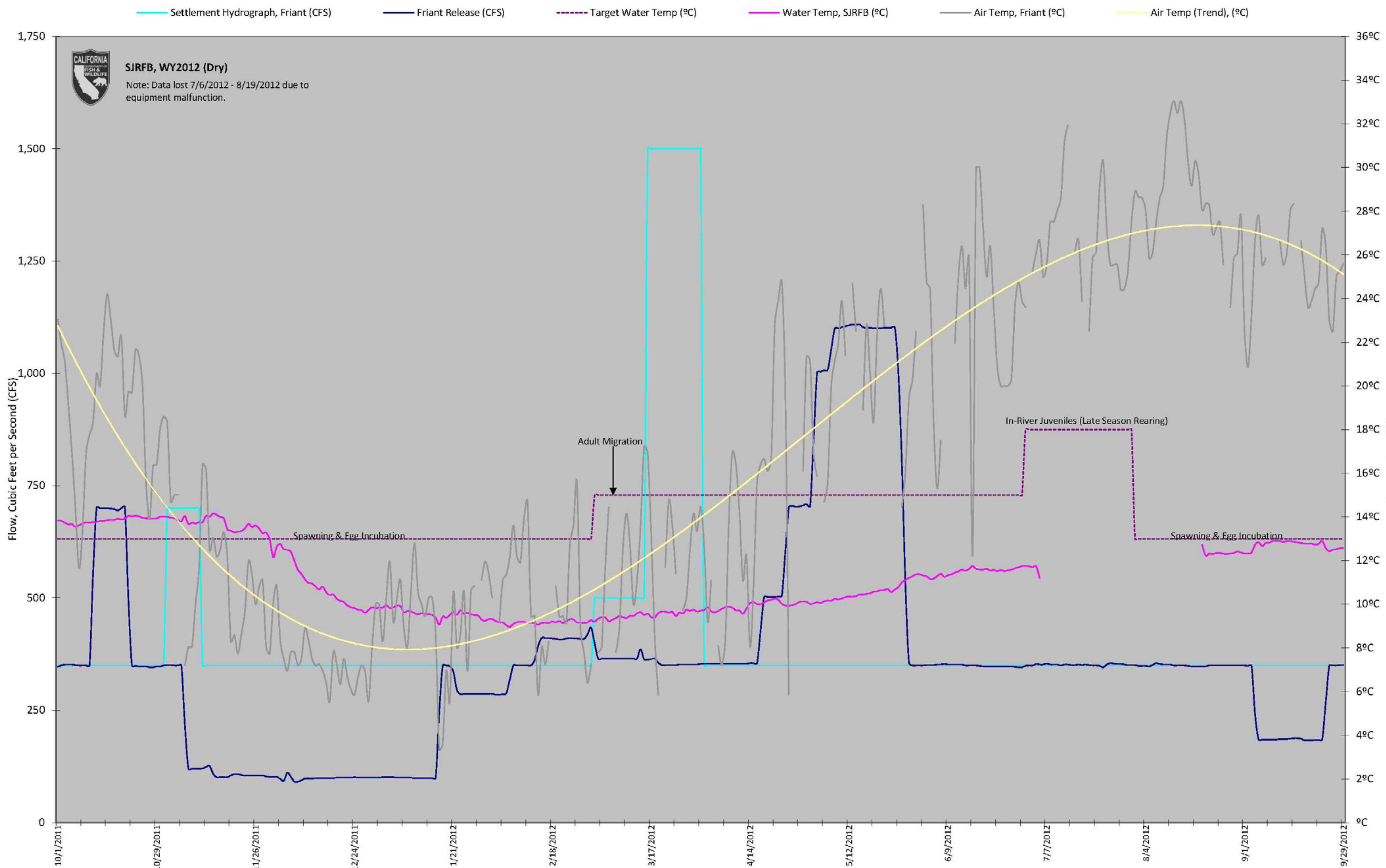

Figure 6: Daily averag5e temperature at the San Joaquin River at Friant Bridge (River Mile 266.6) compared with stream flow and air temperature

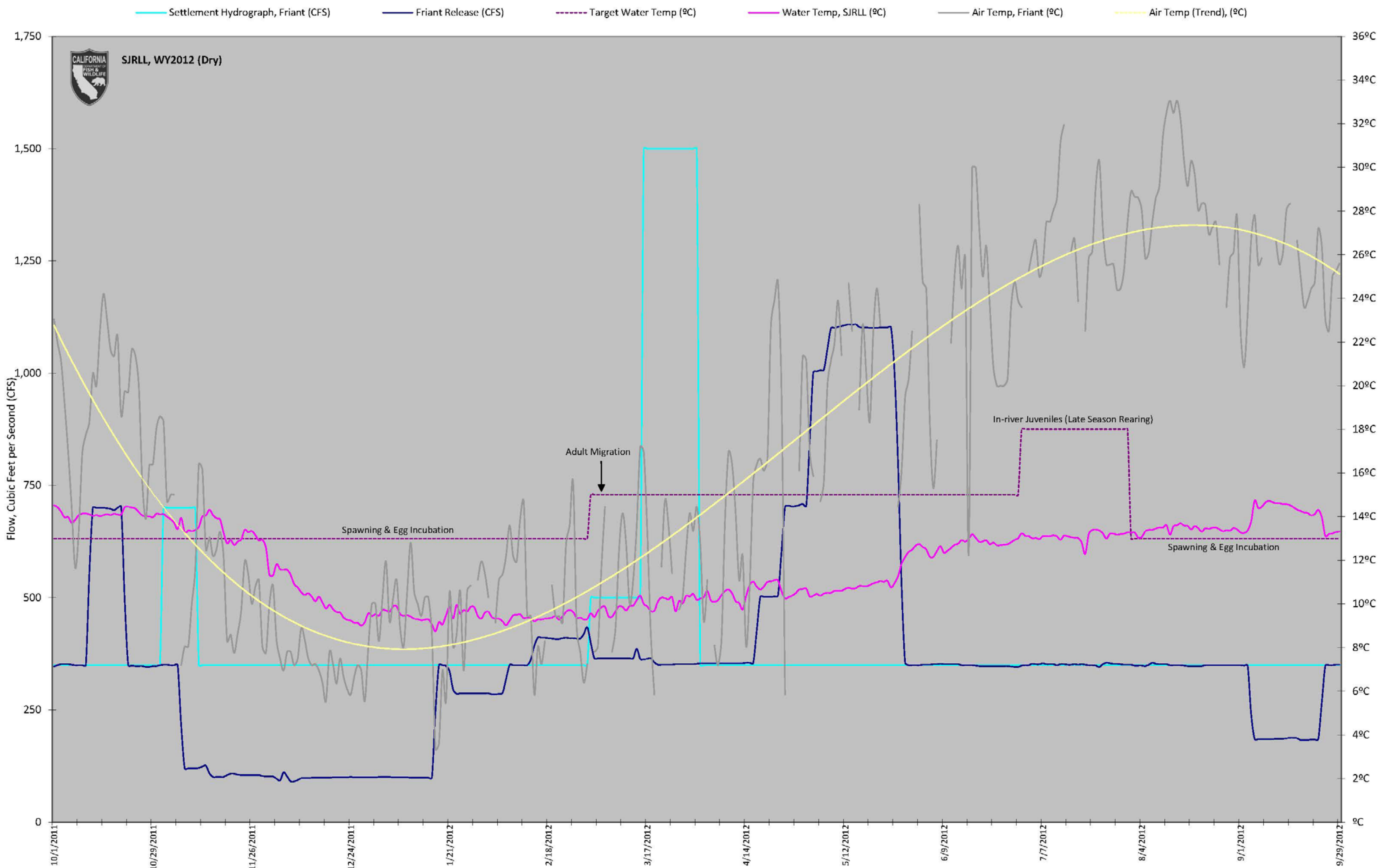

Figure 7: Daily average temperature at the San Joaquin River at Lost Lake (River Mile 264.7) compared with stream flow and air temperature

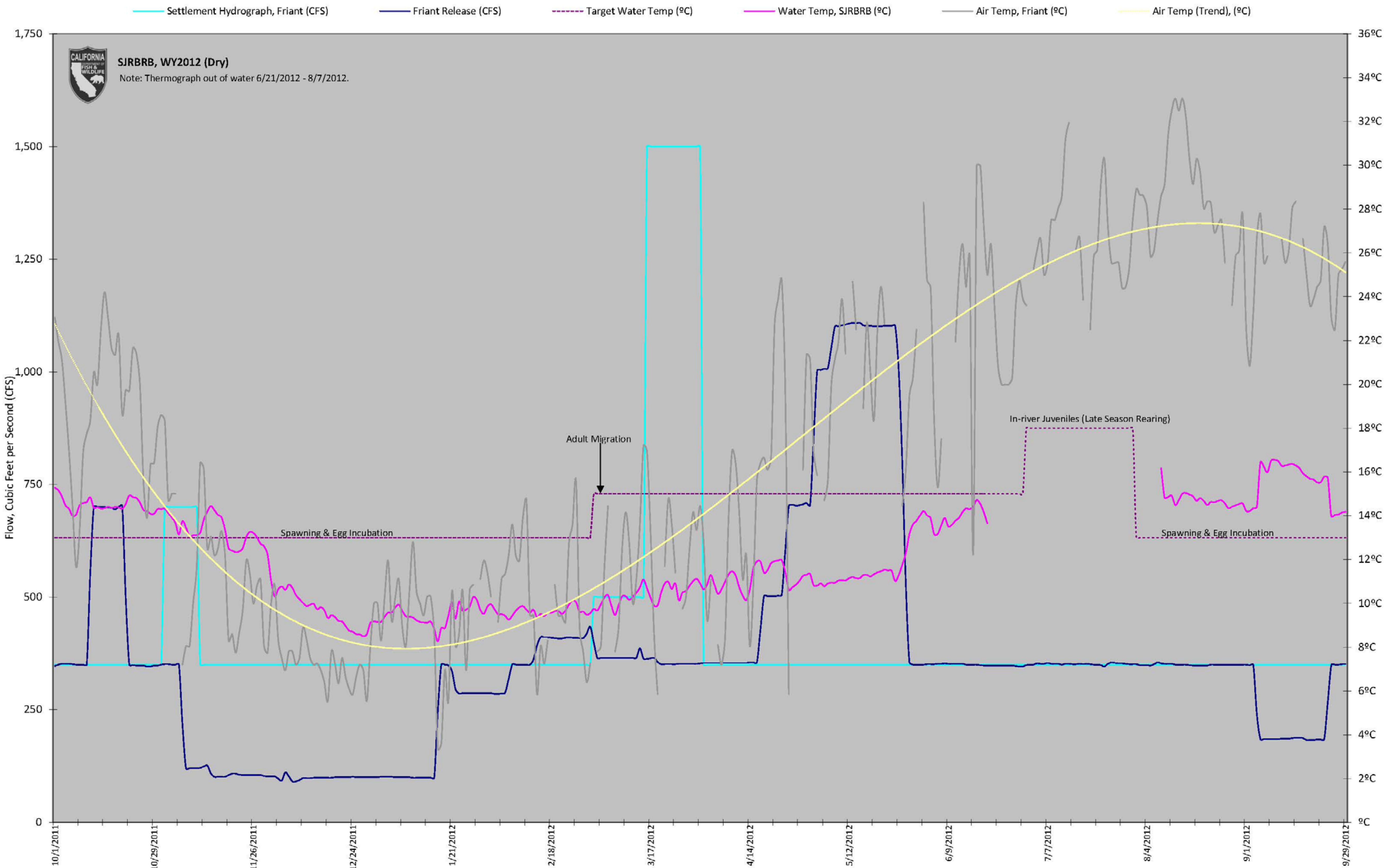

Figure 8: Daily average temperature at the San Joaquin River at Ball Ranch Bridge (River Mile 262.2) compared with stream flow and air temperature

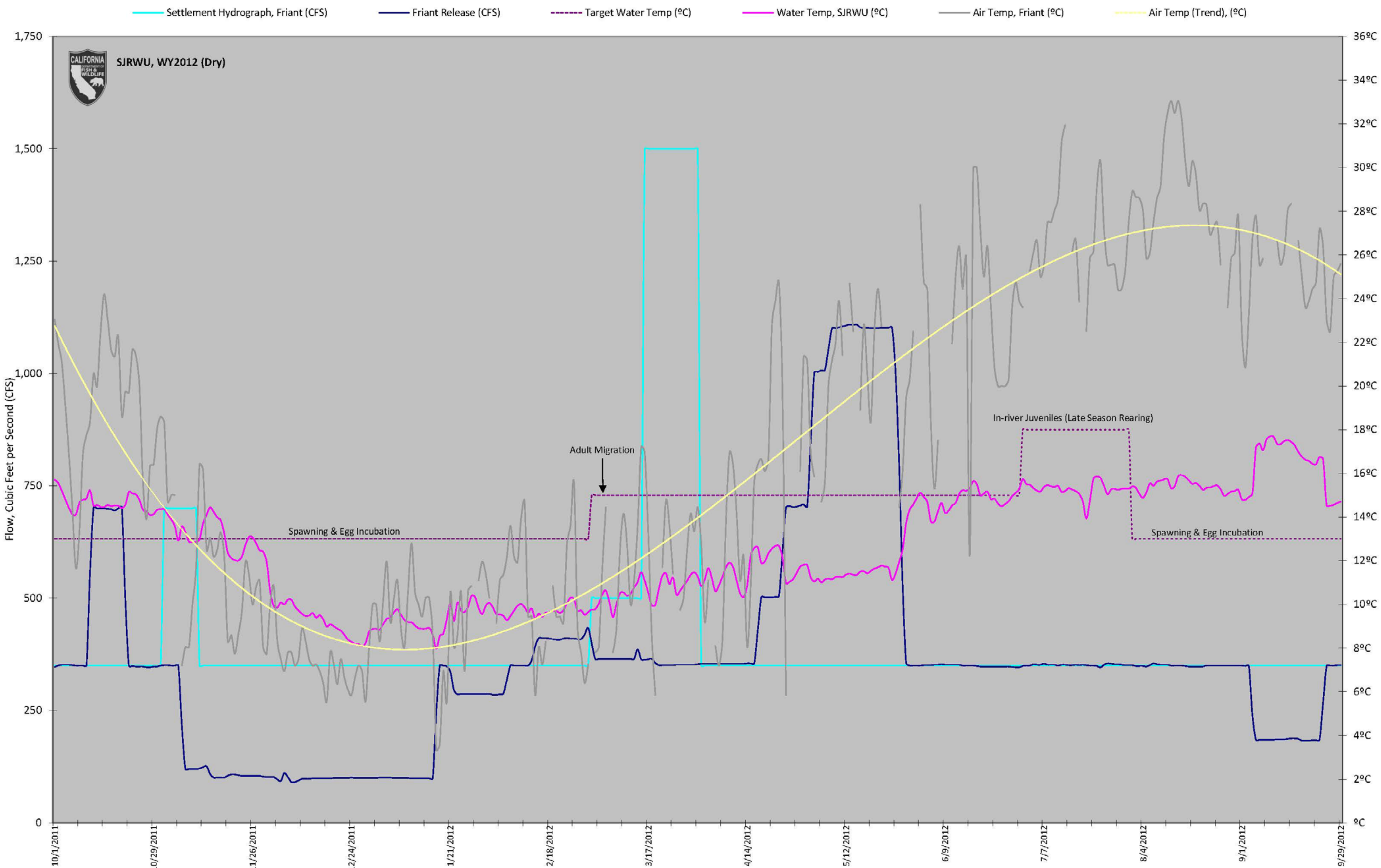

Figure 9: Daily average temperature at the San Joaquin River at Willow Unit (River Mile 260.9) compared with stream flow and air temperature

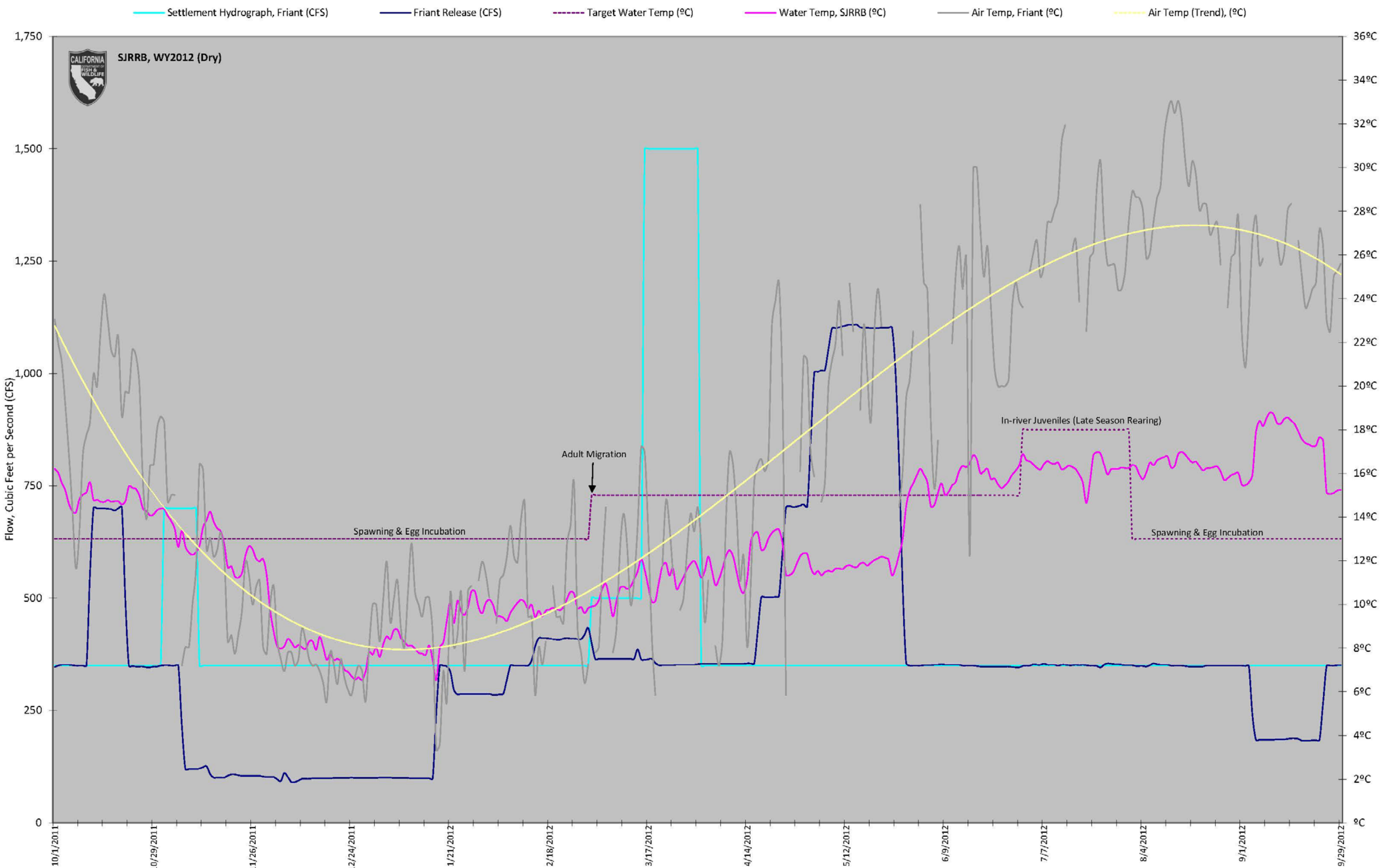

Figure 10: Daily average temperature at the San Joaquin River at River Bend (River Mile 259.5) compared with stream flow and air temperature

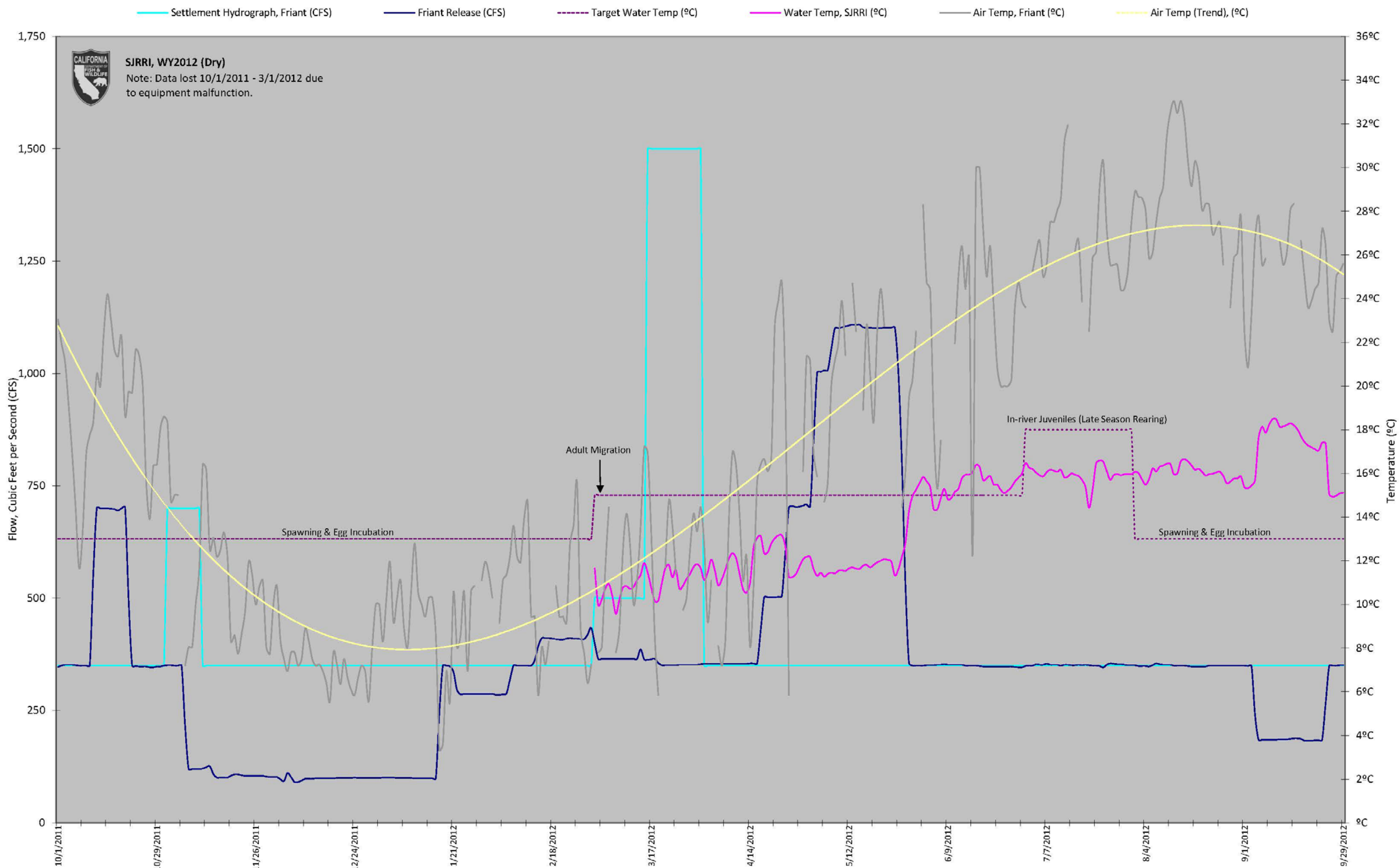

Figure 11: Daily average temperature at the San Joaquin River at Rank Island (River Mile 259.5) compared with stream flow and air temperature

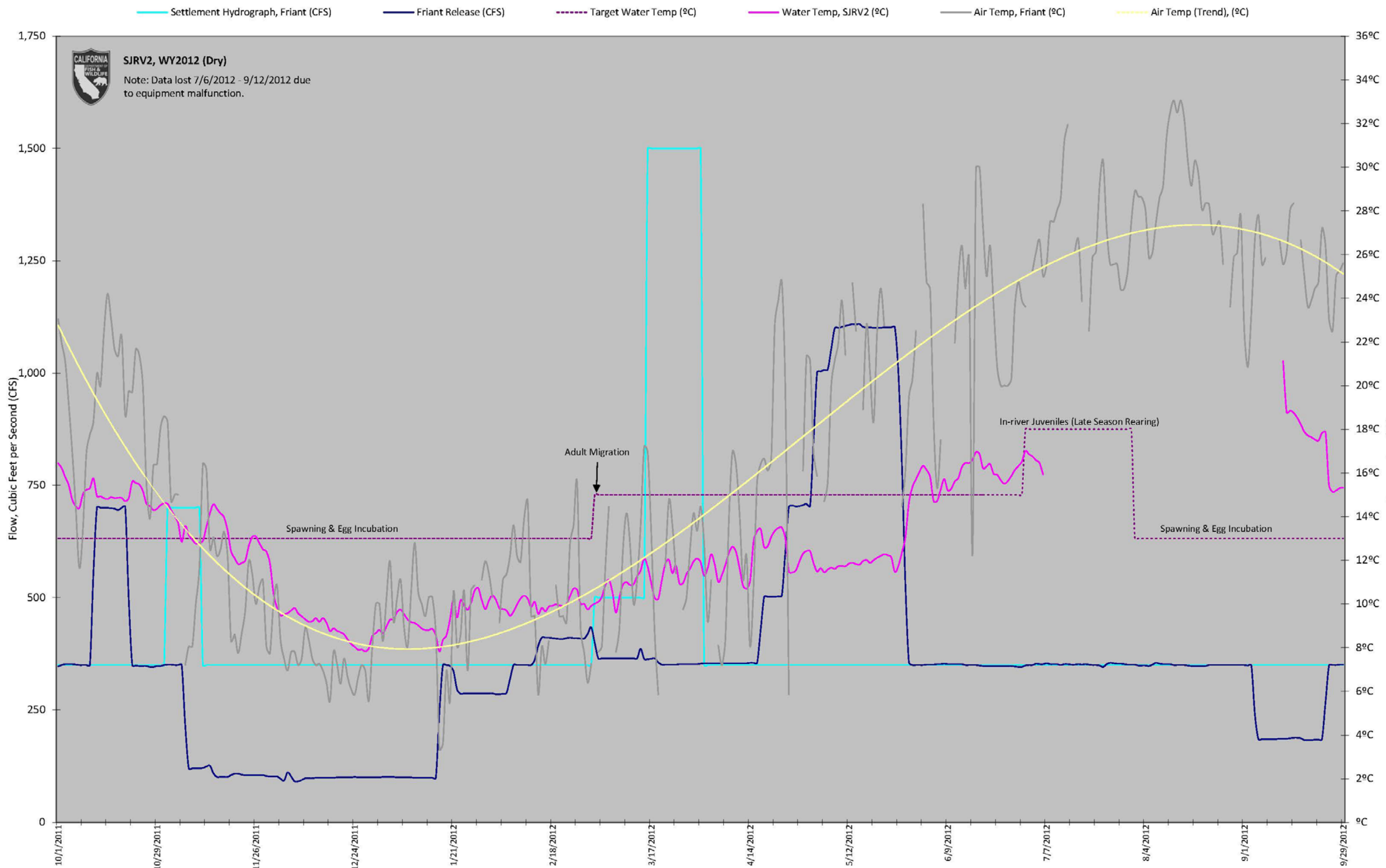

Figure 12: Daily average temperature at the San Joaquin River at Vulcan (River Mile 258.0) compared with stream flow and air temperature

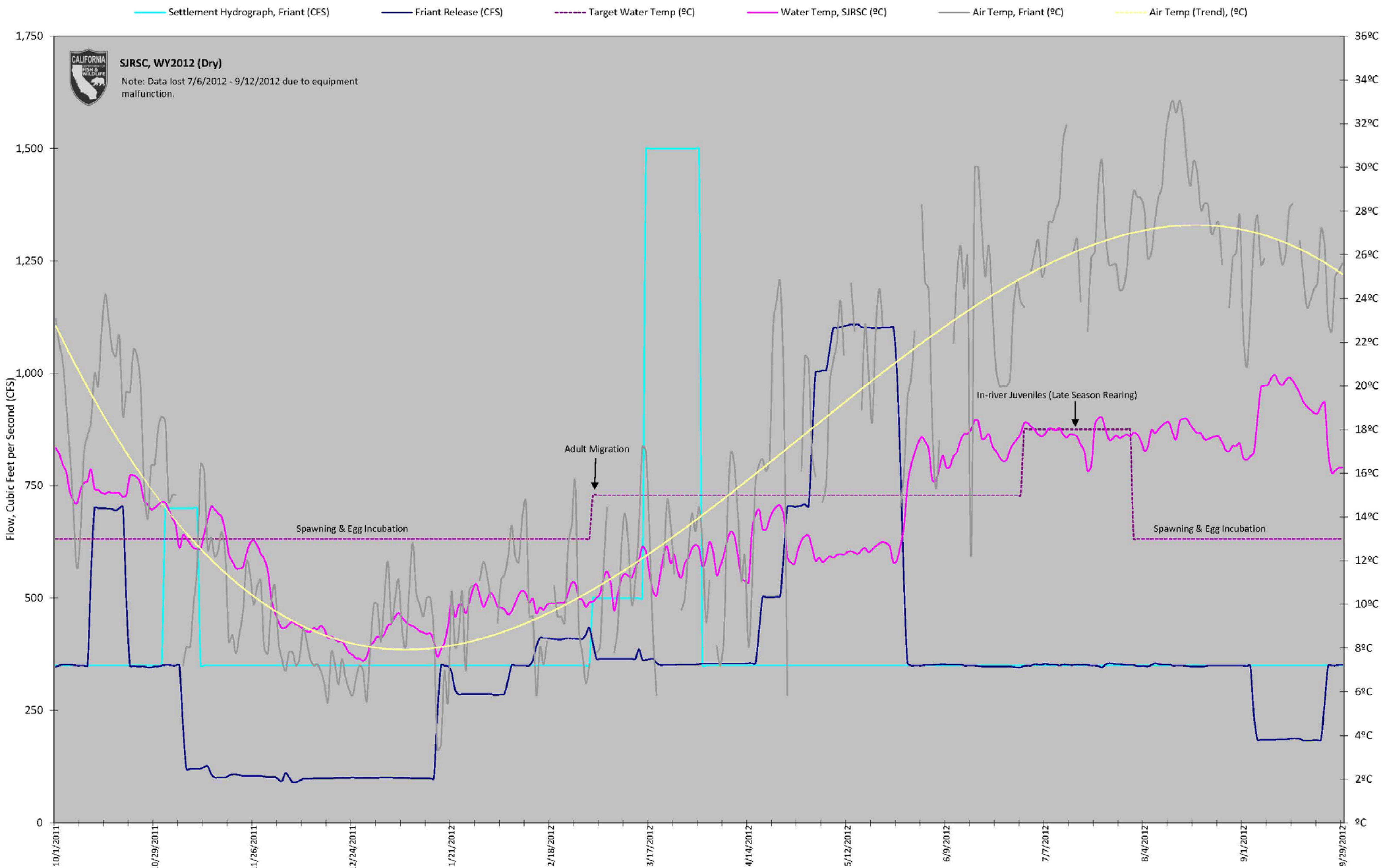

Figure 13: Daily average temperature at the San Joaquin River at Sportsman Club (River Mile 256.4) compared with stream flow and air temperature

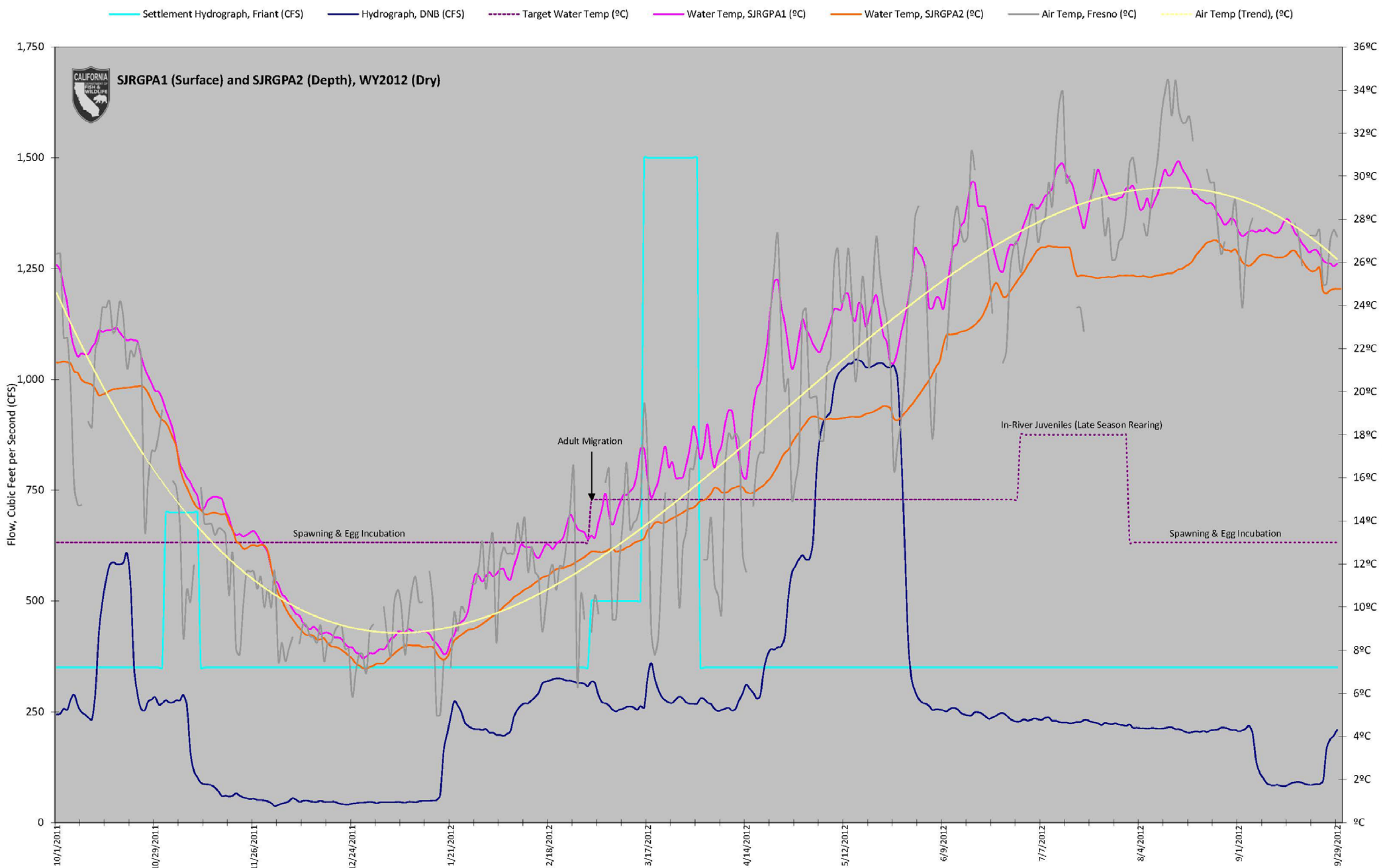

Figure 14: Daily average temperature at the San Joaquin River in Gravel Pit A (River Mile 254.1) compared with stream flow and air temperature

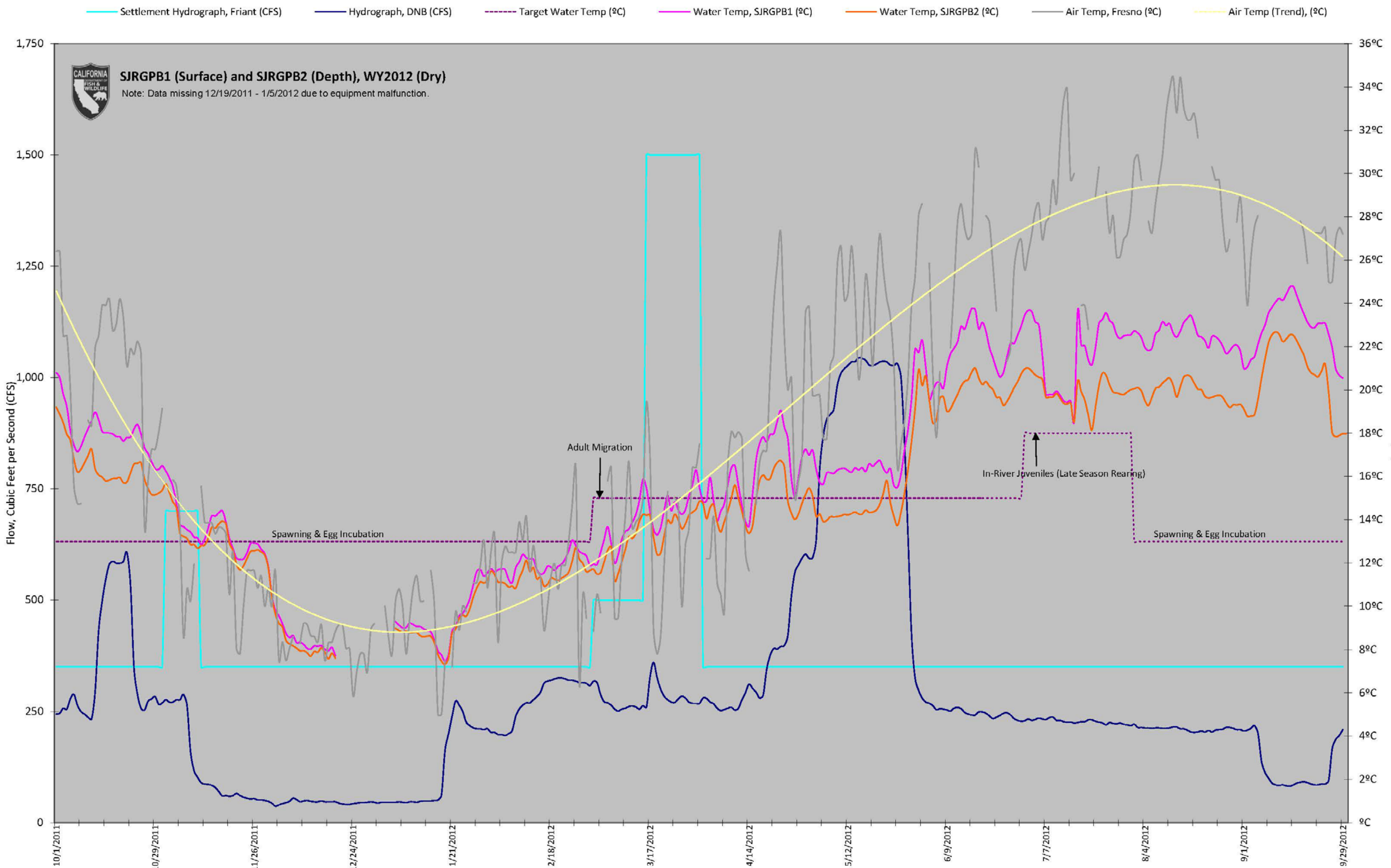

Figure 15: Daily average temperature at the San Joaquin River in Gravel Pit B (River Mile 254.1) compared with stream flow and air temperature

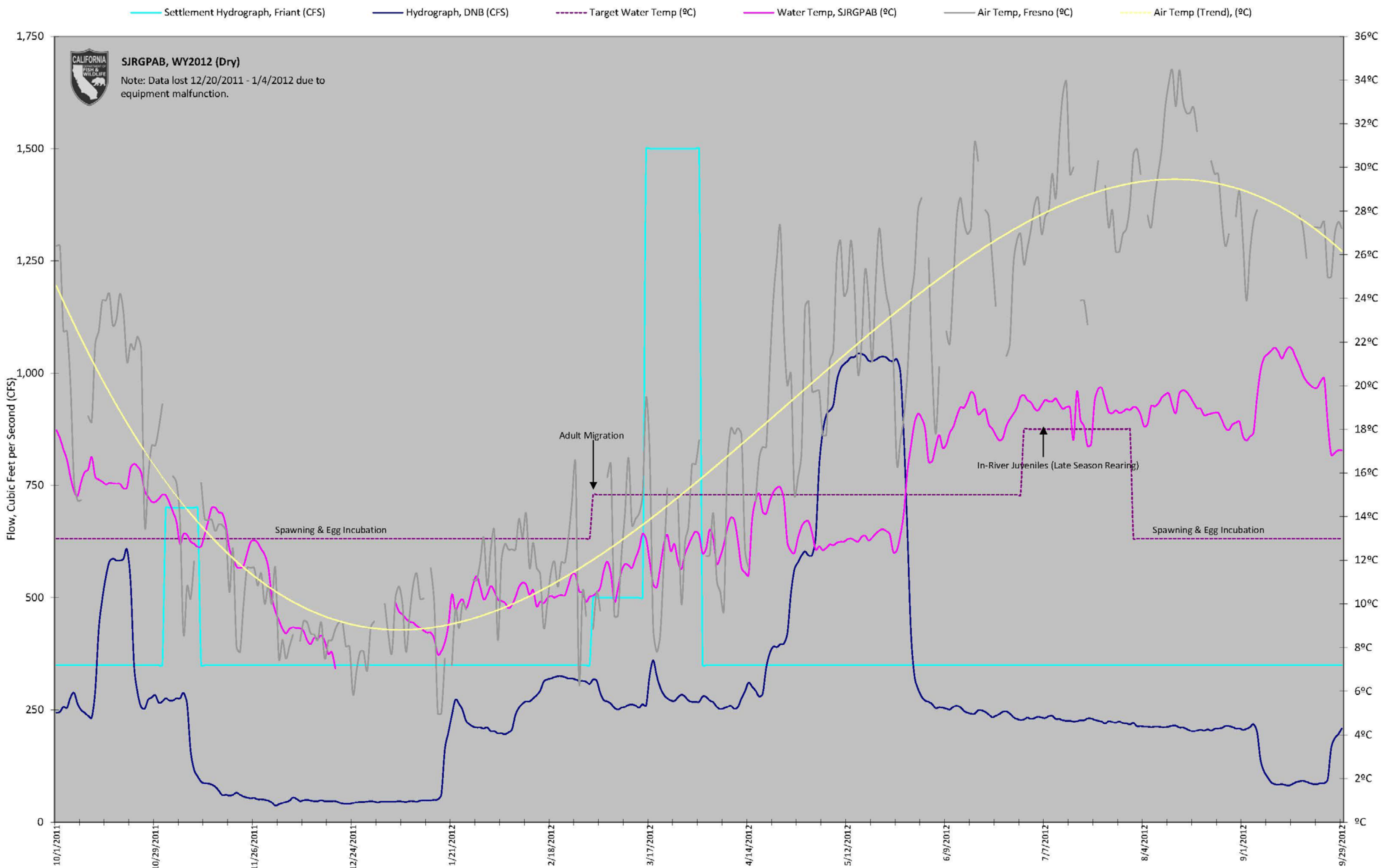

Figure 16: Daily average temperature in the San Joaquin River between Gravel Pits A and B (River Mile 254.0) compared with stream flow and air temperature

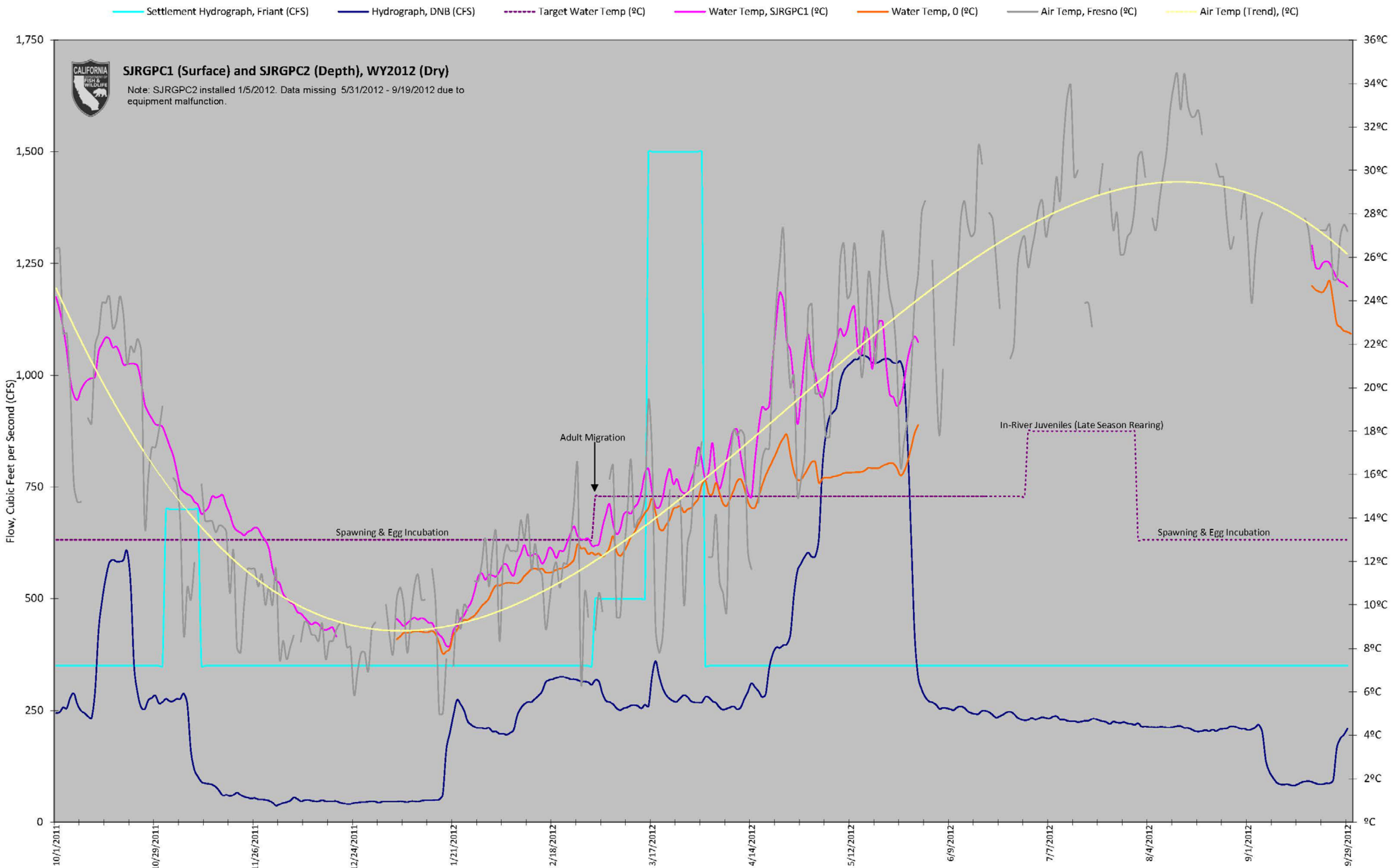

Figure 17: Daily average temperature at the San Joaquin River in Gravel Pit C (River Mile 253.5) compared with stream flow and air temperature

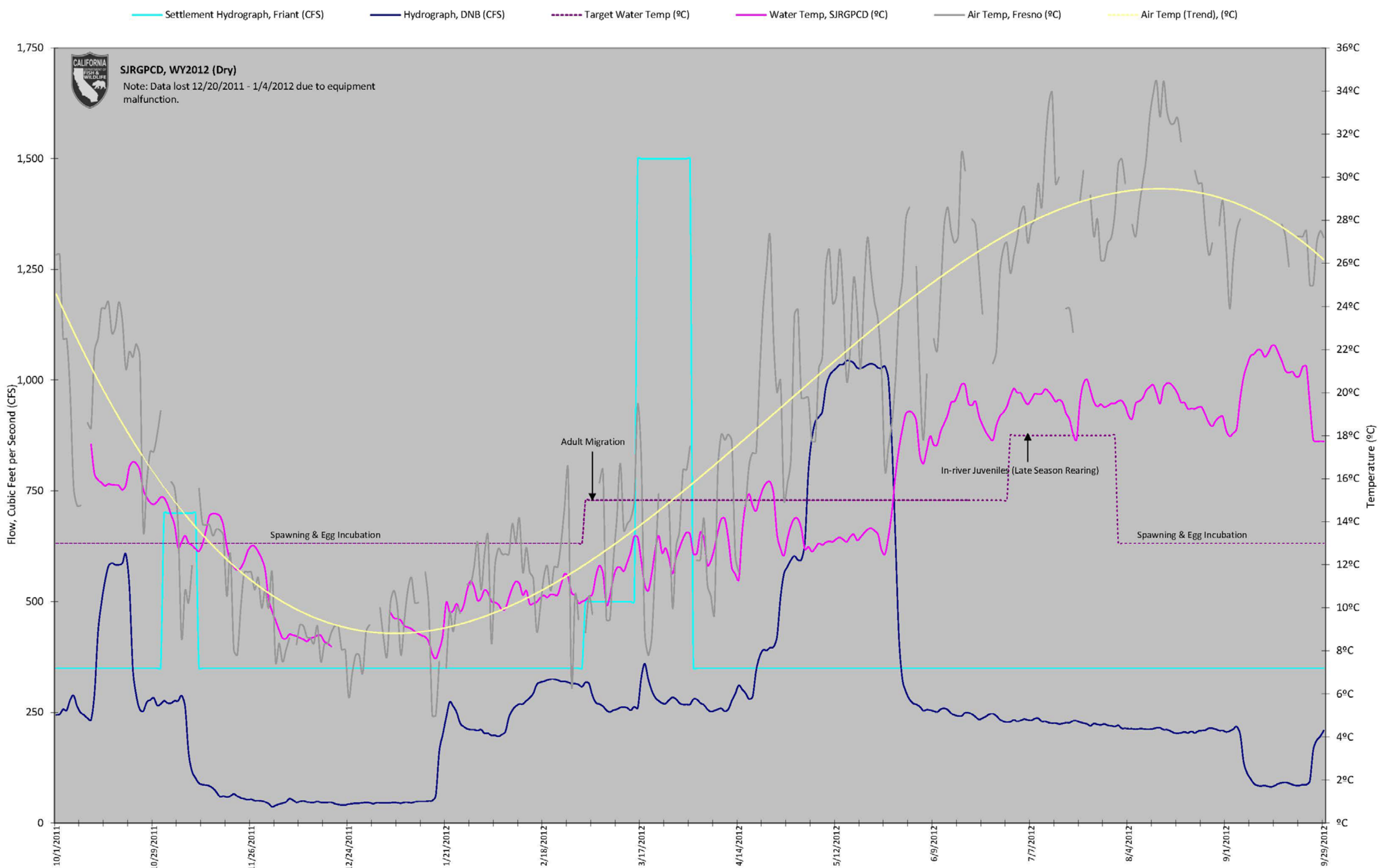

Figure 18: Daily average temperature in the San Joaquin River between Gravel Pits C and D (River Mile 253.5) compared with stream flow and air temperature

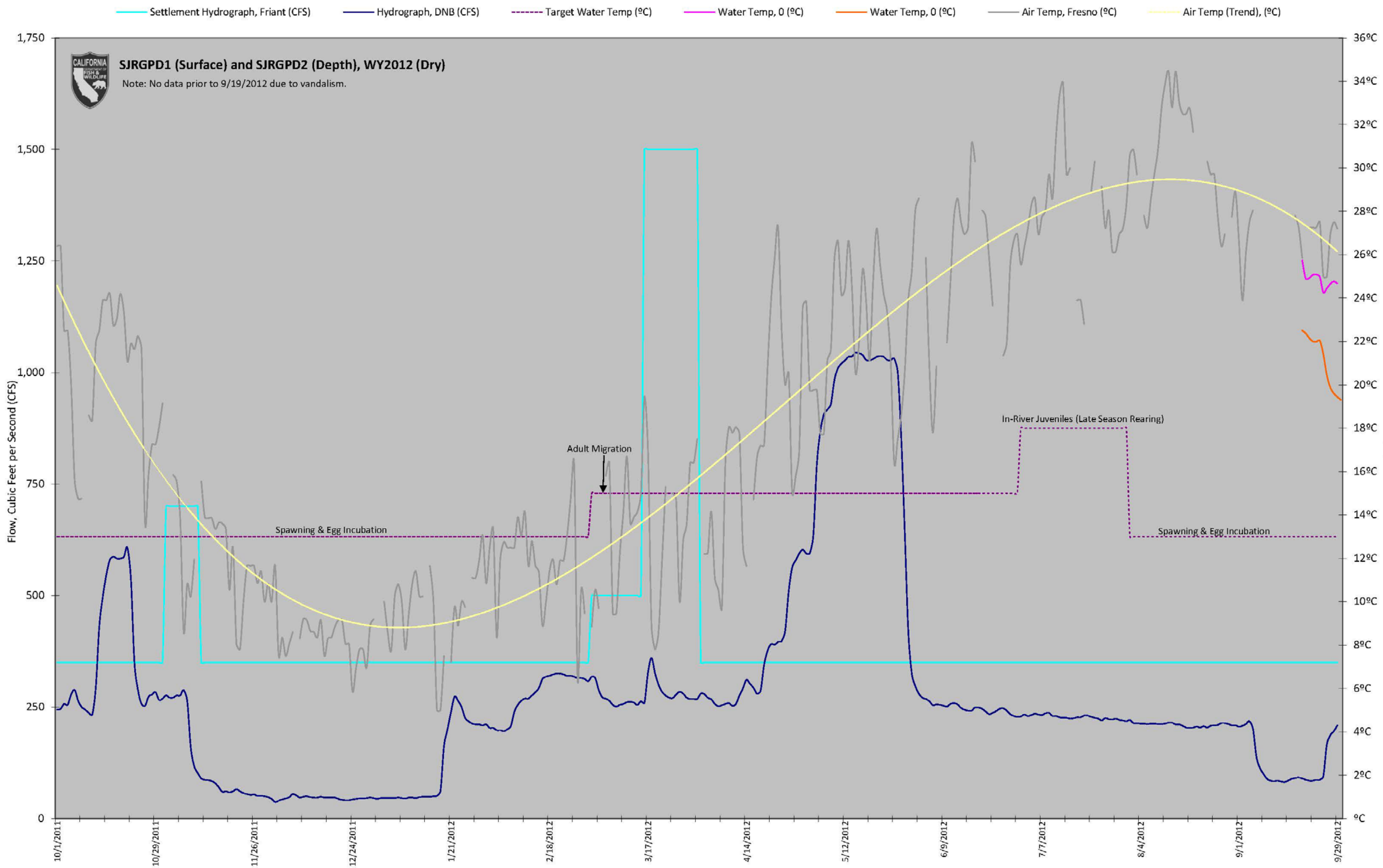

Figure 19: Daily average temperature at the San Joaquin River in Gravel Pit D (River Mile 253.5) compared with stream flow and air temperature

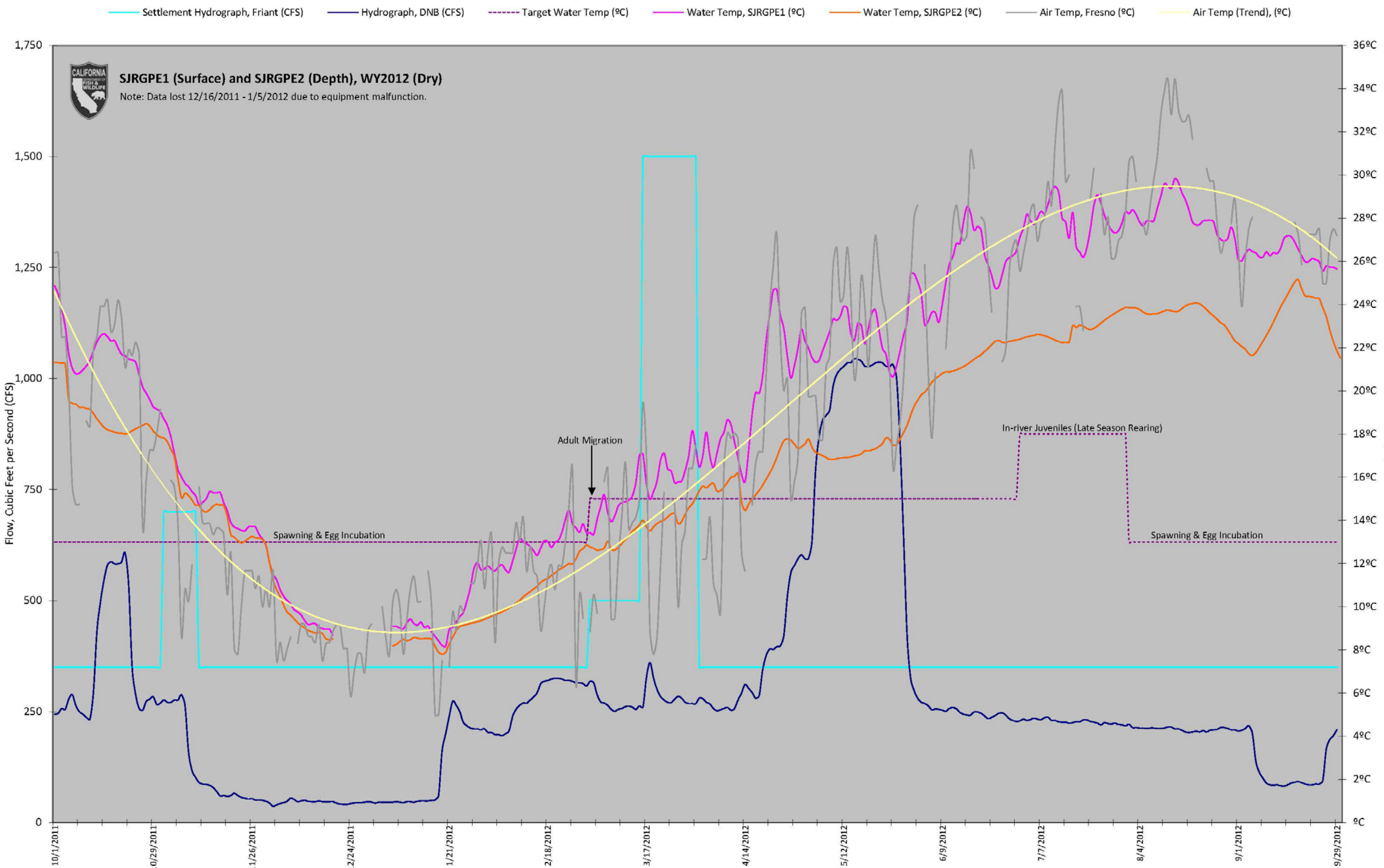

Figure 20: Daily average temperature at the San Joaquin River in Gravel Pit E (River Mile 253.2) compared with stream flow and air temperature

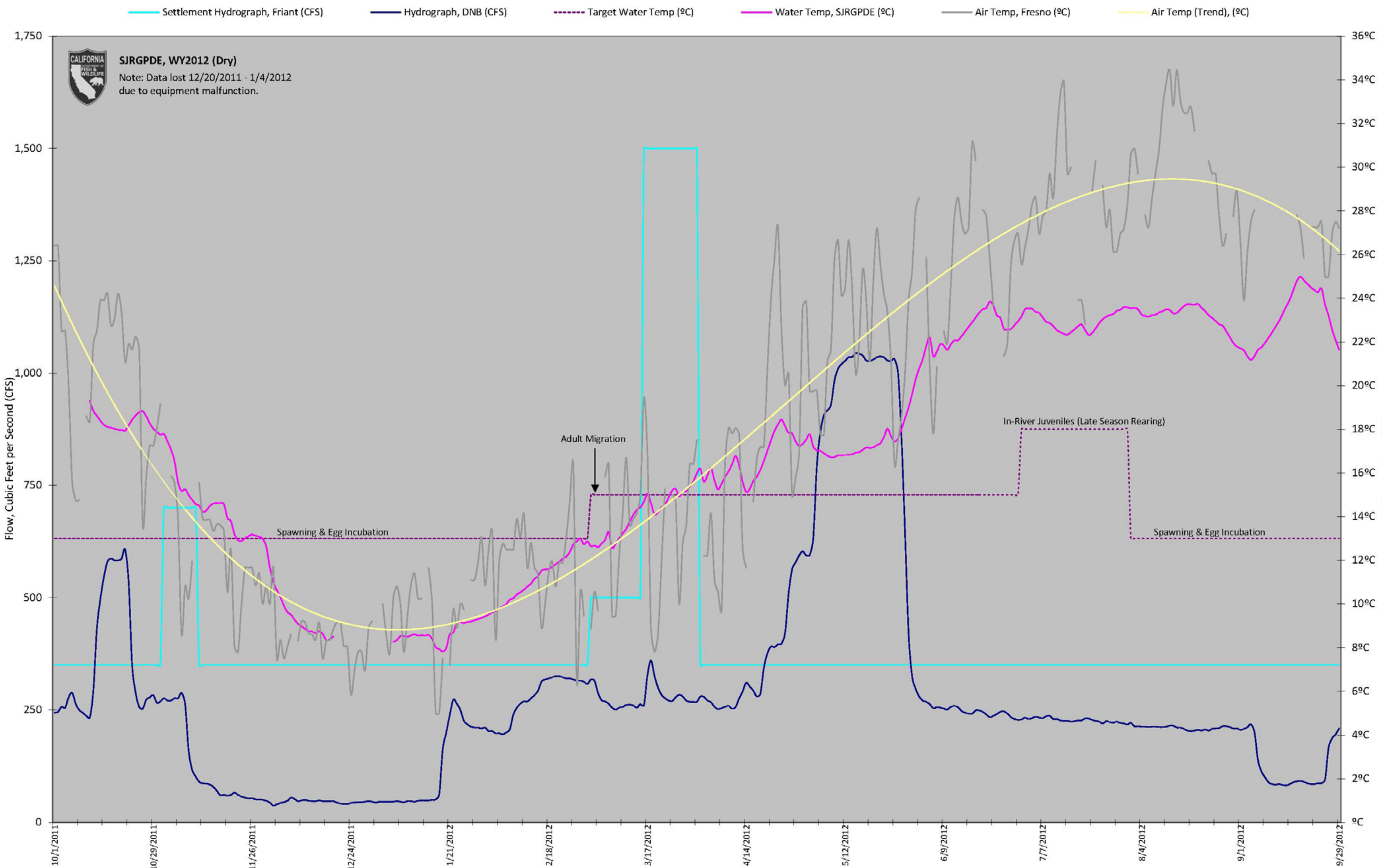

Figure 21: Daily average temperature in the San Joaquin River between Gravel Pits D and E (River Mile 253.1) compared with stream flow and air temperature

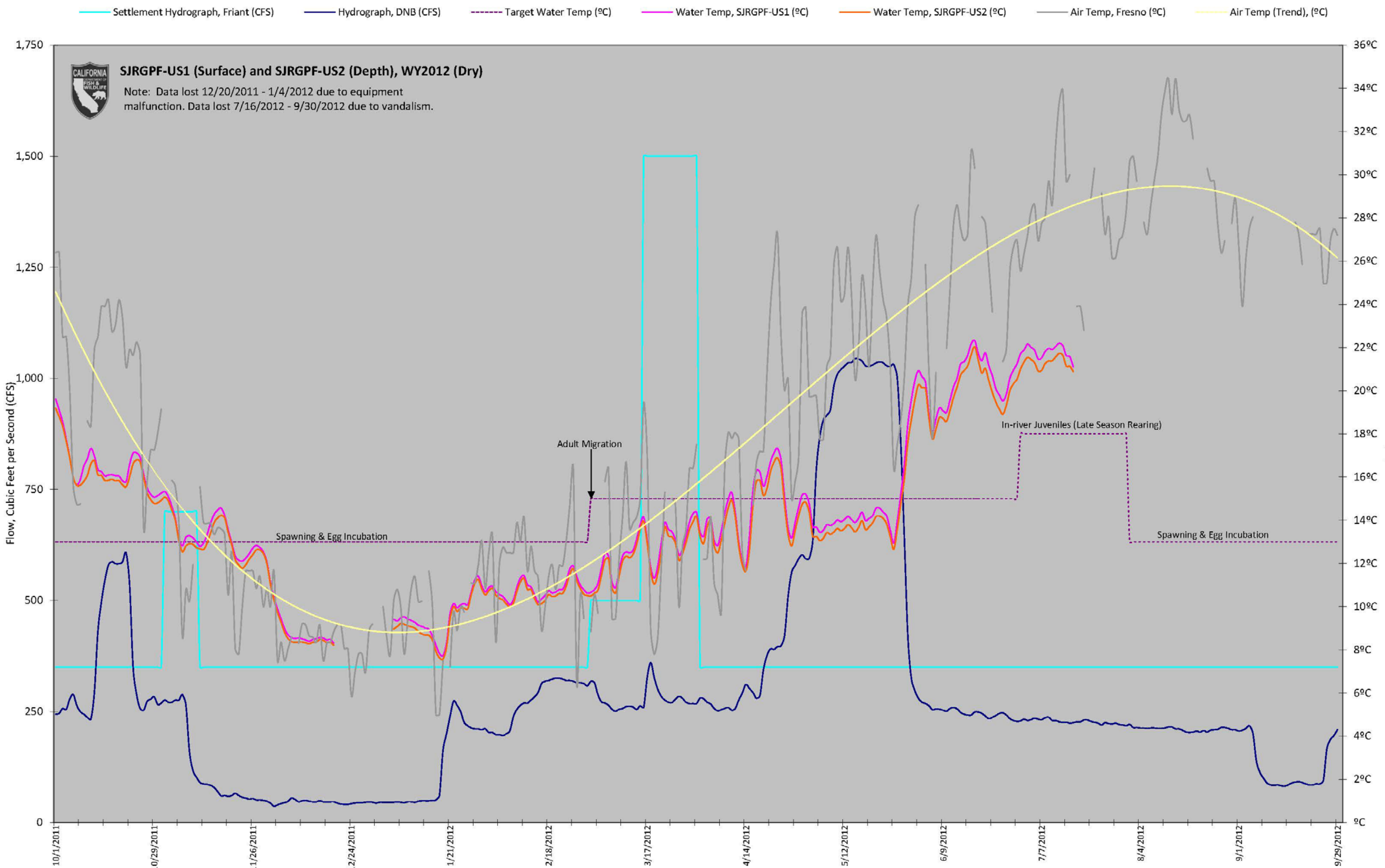

Figure 22: Daily average temperature at the San Joaquin River in the upstream side of Gravel Pit F (River Mile 252.5) compared with stream flow and air temperature

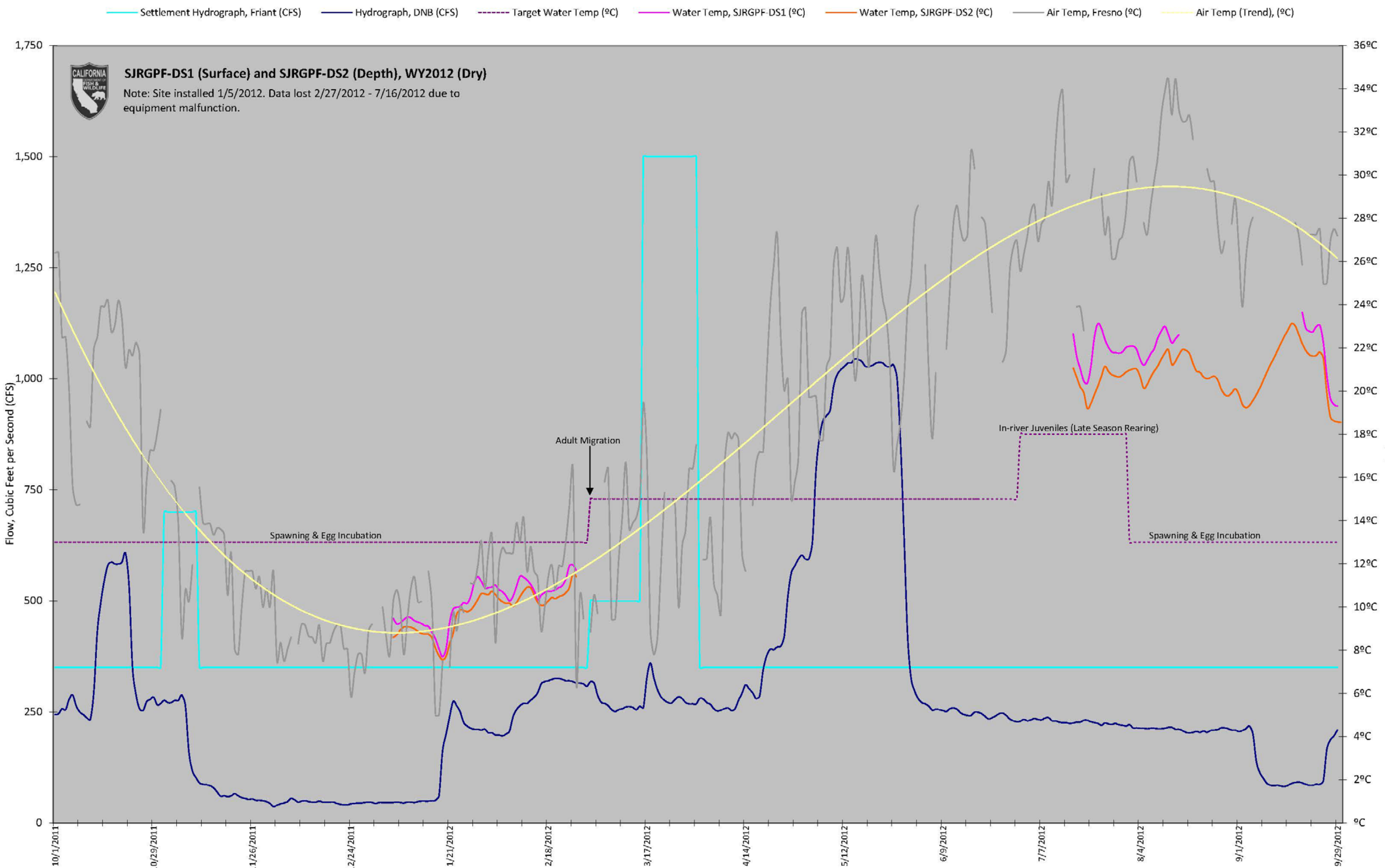

Figure 23: Daily average temperature at the San Joaquin River in the downstream side of Gravel Pit F (River Mile 252.4) compared with stream flow and air temperature

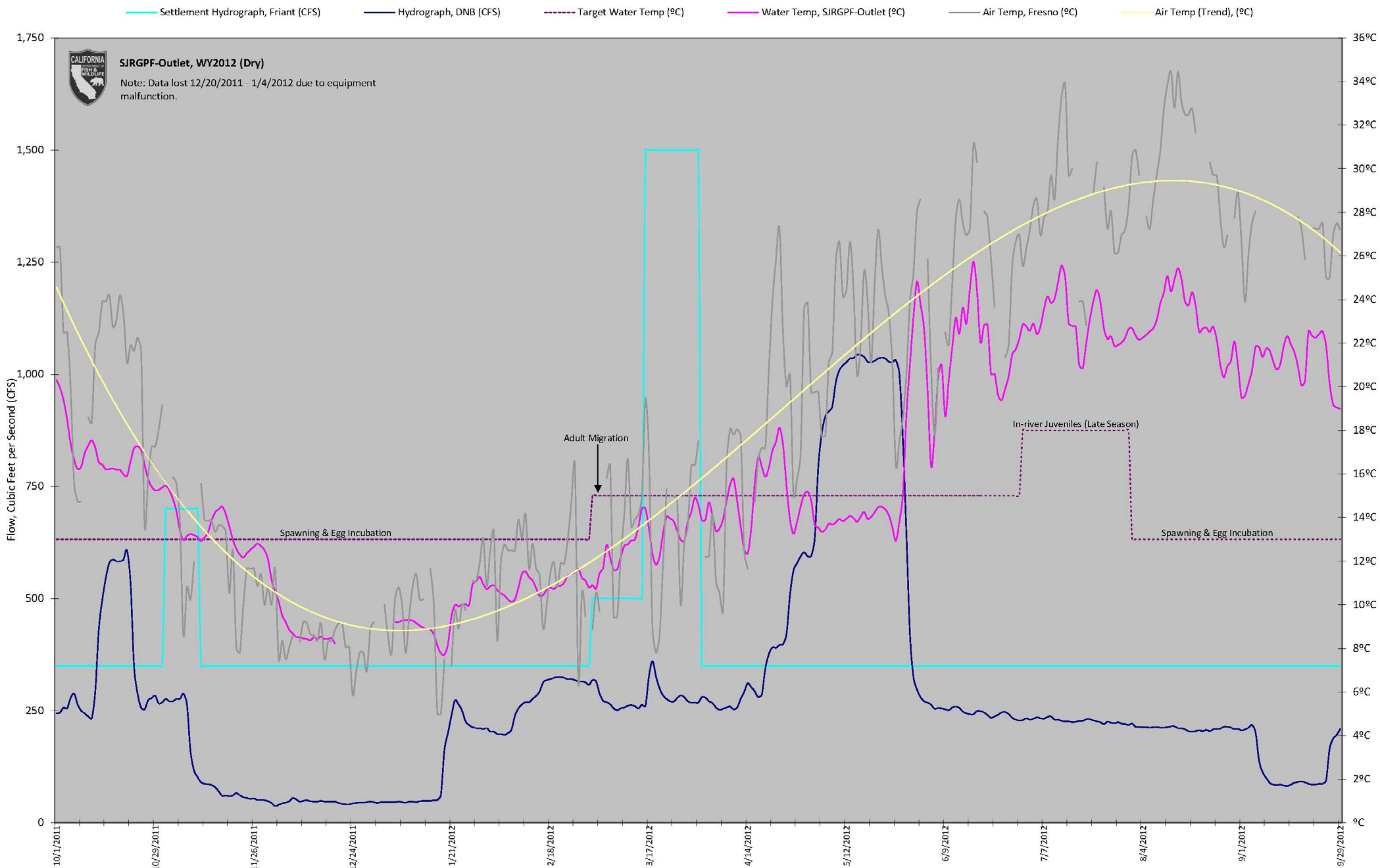

Figure 24: Daily average temperature at outlet of Gravel Pit F to the San Joaquin River (River Mile 252.4) compared with stream flow and air temperature

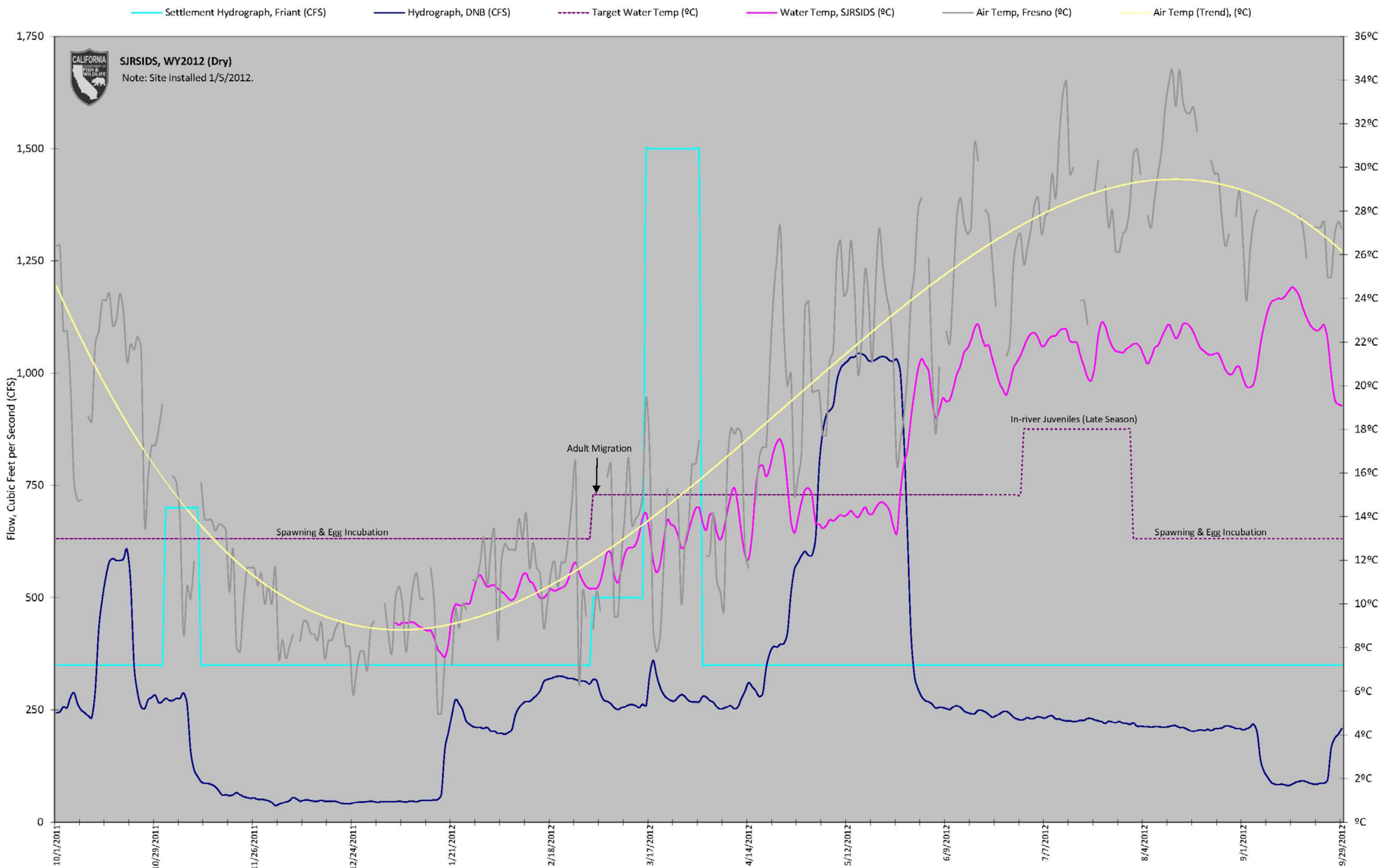

Figure 25: Daily average temperature in the San Joaquin River downstream of Scout Island (River Mile 251.0) compared with stream flow and air temperature

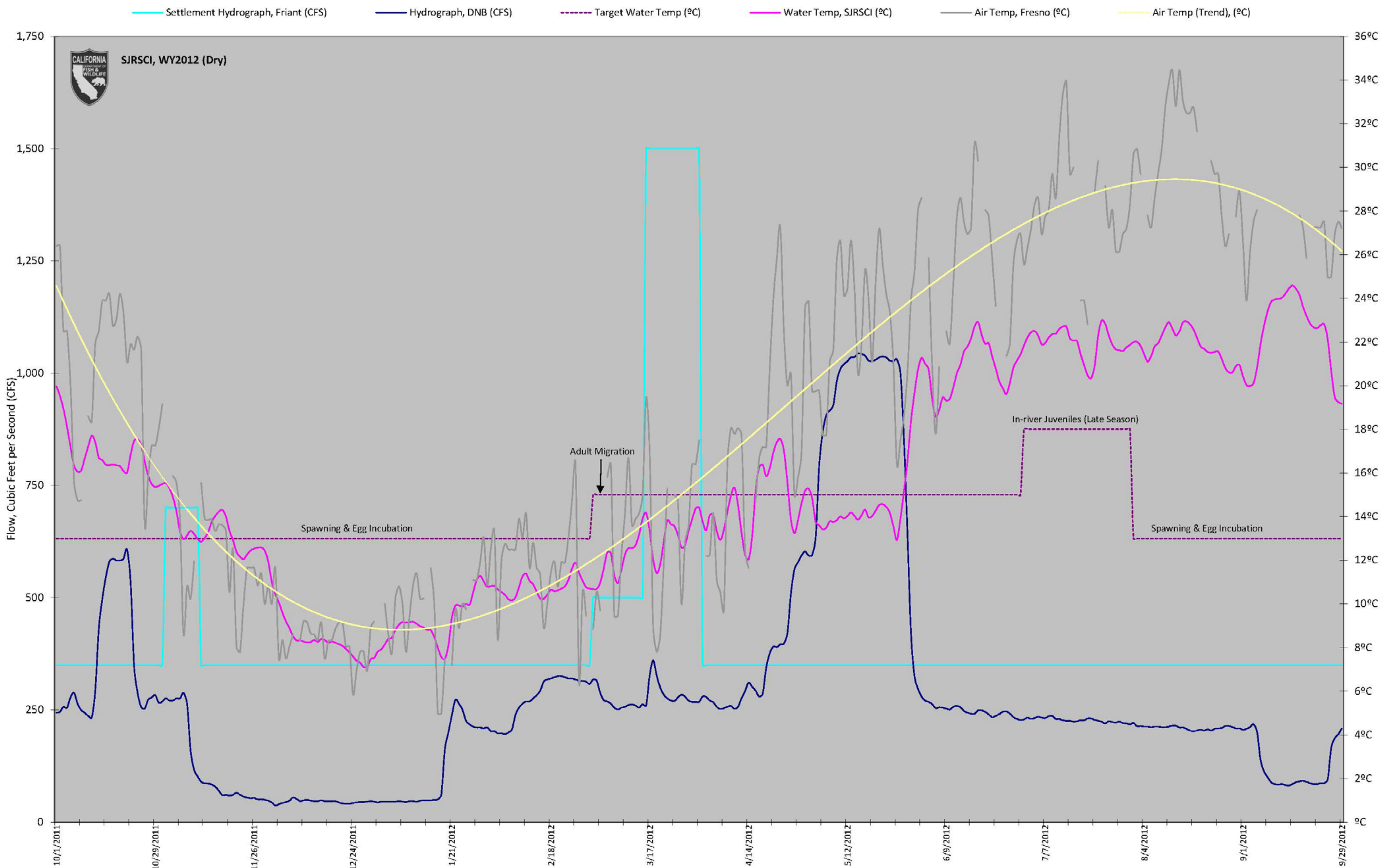

Figure 26: Daily average temperature in the San Joaquin River downstream of Scout Island (River Mile 251.0) compared with stream flow and air temperature

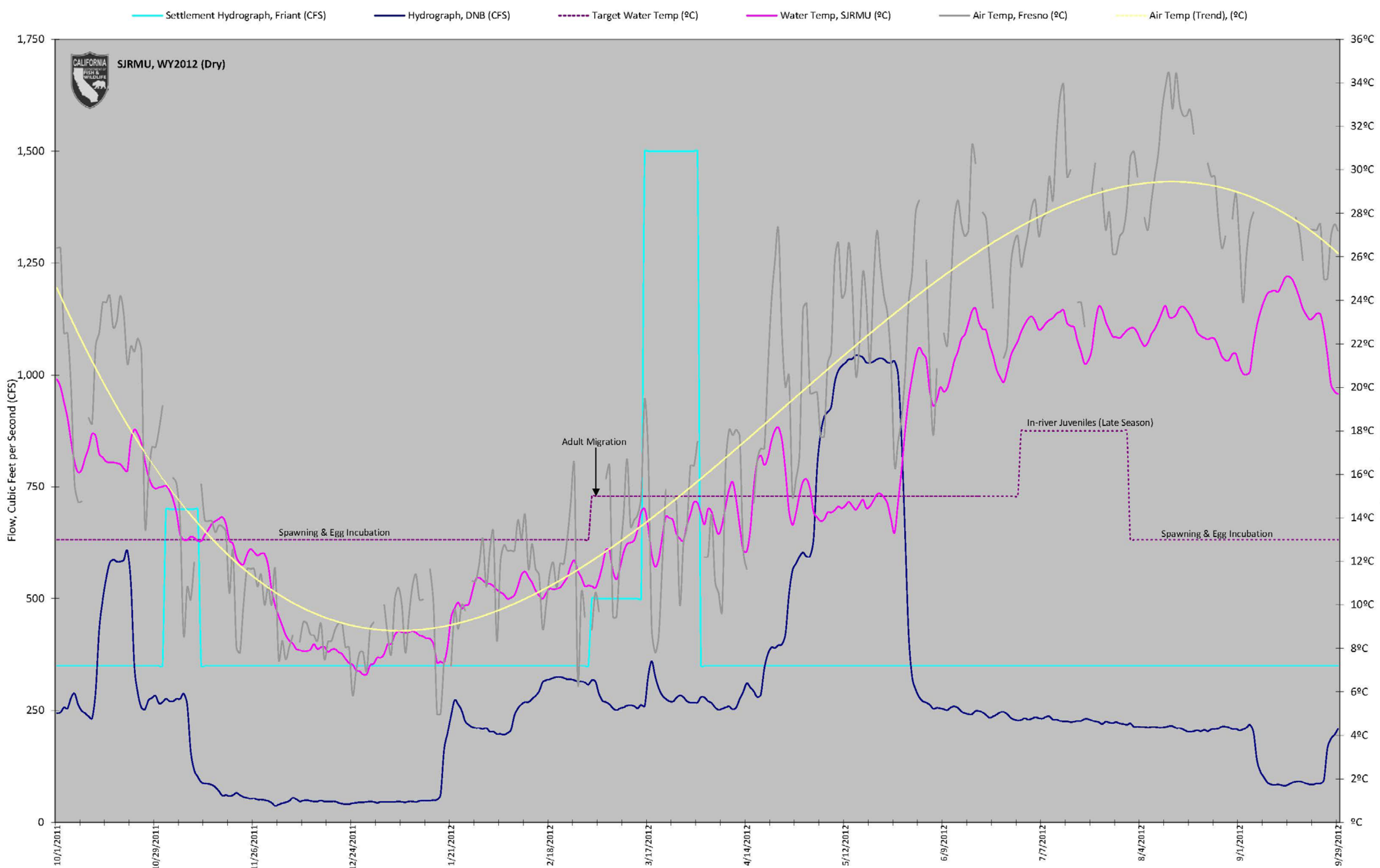

Figure 27: Daily average temperature in the San Joaquin River at Millburn Unit (River Mile 247.5) compared with stream flow and air temperature

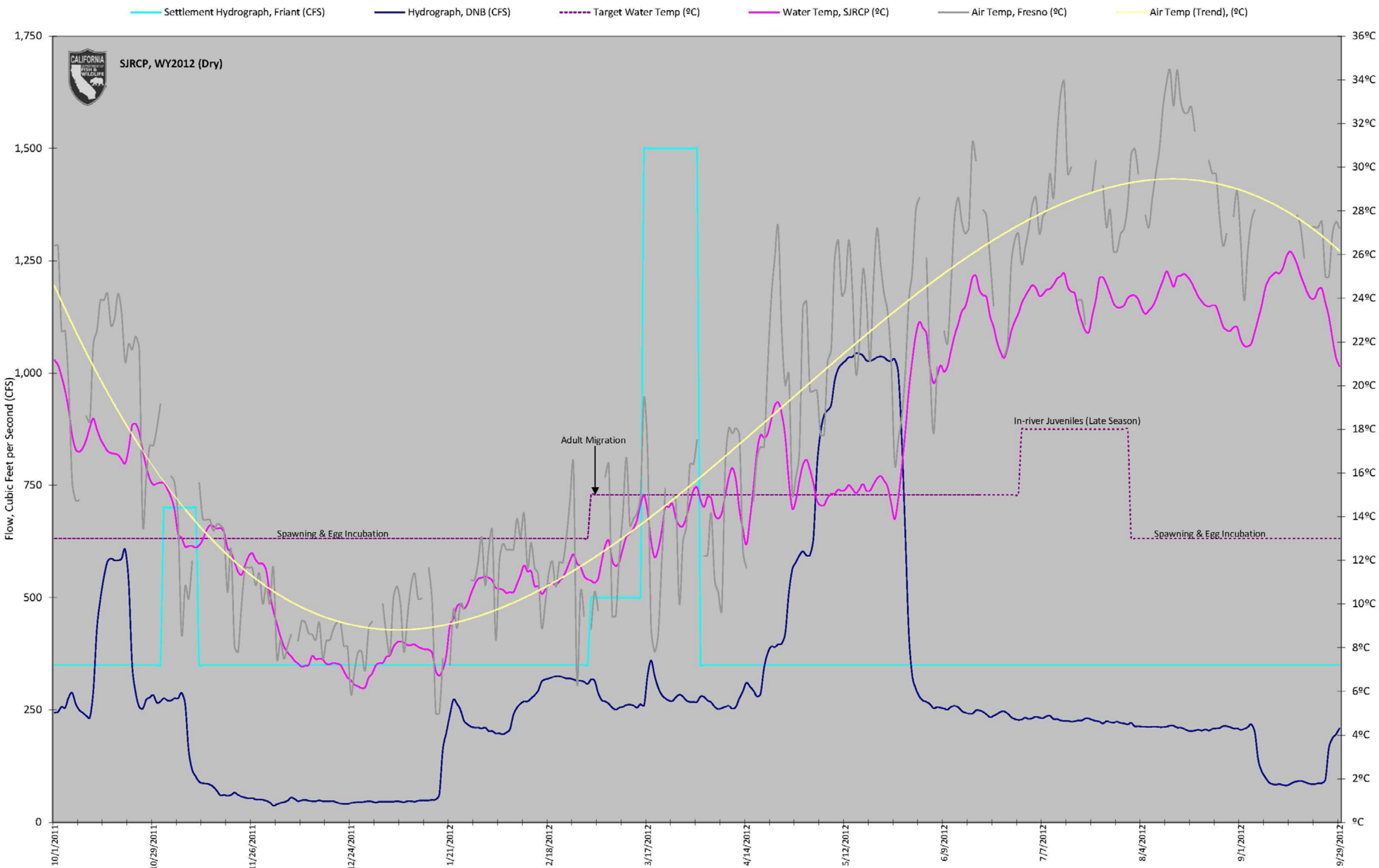

Figure 28: Daily average temperature in the San Joaquin River at Camp Pashayan (River Mile 243.1) compared with stream flow and air temperature

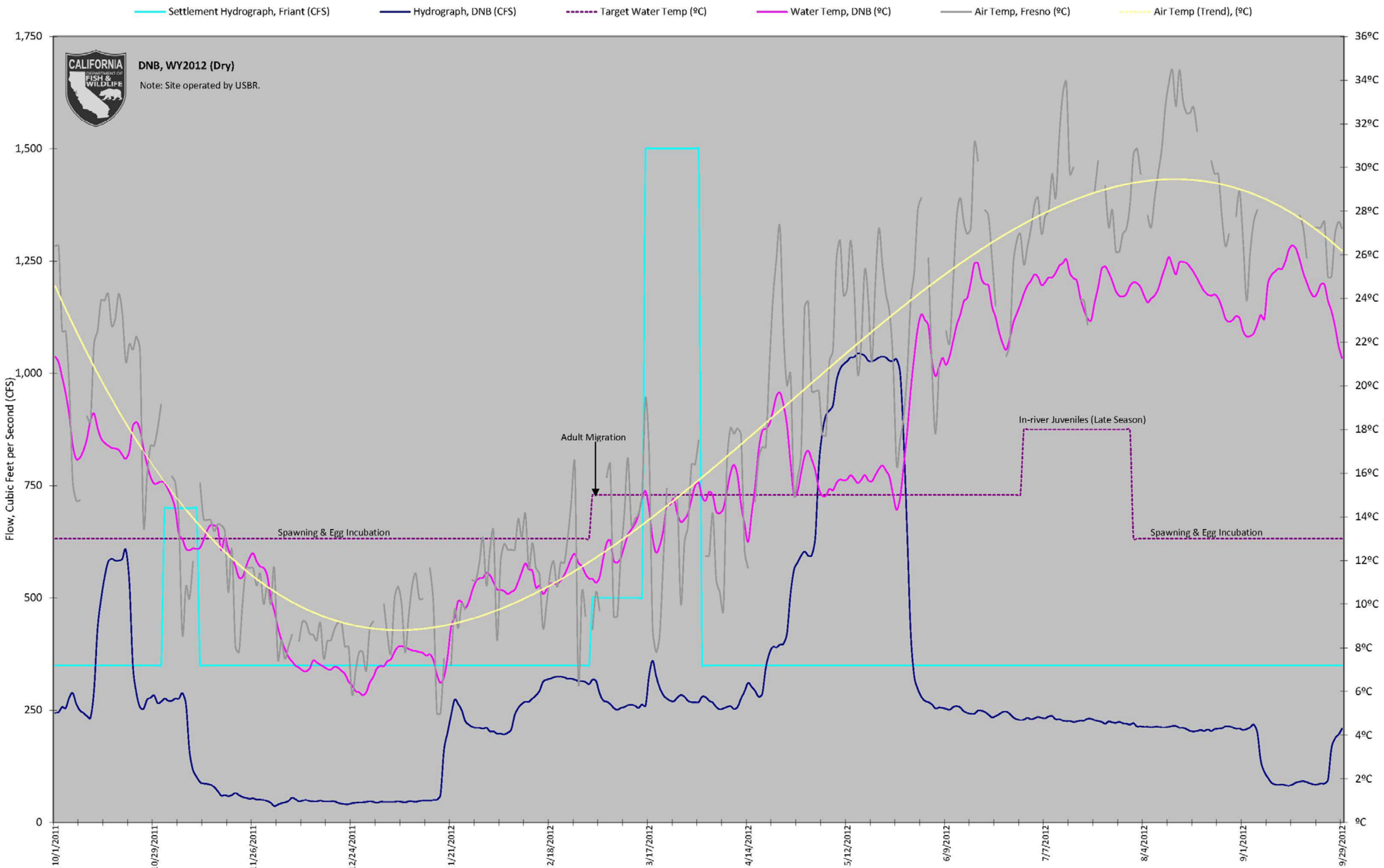

Figure 29: Daily average temperature in the San Joaquin River at Donny Bridge (River Mile 240.6) compared with stream flow and air temperature

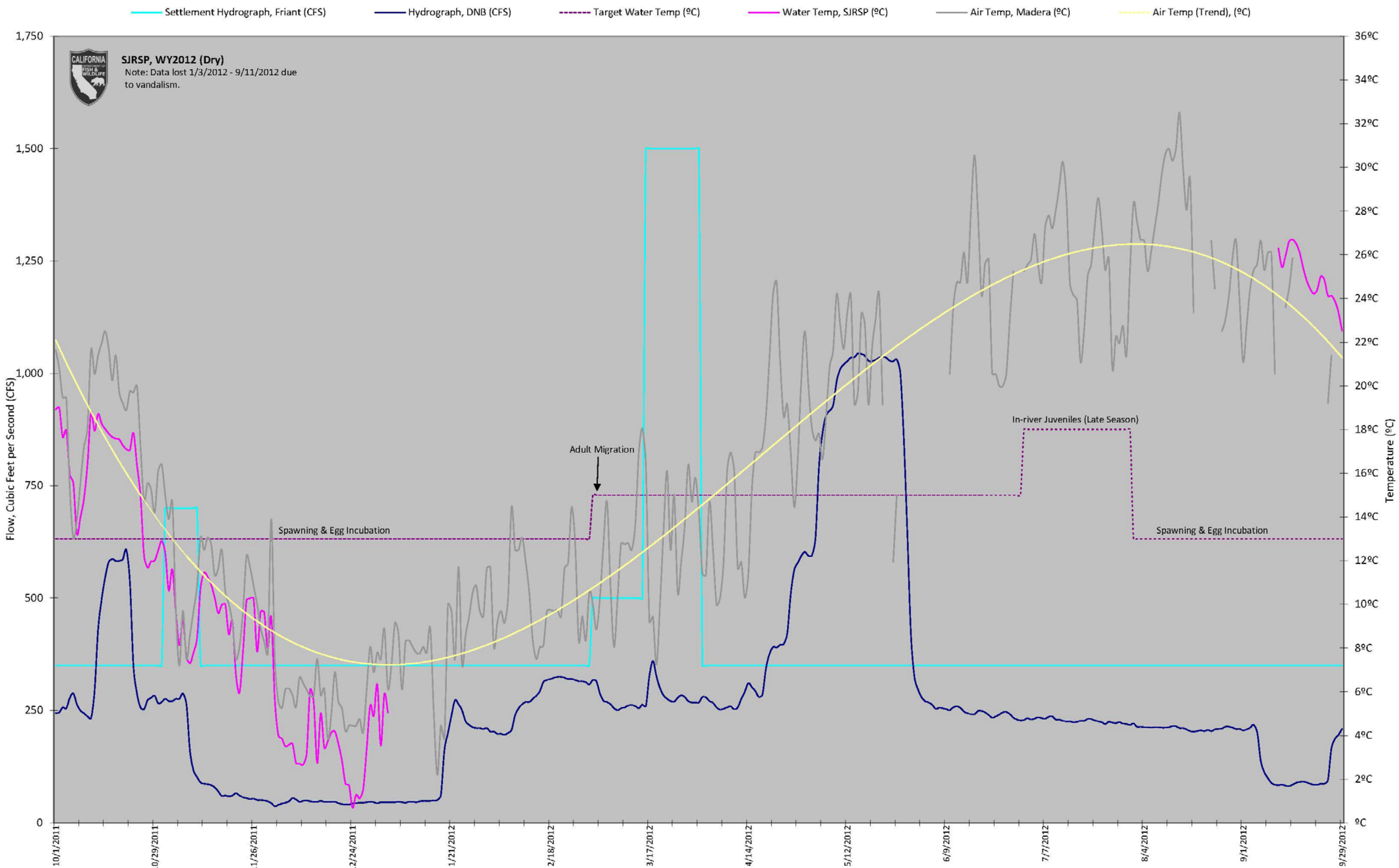

Figure 30: Daily average temperature in the San Joaquin River at Skaggs Park (River Mile 234.0) compared with stream flow and air temperature

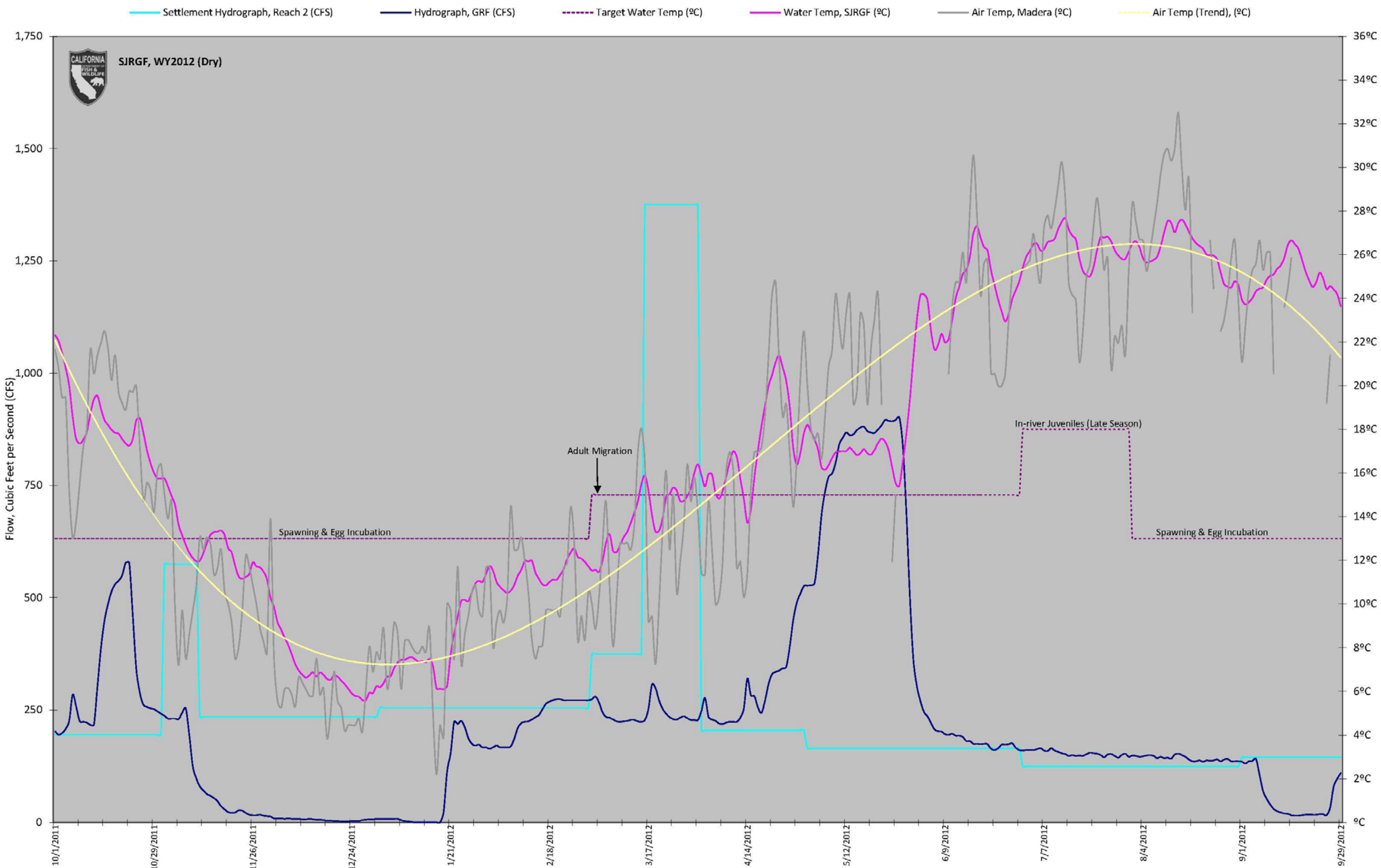

Figure 31: Daily average temperature in the San Joaquin River at Gravelly Ford (River Mile 231.2) compared with stream flow and air temperature

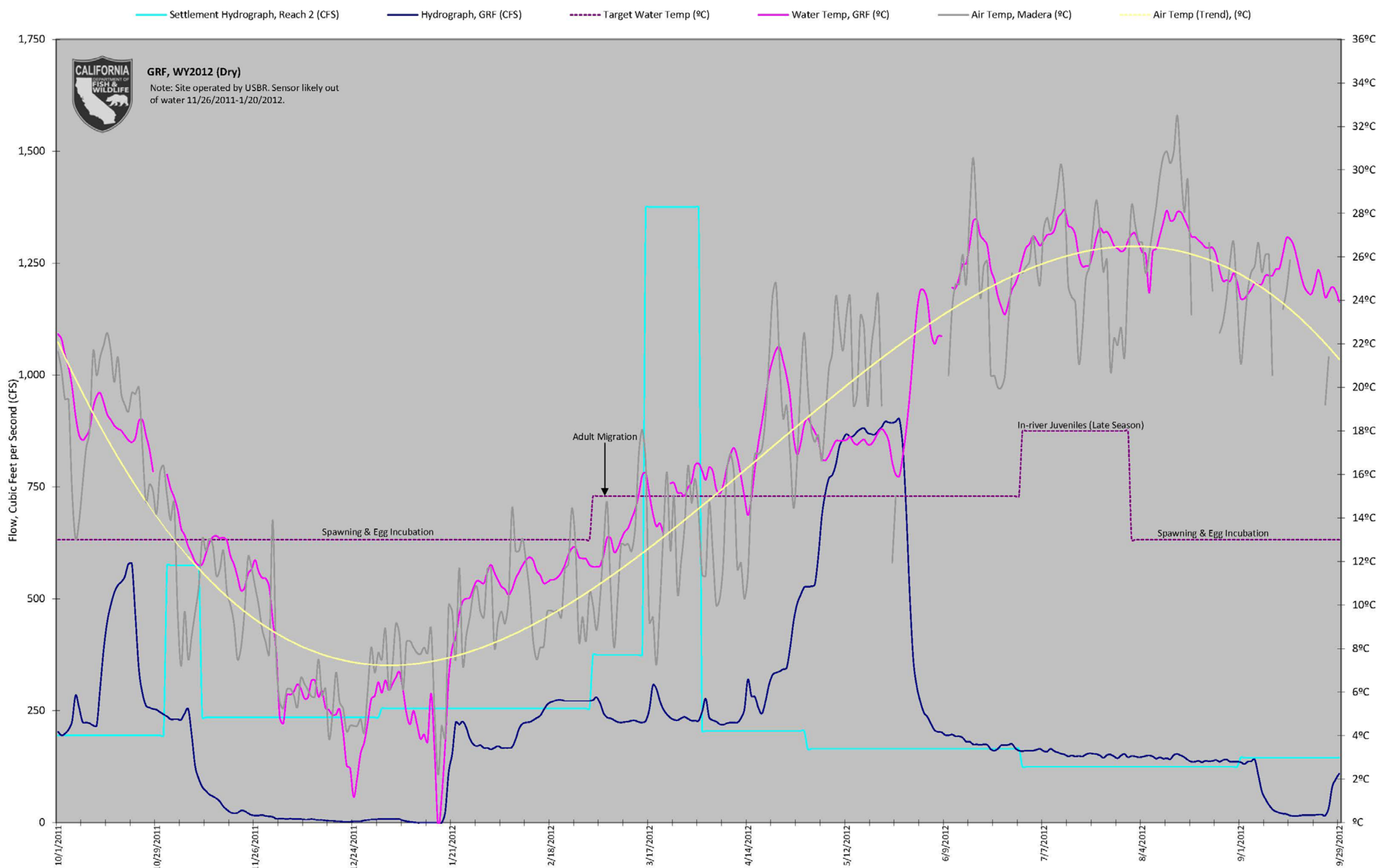

Figure 32: Daily average temperature in the San Joaquin River at Gravelly Ford (River Mile 227.5) compared with stream flow and air temperature

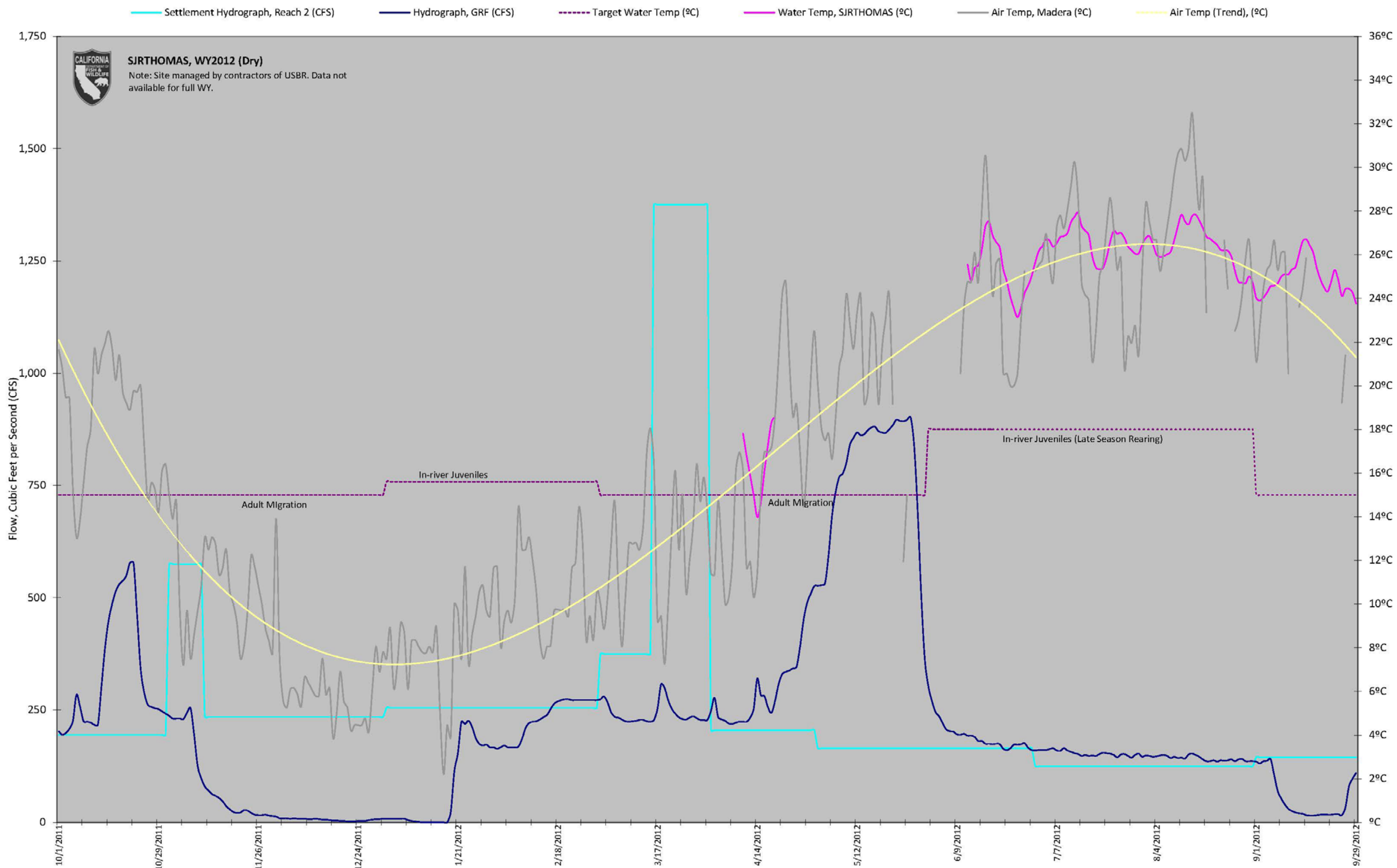

Figure 33: Daily average temperature in the San Joaquin River at Thomas (River Mile 229.1) compared with stream flow and air temperature

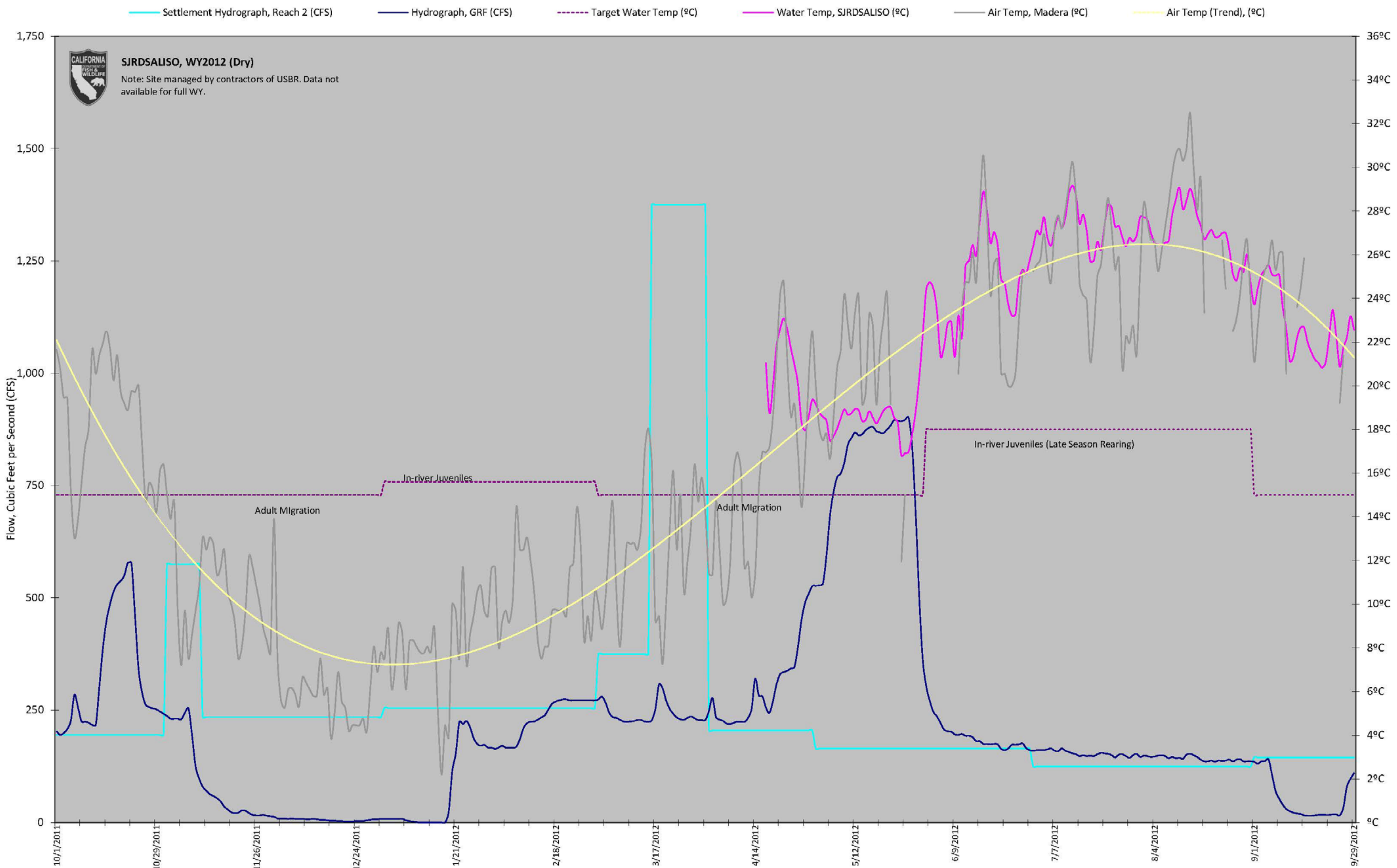

Figure 34: Daily average temperature in the San Joaquin River downstream of Aliso Canal (River Mile 222.1) compared with stream flow and air temperature

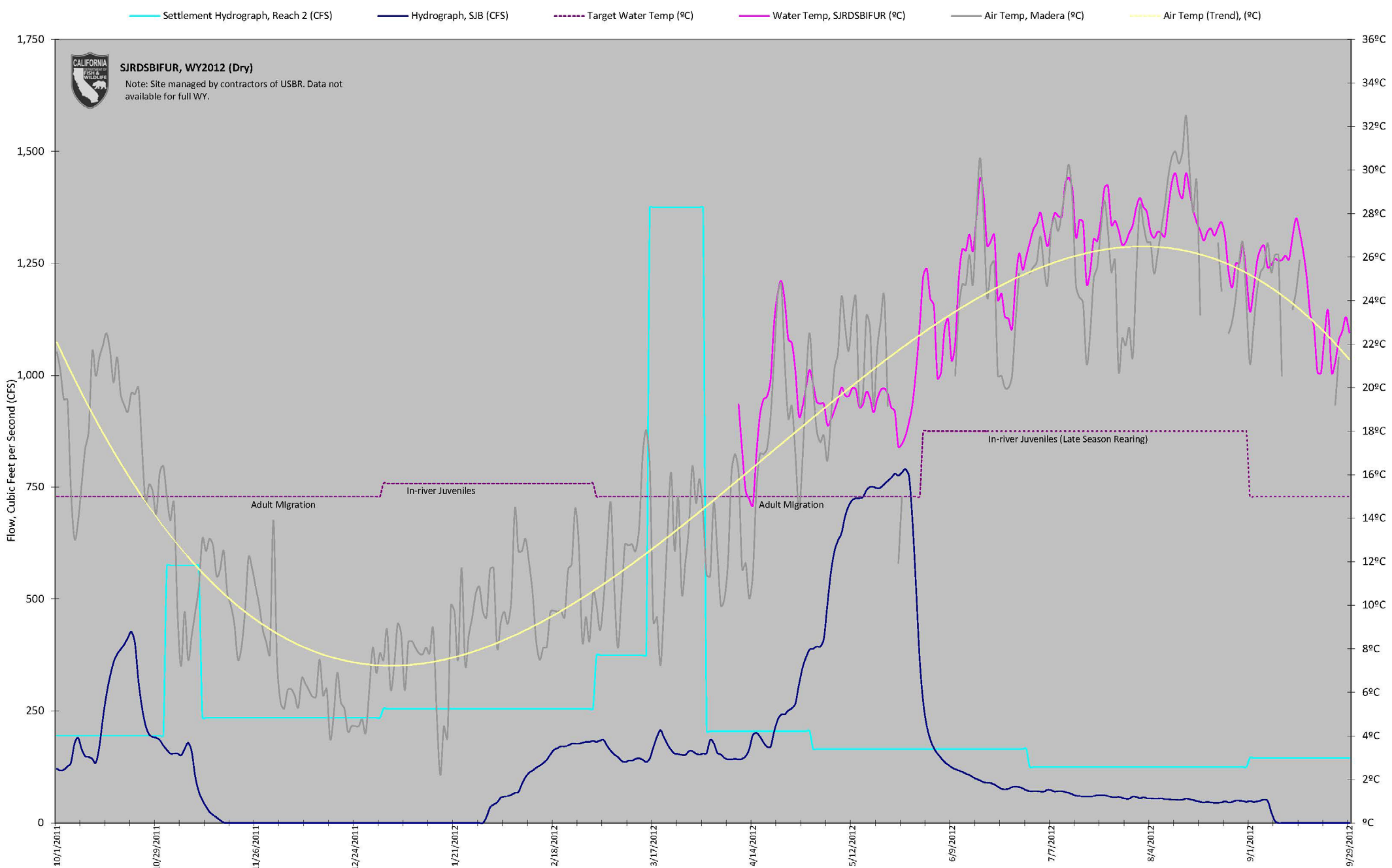

Figure 35: Daily average temperature in the San Joaquin River downstream of the SJR Bifurcation Structure (River Mile 215.7) compared with stream flow and air temperature

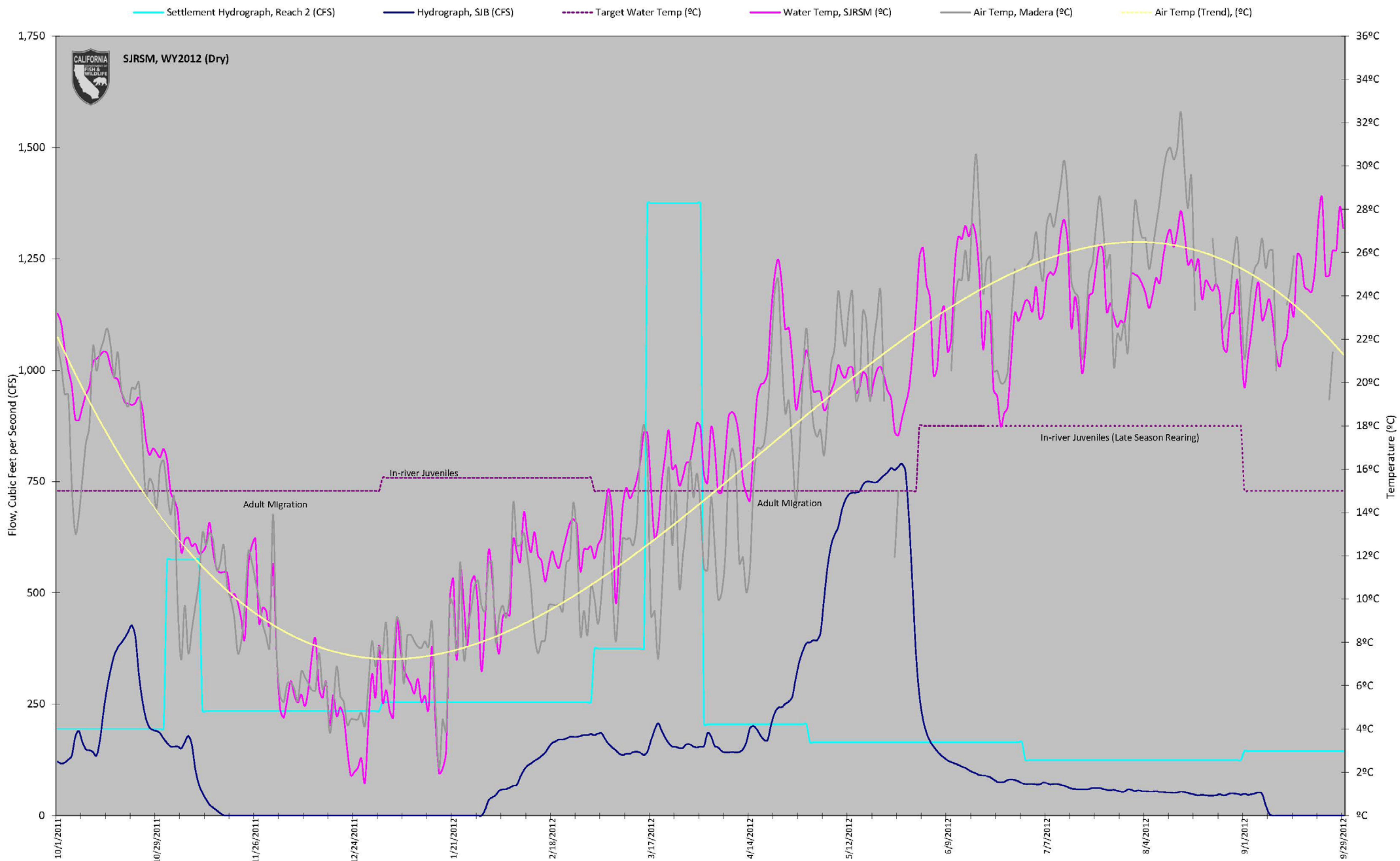

Figure 36: Daily average temperature in the San Joaquin River at San Mateo Crossing (River Mile 211.9) compared with stream flow and air temperature

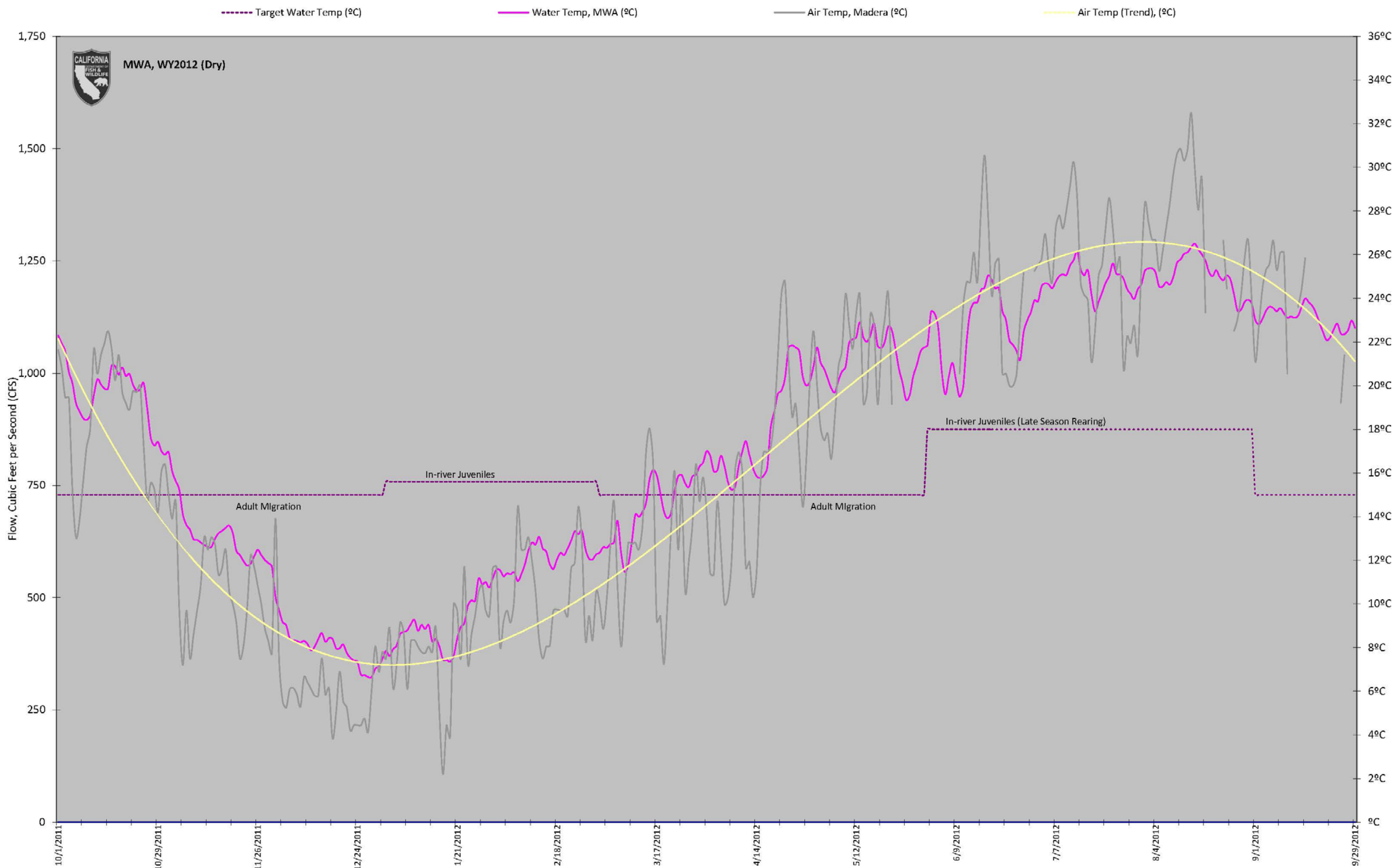

Figure 37: Daily average temperature in Fresno Slough at the Mendota Wildlife Area compared with air temperature

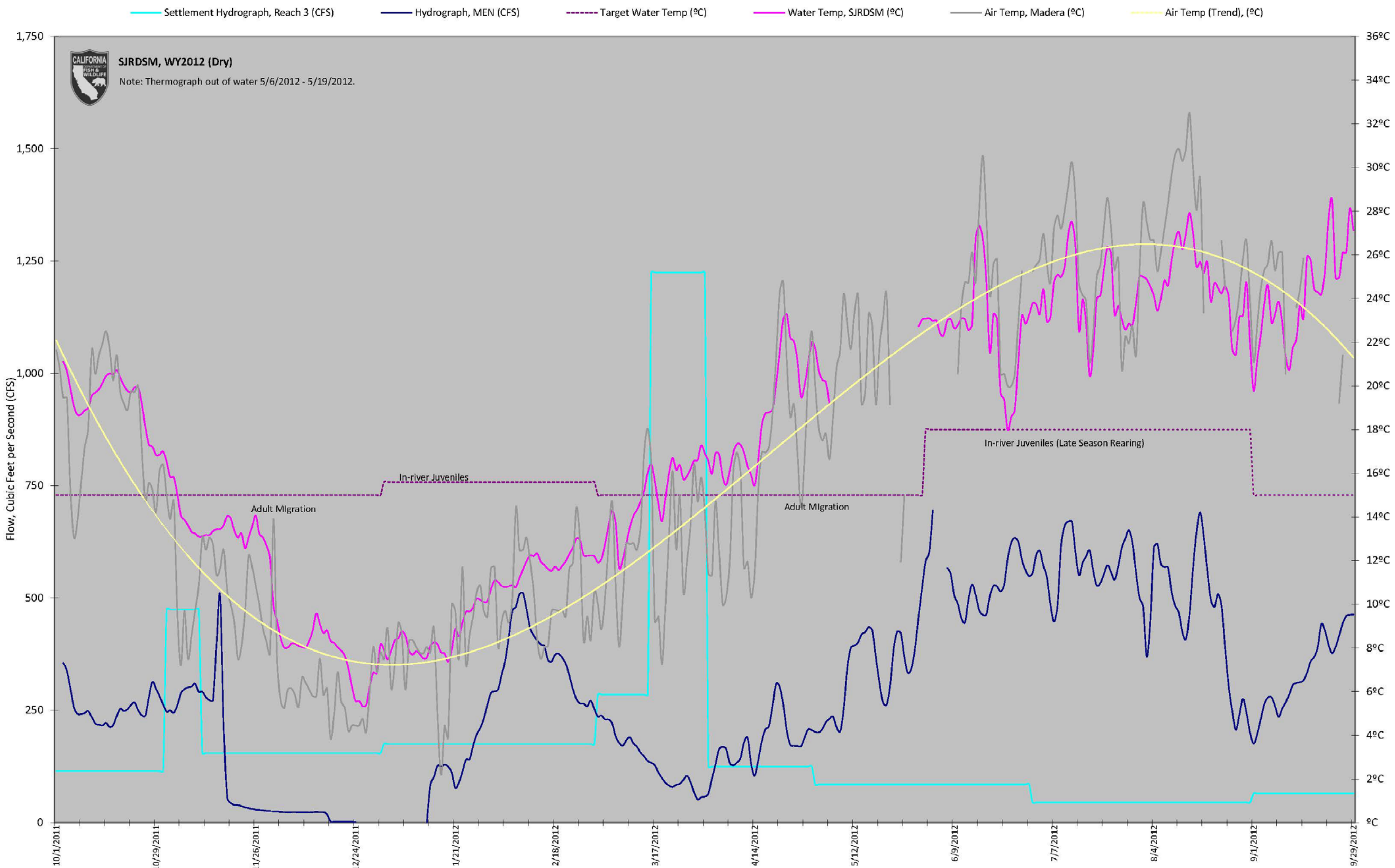

Figure 38: Daily average temperature in the San Joaquin River downstream of Mendota Pool (River Mile 203.5) compared with stream flow and air temperature

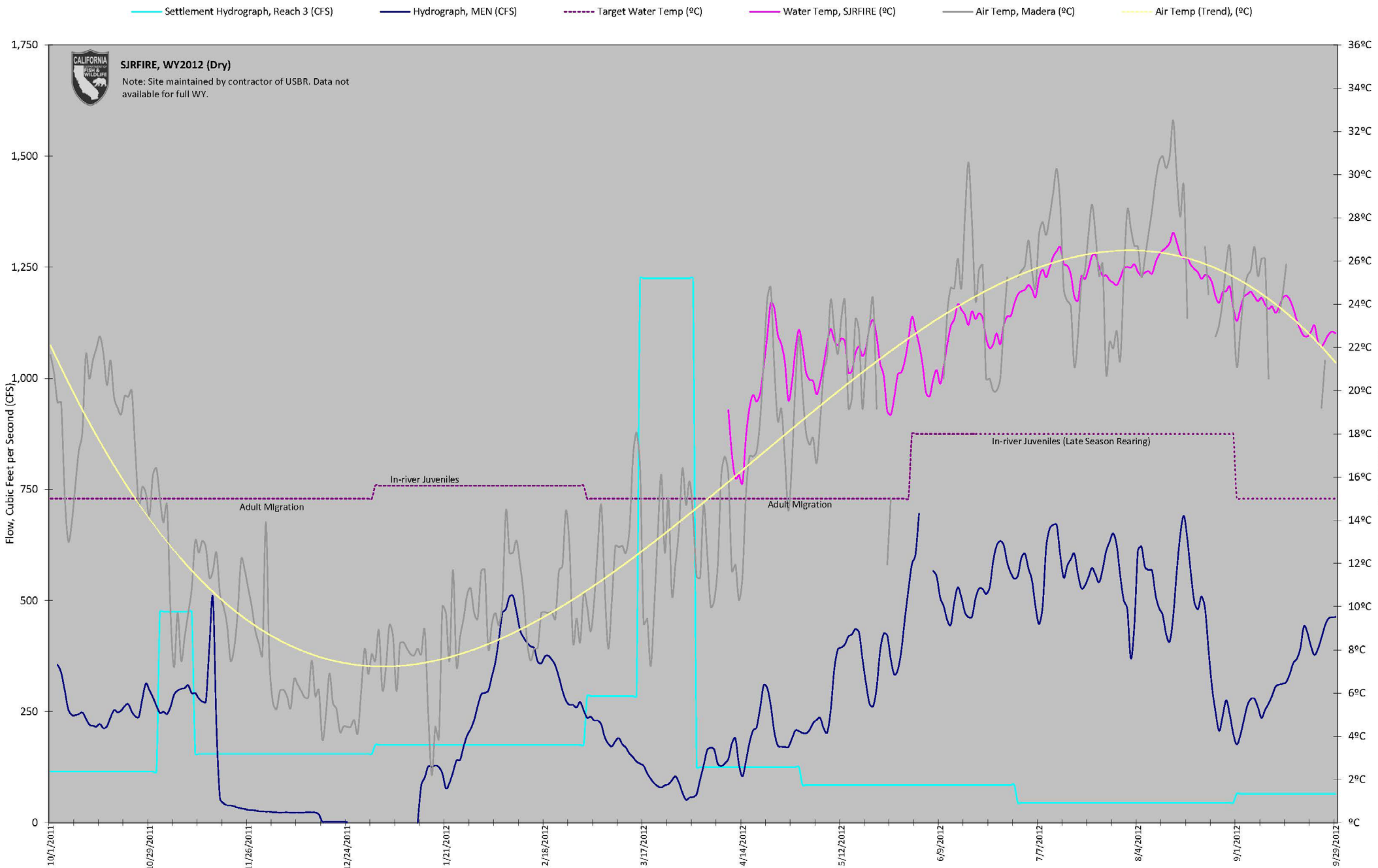

Figure 39: Daily average temperature in the San Joaquin River at Firebaugh Bridge (River Mile 195.1) compared with stream flow and air temperature

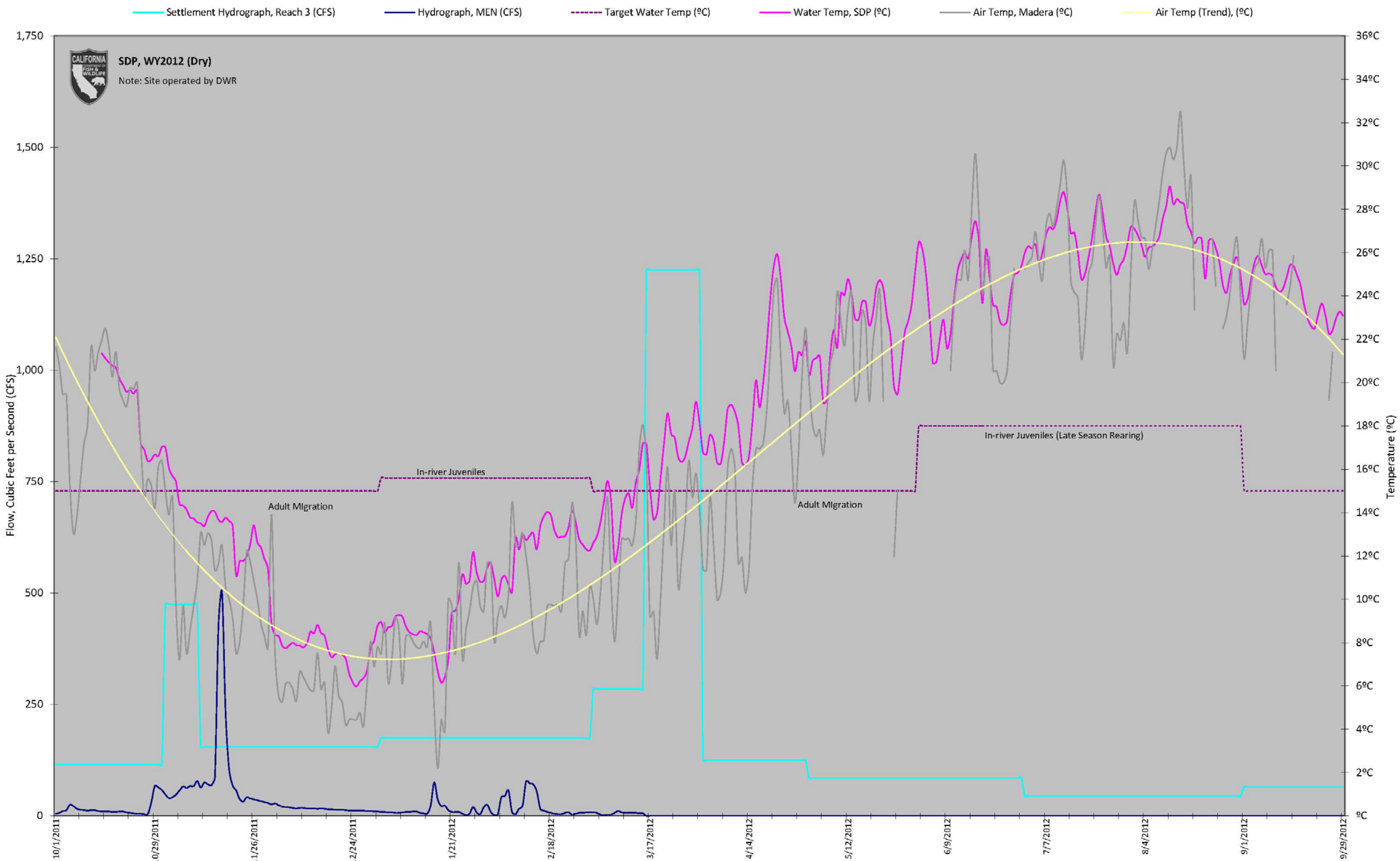

Figure 40: Daily average temperature in the San Joaquin River at Sack Dam near Dos Palos (River Mile 181.2) compared with stream flow and air temperature

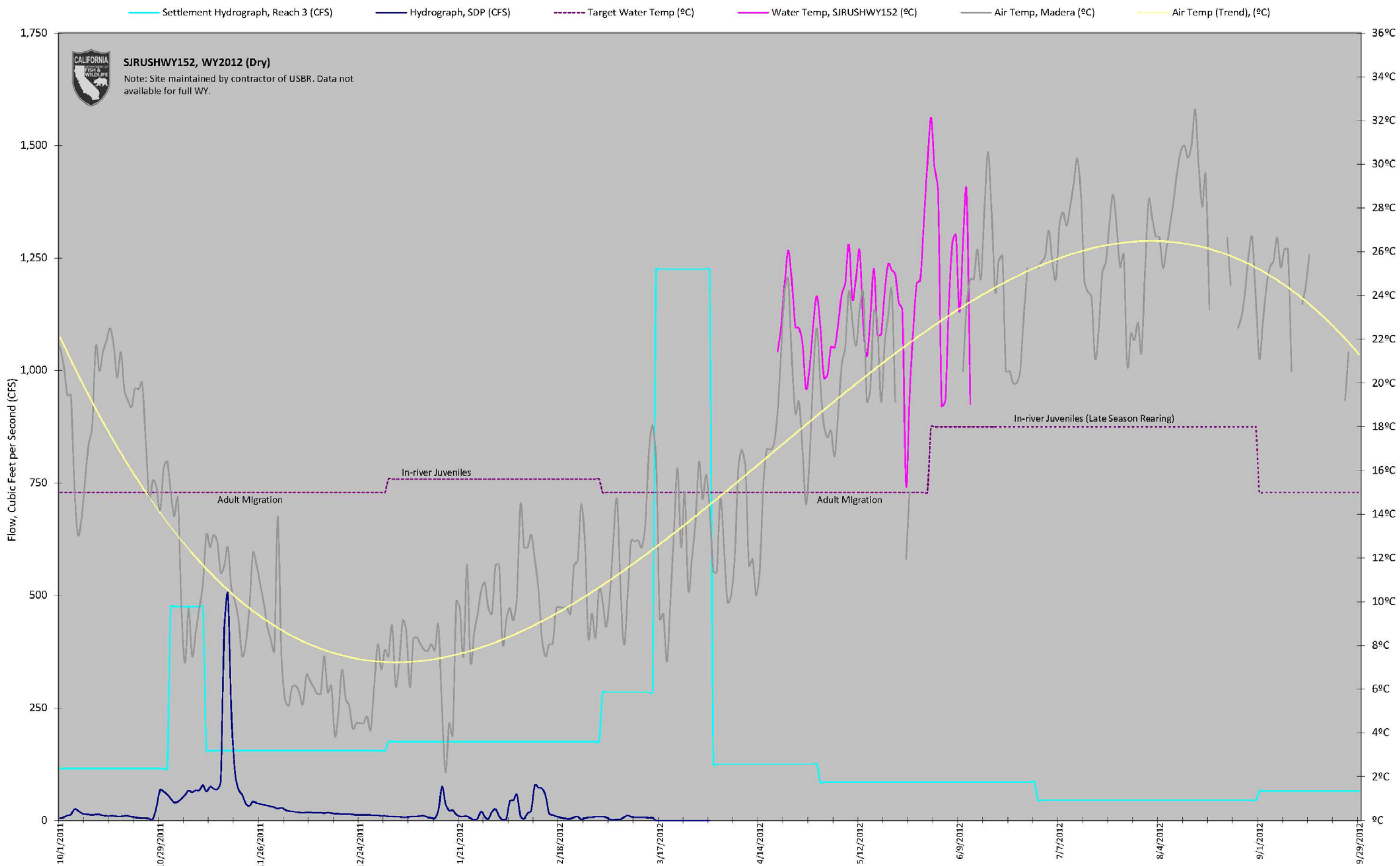

Figure 41: Daily average temperature in the San Joaquin River upstream of Highway 152 (River Mile 174) compared with stream flow and air temperature

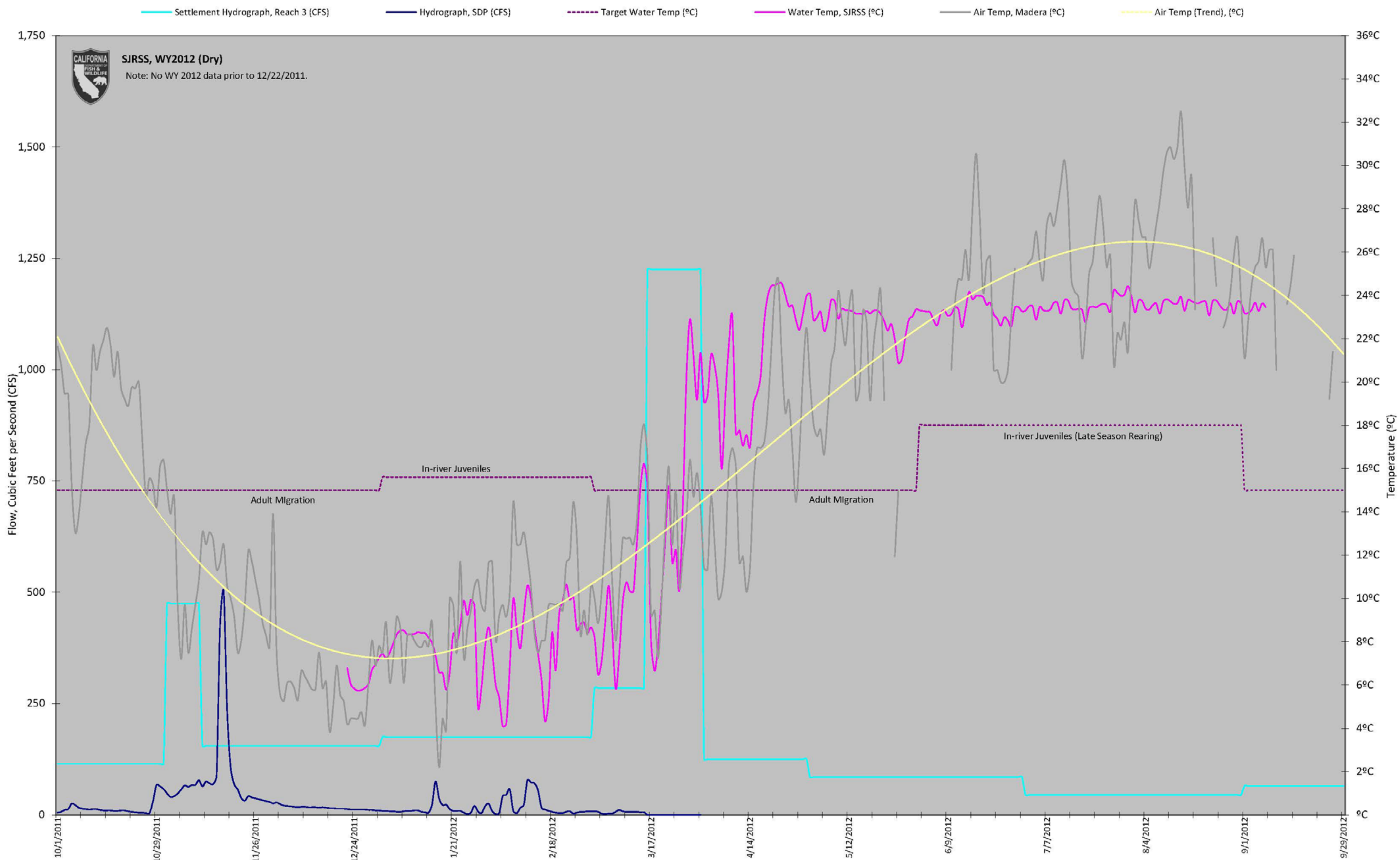

Figure 42: Daily average temperature in the San Joaquin River at Sand Slough Control Structure (River Mile 168.3) compared with stream flow and air temperature

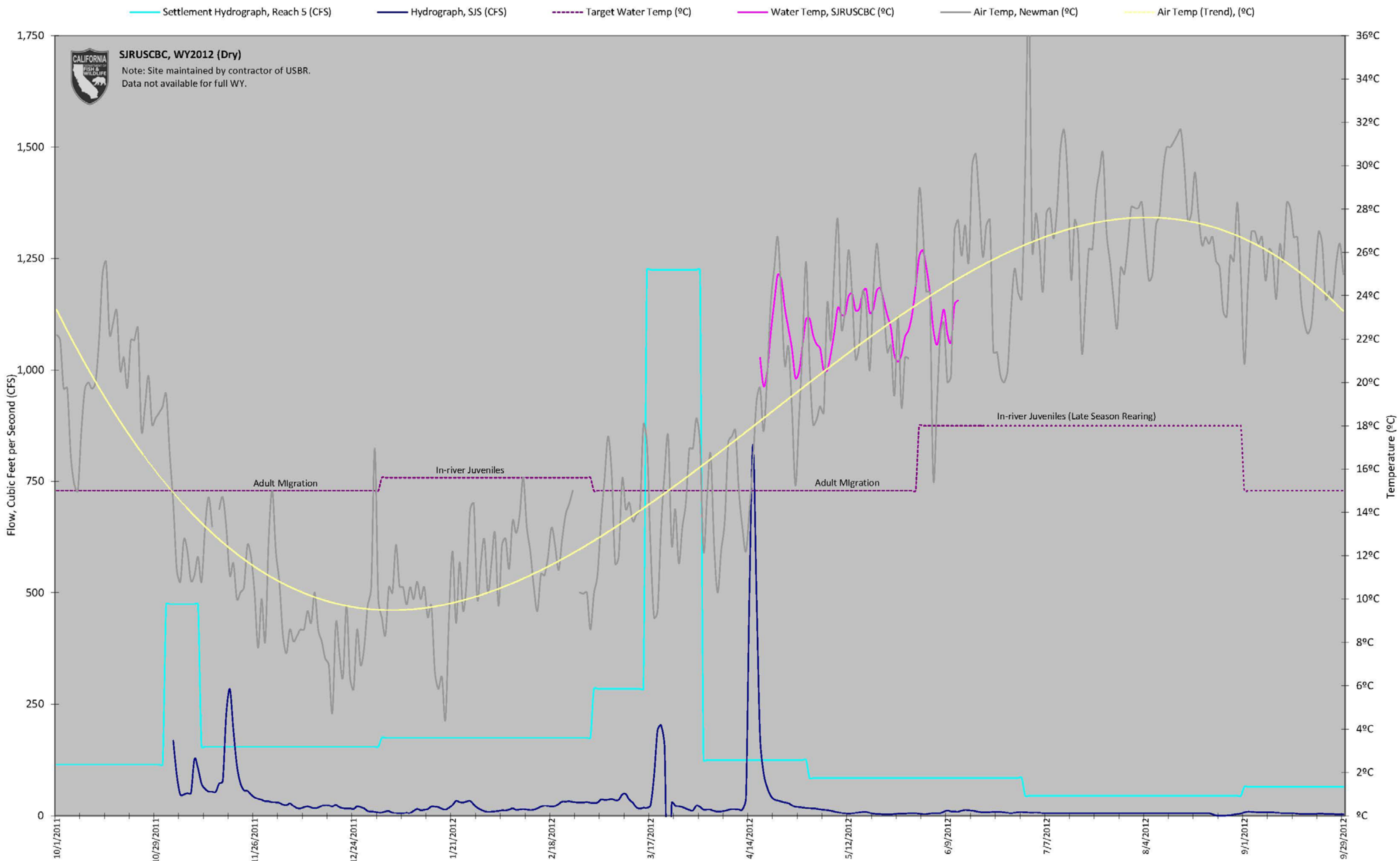

Figure 43: Daily average temperature in the San Joaquin River upstream of the Bear Creek Confluence (River Mile 136.4) compared with stream flow and air temperature

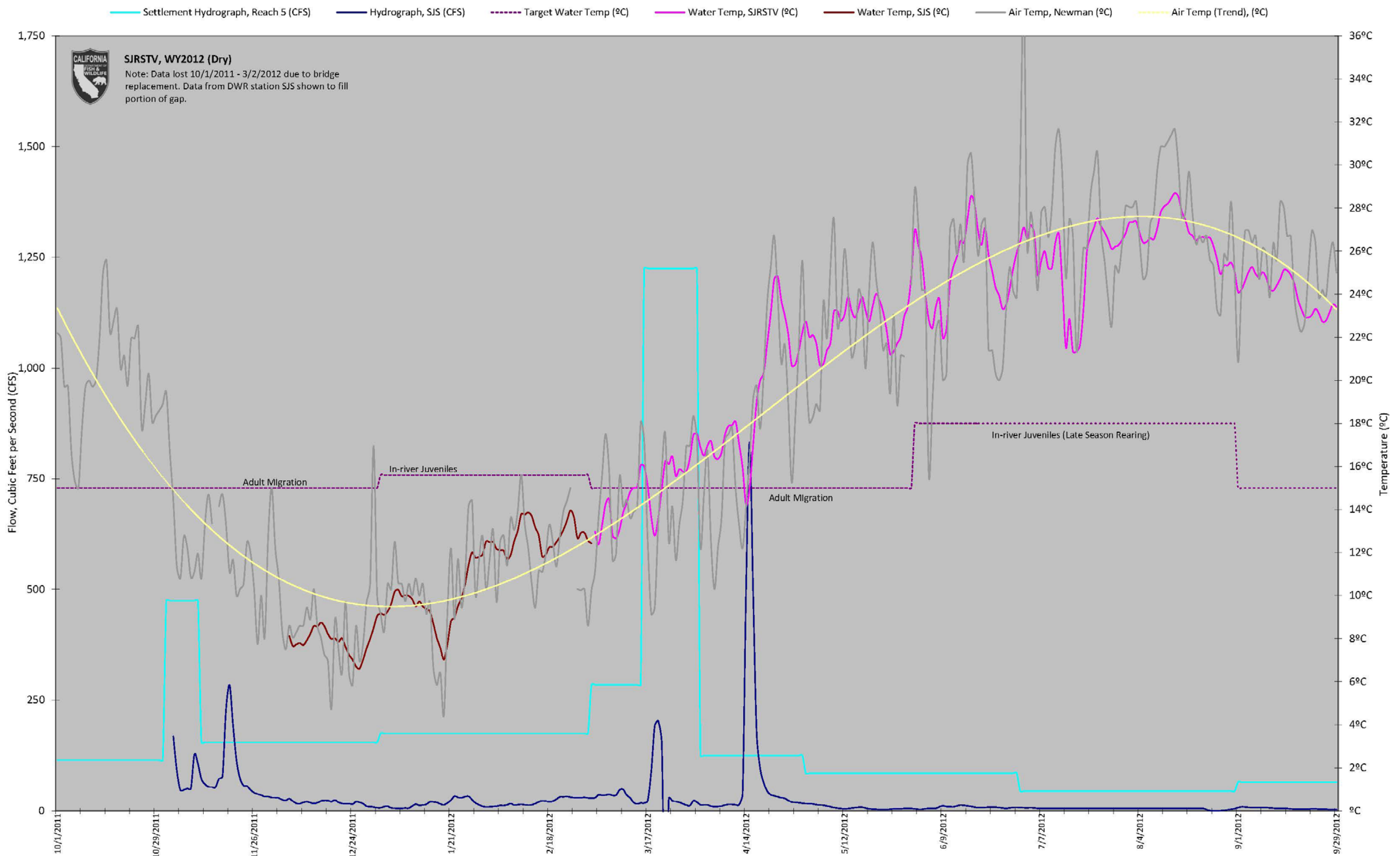

Figure 44: Daily average temperature in the San Joaquin River at Stevenson Bridge (River Mile 132.8) compared with stream flow and air temperature

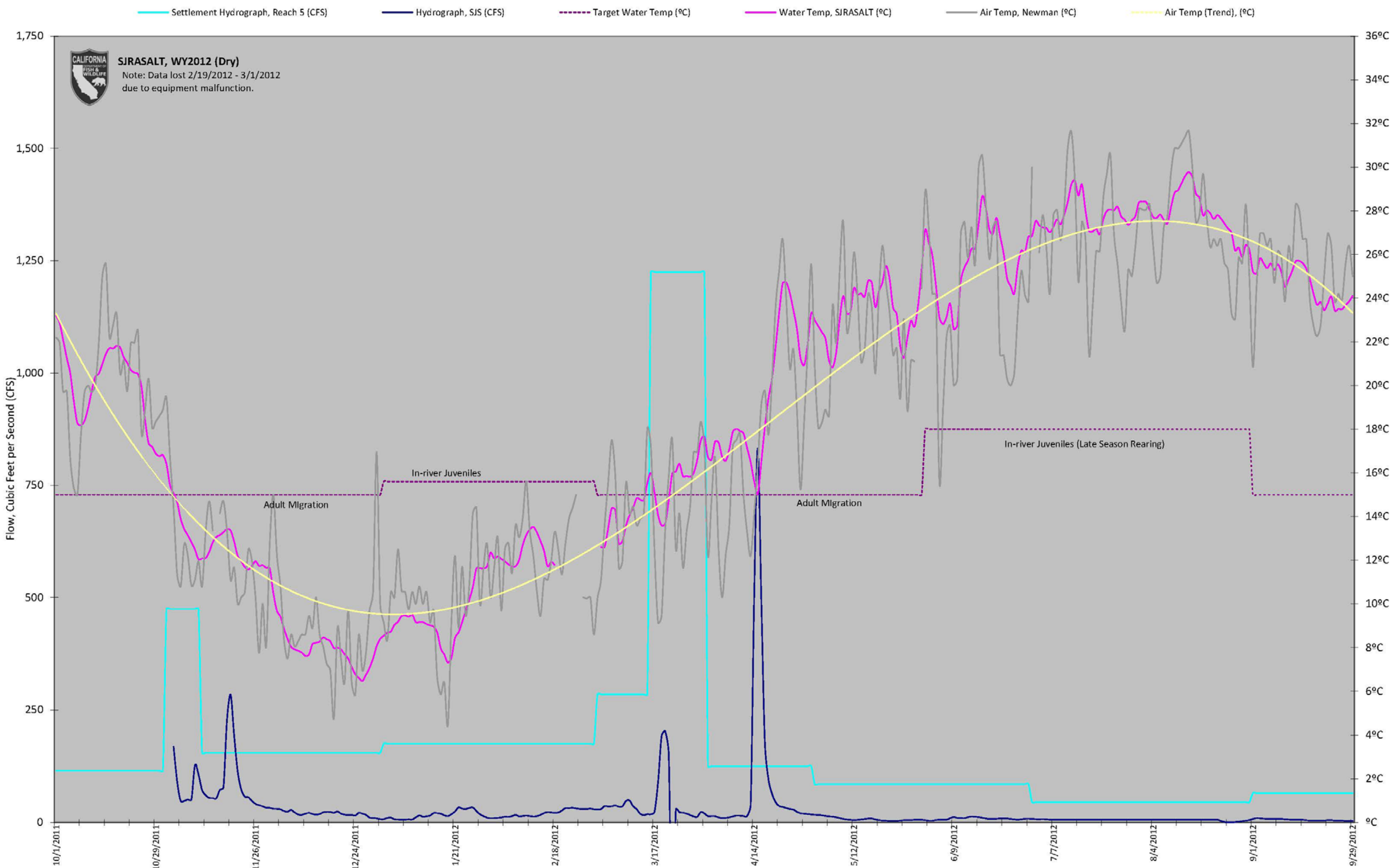

Figure 45: Daily average temperature in the San Joaquin River above Salt Slough (River Mile 131.0) compared with stream flow and air temperature

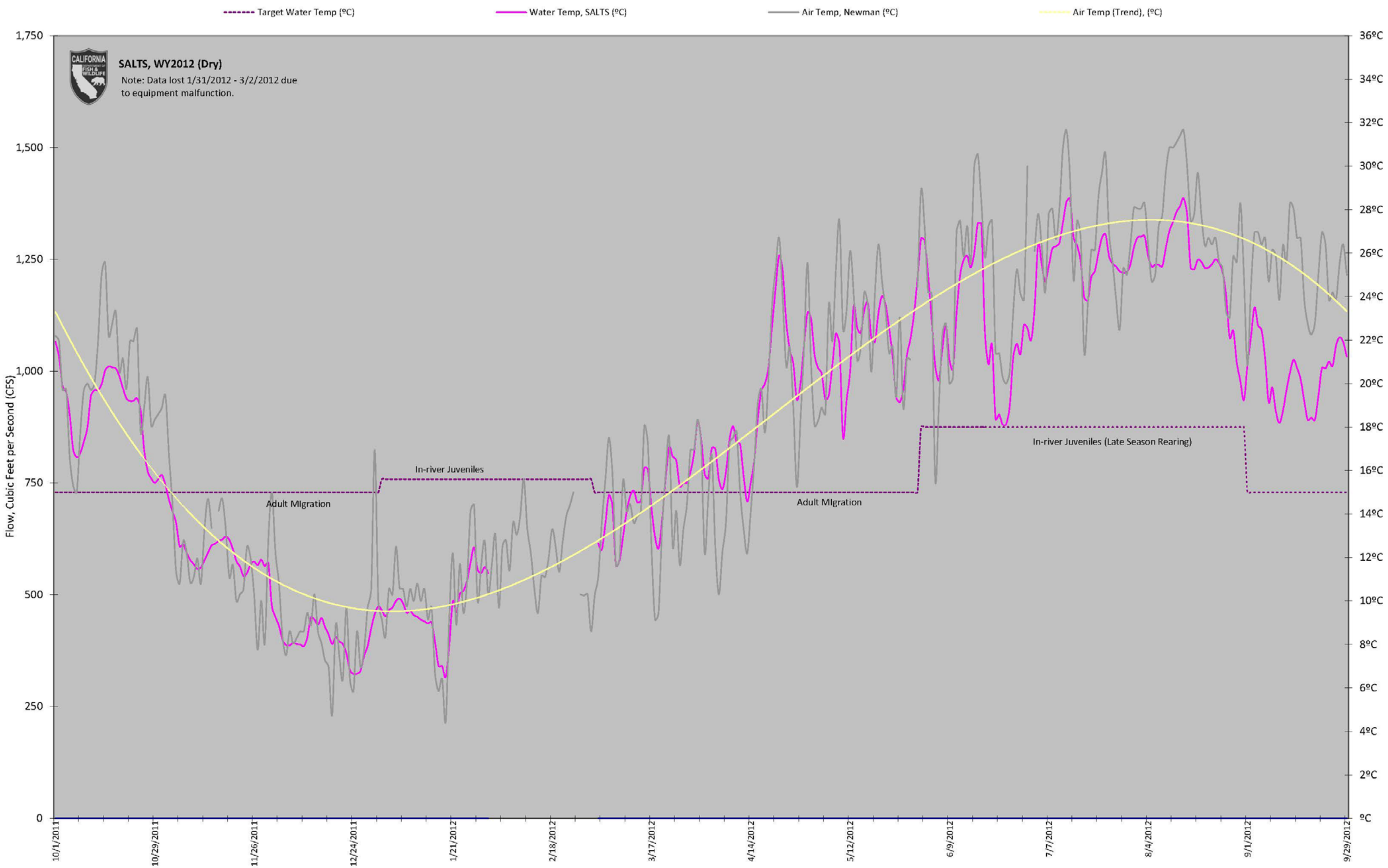

Figure 46: Daily average temperature in Salt Slough compared with air temperature

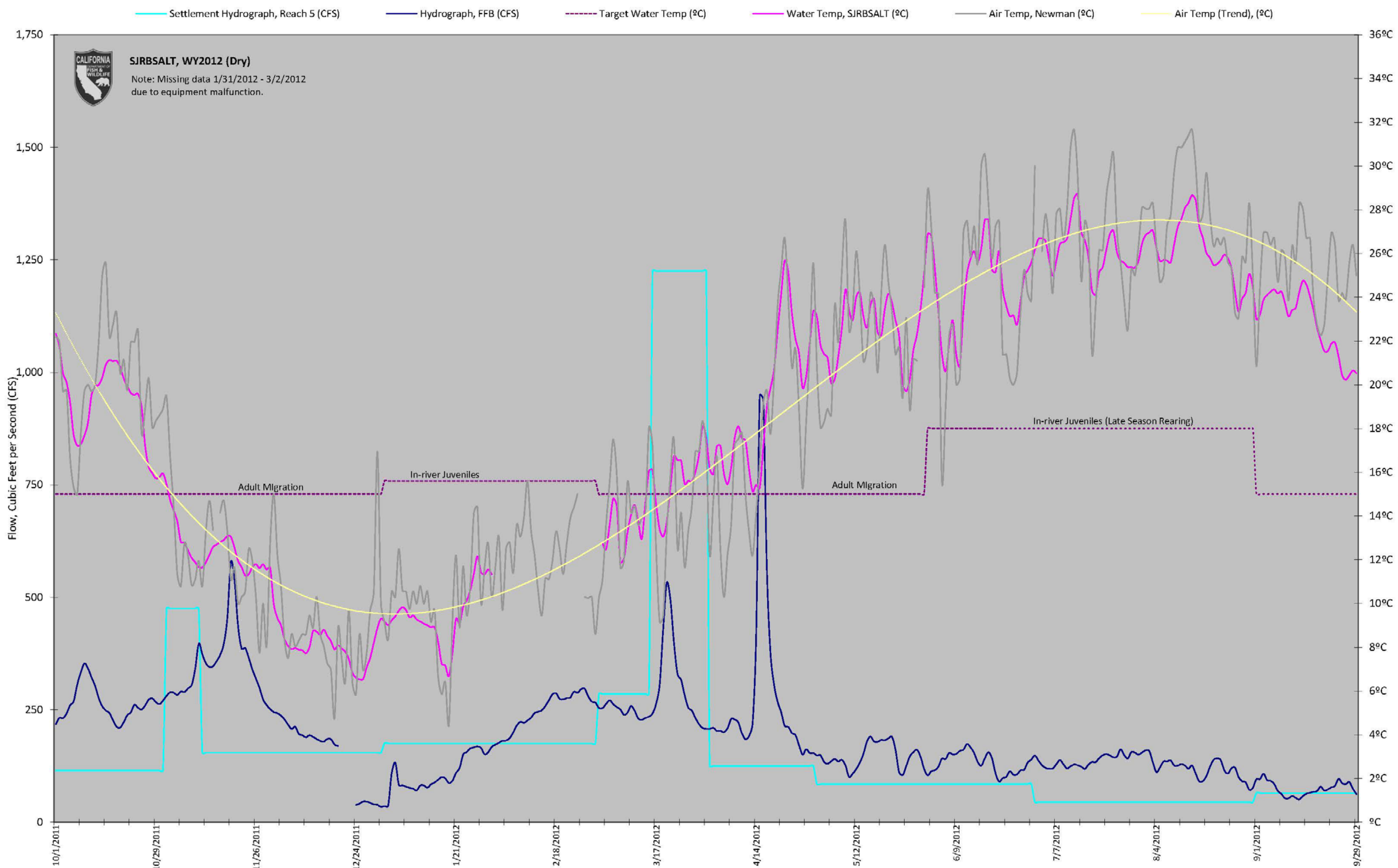

Figure 47: Daily average temperature in the San Joaquin River downstream of Salt Slough (River Mile 130.0) compared with stream flow and air temperature

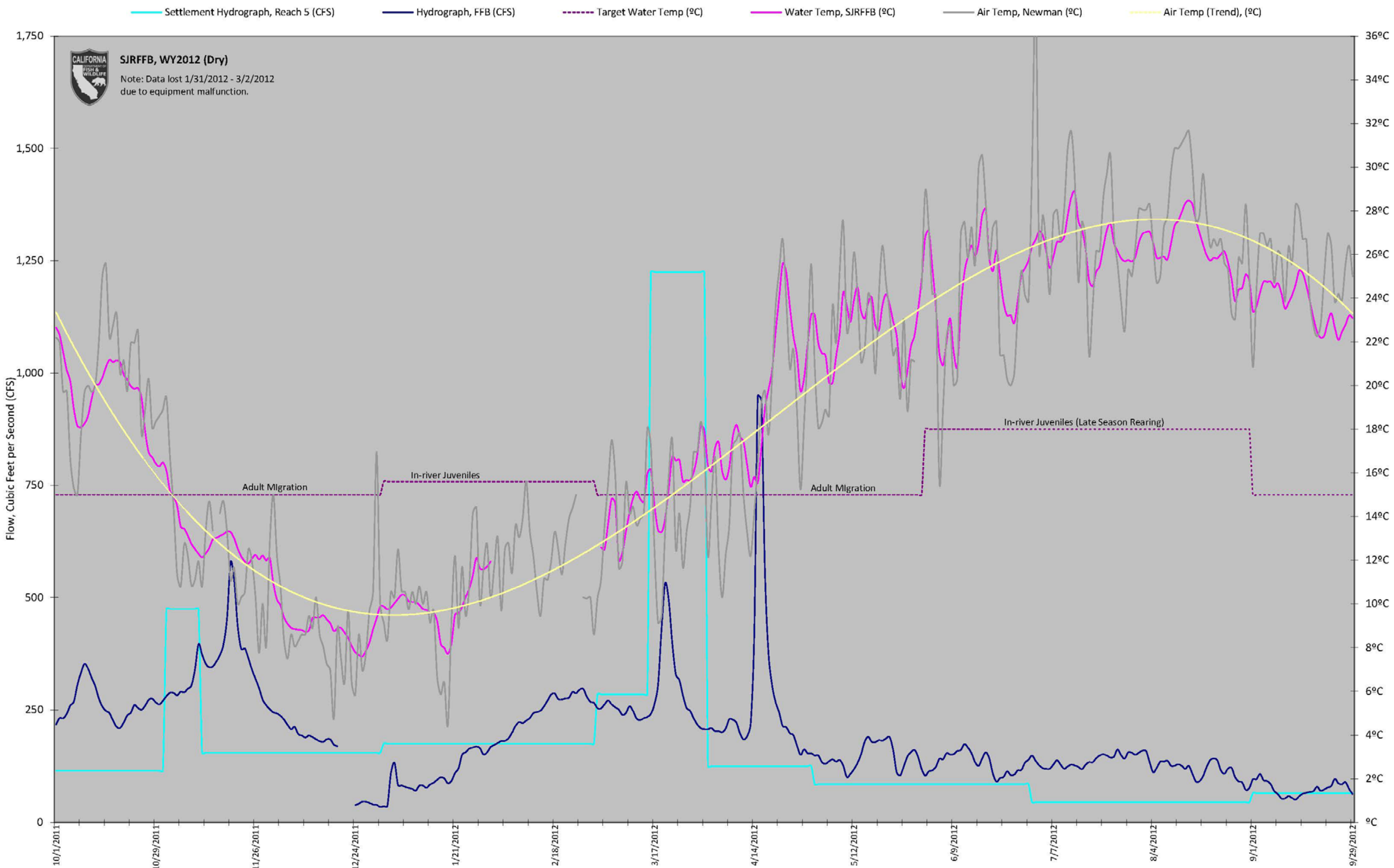

Figure 48: Daily average temperature in the San Joaquin River at Freemont Ford Bridge (River Mile 127.0) compared with stream flow and air temperature

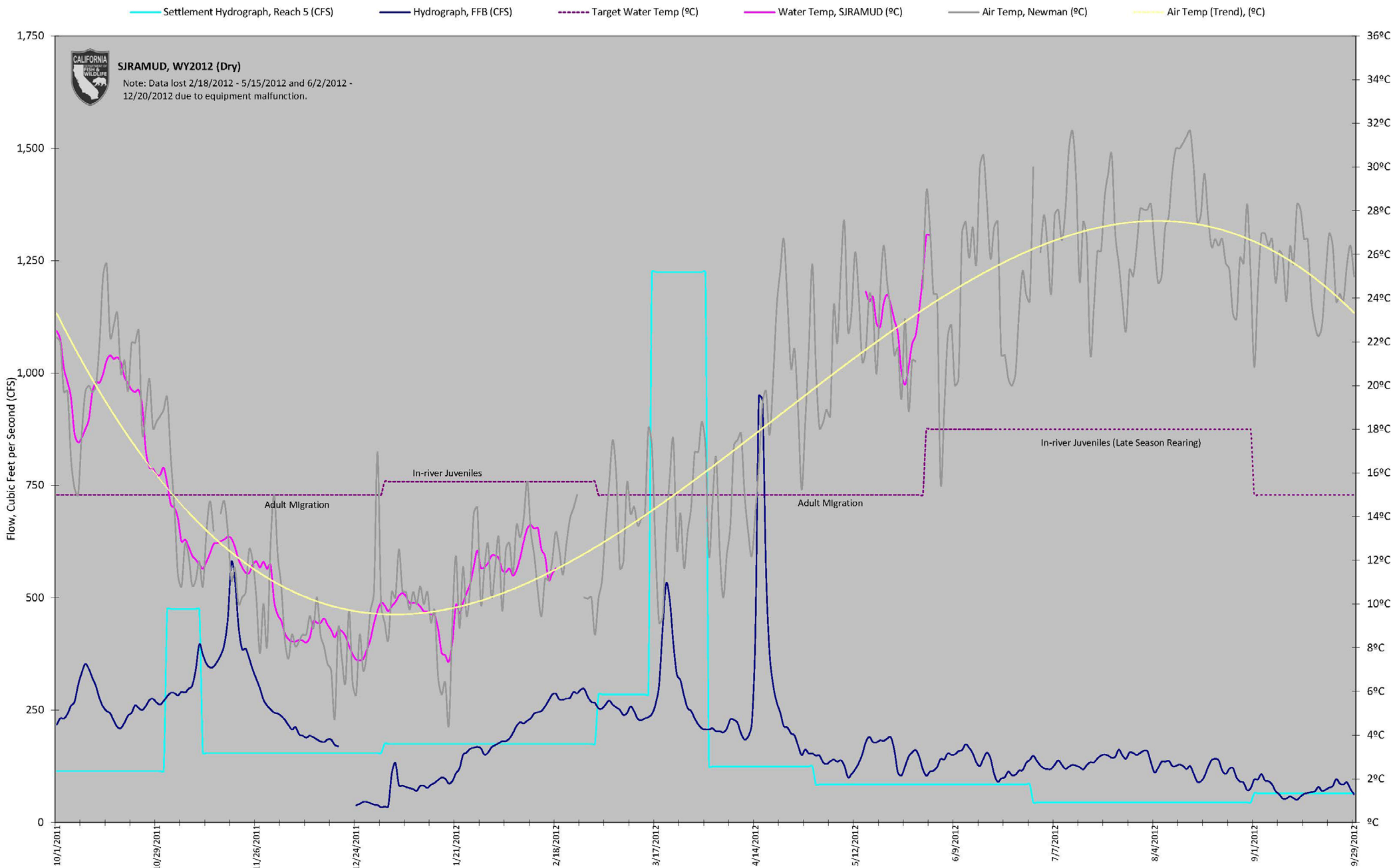

Figure 49: Daily average temperature in the San Joaquin River upstream of Mud Slough (River Mile 125.0) compared with stream flow and air temperature

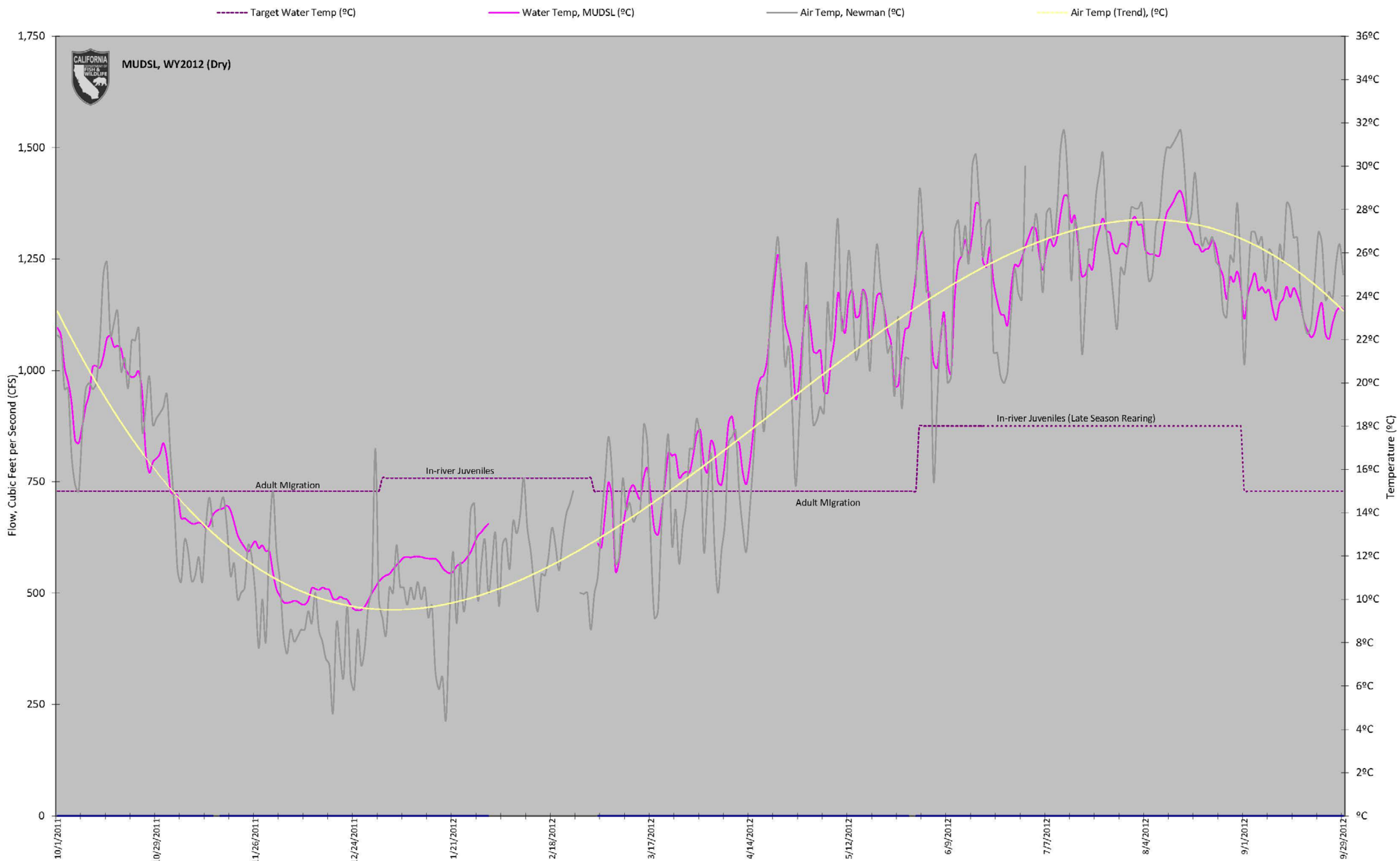

Figure 50: Daily average temperature in Mud Slough compared to air temperature

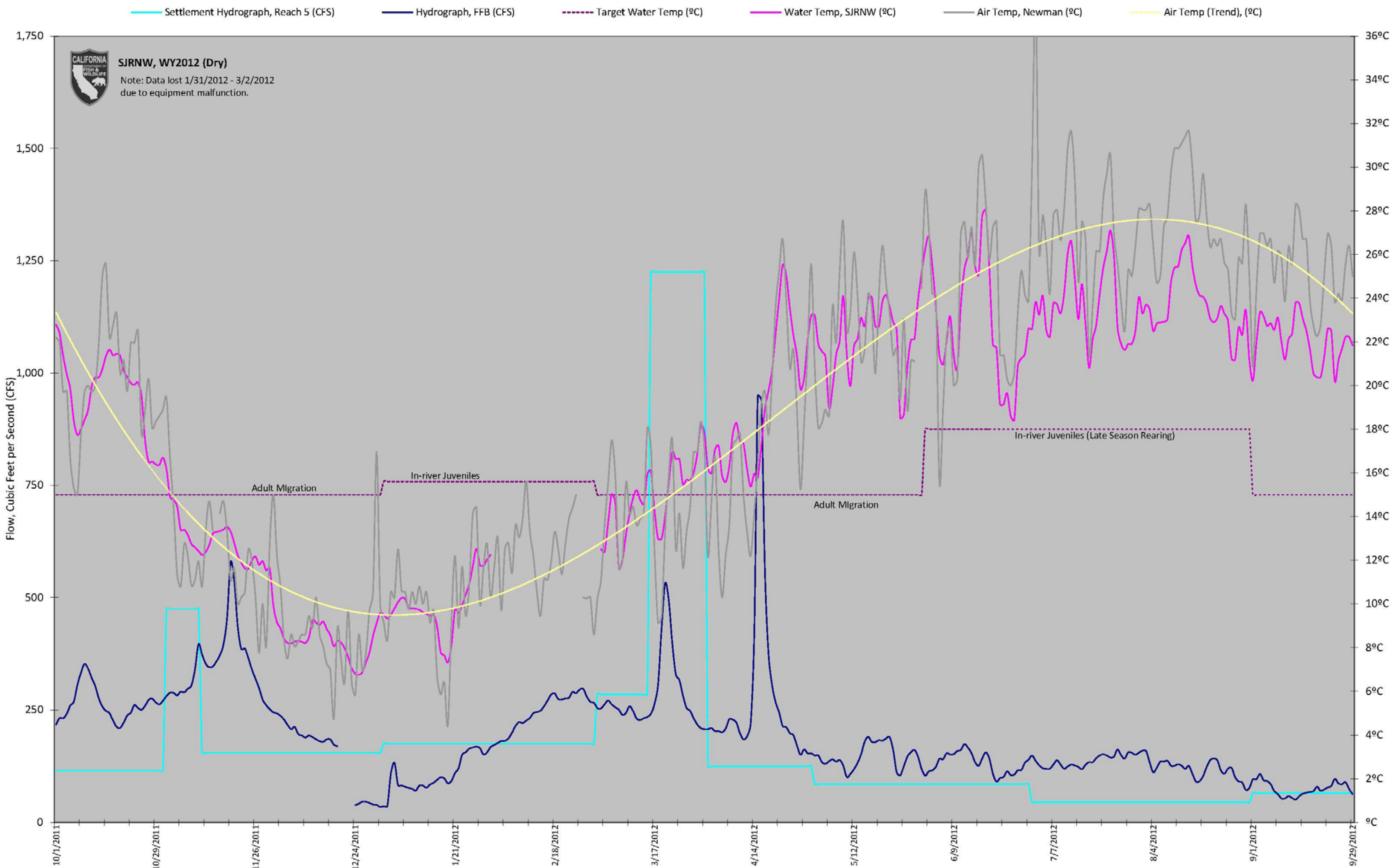

Figure 51: Daily average temperature in the San Joaquin River upstream of Newman Wasteway (River Mile 121.0) compared with stream flow and air temperature

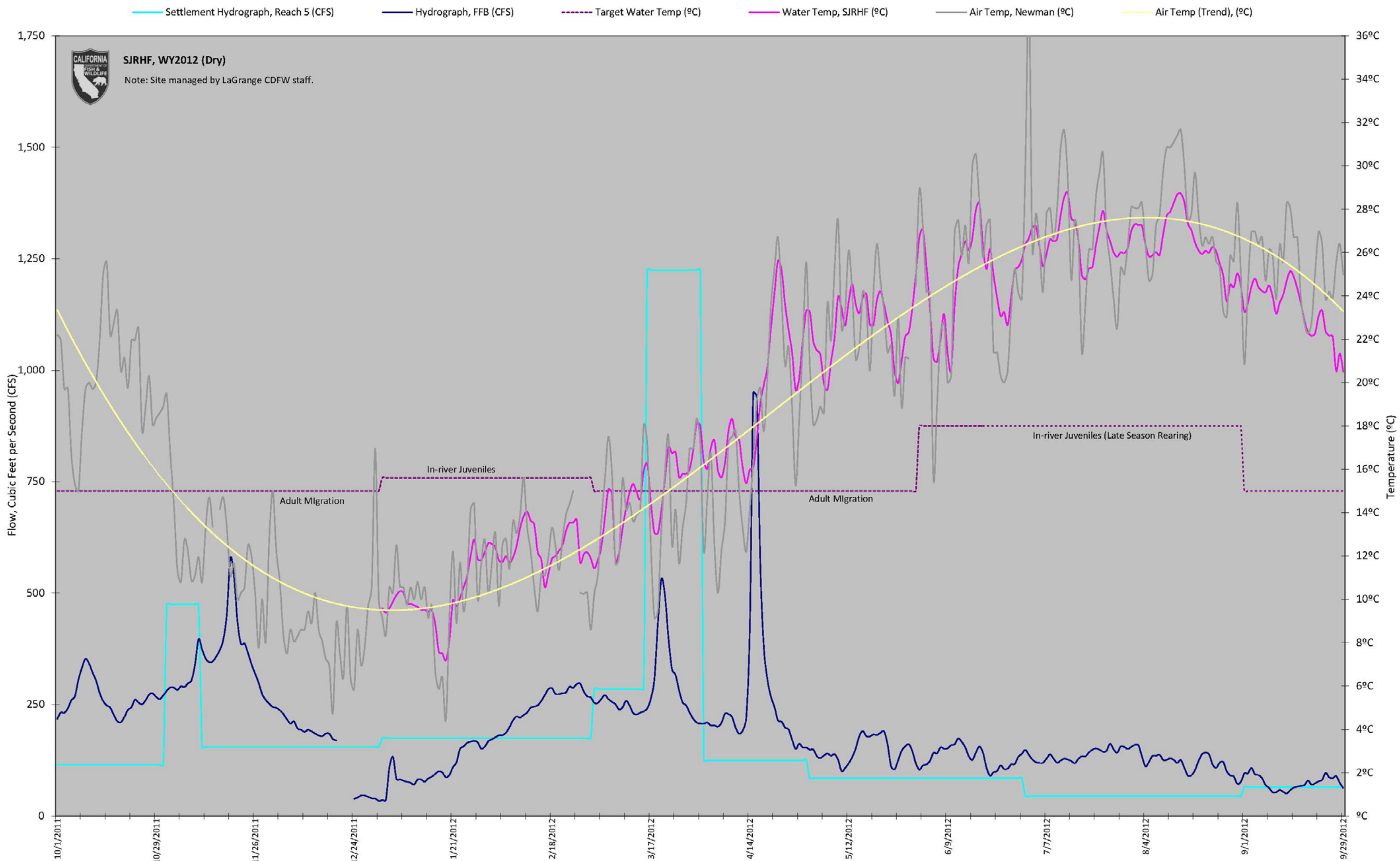

Figure 52: Daily average temperature in the San Joaquin River at Hills Ferry (River Mile 118.5) compared with stream flow and air temperature

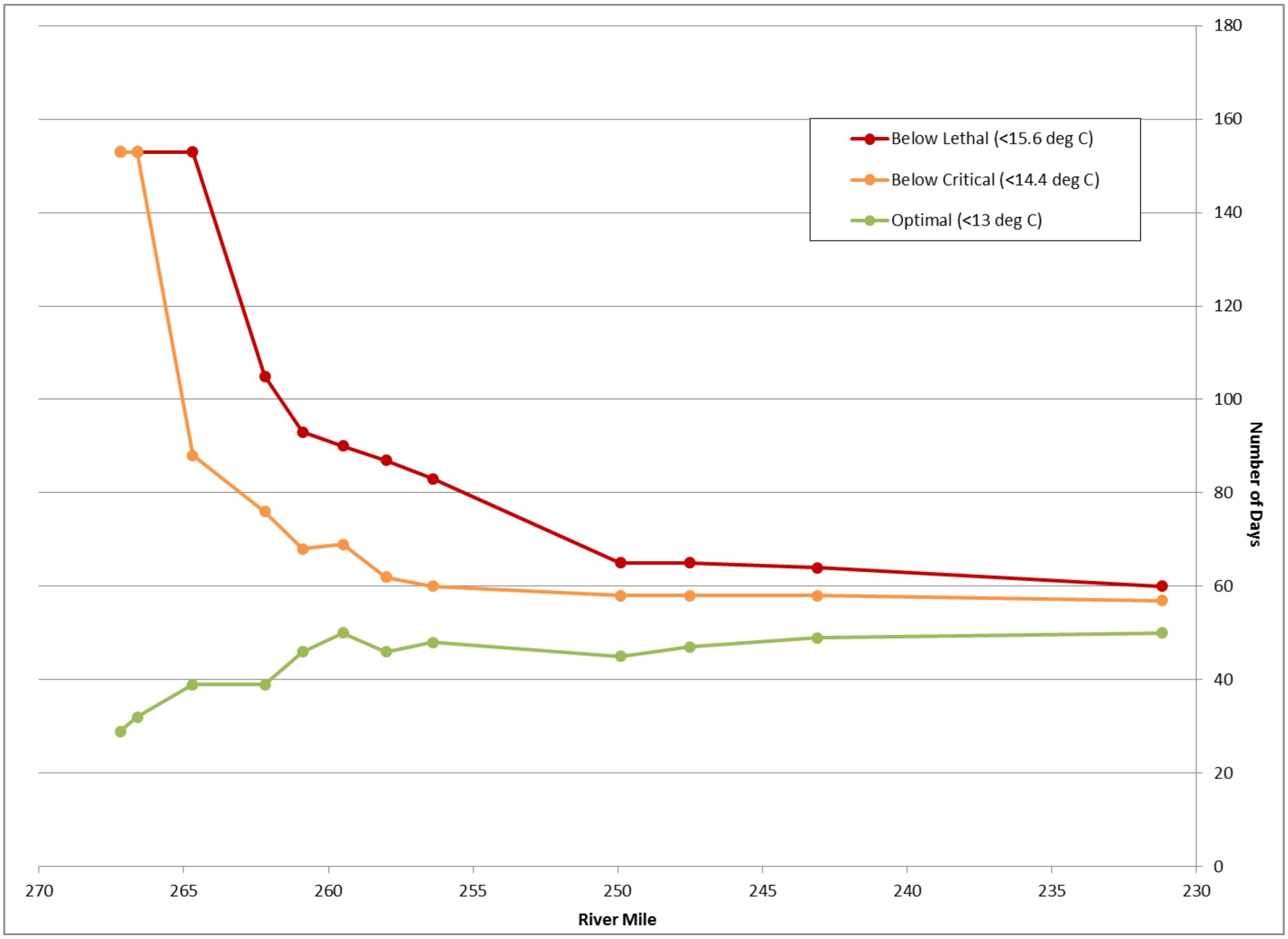

Figure 53: Number of days during expected spawning and incubation period (August through December, 2011) that water temperature was below objectives for incubation and emergence (SJRRP, 2010)

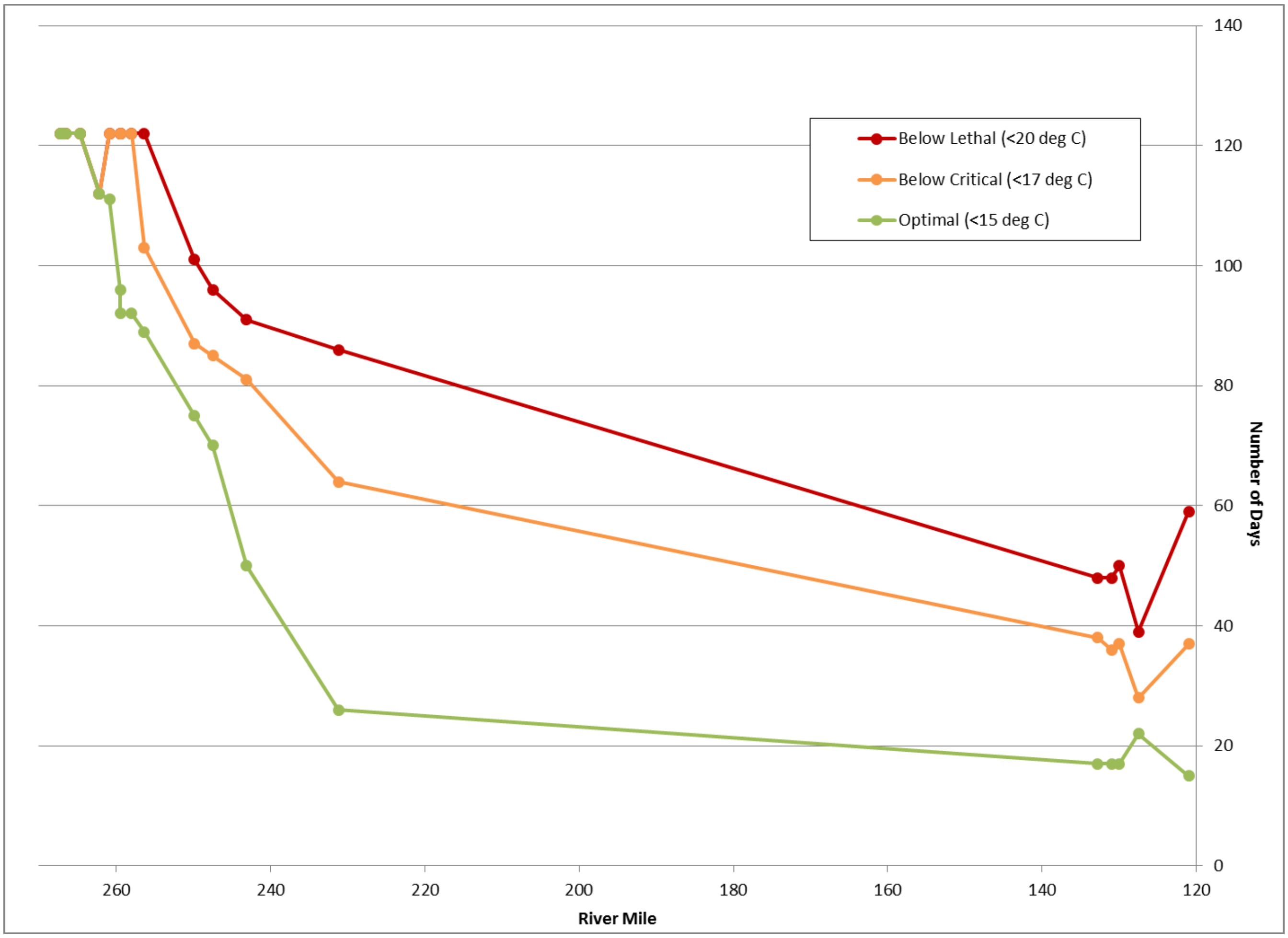

Figure 54: Number of days during expected spring-run adult migration period (March through June, 2012) that water temperature was below objectives for adult migration (SJRRP, 2010)

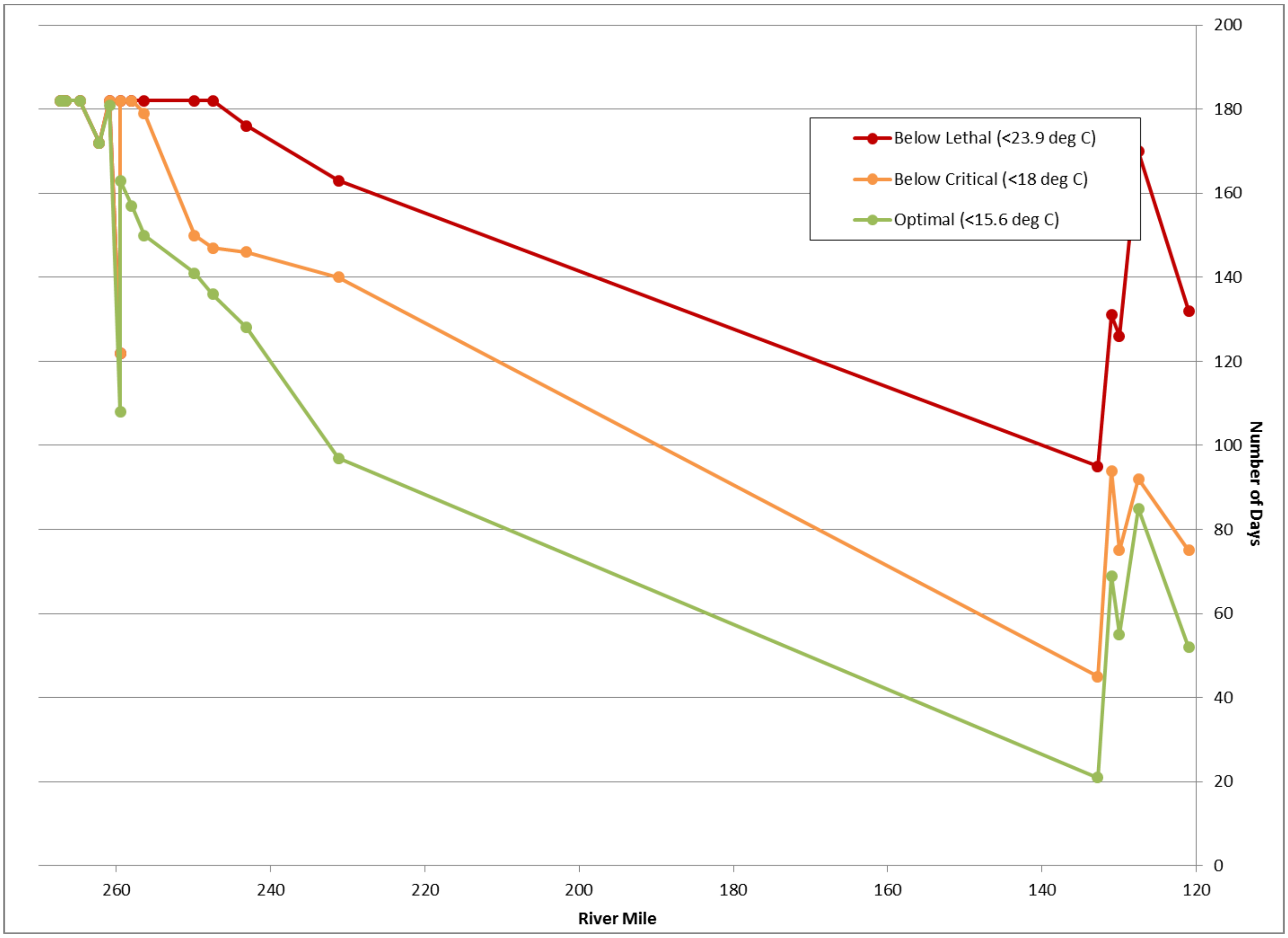

Figure 55: Number of days during expected juvenile outmigration period (January through June, 2012) that water temperature was below objectives for juvenile migration (SJRRP, 2010)

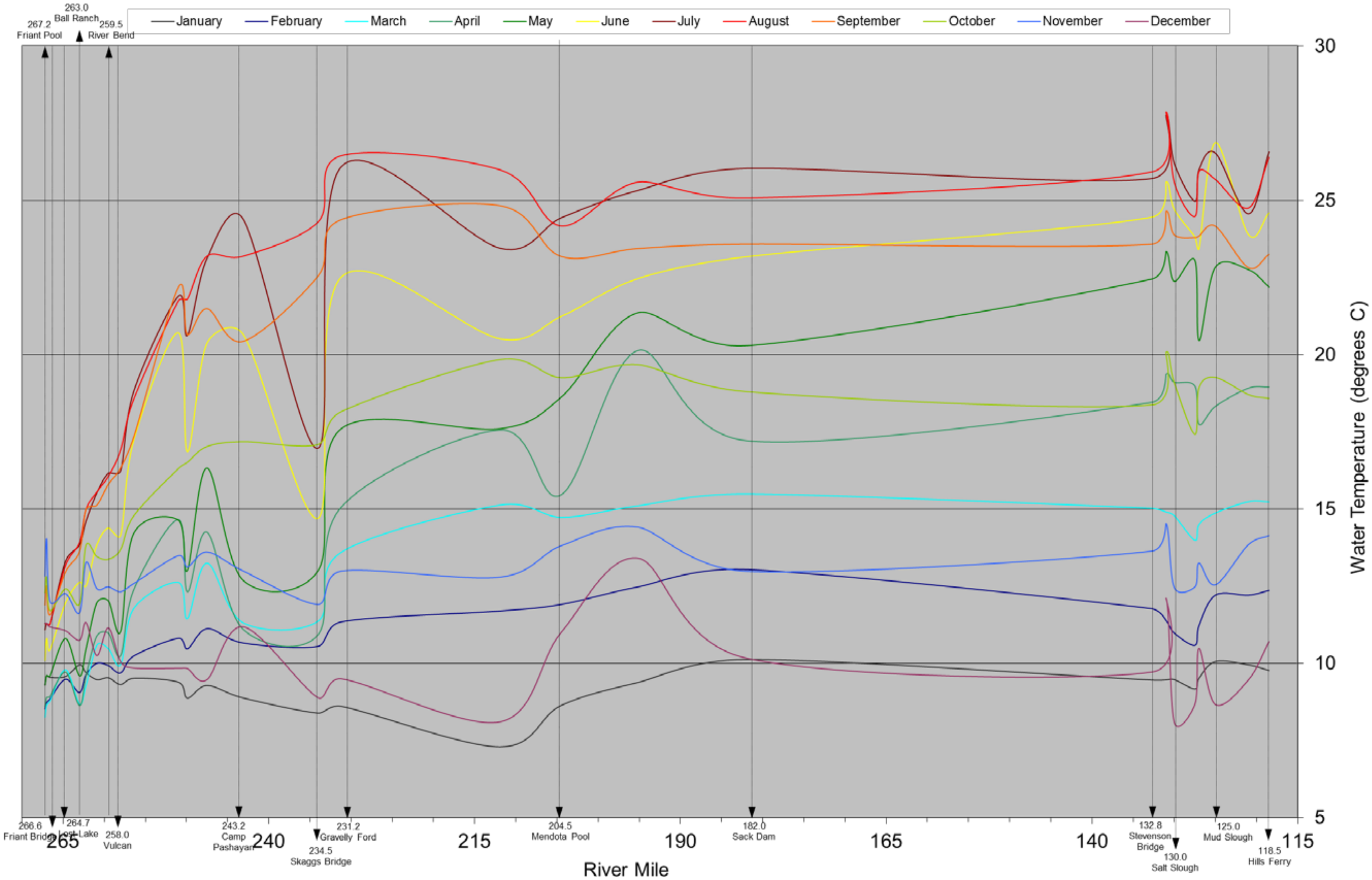

Figure 56: Monthly average temperature by River Mile for period of record

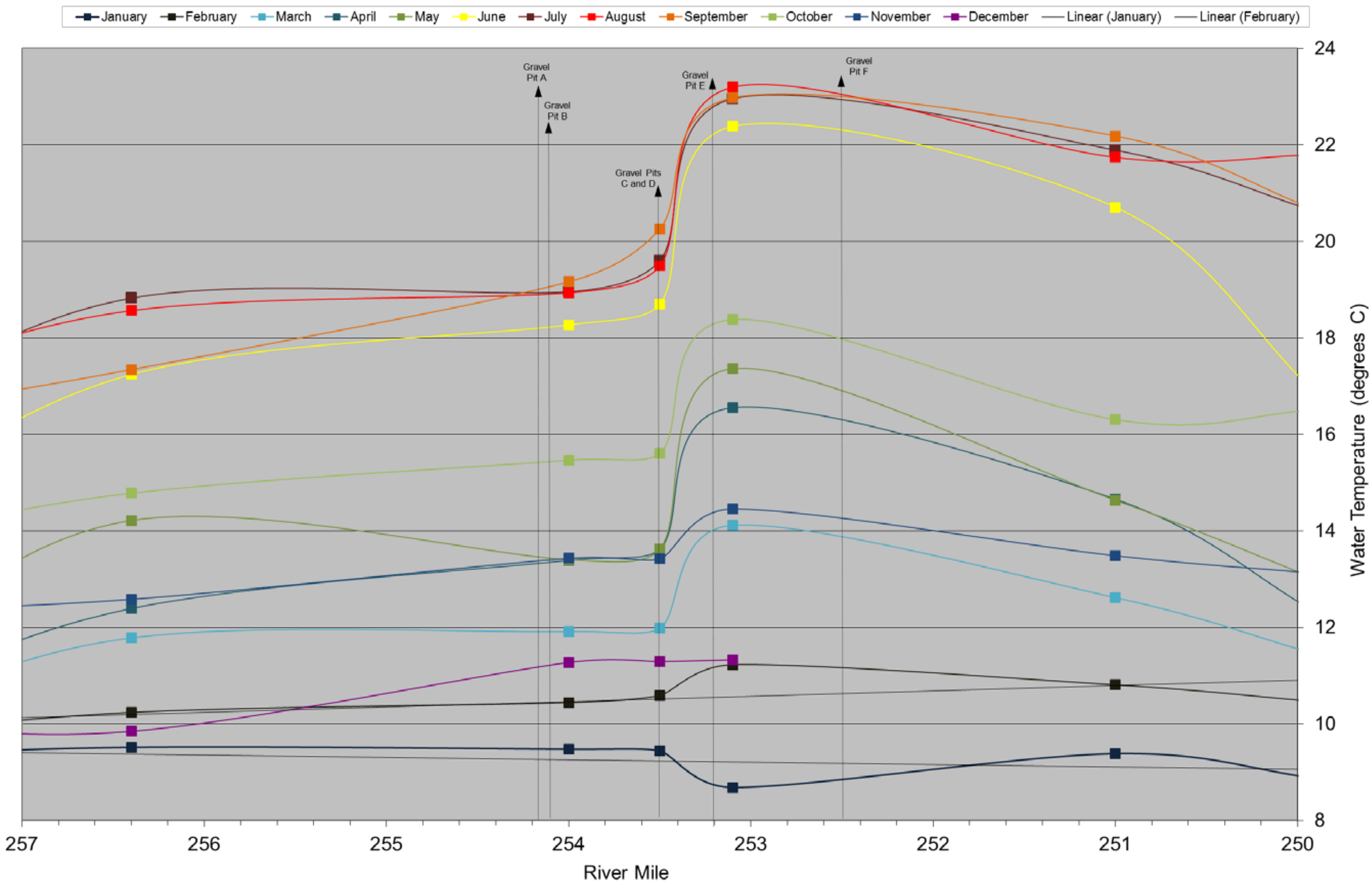

Figure 57: Longitudinal change average instream temperature near gravel pits in Reach 1A by month (RM 250-257) for period of record

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