Appendix I

Comparison of 2019 Klamath River Temperature TMDL Allocations to 2013 – 2018 Source Discharge Data

September 2019

TMDL Program
700 NE Multnomah
Portland, OR 97232
Phone: 503-229-5630
Contact: Ryan Michie

www.oregon.gov/DEQ

DEQ is a leader in restoring, maintaining and enhancing the quality of Oregon's air, land and water.

State of Oregon
Department of Environmental Quality

Prepared by:

Ryan Michie, Senior Analyst

Oregon Department of Environmental Quality, Watershed Management Section

700 NE Multnomah St., Suite #600, Portland, OR 97232

www.oregon.gov/deq

Alternative formats: DEQ can provide documents in an alternate format or in a language other than English upon request. Call DEQ at 800-452-4011 or email deqinfo@deq.state.or.us

Table of Contents

Figures

Tables

I.1. Purpose

This report summarizes the Klamath River and source discharge data from 2013-2018 and how these data compare to the allocations contained in the 2019 Upper Klamath and Lost Subbasins Temperature TMDL. Sources evaluated include Klamath Falls WWTP (Spring Street WWTP), South Suburban WWTP, and warming from Klamath Straits Drain, and Lost River Diversion Channel.

This report is intended as an informational document to assist DEQ and the interested public understand the potential impact of the Klamath River temperature TMDL allocations.

The plots and table summaries in this report contain the following information for years 2013-2018:

- The Klamath River daily mean temperature and daily mean flow.
- For each source, the change in Klamath River temperature at the point of discharge and the difference between that change and the allocated change in river temperature.
- The maximum difference between the current source loading and the TMDL allocated load.
- The current source discharge flow and the calculated maximum reduction to daily mean source discharge flow needed to achieve the allocation. Discharge temperature is the same as current.
- The current source discharge temperature and the calculated maximum reduction to daily mean discharge temperature needed to achieve the allocation. Discharge flow is the same as current.

Please refer to attached spreadsheets for daily data used for plotting and table summaries.

I.2. Data Sources

Source	**Discharge Flow**	**Discharge Temperature**	**River Flow and Temperature**
Klamath Falls WWTP (KF)	DMRs	DMRs	Year 2013 - 2018 USGS 11507500 Link River at Klamath Falls See Figure I-4
Klamath Straits Drain (KSD)	USGS 11509340 KSD near Worden	USGS 420451121510000 KSD near Highway 97	
Lost River Diversion Channel (LRDC)	Net flow derived from measurements at USBOR gages at Lost River Diversion Dam (LRD) Downstream gage (QJ), minus diversions at Station 48, and Miller Hill Pump Plant, OR (MHPO).	USBOR Gage LRVO - Lost River Diversion Channel at Tingley	
South Suburban WWTP (SS)	DMRs	DMRs	

I.3. Equations

Wasteload Allocation Equation

The following equation was used to calculate the thermal waste load allocations.

$$WLA = (\Delta T) \cdot (Q_E + Q_R) \cdot C_F$$ **Equation 2 3**

where,

$WLA =$ Waste load allocation (kilocalories/day).

$\Delta T =$ The maximum temperature increase (°C) using 100% of river flow not to be exceeded by each individual source from all outfalls combined.

$Q_E =$ The daily mean effluent flow (cfs).

$Q_R =$ The daily mean river flow rate, upstream (cfs).

When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the mean daily river flow, upstream.

$C_F =$ Conversion factor using flow in cubic feet per second (cfs): 2,446,665

$$\frac{1\ ft^3}{1\ sec} \cdot \frac{1\ m^3}{35.31\ ft^3} \cdot \frac{1000\ kg}{1\ m^3} \cdot \frac{86400\ sec}{1\ day} \cdot \frac{1\ kcal}{1\ kg\ \cdot 1℃} = 2{,}446{,}665$$

WLA Permit Compliance Equation

The following equation shall be used to determine compliance with the waste load allocation (WLA).

$ETL = (T_E - T_R) \cdot Q_E \cdot C_F$ **Equation 2 4**

where,

$ETL =$ The daily excess thermal load (kilocalories/day) used to evaluate compliance with the waste load allocation (WLA) from Equation 2 3**.**

$T_R =$ The point of discharge applicable river temperature (°C).

T_R is the daily mean river temperature at Link River (USGS 11507500) is used as an appropriate estimate for T_R. Daily mean river temperatures immediately upstream of the outfall may also be used for T_R as long as adjustments are made to eliminate any warming or cooling between the outflow from Upper Klamath Lake and that location not attributed to natural sources.

Between October 1 and May 31, if the daily maximum river temperatures > = 28°C, T_R = 28°C.

$T_E =$ The daily mean effluent temperature (°C)

$Q_E =$ The daily mean effluent flow (cfs or MGD)

$C_F =$ Conversion factor for flow in cubic feet per second (cfs): 2,446,665

$$\frac{1\,ft^3}{1\,sec} \cdot \frac{1\,m^3}{35.31\,ft^3} \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{86400\,sec}{1\,day} \cdot \frac{1\,kcal}{1\,kg\ \cdot 1℃} = 2{,}446{,}665$$

Conversion factor for flow in millions of gallons per day (MGD): 3,785,411

$$\frac{1\,m^3}{264.17\,gal} \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{1000000\,gal}{1\,million\,gal} \cdot \frac{1\,kcal}{1\,kg\ \cdot 1℃} = 3{,}785{,}441$$

Calculating Current Change in Temperature

The following equation is used to determine compliance with the allowed ∆T allocated in the TMDL.

$$\Delta T_{Current} = \left(\frac{Q_E}{Q_E + Q_R}\right) \cdot (T_E - T_R)$$ **Equation I-1**

where,

$\Delta T_{Current} =$ The current river temperature increase (°C) using 100% of river flow.

$Q_E =$ The daily mean effluent flow (cfs).

$Q_R =$ The daily meanriver flow rate, upstream (cfs).

When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the mean daily river flow, upstream.

$T_E =$ The daily mean effluent temperature (°C)

$T_R =$ The point of discharge applicable river temperature (°C).

T_R is the daily mean river temperature at Link River (USGS 11507500) is used as an appropriate estimate for T_R. Daily mean river temperatures immediately upstream of the outfall may also be used for T_R as long as adjustments are made to eliminate any warming or cooling between the outflow from Upper Klamath Lake and that location not attributed to natural sources.

Between October 1 and May 31, if the daily maximum river temperatures > = 28°C, T_R = 28°C.

Calculating Acceptable Effluent Temperatures

The daily mean effluent temperatures (°C) acceptable under the allowed ΔT and the waste load allocation (WLA).

$$T_{E\_WLA} = \frac{(Q_E + Q_R) \cdot (T_R + \Delta T) - (Q_R \cdot T_R)}{Q_E}$$ **Equation I-2a**

$$T_{E\_WLA} = \frac{(WLA)}{Q_E \cdot C_F}$$ **Equation I-2b**

where,

$T_{E\_WLA} =$ Daily mean effluent temperature (°C) allowed under the waste load allocation.

$WLA =$ Waste load allocation (kilocalories/day).

$\Delta T =$ The maximum temperature increase (°C) using 100% of river flow not to be exceeded by each individual source from all outfalls combined.

$Q_E =$ The daily mean effluent flow (cfs).

$Q_R =$ The daily mean river flow rate, upstream (cfs).

When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the average daily river flow, upstream.

$T_R =$ The point of discharge applicable river temperature (°C).

T_R is the daily mean river temperature at Link River (USGS 11507500) is used as an appropriate estimate for T_R. Daily mean river temperatures immediately upstream of the outfall may also be used for T_R as long as adjustments are made to eliminate any warming or cooling between the outflow from Upper Klamath Lake and that location not attributed to natural sources.

Between October 1 and May 31, if the daily maximum river temperatures > = 28°C, T_R = 28°C.

$C_F =$ Conversion factor for flow in cubic feet per second (cfs): 2,446,665

$$\frac{1\,ft^3}{1\,sec} \cdot \frac{1\,m^3}{35.31\,ft^3} \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{86400\,sec}{1\,day} \cdot \frac{1\,kcal}{1\,kg\,\cdot 1℃} = 2{,}446{,}665$$

Calculating Acceptable Effluent Flows

The daily average effluent flow (cfs) acceptable under the allowed ΔT and the waste load allocation (WLA).

$$Q_{E\_WLA} = \frac{(Q_R \cdot T_R) - ((T_R + \Delta T) * Q_R)}{T_R + \Delta T - T_E}$$ **Equation I-3a**

$$Q_{E\_WLA} = \frac{(WLA)}{(T_E - T_R) * C_F}$$ **Equation I-3b**

where,

$Q_{E\_WLA} =$ Daily mean effluent temperature (cfs) allowed under the waste load allocation.

$WLA =$ Waste load allocation (kilocalories/day).

$\Delta T =$ The maximum temperature increase (°C) using 100% of river flow not to be exceeded by each individual source from all outfalls combined.

$T_E =$ The daily mean effluent temperature (°C).

$Q_R =$ The daily mean river flow rate, upstream (cfs).

When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the average daily river flow, upstream.

$T_R =$ The point of discharge applicable river temperature (°C).

T_R is the daily mean river temperature at Link River (USGS 11507500) is used as an appropriate estimate for T_R. Daily mean river temperatures immediately upstream of the outfall may also be used for T_R as long as adjustments are made to eliminate any warming or cooling between the outflow from Upper Klamath Lake and that location not attributed to natural sources.

Between October 1 and May 31, if the daily maximum river temperatures > = 28°C, T_R = 28°C.

$C_F =$ Conversion factor for flow in cubic feet per second (cfs): 2,446,665

$$\frac{1\,ft^3}{1\,sec} \cdot \frac{1\,m^3}{35.31\,ft^3} \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{86400\,sec}{1\,day} \cdot \frac{1\,kcal}{1\,kg\,\cdot 1°C} = 2{,}446{,}665$$

I.4. Monthly summaries

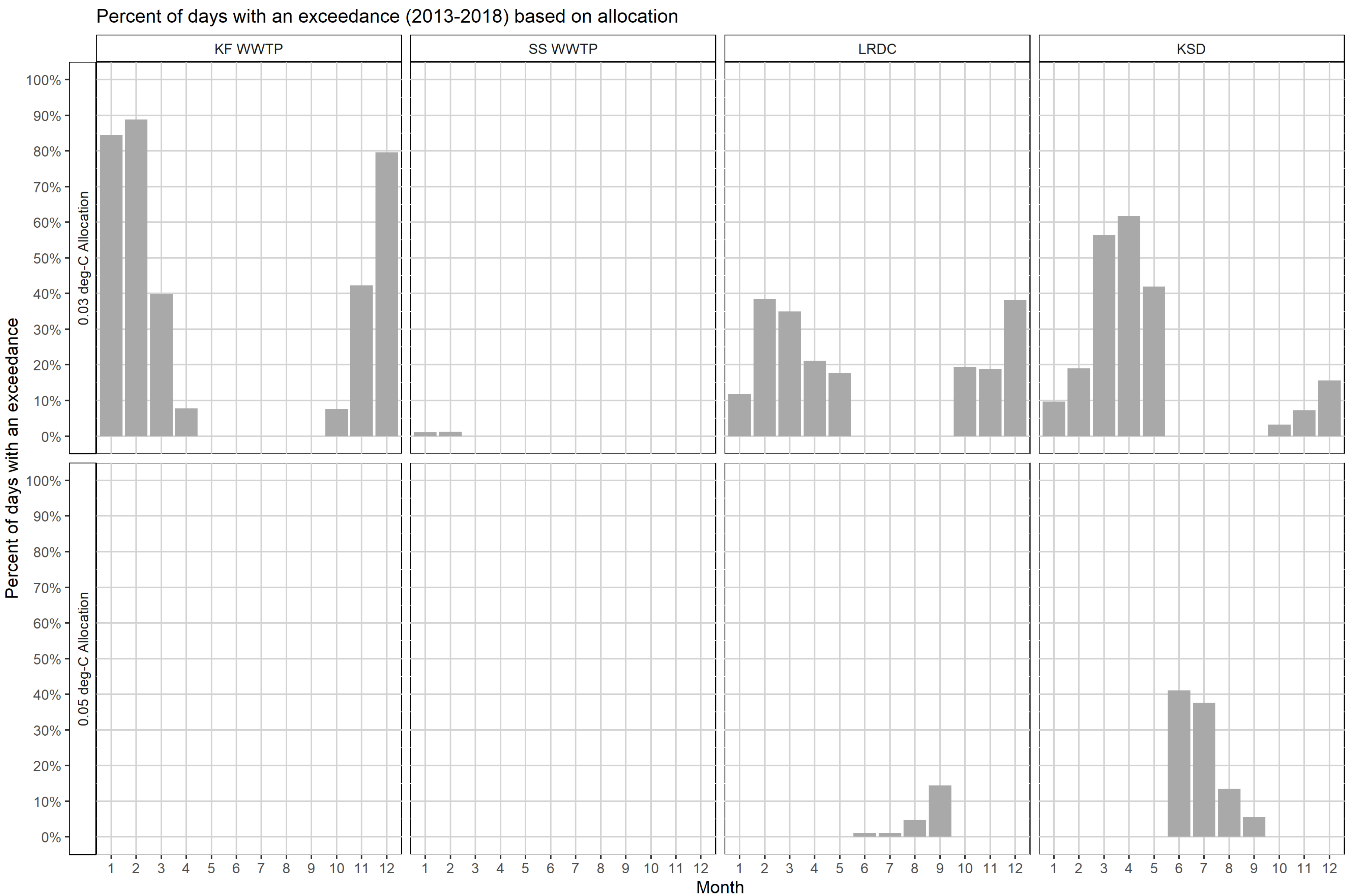

Figure I- 1. Percent of days with an exceedance at the point of discharge in the Klamath River.

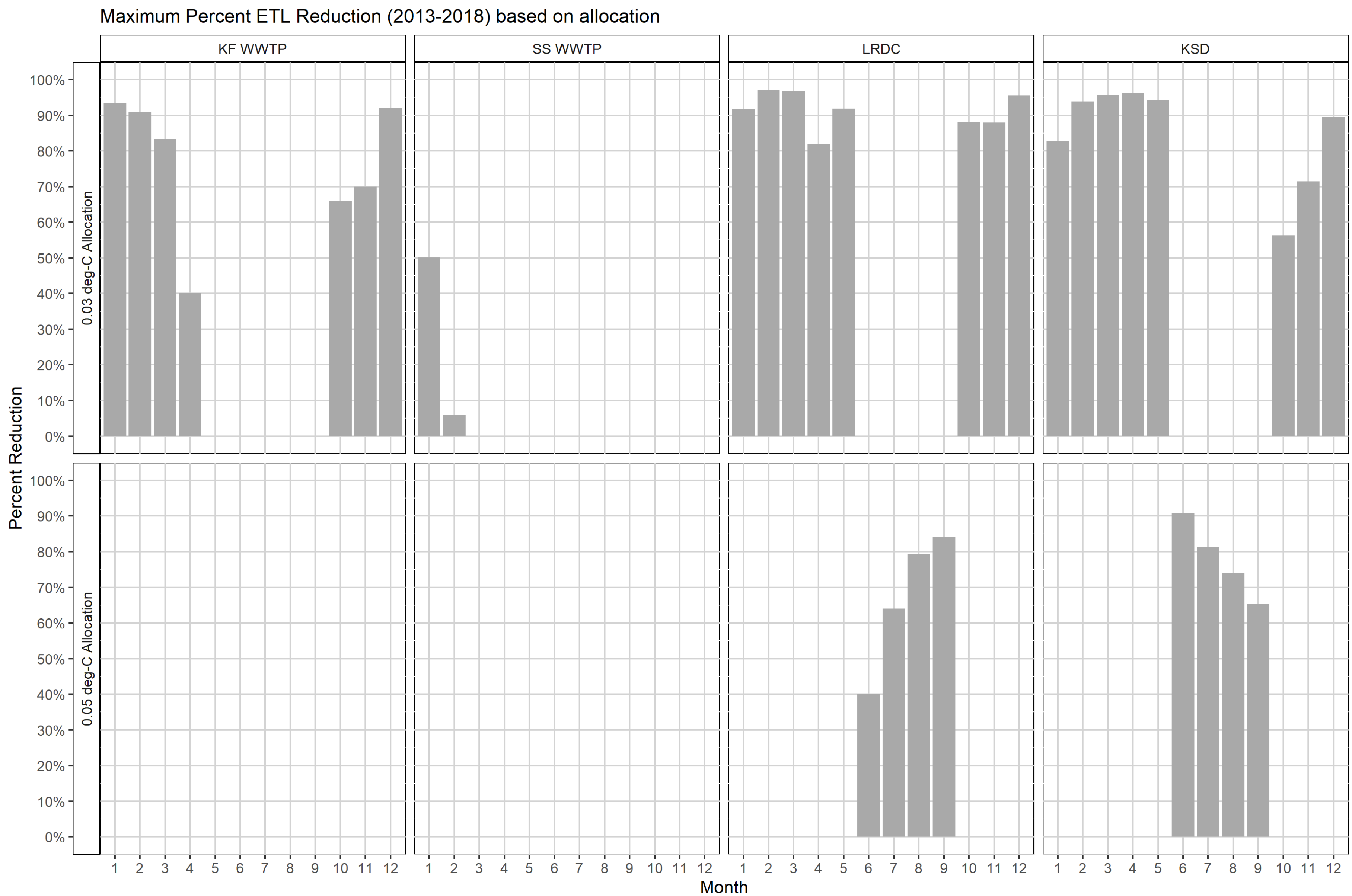

Figure I-2. Maximum monthly percent thermal loading (ETL) reduction in the Klamath River to achieve allocations.

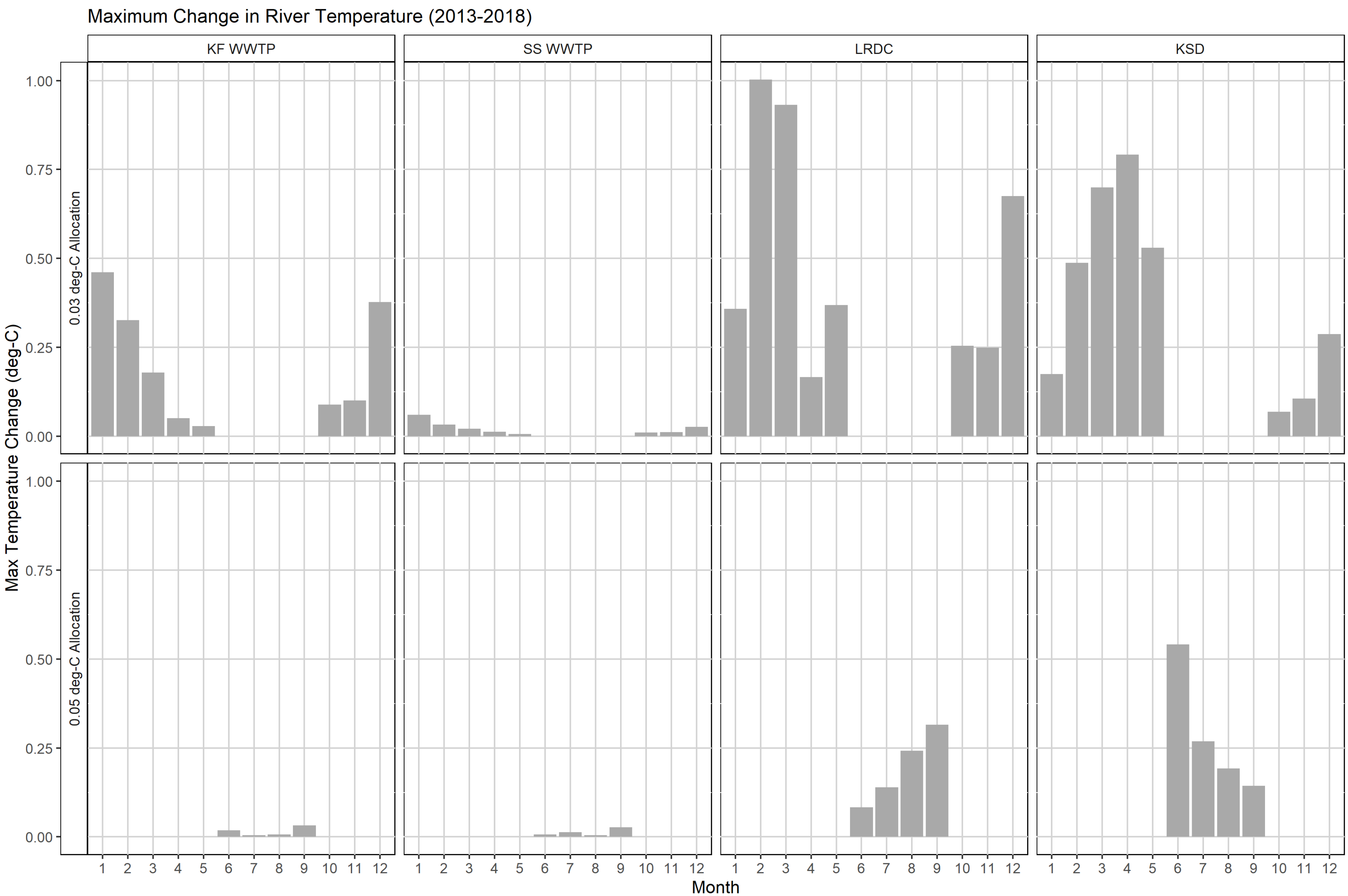

Figure I-3. Maximum monthly river temperature change (dT) in the Klamath River.

Table I-1. Maximum monthly thermal load reduction to achieve TMDL allocations (2013-2018).

Source	Reduction Variable	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
KF WWTP	Thermal Load (ETL)	kcals/day	3.50E+08	2.42E+08	1.59E+08	3.64E+07	0	0	0	0	0	6.44E+07	1.06E+08	2.72E+08
KSD	Thermal Load (ETL)	kcals/day	1.63E+08	1.04E+09	2.07E+09	1.72E+09	9.50E+08	1.13E+09	6.45E+08	3.13E+08	1.75E+08	7.02E+07	1.08E+08	2.22E+08
LRDC	Thermal Load (ETL)	kcals/day	9.03E+08	2.99E+09	4.46E+09	8.22E+08	7.84E+08	4.21E+07	1.15E+08	3.26E+08	3.91E+08	5.10E+08	3.12E+08	1.76E+09
SS WWTP	Thermal Load (ETL)	kcals/day	2.34E+07	2.64E+06	0	0	0	0	0	0	0	0	0	0

Table I-2. Maximum monthly change in river temperature (dT) (2013-2018).

Source	Variable	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
KF WWTP	Current Temp Change	Degrees Celsius	0.46	0.33	0.18	0.05	0.03	0.02	0	0.01	0.03	0.09	0.1	0.38
KSD	Current Temp Change	Degrees Celsius	0.17	0.49	0.7	0.79	0.53	0.54	0.27	0.19	0.14	0.07	0.11	0.29
LRDC	Current Temp Change	Degrees Celsius	0.36	1.00	0.93	0.17	0.37	0.08	0.14	0.24	0.32	0.25	0.25	0.68
SS WWTP	Current Temp Change	Degrees Celsius	0.06	0.03	0.02	0.01	0.01	0.01	0.01	0	0.03	0.01	0.01	0.03

Table I-3. Maximum monthly percent thermal load reduction to achieve TMDL allocations (2013-2018).

Source	Reduction Variable	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
KF WWTP	Thermal Load (ETL)	Percent kcals/day	93	91	83	40	0	0	0	0	0	66	70	92
KSD	Thermal Load (ETL)	Percent kcals/day	83	94	96	96	94	91	81	74	65	56	71	90
LRDC	Thermal Load (ETL)	Percent kcals/day	92	97	97	82	92	40	64	79	84	88	88	96
SS WWTP	Thermal Load (ETL)	Percent kcals/day	50	6	0	0	0	0	0	0	0	0	0	0

Table I-4. Calculated maximum reduction to the effluent/source daily average flow needed to achieve TMDL allocations (2013-2018). Calculated with no reduction to effluent/source temperatures.

Source	Reduction Variable	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
KF WWTP	Discharge Flow	Cubic feet/second	12.4	17.1	7.6	1.9	0	0	0	0	0	3.4	3.4	10.3
KSD	Discharge Flow	Cubic feet/second	62.3	227	355.2	254.2	171.1	173.9	112.2	94.8	59.1	34.5	52.1	75.2
LRDC	Discharge Flow	Cubic feet/second	785	830.2	893.4	230.8	357.4	15	49.7	80.8	111.3	178.1	119.1	673.7
SS WWTP	Discharge Flow	Cubic feet/second	3.3	0.3	0	0	0	0	0	0	0	0	0	0

Table I-5. Calculated maximum reduction to the effluent/source daily maximum temperatures needed to achieve TMDL allocations (2013-2018). Calculated with no reduction to effluent/source flows.

Source	Reduction Variable	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
KF WWTP	**Discharge Temperature**	**Degrees Celsius**	11.4	10.1	8.4	2.9	0	0	0	0	0	5.2	9	11.6
KSD	**Discharge Temperature**	**Degrees Celsius**	0.9	3.4	5.8	3.5	2.4	3	2.2	1.3	0.8	0.7	1.1	1.5
LRDC	**Discharge Temperature**	**Degrees Celsius**	0.7	3.2	3.9	1.4	3.9	0.5	0.7	1.5	1.8	1.3	1.3	1.7
SS WWTP	**Discharge Temperature**	**Degrees Celsius**	1.5	0.2	0	0	0	0	0	0	0	0	0	0

I.5. Klamath River

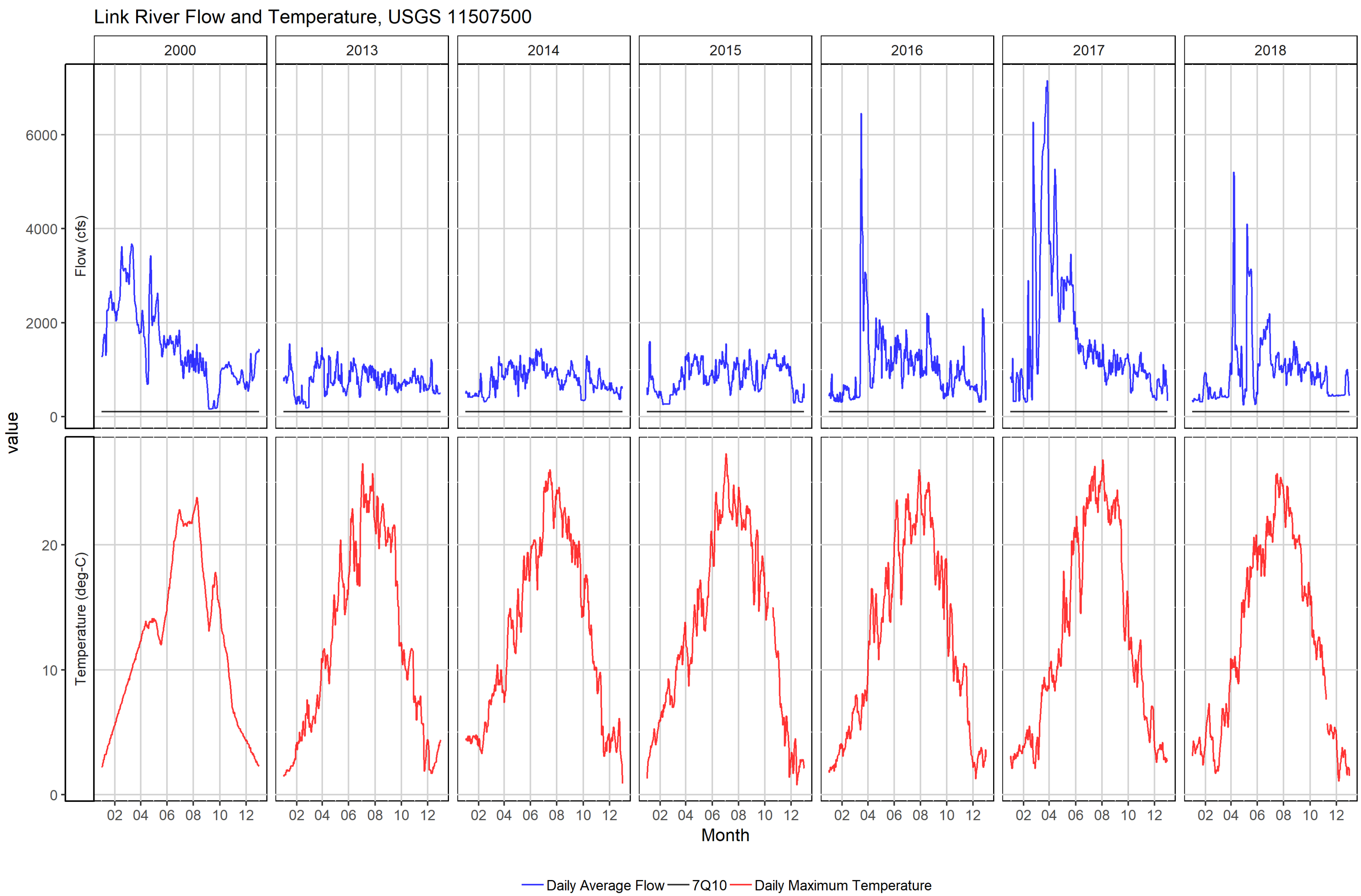

Figure I-4. Link River daily maximum temperature and daily average flow at USGS station 11507500.

I.6. Klamath Falls WWTP

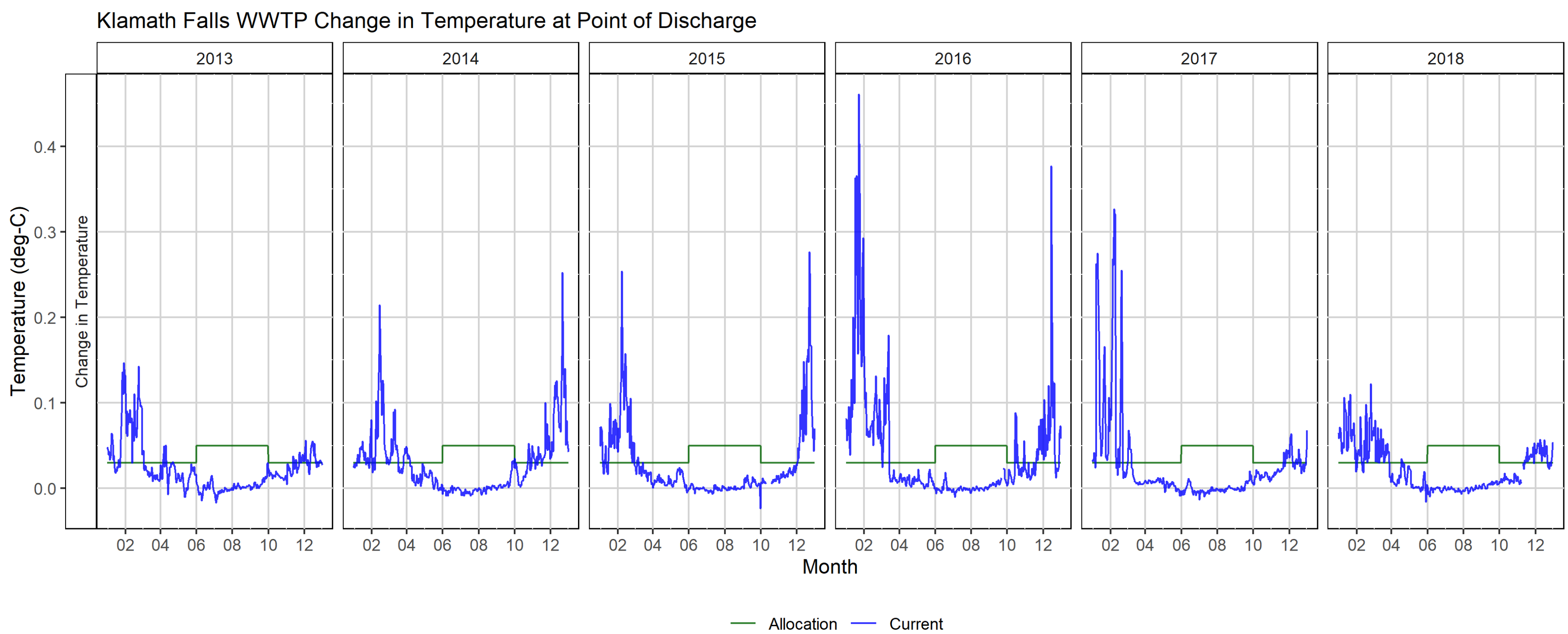

Figure I-5. Klamath Falls WWTP change in Klamath River temperature at the point of discharge.

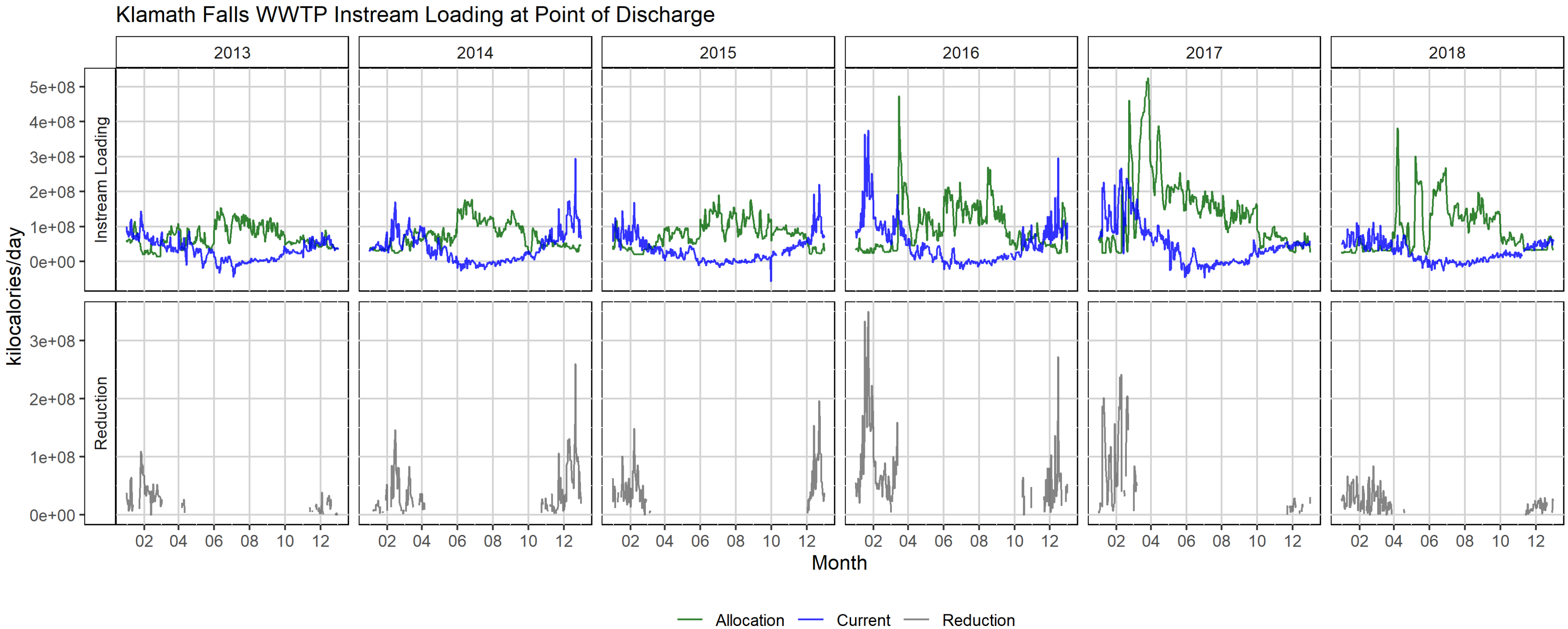

Figure I-6. Klamath Falls WWTP thermal loading in the Klamath River.

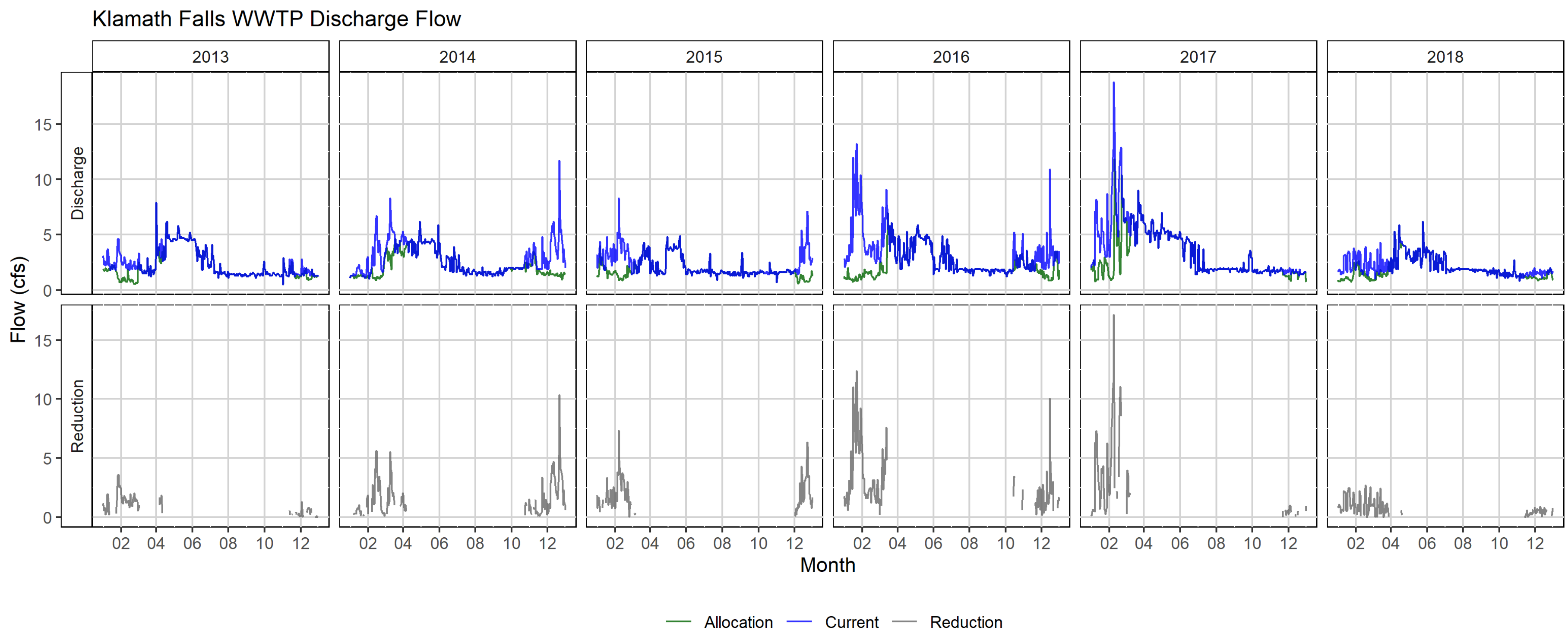

Figure I-7. Klamath Falls WWTP effluent discharge flow to the Klamath River.

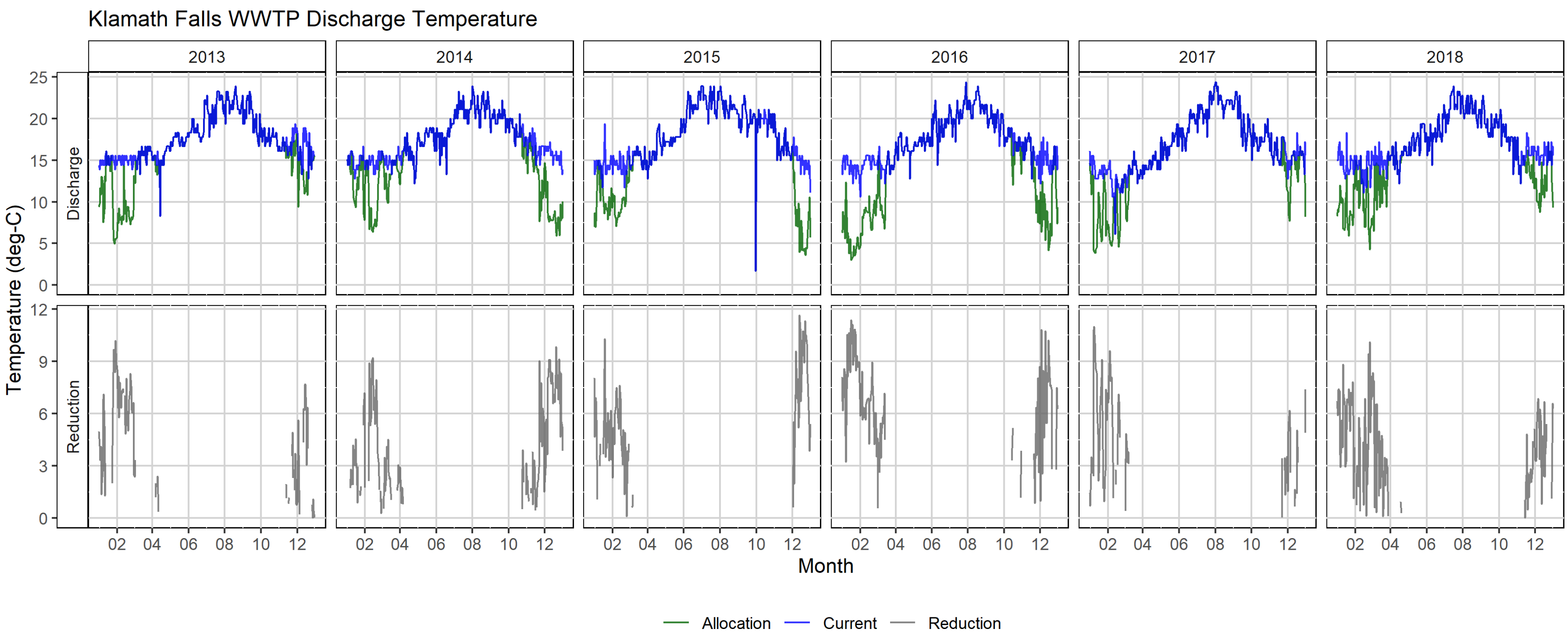

Figure I-8. Klamath Falls WWTP effluent discharge temperature to the Klamath River.

I.7. South Suburban WWTP

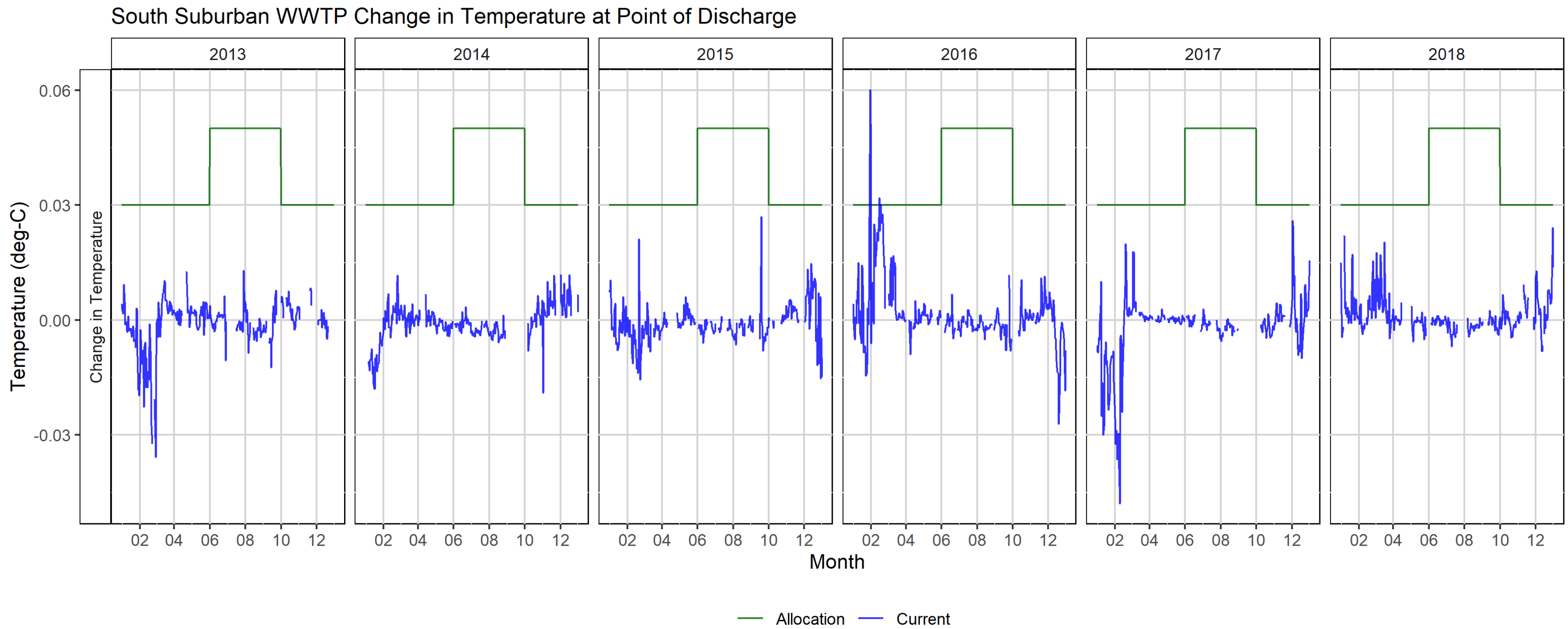

Figure I-9. South Suburban WWTP change in Klamath River temperature at the point of discharge.

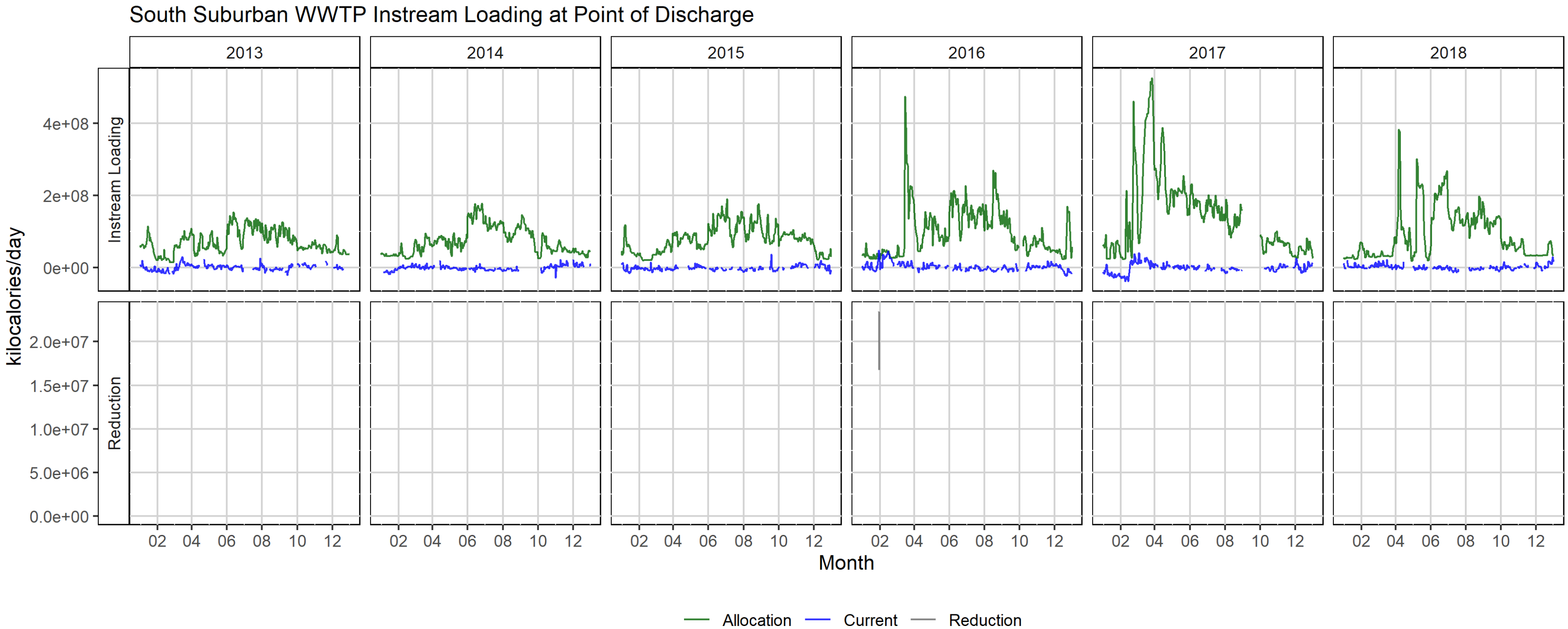

Figure I-10. South Suburban WWTP thermal loading in the Klamath River.

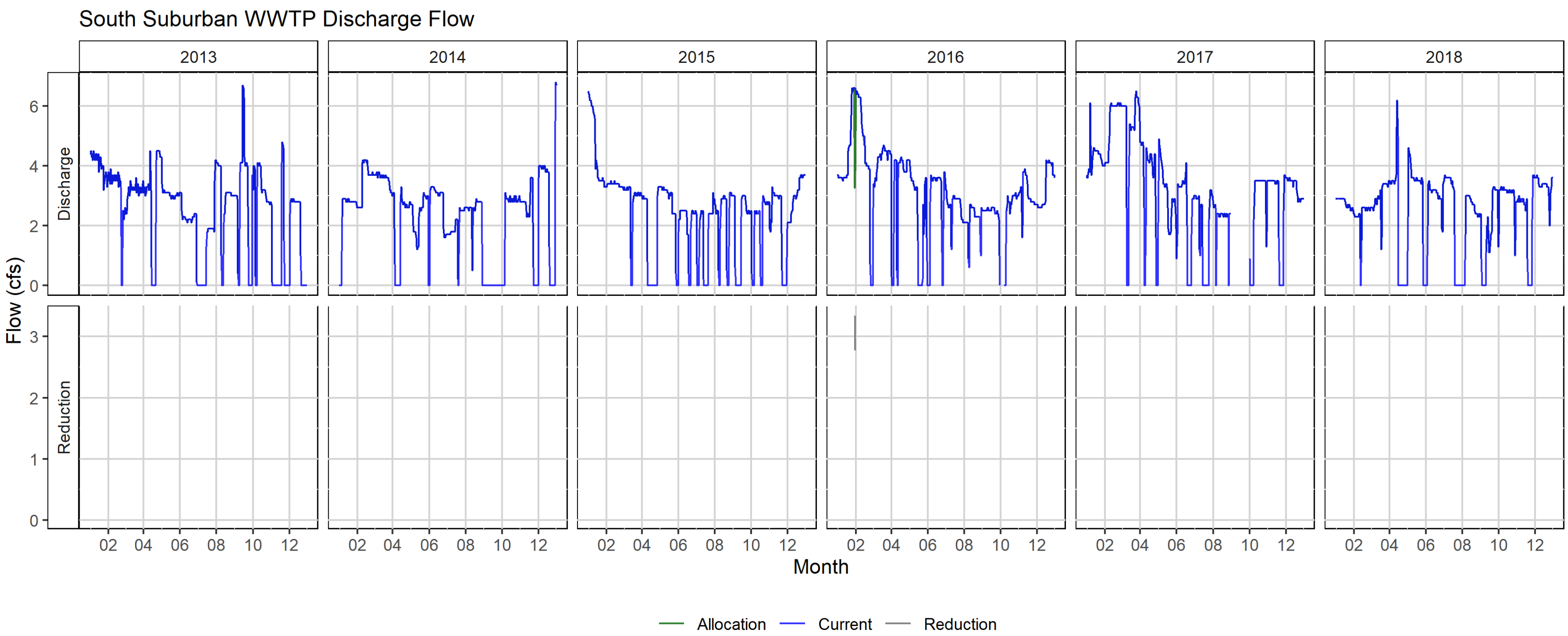

Figure I-11. South Suburban WWTP effluent discharge flow to the Klamath River.

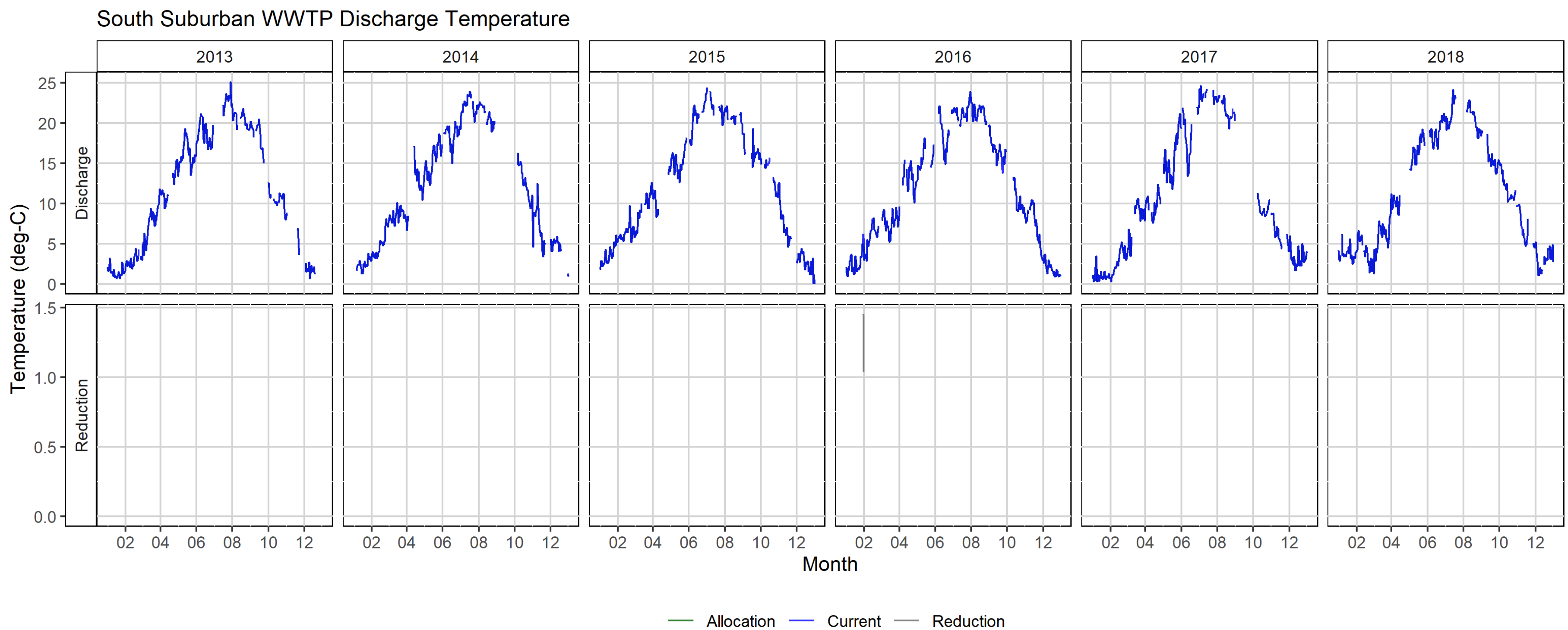

Figure I-12. South Suburban WWTP effluent discharge temperature to the Klamath River.

I.8. Lost River Diversion Channel

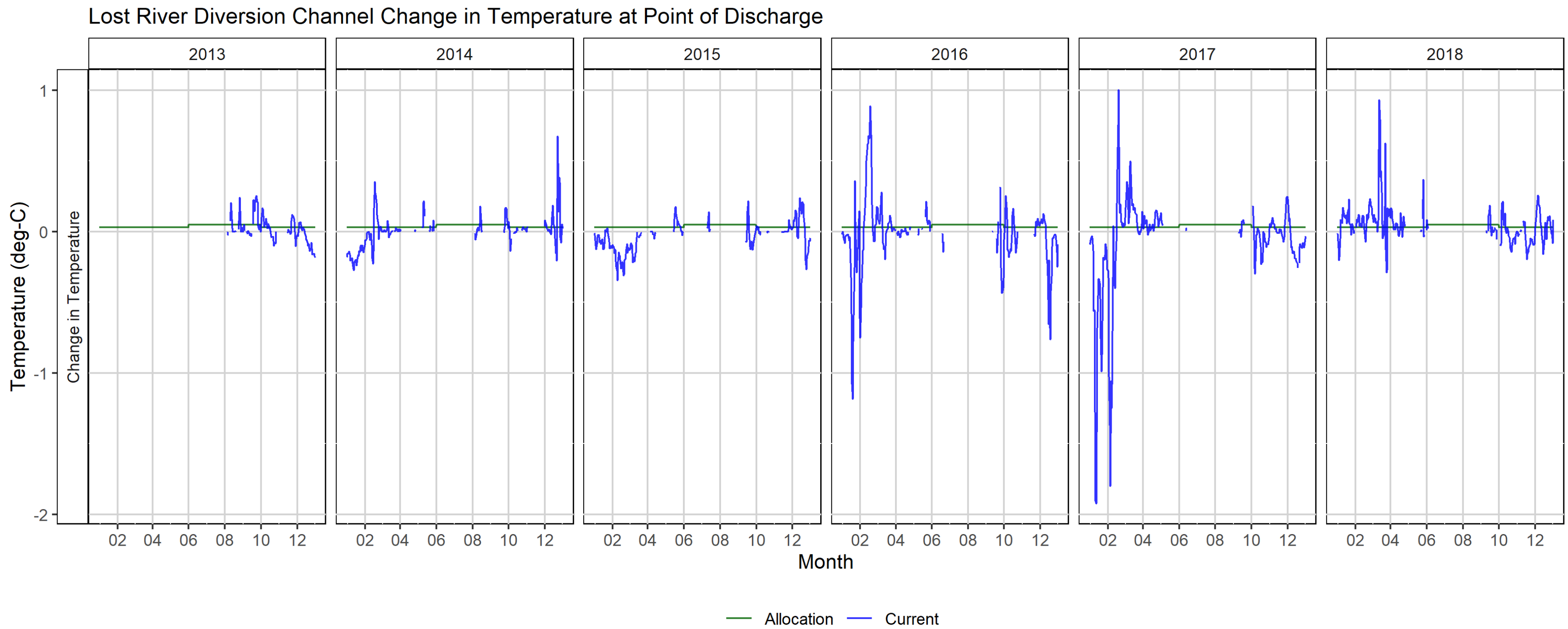

Figure I-13. Lost River Diversion Channel change in Klamath River temperature at the point of discharge.

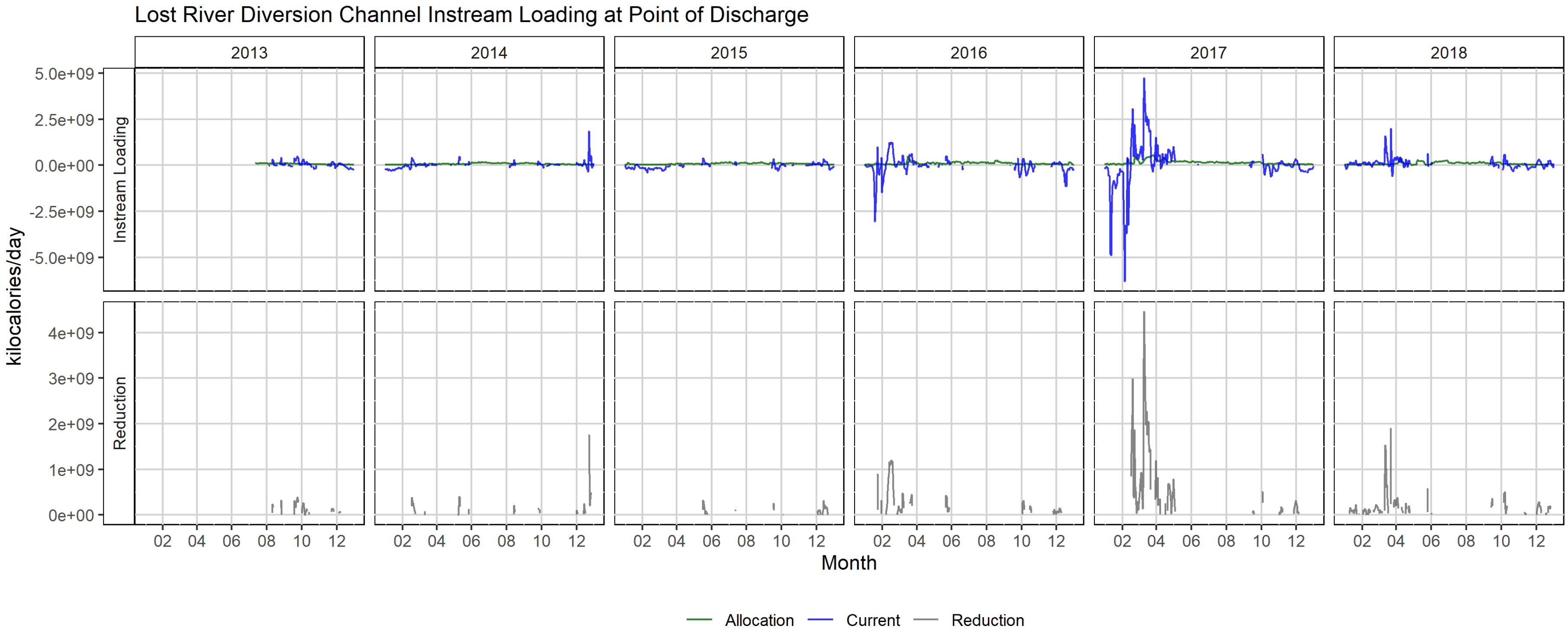

Figure I-14. Lost River Diversion Channel thermal loading in the Klamath River.

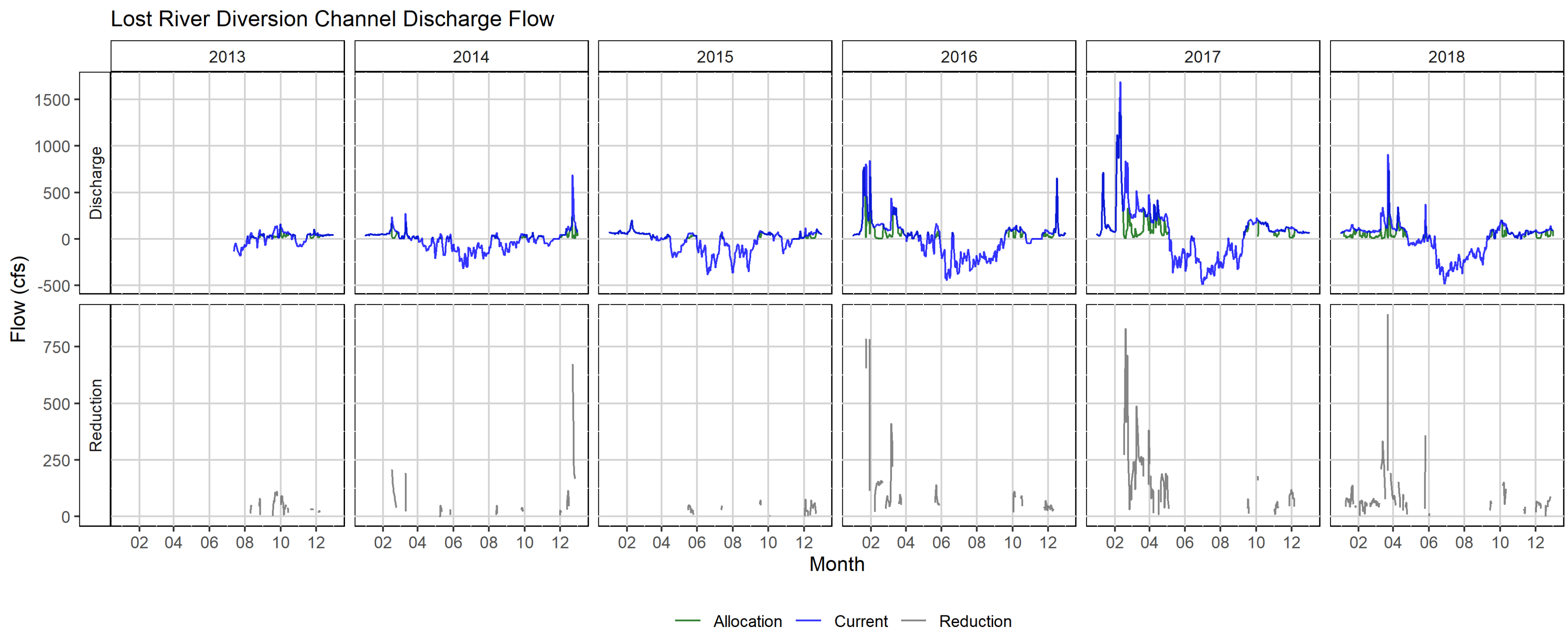

Figure I-15. Lost River Diversion Channel discharge flow to the Klamath River.

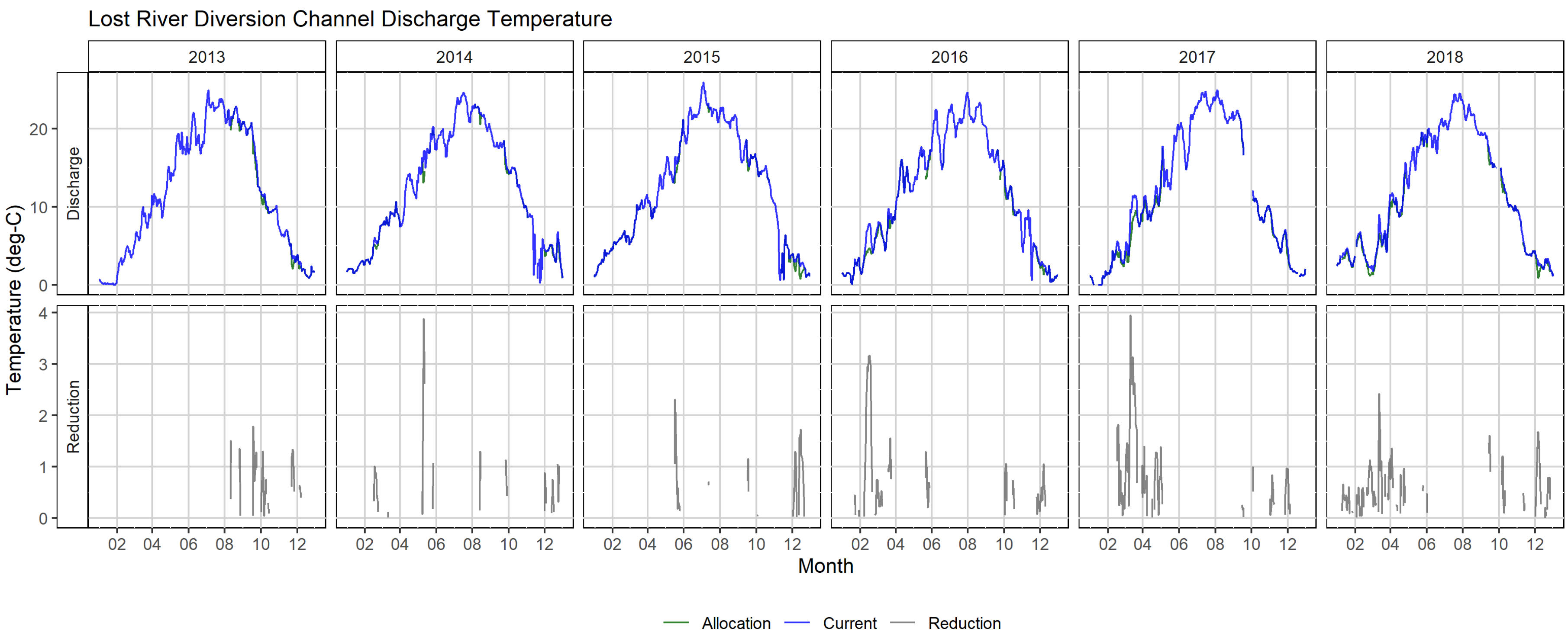

Figure I-16. Lost River Diversion Channel discharge temperature to the Klamath River.

I.9. Klamath Straits Drain

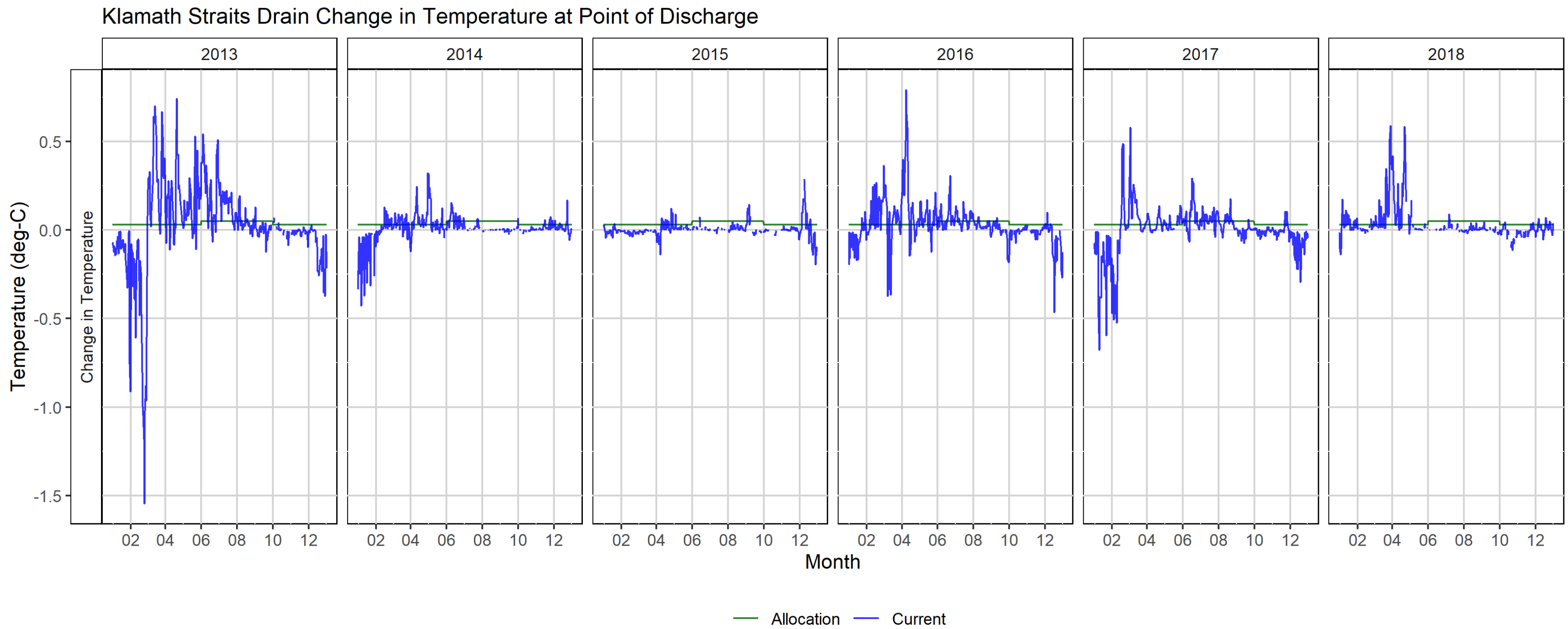

Figure I-17. Klamath Straits Drain change in Klamath River temperature at the point of discharge.

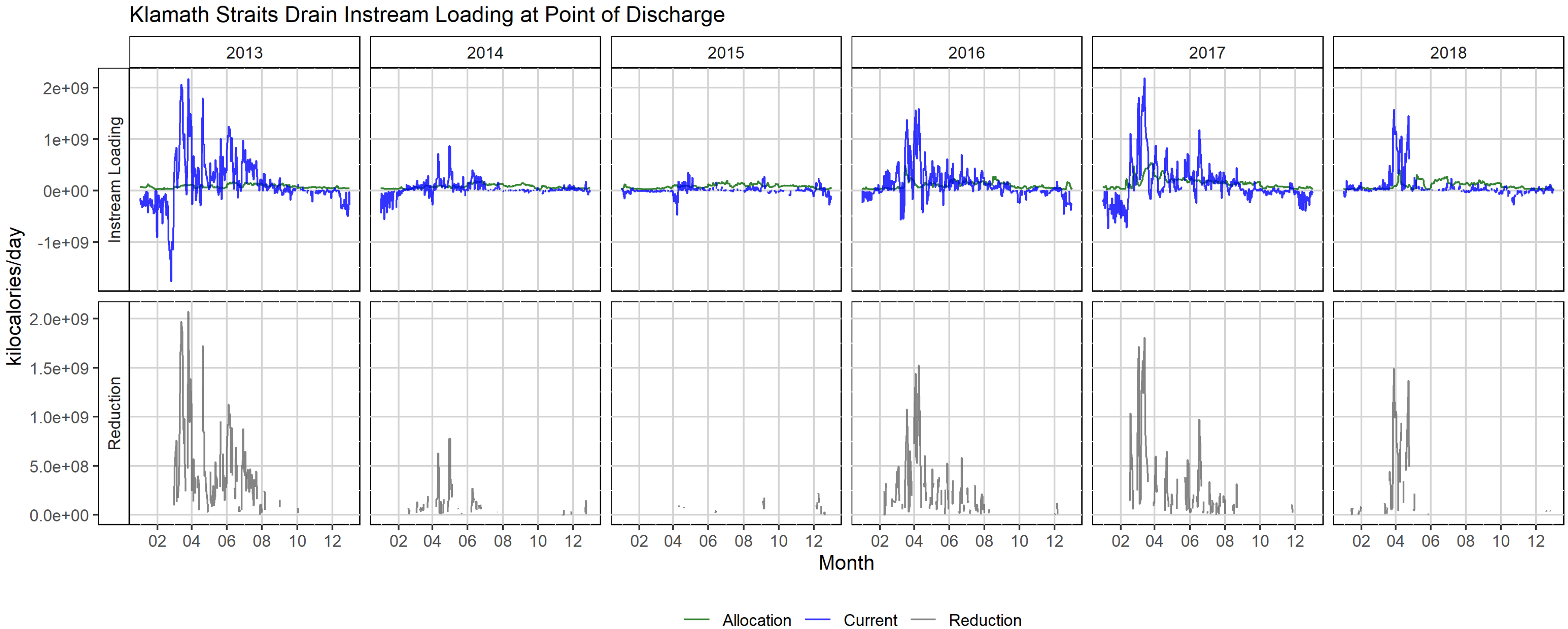

Figure I-18. Klamath Straits Drain thermal loading in the Klamath River.

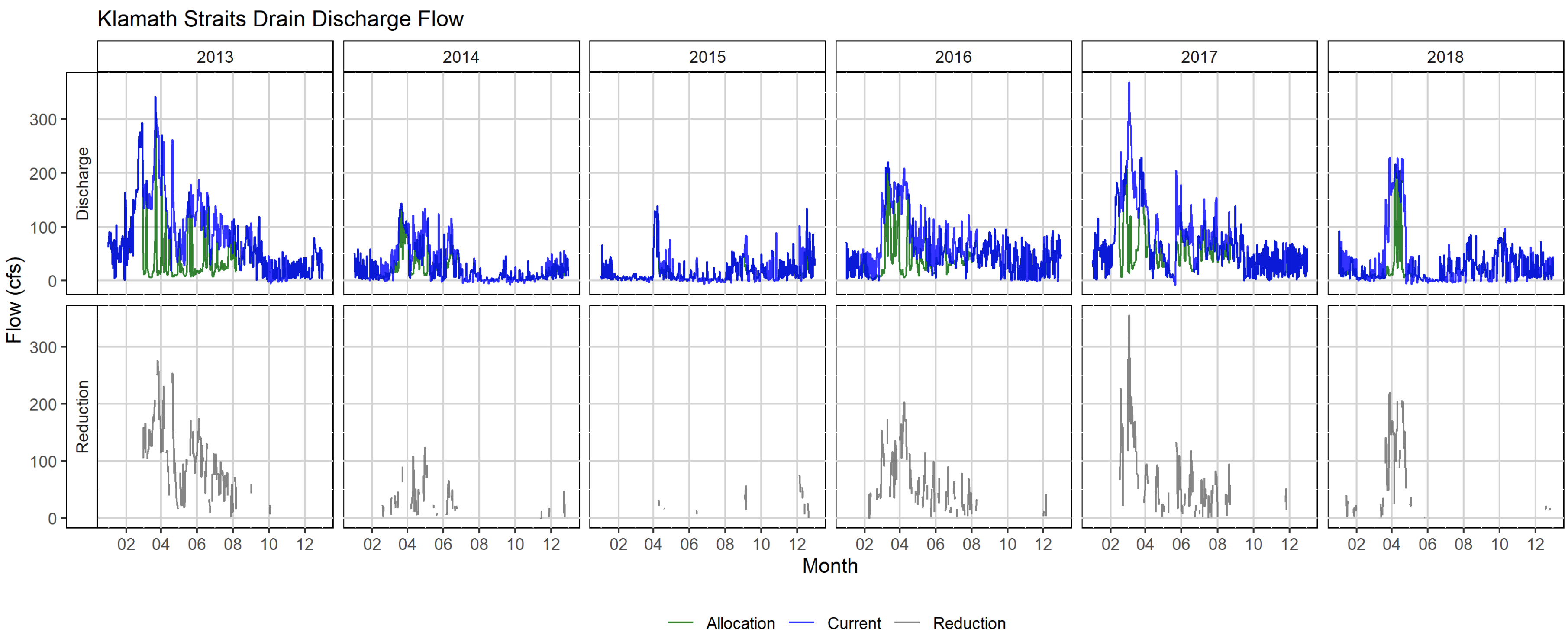

Figure I-19. Klamath Straits Drain discharge flow to the Klamath River.

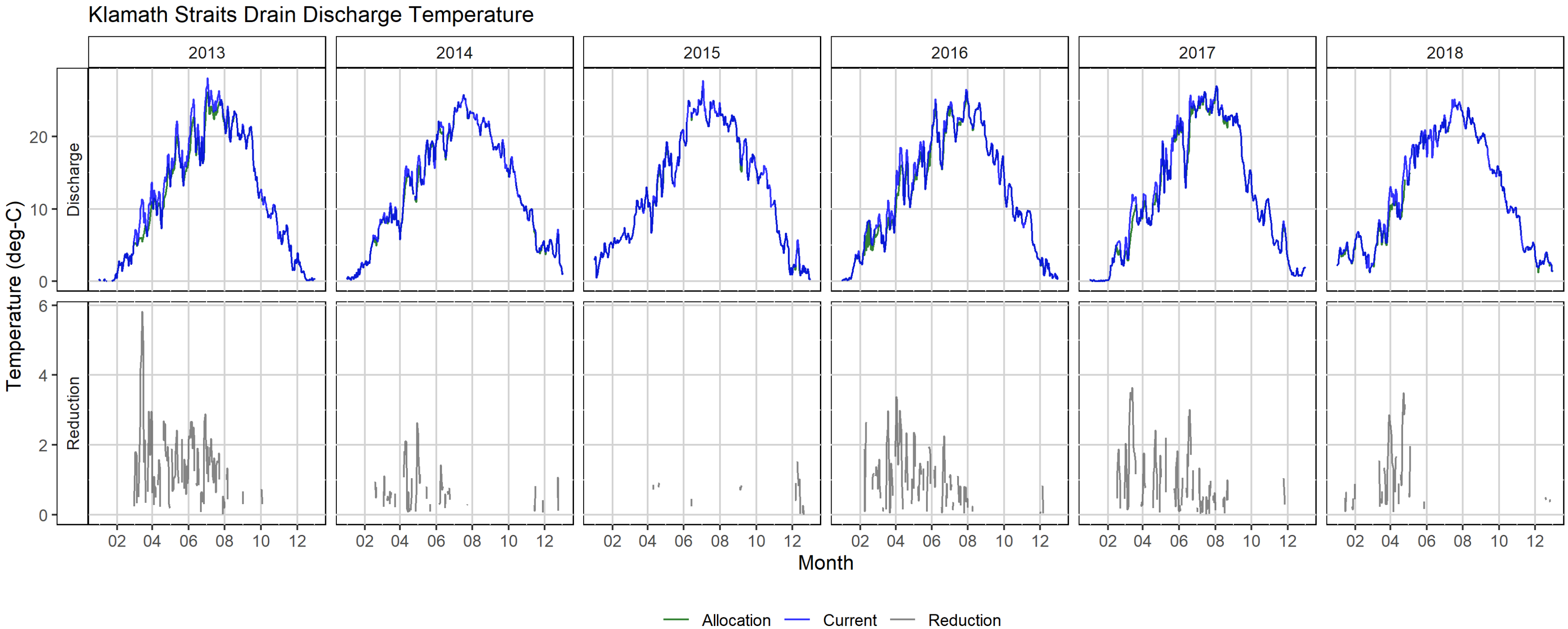

Figure I-20. Klamath Straits Drain discharge temperature to the Klamath River.