



Water Resources ♦ Flood Control ♦ Water Rights

TECHNICAL MEMORANDUM

DATE: July 13, 2018
TO: North Delta Water Agency
FROM: Shankar Parvathinathan and Gary Kienlen
SUBJECT: Technical Comments on California Water Fix Modeling

Introduction

This technical memorandum is a summary of MBK Engineers' findings based on our review of the hydrodynamic modeling performed by the California Department of Water Resources (DWR) for the California Water Fix No Action Alternative ("NAA") and the proposed Project, under Early Long Term climate change ("CWF H3+"). This review of the California Water Fix ("CWF" or "Project") modeling focuses on water quality at two locations within the North Delta Water Agency ("NDWA"):

- Sacramento River at Emmaton
- Sacramento River at Three Mile Slough

This technical memorandum summarizes water quality results from DSM2 modeling for CWF performed by DWR. The DSM2 modeling for CWF simulates the hydrologic period from October 1975 to September 1991 and produces output at 15-minute intervals. This memorandum presents 1) a comparative analysis of NAA and CWF H3+ scenarios using monthly average electrical conductivity (EC) values computed from 15-minute DSM2 output¹ and 2) a summary of violations of water quality criteria in the 1981 Contract (DWR-306) under NAA and CWF H3+ using 14-day average EC output tables² provided by DWR.

¹ 15-minute DSM2 outputs for NAA and CWF H3+ scenario is from DWR-500 and DWR-1078 respectively.

² In response to a request for the underlying analysis of 1981 Contract compliance referenced in DWR witness Ms. Tara Smith's answers on cross-examination, DWR provided a PDF and native Excel file containing 14-day average EC data for NAA and CWF H3+ compared against NDWA Contract criteria for Three Mile slough for the period

Monthly Average EC Analysis in Sacramento River at Emmaton

Figure 1 compares monthly average EC values in the Sacramento River at Emmaton under CWF H3+ and NAA. On average, the EC increases under CWF H3+ by 10 percent in comparison to the NAA. Average EC values under CWF H3+ are higher than NAA between July and December, with greatest increase of 23 percent occurring in September.

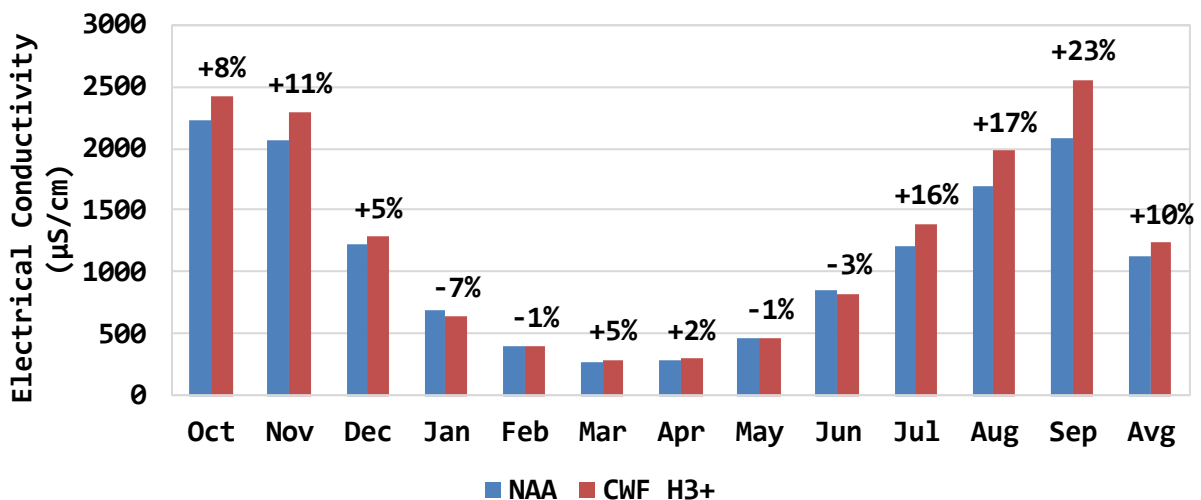


Figure 1. Monthly Average Electrical Conductivity and Percent Change in the Sacramento River at Emmaton

To provide detail on the temporal changes in EC, Table 1 shows monthly changes in EC values at Emmaton under CWF H3+, relative to NAA. This table shows cells highlighted in color for the months with changes greater than 5 percent. EC values during the months of July through December are consistently greater under CWF H3+ in comparison to NAA. There are months when the increases in EC values are significantly greater than the average, such as during September 1989, when the EC values increase by nearly 77 percent (1,696 microSiemens per centimeter [$\mu\text{S}/\text{cm}$]) from a NAA value of 2,194 $\mu\text{S}/\text{cm}$ to 3,890 $\mu\text{S}/\text{cm}$ under CWF H3+.

10/1/1974 through 9/28/1991. DWR transmitted the PDF data tables via email on 3/7/2018 and the native Excel file on 3/9/2018. The PDF file is submitted as NDWA-503.

Table 1. Monthly Changes in Average Electrical Conductivity in the Sacramento River at Emmaton under CWF H3+

Water Year	Change in Electrical Conductivity ($\mu\text{S}/\text{cm}$) ¹												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg
1976	23(+8%)	33(+13%)	101(+22%)	-389(-40%)	-364(-50%)	-31(-10%)	5(+1%)	-18(-4%)	10(+1%)	294(+17%)	168(+8%)	559(+19%)	33(-1%)
1977	243(+7%)	311(+10%)	166(+6%)	-233(-12%)	29(+3%)	17(+2%)	0(-0%)	-35(-2%)	89(+3%)	38(+1%)	43(+1%)	424(+11%)	91(+3%)
1978	-35(-1%)	-143(-3%)	111(+5%)	11(+5%)	11(+6%)	10(+5%)	10(+5%)	2(+1%)	-57(-18%)	-55(-10%)	185(+17%)	84(+15%)	11(+2%)
1979	114(+18%)	15(+2%)	333(+40%)	13(+2%)	-1(-0%)	17(+8%)	12(+6%)	10(+5%)	10(+3%)	290(+35%)	578(+36%)	1228(+50%)	218(+17%)
1980	526(+17%)	1479(+85%)	67(+7%)	-7(-4%)	2(+1%)	2(+1%)	4(+2%)	11(+5%)	-50(-15%)	5(+1%)	155(+14%)	66(+10%)	188(+10%)
1981	61(+10%)	87(+14%)	53(+7%)	-29(-4%)	7(+4%)	15(+7%)	26(+11%)	-34(-7%)	-42(-6%)	352(+31%)	154(+9%)	770(+29%)	118(+9%)
1982	558(+18%)	830(+53%)	3(+2%)	4(+2%)	5(+3%)	5(+2%)	1(+0%)	0(+0%)	2(+1%)	68(+16%)	286(+23%)	13(+4%)	148(+10%)
1983	87(+37%)	17(+9%)	3(+2%)	6(+3%)	1(+0%)	0(+0%)	1(+0%)	1(+1%)	3(+1%)	18(+9%)	120(+43%)	33(+16%)	24(+10%)
1984	29(+12%)	12(+6%)	0(+0%)	4(+2%)	4(+2%)	6(+3%)	9(+5%)	3(+1%)	-64(-14%)	136(+35%)	434(+51%)	32(+9%)	51(+9%)
1985	20(+7%)	164(+42%)	13(+6%)	-93(-26%)	-50(-18%)	-4(-2%)	12(+5%)	9(+2%)	0(-0%)	397(+69%)	574(+50%)	792(+32%)	153(+14%)
1986	87(+3%)	266(+8%)	74(+10%)	41(+12%)	1(+1%)	1(+1%)	1(+0%)	0(+0%)	-175(-36%)	178(+44%)	457(+60%)	34(+8%)	80(+9%)
1987	17(+6%)	1(+0%)	41(+5%)	-253(-34%)	-46(-17%)	11(+6%)	37(+13%)	-23(-5%)	-59(-8%)	1(+0%)	83(+4%)	640(+21%)	38(-1%)
1988	148(+5%)	61(+2%)	83(+9%)	26(+11%)	143(+66%)	123(+22%)	-43(-9%)	5(+1%)	-24(-2%)	173(+9%)	132(+5%)	520(+14%)	112(+11%)
1989	84(+2%)	164(+4%)	203(+8%)	109(+11%)	65(+7%)	18(+8%)	5(+2%)	1(+0%)	-71(-12%)	586(+53%)	512(+37%)	1696(+77%)	281(+16%)
1990	1040(+40%)	352(+12%)	133(+5%)	57(+8%)	5(+2%)	-9(-3%)	-6(-2%)	3(+0%)	-32(-2%)	412(+16%)	388(+15%)	368(+10%)	226(+8%)
1991	-71(-1%)	-103(-2%)	-436(-13%)	-84(-3%)	154(+15%)	37(+14%)	12(+5%)	-21(-3%)	69(+4%)	171(+7%)	401(+14%)	380(+10%)	42(+4%)
Average	183(+8%)	222(+11%)	59(+5%)	-51(-7%)	-2(-1%)	14(+5%)	5(+2%)	-5(-1%)	-24(-3%)	192(+16%)	292(+17%)	477(+23%)	113(+10%)

Note

¹ Change is calculated as difference in monthly electrical conductivity values between the Project and the baseline (CWF H3+ minus NAA). Values in parenthesis indicate percent change, calculated as ((CWF H3+ minus NAA)/ NAA)*100.

Colored cells indicate months when the changes under CWF H3+ are greater than 5 percent.

Monthly Average EC Analysis in Sacramento River at Three Mile Slough

Figure 2 compares monthly average EC values in the Sacramento River at Three Mile Slough under CWF H3+ and NAA. On average, the EC increases under CWF H3+ by 7 percent in comparison to the NAA. Average EC values under CWF H3+ are higher than NAA between July and December, with the greatest increase of 20 percent occurring in September.

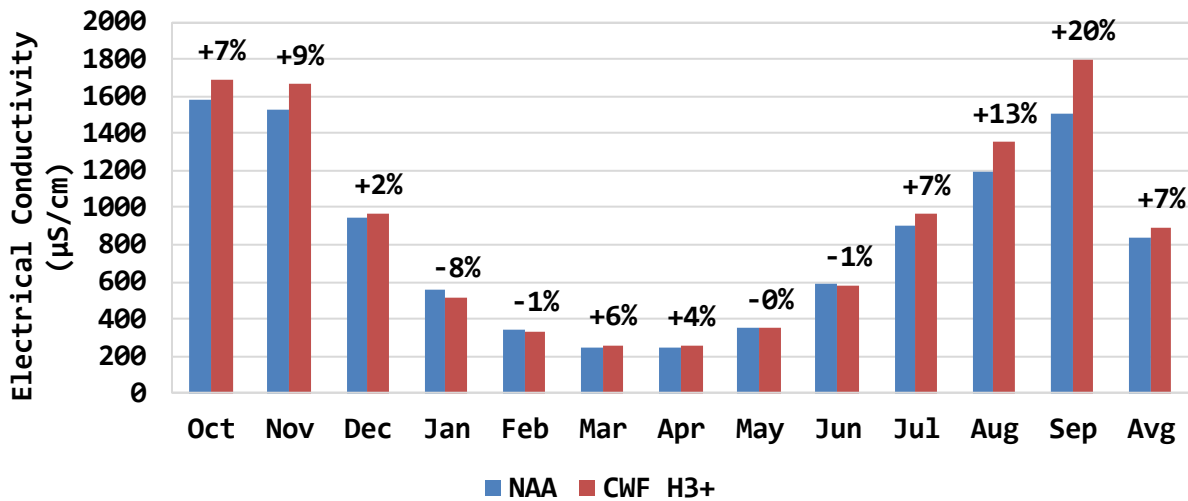


Figure 2. Monthly Average Electrical Conductivity and Percent Change in the Sacramento River at Three Mile Slough

To provide detail on the temporal changes in EC, Table 2 shows monthly changes in EC values at Three Mile Slough under CWF H3+, relative to NAA. This table shows cells highlighted in color for the months with changes greater than 5 percent. EC values during the months of July through December are consistently greater under CWF H3+ in comparison to NAA.

Table 2. Monthly Changes in Average Electrical Conductivity in the Sacramento River at Three Mile Slough under CWF H3+

Water Year	Change in Electrical Conductivity ($\mu\text{S}/\text{cm}$) ¹												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg
1976	10(+4%)	37(+18%)	56(+15%)	-297(-40%)	-288(-50%)	-36(-13%)	1(+0%)	-8(-2%)	11(+1%)	137(+11%)	152(+11%)	440(+23%)	18(-2%)
1977	182(+8%)	149(+7%)	48(+2%)	-121(-9%)	29(+4%)	14(+2%)	2(+0%)	-23(-2%)	75(+3%)	39(+2%)	87(+4%)	329(+12%)	67(+3%)
1978	-1(-0%)	-102(-3%)	70(+4%)	14(+5%)	21(+10%)	31(+15%)	20(+10%)	1(+1%)	-15(-6%)	-89(-20%)	-12(-1%)	-56(-11%)	-10(+0%)
1979	40(+9%)	-69(-13%)	90(+13%)	-58(-10%)	5(+2%)	25(+12%)	15(+7%)	13(+6%)	9(+4%)	95(+15%)	291(+25%)	681(+37%)	95(+9%)
1980	288(+13%)	1012(+80%)	-26(-3%)	-20(-9%)	6(+3%)	2(+1%)	5(+3%)	12(+5%)	-7(-3%)	-8(-2%)	-15(-2%)	-18(-3%)	103(+7%)
1981	31(+7%)	37(+9%)	-24(-4%)	-73(-11%)	5(+3%)	26(+13%)	40(+18%)	-10(-3%)	-25(-5%)	86(+9%)	44(+4%)	476(+25%)	51(+5%)
1982	360(+16%)	683(+48%)	10(+5%)	10(+5%)	18(+10%)	14(+7%)	2(+1%)	0(+0%)	11(+6%)	44(+14%)	94(+10%)	-62(-17%)	99(+9%)
1983	40(+19%)	8(+4%)	6(+3%)	14(+6%)	3(+2%)	0(+0%)	1(+0%)	1(+1%)	4(+2%)	17(+8%)	73(+32%)	20(+10%)	16(+7%)
1984	14(+6%)	12(+6%)	1(+1%)	9(+5%)	7(+4%)	12(+6%)	12(+6%)	6(+3%)	-32(-10%)	52(+16%)	204(+31%)	-98(-24%)	17(+4%)
1985	5(+2%)	89(+25%)	7(+3%)	-61(-20%)	-25(-10%)	3(+1%)	12(+6%)	5(+2%)	-1(-0%)	158(+32%)	297(+35%)	466(+26%)	80(+8%)
1986	15(+1%)	19(+1%)	-27(-4%)	22(+7%)	4(+2%)	5(+3%)	1(+0%)	0(+0%)	-85(-24%)	52(+15%)	216(+37%)	-10(-3%)	18(+3%)
1987	18(+8%)	16(+6%)	27(+5%)	-179(-32%)	-35(-14%)	26(+13%)	42(+18%)	-9(-3%)	-33(-7%)	-5(-1%)	119(+8%)	506(+24%)	41(+2%)
1988	113(+5%)	50(+2%)	59(+8%)	20(+8%)	73(+34%)	64(+16%)	-21(-6%)	5(+1%)	-13(-2%)	77(+6%)	148(+8%)	436(+17%)	84(+8%)
1989	85(+3%)	74(+2%)	117(+6%)	57(+7%)	37(+5%)	13(+6%)	7(+4%)	3(+1%)	-49(-12%)	170(+17%)	238(+23%)	1040(+61%)	149(+10%)
1990	655(+35%)	234(+11%)	95(+5%)	33(+6%)	-1(-0%)	-2(-1%)	2(+1%)	4(+1%)	-23(-2%)	189(+9%)	237(+13%)	273(+11%)	141(+7%)
1991	-33(-1%)	-58(-2%)	-264(-11%)	-52(-3%)	86(+11%)	27(+10%)	15(+6%)	-11(-2%)	32(+3%)	48(+3%)	269(+13%)	302(+11%)	30(+3%)
Average	114(+7%)	137(+9%)	15(+2%)	-43(-8%)	-3(-1%)	14(+6%)	10(+4%)	-1(-0%)	-9(-1%)	66(+7%)	153(+13%)	295(+20%)	62(+7%)

Note

¹ Change is calculated as difference in monthly Electrical Conductivity values between the Project and the baseline (CWF H3+ minus NAA). Values in parenthesis indicate percent change, calculated as ((CWF H3+ minus NAA)/ NAA)*100.

Colored cells indicate months when the changes under CWF H3+ are greater than 5 percent.

1981 Contract Standards Analysis using 14-day Average EC at Three Mile Slough

This section presents a summary of 1981 Contract violations under the CWF H3+ scenario. Table 3 presents the number of days in each month of the simulation period, when water quality criteria in the 1981 Contract were exceeded under the NAA (NDWA-503). The water quality criteria are described in NDWA-3. Overall, the 1981 Contract was not met for 579 days out of 5843 days (9.9 percent) under the NAA. Table 4 presents a similar table of violations for CWF H3+ (NDWA-503). Results show an increase in violations of the 1981 Contract water quality criteria under CWF as compared to NAA. Table 5 presents the difference in violations between CWF H3+ and NAA. Overall, the violations increase from 579 days under NAA to 870 days under CWF H3+ which is an increase of 5 percent or 291 additional days in the 16-year period of simulation. Results shown in Tables 3, 4 and 5 are summarized from the 14-day average EC data tables provided by DWR (NDWA-503).

Table 3. Violations of NDWA Contract Standards at Three Mile Slough under NAA

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1976	0	0	0	0	27	0	0	0	0	0	0	0	27
1977	0	0	0	0	0	0	0	0	9	31	15	5	60
1978	31	30	4	0	0	0	0	0	0	31	15	0	111
1979	0	0	9	13	0	0	0	0	0	0	0	0	22
1980	17	0	0	0	0	0	0	0	0	3	15	0	35
1981	0	0	6	3	0	0	0	0	0	0	0	0	9
1982	0	0	0	0	0	0	0	0	0	8	15	0	23
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	1	16	3	0	20
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	2	14	0	0	0	0	0	0	1	16	1	0	34
1987	0	0	0	0	6	0	0	0	0	0	0	0	6
1988	0	9	0	0	0	0	0	0	0	0	0	0	9
1989	14	28	0	0	0	0	0	0	0	25	0	1	68
1990	12	16	8	0	0	0	0	0	0	19	0	3	58
1991	31	30	18	0	0	0	0	0	0	0	8	10	97
Total	107	127	45	16	33	0	0	0	11	149	72	19	579

Table 4. Violations of NDWA Contract Standards at Three Mile Slough under CWF H3+

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	9	0	0	0	0	0	0	0	9	31	15	11	75
1978	31	30	5	0	0	0	0	0	0	15	15	0	96
1979	0	0	14	12	0	0	0	0	0	2	6	21	55
1980	31	21	0	0	0	0	0	0	0	13	15	0	80
1981	0	0	6	0	0	0	0	0	0	0	0	6	12
1982	19	24	0	0	0	0	0	0	0	9	15	0	67
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	23	12	0	35
1985	0	0	0	0	0	0	0	0	0	0	0	3	3
1986	7	16	0	0	0	0	0	0	0	28	15	0	66
1987	0	0	1	0	0	0	0	0	0	0	0	0	1
1988	4	11	0	0	0	0	0	0	0	0	0	26	41
1989	20	30	0	0	0	0	0	0	0	23	15	27	115
1990	31	30	12	0	0	0	0	0	0	23	15	7	118
1991	31	30	16	0	0	0	0	0	0	0	12	17	106
Total	183	192	54	12	0	0	0	0	9	167	135	118	870

Table 5: Difference in Violations of NDWA Contract Standards at Three Mile Slough under CWF H3+

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1976	0	0	0	0	-27	0	0	0	0	0	0	0	-27
1977	9	0	0	0	0	0	0	0	0	0	0	6	15
1978	0	0	1	0	0	0	0	0	0	-16	0	0	-15
1979	0	0	5	-1	0	0	0	0	0	2	6	21	33
1980	14	21	0	0	0	0	0	0	0	10	0	0	45
1981	0	0	0	-3	0	0	0	0	0	0	0	6	3
1982	19	24	0	0	0	0	0	0	0	1	0	0	44
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	-1	7	9	0	15
1985	0	0	0	0	0	0	0	0	0	0	0	3	3
1986	5	2	0	0	0	0	0	0	-1	12	14	0	32
1987	0	0	1	0	-6	0	0	0	0	0	0	0	-5
1988	4	2	0	0	0	0	0	0	0	0	0	26	32
1989	6	2	0	0	0	0	0	0	0	-2	15	26	47
1990	19	14	4	0	0	0	0	0	0	4	15	4	60
1991	0	0	-2	0	0	0	0	0	0	0	4	7	9
Total	76	65	9	-4	-33	0	0	0	-2	18	63	99	291

MBK attempted to validate the results provided by DWR on the NDWA Contract violations; however, we were unable to reproduce the 14-day average EC data provided by DWR (NDWA-503) summarized in Tables 2 through 5. MBK then proceeded to independently calculate 14-day average EC values in the Sacramento River at Three Mile Slough from 15-minute data available in DWR-500 and DWR-1078 for NAA and CWF H3+ respectively and used these values to

determine the violations of the water quality criteria in NDWA Contract under CWF H3+. Results of NDWA Contract violations from MBK’s independent analysis are presented in Table 6.

Table 6: Change in Violations of NDWA Contract Standards at Three Mile Slough under CWF H3+ based on MBK Analysis

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1976	0	0	0	0	-27	0	0	0	0	0	0	0	-27
1977	9	0	0	0	0	0	0	0	0	0	0	6	15
1978	0	0	1	0	0	0	0	0	0	-10	-11	0	-20
1979	0	0	6	-1	0	0	0	0	0	0	0	21	26
1980	15	21	0	0	0	0	0	0	0	0	-2	0	34
1981	0	0	0	-3	0	0	0	0	0	0	0	6	3
1982	19	24	0	0	0	0	0	0	0	5	2	0	50
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	5	0	5
1985	0	0	0	0	0	0	0	0	0	0	0	3	3
1986	7	1	0	0	0	0	0	0	-1	-11	3	0	-1
1987	0	0	1	0	-6	0	0	0	0	0	0	0	-5
1988	4	2	0	0	0	0	0	0	0	0	0	26	32
1989	6	1	0	0	0	0	0	0	0	4	4	26	41
1990	19	14	4	0	0	0	0	0	0	0	0	5	42
1991	0	0	-2	0	0	0	0	0	0	0	0	7	5
Total	79	63	10	-4	-33	0	0	0	-1	-12	1	100	203

MBK analysis show an additional 203 days of violations (+3.5 percent) in the 16 years of simulation under CWF H3+ which is fewer than the +5 percent violation statistic presented by Ms. Smith in her oral testimony and shown in Table 5. Reasons for the difference between DWR and MBK calculations have not been fully analyzed due to lack of adequate information to compare the two results. Overall, both results show increased violations in the Sacramento River at Three Mile Slough under CWF H3+.

Conclusions:

Modeling results show an increase in EC concentration in the Sacramento River at Emmaton, and at Three Mile Slough under CWF H3+, as compared to NAA. EC concentrations in the Sacramento River at Emmaton increase by 10 percent on an average annual scale, and a maximum of up of 77 percent in September 1989. Similar increases in EC occur in the Sacramento River at Three Mile Slough.

Water quality criteria in the 1981 Contract in the Sacramento River at Three Mile Slough, are exceeded by nearly 5 percent under CWF as compared to NAA based on the information presented by Ms. Smith. An independent MBK analysis found a 3.5 percent increase in violations under CWF H3+. Most of the violations occur between September and December.