Chicago Area Waterway System Microbiome Research

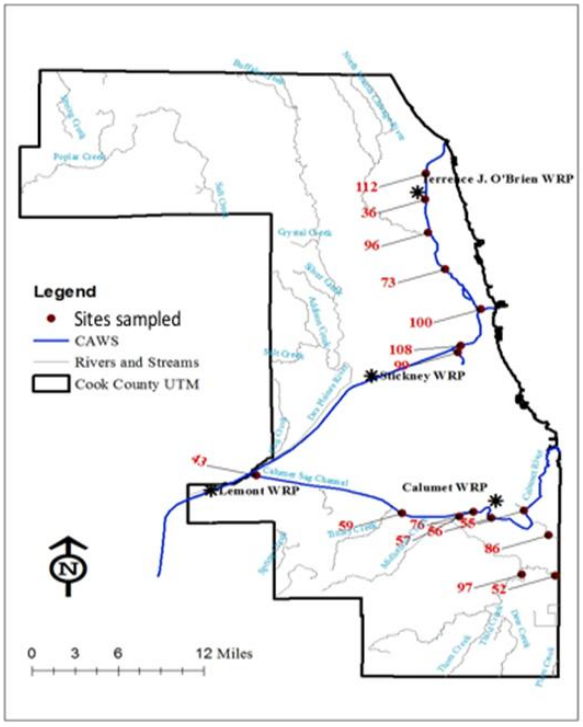
Phase III Final Report - Addendum

September 2020

Introduction

Phase II of the Chicago Area Waterway (CAWS) microbiome research project examined the impacts of the implementation of new disinfection measures at the Calumet and Terrence J. O'Brien (O'Brien) Water Reclamation Plants (WRP) as well as the completion of the Thornton Composite Reservoir (TCR). The completion of Stage 1 of the McCook Reservoir in December 2017 marks the beginning of Phase III of the CAWS microbiome research project. The McCook Reservoir is located along the Stevenson Expressway between the Des Plaines River and the Chicago Sanitary and Ship Canal. The McCook Reservoir was constructed to significantly reduce flood damage and combined sewer overflows (CSOs), with Stage 1 of the reservoir providing 3.5 billion gallons of water storage for the combined sewer system areas in the Chicago River watershed and a portion of the Des Plaines River watershed.

The goal of this addendum is specifically to evaluate the effects of the completion of the McCook Reservoir Stage 1 on microbial communities, particularly sewage indicator bacteria, in the CAWS. To isolate the effects of the McCook Reservoir from the disinfection implementation at the O'Brien WRP in 2016, a comparison was made between the CAWS microbiome before the completion of the McCook Reservoir and after implementation of disinfection at the O'Brien WRP (Phase II - 2016-2017) to the period after the completion of the McCook Reservoir Stage 1 (Phase III - 2018-2019). All the data collected during these periods were used in comparison. Specifically, comparison was done between the Phase II and Phase III microbial communities at sites 112, 36, 96, and 73 from the CAWS north region and sites 99, 100, and 108 from the central CAWS region (Main Stem and South Branch of the Chicago River) (Figure 1), where CSO frequency has decreased after the McCook Reservoir Stage 1 became operational.



Site	Address
36	North Shore Channel @ Touhy Ave.
43	Cal-Sag Channel @ Route # 83
52	**Little Calumet River @ Wentworth Ave.**
55	*Calumet River @ 130th St.*
56	*Little Calumet River @ Indiana Ave.*
57	**Little Calumet River @ Ashland Ave.**
59	Cal-Sag Channel @ Cicero Ave.
73	North Branch Chicago River @ Diversey Ave.
76	Little Calumet River @ Halsted St.
86	*Grand Calumet River @ Burnham Ave.*
96	**North Branch Chicago River @ Albany Ave.**
97	**Thorn Creek @ 170th St.**
99	South Fork, South Branch Chicago River @ Archer Ave.
100	Chicago River Main Stem @ Wells St.
108	South Branch Chicago River @ Loomis St.
112	*North Shore Channel @ Dempster Street*

FIGURE 1 CAWS and Water Reclamation Plant (*) Sampling Locations. Tributaries feeding to the CAWS are in bold and upstream sites are in italics.

Results

In the CAWS north region, there was a significant reduction (Mann Whitney U, $p < 0.05$) of fecal-associated bacteria, such as *Bacteroides*, *Paludibacter*, *Coprococcus*, and sewage indicator *Arcobacter* in Phase III (after McCook Reservoir completion), in comparison to Phase II (pre-McCook Reservoir completion) (A and B of Figure 2). Additionally, the freshwater indicator *Flavobacterium* increased significantly in Phase III at sites 96 and 73 (C and D of Figure 2).

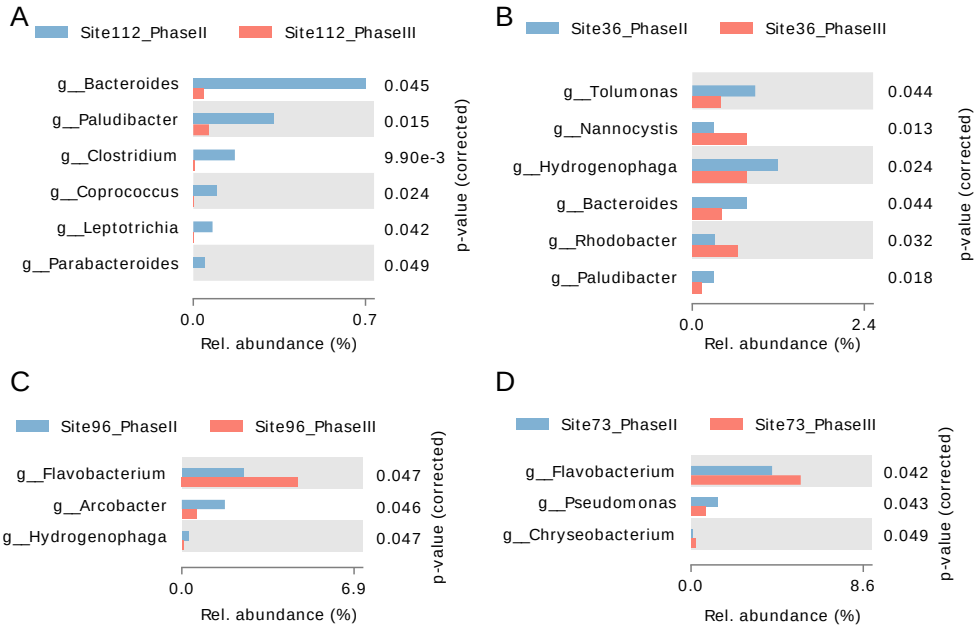


FIGURE 2 Comparison of relative abundance of bacterial genera in the CAWS north region between Phase II (2016-2017; pre-McCook Reservoir completion) and Phase III (2018-2019; post-McCook Reservoir completion). The Benjamini-Hochberg false discovery rate (FDR) corrected p-values (< 0.05) are labelled for each taxon. Site 96 is a tributary.

Similarly, in the central CAWS region, fecal and sewage indicator bacteria, such as *Bacteroides*, *Prevotella*, *Parabacteroides*, *Paludibacter*, and *Cloacibacterium*, were significantly reduced (Mann Whitney U, $p < 0.05$) after the McCook Reservoir Stage 1 came online (Figure 3).

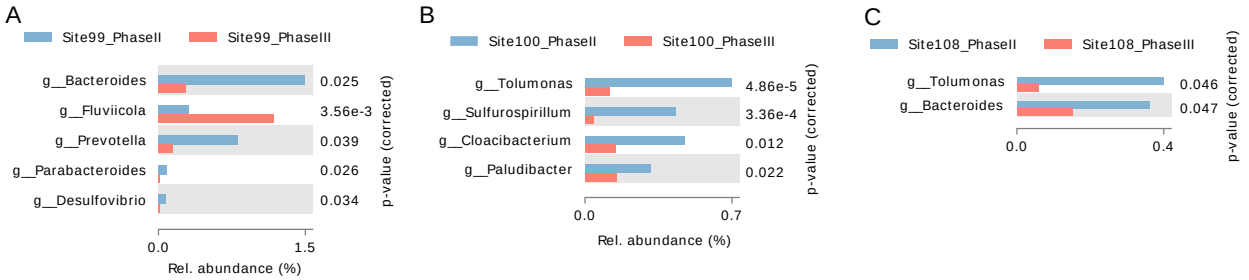


FIGURE 3 Comparison of relative abundance of bacterial genera in the CAWS central region (Main Stem and South Branch of the Chicago River) between Phase II (2016-2017; pre- McCook Reservoir completion) and Phase III (2018-2019; post-McCook Reservoir completion). The Benjamini-Hochberg FDR corrected p-values (< 0.05) are labelled for each taxon.

The abundance patterns of the bacterial genera that were positively correlated with fecal coliform plate counts (data generated from the Metropolitan Water Reclamation District of Greater Chicago monitoring) at the sites from the CAWS north (112, 36, 96, 73) and the CAWS central region (100, 99, 108) were evaluated. For this analysis, changes in the relative percentage of bacteria were examined separately for dry weather, wet weather, and wet weather with CSOs. Overall, there was an increase in the relative percentage of taxa correlated with fecal coliform during the wet weather events (particularly with CSOs) compared to the dry weather events (Figure 4). However, the most dominant sewage/fecal indicator bacteria, such as *Acinetobacter*, *Bacteroides*, *Arcobacter*, *Cloacibacterium*, *Tolumonas*, decreased significantly after the McCook Reservoir Stage 1 became operational. The reduction in fecal/sewage indicator bacteria between Phase II and Phase III was most evident during wet events with CSOs (Figure 4), and also the magnitude of the reduction was greatest at the locations where CSO flow and/or pollutant loads from CSOs were significant, such as Site 112 (upstream of the O'Brien WRP on the North Shore Channel), Site 96 (upper North Branch Chicago River before the junction with the North Shore Channel) and Site 99 (Bubbly Creek).

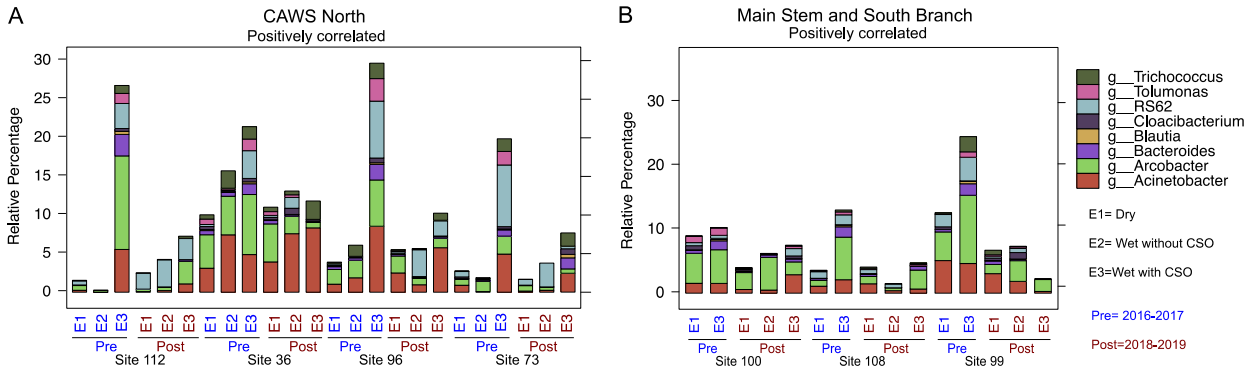


FIGURE 4 Stack plots comparing relative percentage of bacterial genera in Phase II and Phase III under dry, wet weather, and wet weather with CSO conditions at the CAWS north and CAWS central (Main Stem and South Branch of the Chicago River) sites. The genera shown had a significant positive correlation with fecal coliform abundance. Site 96 is a tributary.

As shown in the Chicago Area Waterway System Microbiome Research Phase III Final Report, the completion of the Thornton Composite Reservoir and disinfection at the Calumet and O'Brien WRPs substantially reduced sewage-associated bacteria in the CAWS during Phase II and Phase III. The analysis presented in this addendum, comparing the CAWS microbiome in Phase II and Phase III, suggests the McCook Reservoir Stage 1 also contributed to a significant reduction in sewage/fecal associated microbes in surface water in the CAWS north region as well as the Main Stem and South Branch of the Chicago River. Thus, the McCook Reservoir Stage 1, as well as disinfection at the O'Brien WRP, contributed to the reduction in sewage-associated bacteria in the CAWS.