memo

Project Name	Brown's Creek Park Rock Crib	**Date**	5/2/24
To / Contact info	BCWD Board of Managers		
Cc / Contact info	Karen Kill, District Administrator		
From / Contact info	Kajol Annaduzzaman, PhD.; Alec Olson; Camilla Correll, PE		
Regarding	Rock Crib Performance Evaluation		

Introduction

This memo provides an overview of the operational performance of the Rock Crib structure within the Brown's Creek Park Stormwater Project, completed in Spring 2017. Situated south of McKusick Road and west of Neal Avenue North in Stillwater, MN, the project was a collaborative effort involving the City of Stillwater, Washington County, Brown's Creek Watershed District, Middle St. Croix Watershed Management Organization, Emmons & Olivier Resources, and Prinsco (Manufacturer) (refer to **Figure 1** for the location map).

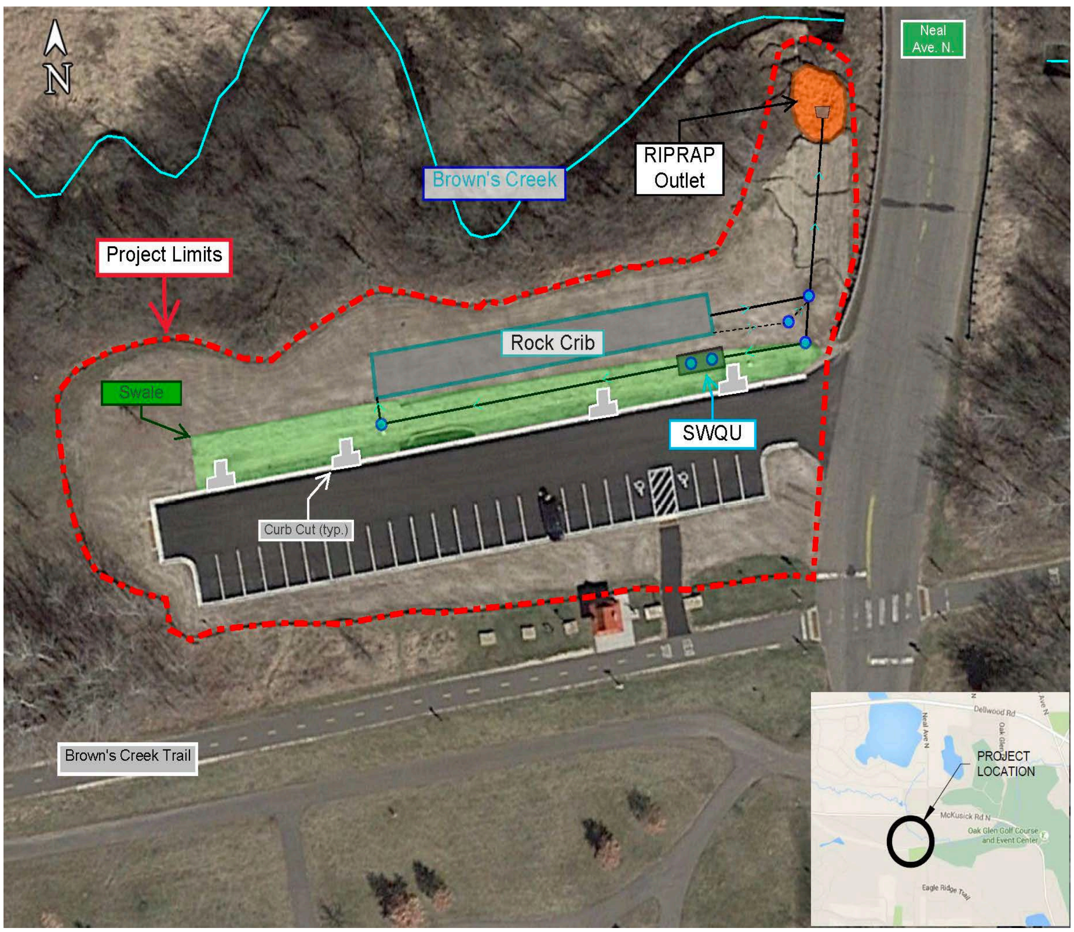

Figure 1. Location map for Brown's Creek Park Stormwater Project.

The primary objective of the project was to mitigate thermal and sediment loading from the parking lot area and Neal Avenue, preventing untreated drainage into Brown's Creek. The development of plans and specifications for the Brown's Creek Park Parking Lot BMPs involved the installation of a rock crib and bioretention basin, as well as the construction of a new parking lot. This initiative aimed to reduce thermal loading to Brown's Creek and enhance water quality by addressing runoff from the impervious parking lot paving.

The targeted outcomes included the reduction of Total Suspended Solids (TSS) from 155 to 34 lbs/year, Total Phosphorous (TP) from 0.60 to 0.20 lbs/year, and Thermal Loading from 23.45 to 18.3°C. Additionally, the BMPs were strategically designed to accommodate future improvements to Neal Avenue, incorporating connections for storm sewer integration from existing roads. The successful connection of the Neal Avenue storm sewer to the rock crib occurred in 2020, specifically between August 25 and September 14, broadening the system's functionality beyond the parking lot.

It's crucial to note that the rock crib functioned solely for the parking lot before the 2020 sewer connections. The subsequent sections of this memo will delve into the performance evaluation of the rock crib, focusing on pre-Neal Avenue storm sewer connection (before August 2020) and post-Neal Avenue storm sewer connection (after August 2020). The assessment will include key parameters such as inlet and effluent water quality and temperature during these phases. This comprehensive analysis aims to provide valuable insights into the efficacy and adaptability of the rock crib structure in fulfilling its stormwater management objectives.

Project summary

The stormwater management system within this project meticulously follows a designated drainage path, commencing at a paved driveway equipped with curb & gutter, catch basins, and curb cuts. This purposeful design directs site drainage seamlessly through a bio swale, culminating in a Prinsco underground stormwater quality unit (SWQU) (see **Figure 2**). The 5-foot diameter by 20-foot-long underground storage tank stands as a strategic element, engineered to adeptly capture various debris, including trash, sediment, oils, and suspended solids.

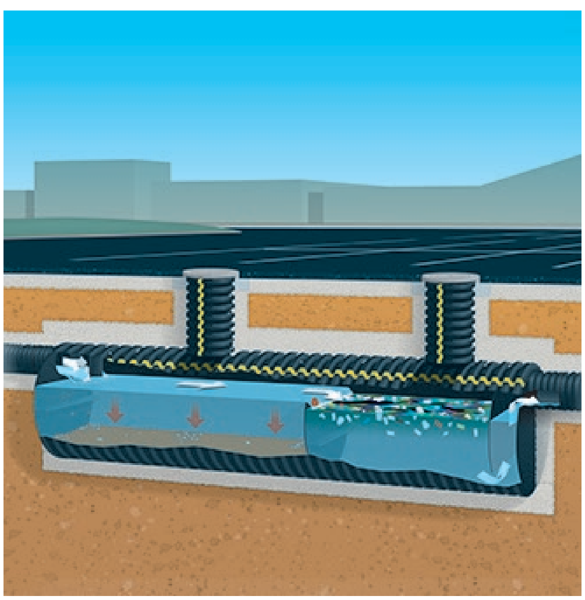

Figure 2. Prinsco Underground SWQU.

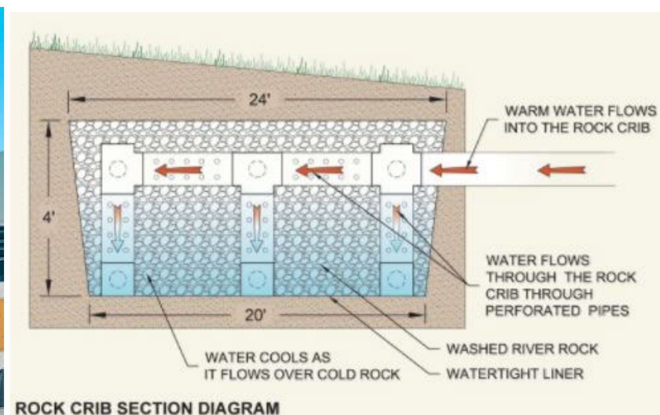

Figure 3. Rock Crib Design.

Subsequently, the orchestrated flow of stormwater continues through a rock crib (**Figure 3**), strategically designed to address thermal loadings. This ensemble of constructed features ensures that cleaner and cooler stormwater is being discharged into Brown's Creek. To preempt overflow scenarios, a well-integrated bypass system redirects excess water directly to Brown's Creek via an underground pipe. The thermal reduction is achieved by enabling stormwater to traverse a series of perforated pipes surrounded by 1.5" – 3.0" river rock.

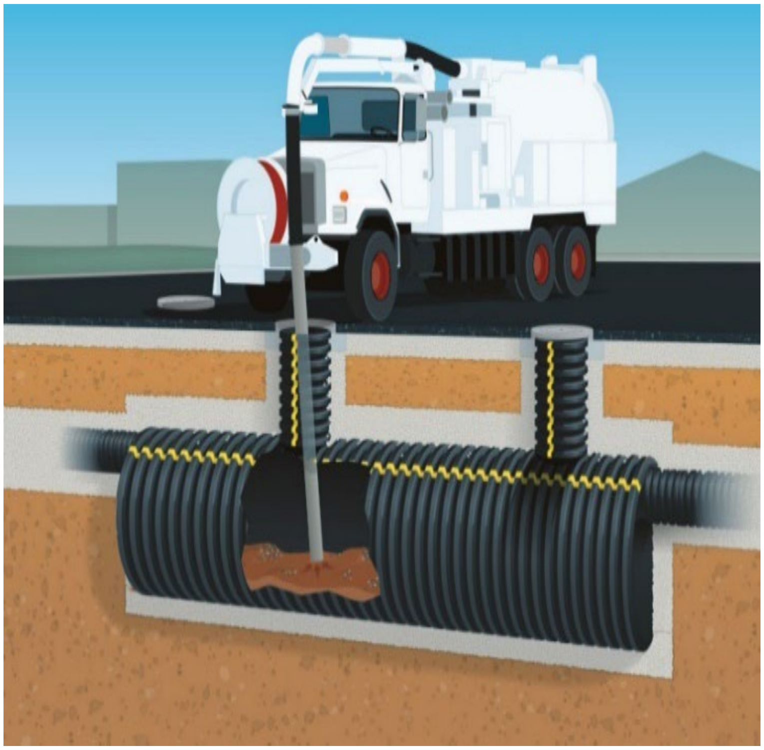

Figure 4. Maintenance of SWQU

In terms of accessibility for maintenance purposes, a thoughtful layout facilitates easy entry from the adjacent parking lot. Manhole risers on the SWQU play a crucial role in aiding the removal of debris and sediment, while PVC cleanouts strategically positioned on both sides of the SWQU and the western edge of the Rock Crib assist in systematic flushing. Maintenance equipment, weighing approximately 10 to 15 tons dry, with a gross weight nearing 30-tons, can be seamlessly operated without intruding into the vegetated area. This strategic placement owes itself to the proximity of the SWQU and Rock Crib to the parking lot edge, exemplifying a well-thought-out approach to system accessibility and upkeep (**Figure 4**).

Methods

To evaluate the performance of the BCWD Rock Crib, data collection followed the parameters outlined in the BC Park Rock Crib Standard Operating Procedures Manual (BC Park Rock Crib_SOPM). However, post-construction data focused solely on temperature monitoring at five specific locations: Rock Crib Inlet, Underdrain, High Drain, Main Outlet, and Overflow Inlet Pipe (refer to **Figure 5**). Notably, Total Suspended Solids (TSS) and Total Phosphorus (TP) monitoring were omitted, as per discussions with the Washington Conservation District on February 26, 2024. Monitoring of the volume input to the Rock Crib was conducted effectively, alongside recording stage, velocity, and flow rate data for the outlet during the specified timeframe, although these details are not elaborated in this memo.

Given the available data, this memo exclusively focuses on evaluating temperature reduction from source water to discharge at the Creek. The temperature monitoring sensors were strategically located within the rock crib system, facilitating comprehensive data collection. The installation of rock cribs adhered to established procedures, ensuring proper alignment and stability. This section outlines the methods employed for rock crib installation and temperature monitoring, while acknowledging the absence of TSS and TP data. It also clarifies that sediment removal data was not collected as it was not deemed necessary for the scope of the study.

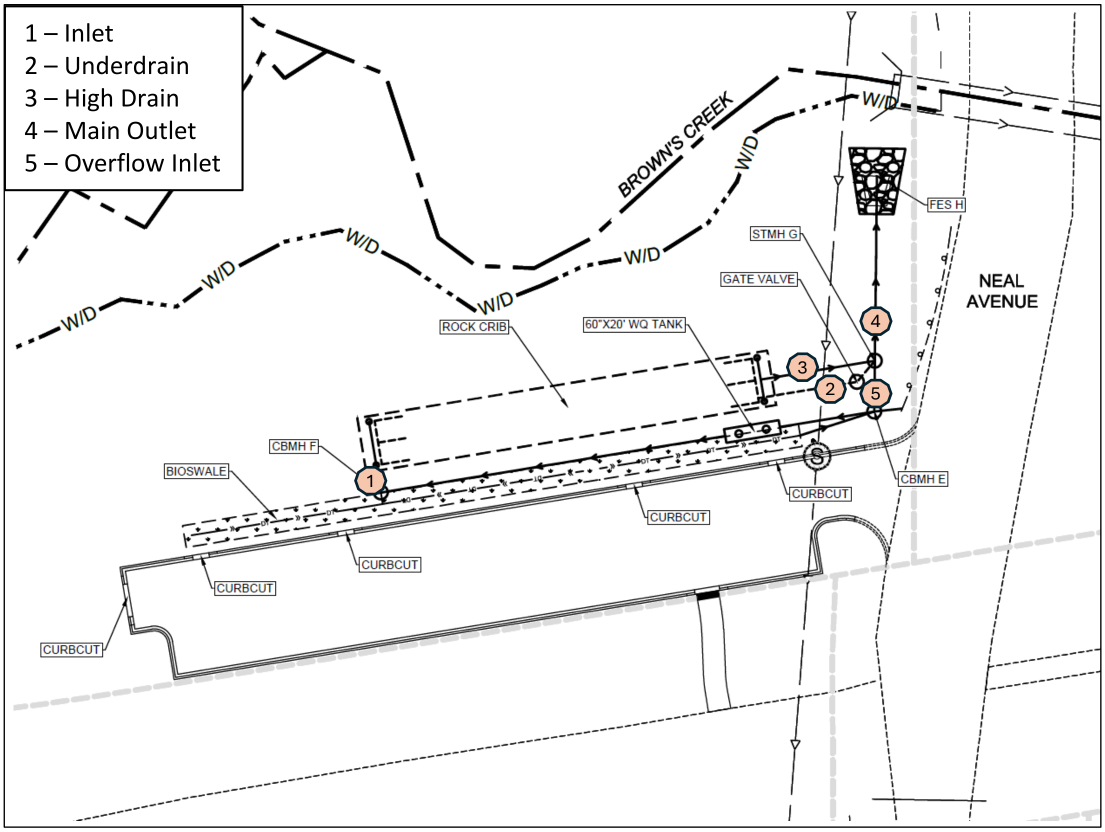

Figure 5: Location of temperature monitoring sensor within the rock crib system.

Results

The temperature variations in Rock Crib outlet compared to its inlet are depicted in **Figure 6**, focusing on two distinct operational periods: pre-summer 2020 (pre-2020) and post-summer 2020 (inclusive). This delineation captures the system's operation from its installation in 2017, initially addressing only the parking lot, up to the point when Neal Avenue's stormwater began discharging to the Creek via the rock crib system in summer 2020 (which is referred to as "inclusive" in the legend).

The study reveals that the rock crib exerts its most significant cooling influence on runoff, notably reducing temperatures by approximately 3°C, particularly during peak air temperatures in June and July. This cooling effect persists year-round, maintaining temperatures close to the targeted 18.3°C, except for a deviation in October, which is likely due to higher ground temperatures which serves to warm the cooler stormwater runoff as it travels through the rock crib. Notably, before 2020, the rock crib consistently produced cooler water compared to post-2020 conditions. The increase in outlet temperature post-2020 is attributed to elevated flow rates from Neal Avenue stormwater and higher inlet water temperature (**Figure 7**). However, the effectiveness of the rock crib remains steady in both pre- and post-2020 scenarios. Although the volume increase from Neal Avenue connections reduced residence time with the rock, diminishing its efficacy, it generally maintains consistency. Noteworthy is the slight deviation in the initial weeks of September post-2020, correlating with significantly higher flow rates. These findings underscore the rock crib's enduring importance despite operational variations, suggesting the need for adaptive strategies to optimize its performance under changing conditions.

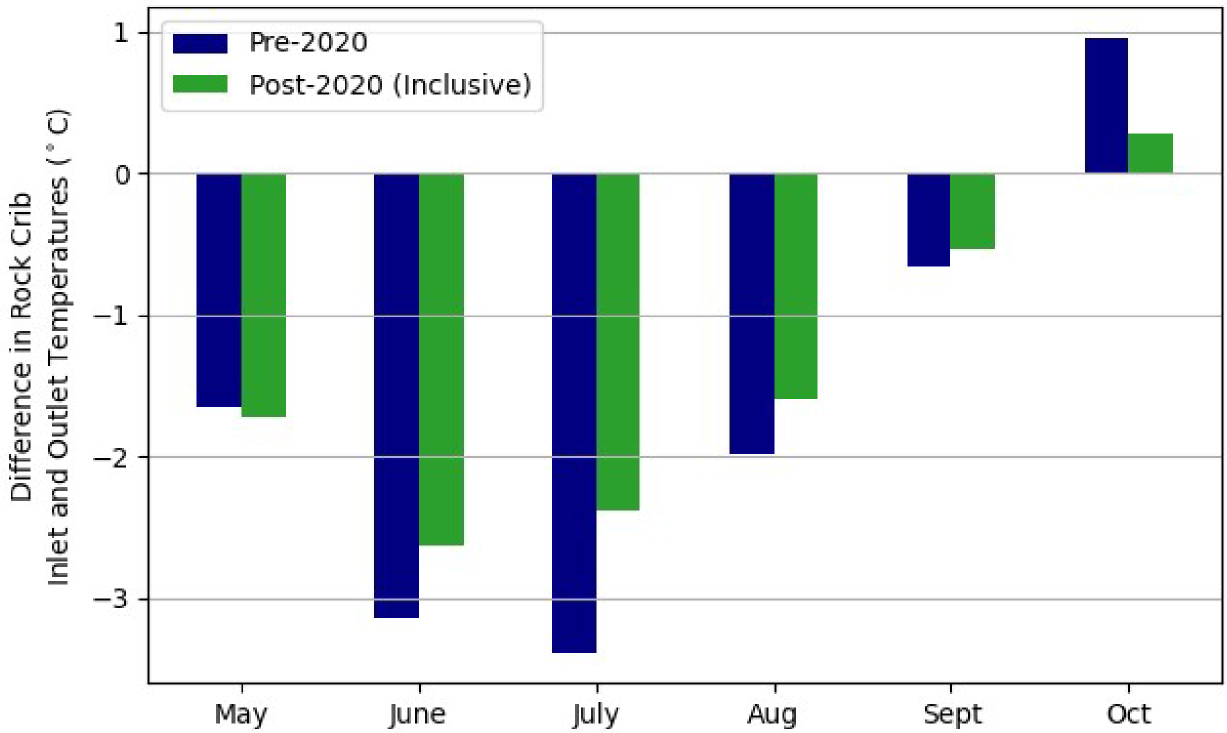

Figure 6: Temperature variation in the rock crib discharge water over pre-and post-2020.

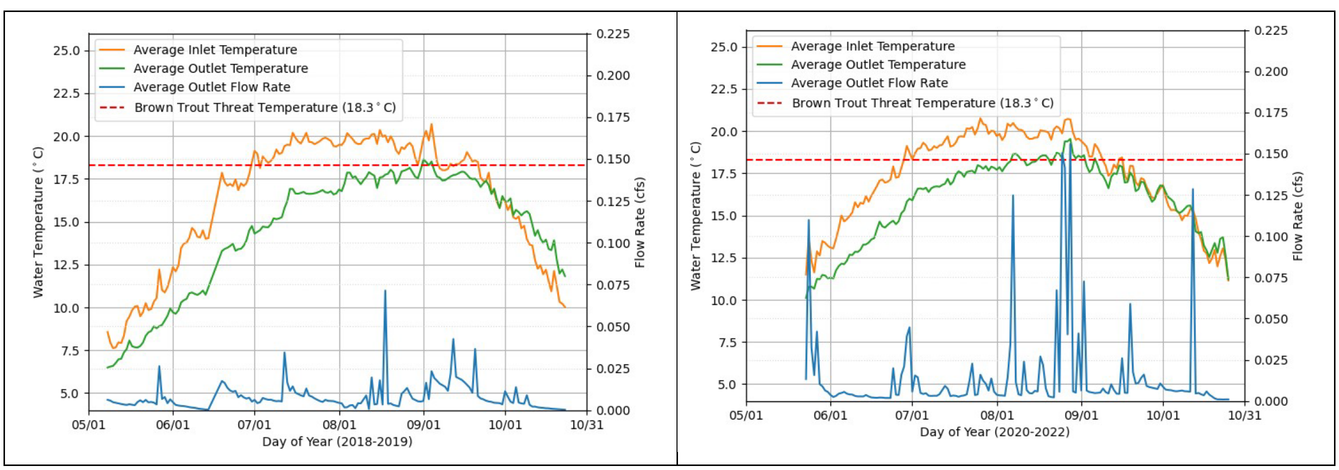

Figure 7: Temperature and flow rate in the rock crib system over pre-2020 (left) and post-2020 (right).

Despite the lower temperature at the rock crib outlet, the higher temperature observed in the discharged water is primarily attributed to the mixing of warmer inlet overflow and high drain temperatures (as illustrated in **Figure 8**).

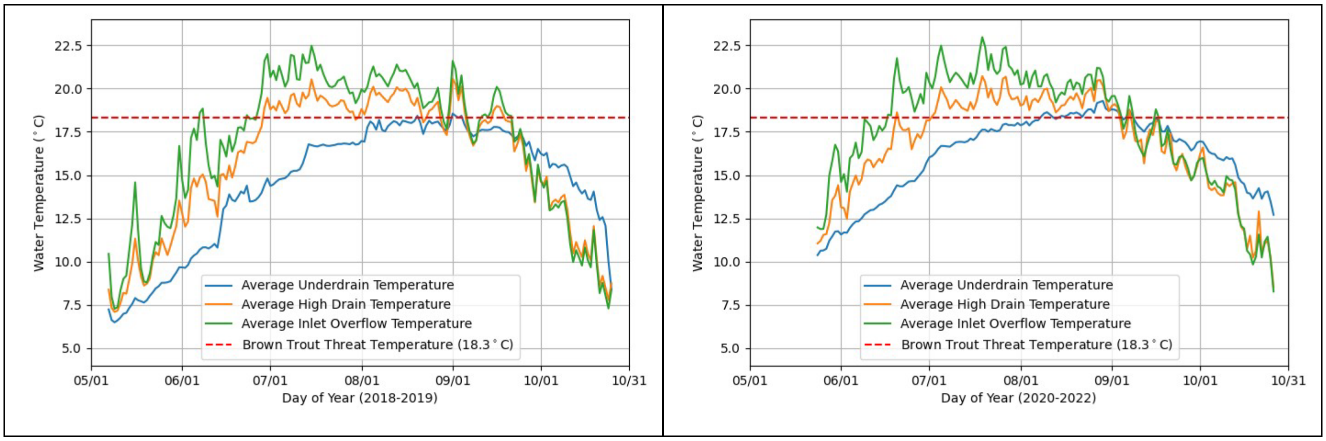

Figure 8: Temperature variation in the underdrain, high drain, and inlet overflow in the rock crib system over pre-2020 (left) and post-2020 (right).

Although the Rock Crib shows lower inlet and outlet temperatures, downstream creek temperatures remain high due to elevated atmospheric temperatures until mid-July, for both pre- and post-2020 conditions (in **Figure 9**). Subsequently, as atmospheric temperatures decrease post-mid-July, high stormwater temperatures from ground runoff elevate inlet temperatures. However, following this, outlet temperatures also rise but are notably reduced from the inlet temperature. This increase in inlet and outlet temperatures is primarily attributed to the elevation of ground temperature over the high atmospheric temperature season (before mid-July), maintaining high ground temperature until reaching its peak at the end of August. The ground temperature decreases after the end of August, coinciding with the decline in atmospheric temperatures post-mid-July.

As a result, it can be deduced that approximately 1.5 months are needed for the elevated temperature to dissipate, allowing inlet temperatures to align with the guideline temperature for the outlet. Hence, it can be inferred that approximately 1.5 months are required for the elevated temperature to dissipate, allowing inlet temperatures to align with the guideline temperature for the outlet.

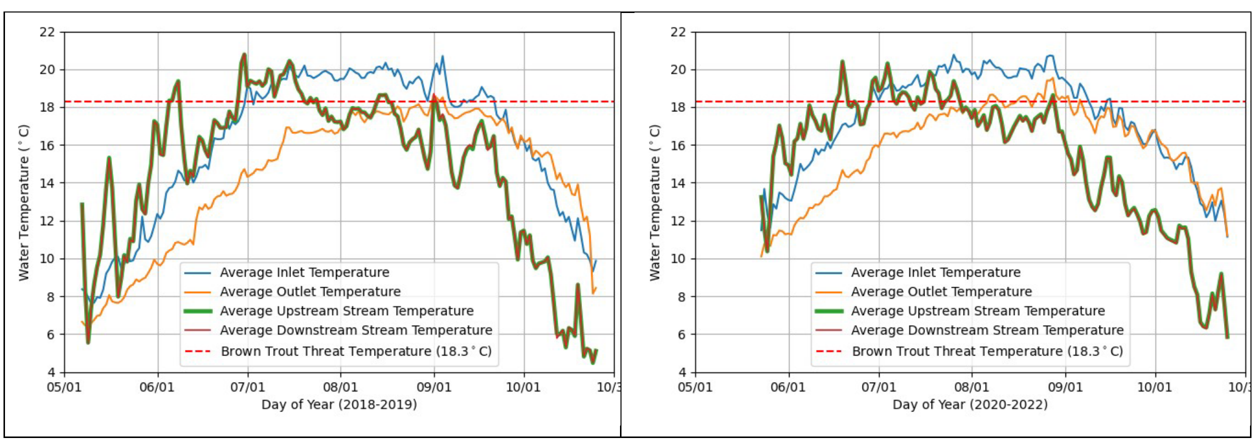

Figure 9: Temperature variation in the downstream, inlet and outlet for the rock crib system over pre-2020 (left) and post-2020 (right) condition.

Recommendations

Enhanced Monitoring: Implement a more comprehensive monitoring system to continuously track both inlet and outlet temperatures, as well as atmospheric and ground temperatures, to better understand the system's behavior over time. Furthermore, it is important to monitor the water quality parameters (i.e., TSS and TP) to maintain the creek water quality, which can directly affect the aquatic environment.

Optimized Stormwater Management: Develop strategies to mitigate the impact of high stormwater temperatures caused by ground runoff, possibly through improved/increased drainage systems or vegetation area around the rock crib to dissipate the inlet temperature for rock crib.

Consider Expansion: Evaluate the feasibility of expanding the rock crib system to other relevant parking lots or similar condition within the area to further enhance its overall effectiveness in reducing thermal, TSS, and TP loading and improving water quality in the creek.

Regular Maintenance: Continue to conduct regular inspections and maintenance of the rock crib system to ensure its proper functioning, including sediment removal and cleaning of inlet and outlet structures to prevent blockages and maintain optimal flow.

Adaptive Management: Continuously assess the performance of the rock crib system and adapt management practices accordingly to address any emerging issues or challenges, ensuring its effectiveness in mitigating thermal loading to the downstream creek.

Public Awareness: Enhance awareness regarding how the built environment impacts natural resources, the significance of stormwater management and the role played by the rock crib system in mitigating thermal loading. Encourage community engagement and support for continuous maintenance and improvement endeavors. This can be achieved through dissemination of information via the district web portal and/or utilization of existing signage at the site.

Concluding Remarks

In conclusion, the analysis of the rock crib's performance underscores its pivotal role in mitigating thermal loading and improving water quality downstream. Regardless of challenges such as elevated stormwater temperatures and seasonal variations, the rock crib consistently demonstrates its effectiveness in cooling runoff, particularly during peak air temperatures. Recommendations for enhanced monitoring, optimized stormwater management, regular maintenance, and adaptive management are crucial for sustaining its efficiency. Moving forward, a holistic approach encompassing expansion, public awareness, and continuous improvement efforts will further fortify the rock crib's contribution to preserving the environmental integrity of the downstream creek, ensuring a sustainable and resilient stormwater management system.