Geomorphic assessments helped the VRWJPO explore all of the reaches of the Vermillion River and its tributaries, from the wide open reaches to the narrow reaches hidden by vegetation.

1.0 Executive Summary

Stream-Cooling Demonstrations in the Vermillion River Watershed

EPA Section 319 Grant FINAL REPORT

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Stream-Cooling Demonstrations in the Vermillion River Watershed

1.0 Section 319 Grant

The Vermillion River Watershed Joint Powers Organization (VRWJPO) and the Minnesota Pollution Control Agency (MPCA) co-sponsored the U.S. Environmental Protection Agency (EPA) Section 319 Stream-Cooling Demonstration project from 2009 through 2012. The project's primary goal was to demonstrate and evaluate stormwater best management practices (BMPs) thought to maintain or decrease stream temperature.

The demonstration project is part of the VRWJPO's ongoing efforts to manage thermal impacts on the Vermillion River and its tributaries, as well as its self-sustaining brown trout population. The EPA's Section 319 grant program provided $260,000 for this project, matched by $260,000 in funding and in-kind services from the VRWJPO and its partners. The four objectives of the project as described in the approved Work Plan were:

- To monitor at least eight new or existing selected thermal reduction BMPs in the upper Vermillion River watershed and assess costs and benefits of these practices.
- To verify whether the Surface Heat Loading Model developed during a previous EPA Targeted Watershed Grant is an effective tool for estimating thermal impacts of land use changes.
- To increase the percentage of citizens in the watershed who understand that increasing stream temperature is a threat to water quality and the trout population.
- To maintain no net increase in stream temperature during the period of the demonstration project, as determined by results for stream temperature in the Vermillion River Monitoring Network annual report.

Following initial site screening and development, the focus of the project changed from evaluation of all thermal BMPs to evaluation of practices based on mechanical cooling properties, rather than infiltration and volume control. Less is known about the cost and effectiveness of mechanical cooling. The Work Plan was amended to incorporate this change.

1.1 Thermal Reduction BMP Results

Dakota County Soil and Water Conservation District (SWCD) implemented the demonstration project BMPs, following a comprehensive process that included: surveying key stakeholders about thermal-reduction BMPs with insufficient performance data; prioritizing survey results; sorting BMPs into infiltration versus mechanical cooling; GIS mapping potential locations within 1,000 feet of the Vermillion River designated trout reaches; monitoring stormwater pond water temperature and flow (intermittent versus continuous); working with landowners to develop and monitor BMPs; collecting temperature data; comparing data with precipitation events; calculating BMP effectiveness; and documenting results. These results are summarized below.

Temperature Reduction During Critical Precipitation Events

Evaluated BMPs Ranked By Cost Effectiveness	BMP Cost ($)	Data Year	Weighted Average Inlet Temperature (C)	Weighted Average Outlet Temperature (C)	Weighted Average Temperature Reduction During Critical Events (C)	BMP Cost to Temperature Reduction Ratio ($/C)
Pond Shading with Trees	Existing BMP Used At No Cost	2011	SHADED POND 23.42	UNSHADED POND 27.97	4.55	0
Vegetated Wet Swale	Existing BMP Used At No Cost	2010	26.55	26.46	0.09	0
Rock Crib with a Wet Sump	$7,268	2011	23.22	20.59	2.63	2,763
Biofiltration Cell #1	$8,348	2011	24.57	21.80	2.77	3,014
Bottom Draw Pond Outlet	$15,950	2012	27	22.37	4.63	3,445
Biofiltration Cell #2	$8,348	2011	24.29	21.89	2.40	3,478
Vegetated Buffer Swale with Storage	$6,422	2011	24.92	23.74	1.18	5,442
Rock Crib with a Dry Sump	$7,268	2011	23.34	22.18	1.16	6,266
Pond Bench Trench Filter	Existing BMP Used At No Cost	2011			NOT ABLE TO MEASURE	0
Iron Enhanced Sand Filter	Existing BMP Used At No Cost	2011	24.38	24.52	TEMPERATURE INCREASED 0.14	0

BMP Performance During All Natural Precipitation Events

Evaluated BMP	Thermal Performance Results Based On Data during All Precipitation Events
Rock Crib with a Wet Sump	The overall weighted average temperature of runoff during 33 natural precipitation events in 2011 was reduced 0.84 C.
Rock Crib with a Dry Sump	The overall weighted average temperature of runoff during 31 natural precipitation events in 2011 was reduced 0.74 C.
Biofiltration Cell #1	The overall weighted average temperature of runoff during 29 natural precipitation events in 2011 was reduced 1.02 C.
Biofiltration Cell #2	The overall weighted average temperature of runoff during 28 natural precipitation events in 2011 was reduced 1.25 C.
Vegetated Buffer Swale with Storage	The overall weighted average temperature of runoff during 29 natural precipitation events in 2011 was reduced 0.89 C.
Bottom Draw Pond Outlet	The overall average temperature of pond discharge recorded in 2012 was 3.69 degrees cooler than surface water in the pond.
Pond Shading with Trees	The overall average temperature of pond discharge recorded in 2011 was 3.66 C cooler from a shaded pond than from a comparable non-shaded pond.
Vegetated Wet Swale	The overall average temperature of outlet flow recorded in 2010 was 0.47 C cooler than the inlet flow.
Pond Bench Trench Filter	Data collected in 2010 and 2011 indicated no measurable difference for in-stream temperatures located just upstream and downstream of the BMP outlets.
Iron Enhanced Sand Filter	The overall weighted average temperature of pond discharge during 8 natural precipitation events in 2011 was increased 0.24 C.

1.2 Surface Heat Loading Model Results

The Surface Heat Loading Model was designed to support thermal trading and if the VRWJPO had established a robust trading program, the model would have been regularly updated and adjusted to the scale of development projects. When the VRWJPO did not establish a trading program, the model became a “snapshot in time” rather than a routinely updated tool.

When developing the demonstration proposal, VRWJPO staff had limited experience in using the model. VRWJPO staff had to learn the model before fully understanding its assets and limitations. To field validate the model, all of the sites monitored in the study should have had volume monitoring. The decision not to monitor volume concurrently with temperature created problems in comparing actual BMP monitoring data with model results.

Where the model provides more interesting and helpful information is in pinpointing the highest heat export areas in the western portion of the watershed. These are areas that produce hot stormwater runoff – but not necessarily runoff to the trout streams. The model also provides, however, a map of heat contribution areas. These are areas that actually contribute hot stormwater runoff to the stream. The model may have more benefit as a tool to allow the watershed to focus its efforts at mitigating stormwater impacts on stream temperature. The model was run on one specific BMP type, the rock cribs, to compare its calculations with the monitored data.

1.3 Public Awareness of Thermal Impacts

The VRWJPO collected data related to public awareness of environmental issues and trout streams in general, and specifically the impact of stream temperature on trout health and viability. Public awareness about the brown trout population and temperature issues is well established among specific groups: elected and city officials (because of regulatory aspects of watershed management for 2A reaches of the Vermillion River), landowners in close proximity to the trout streams, sportsmen's groups, and middle- and high-school students, especially boys over the age of 12.

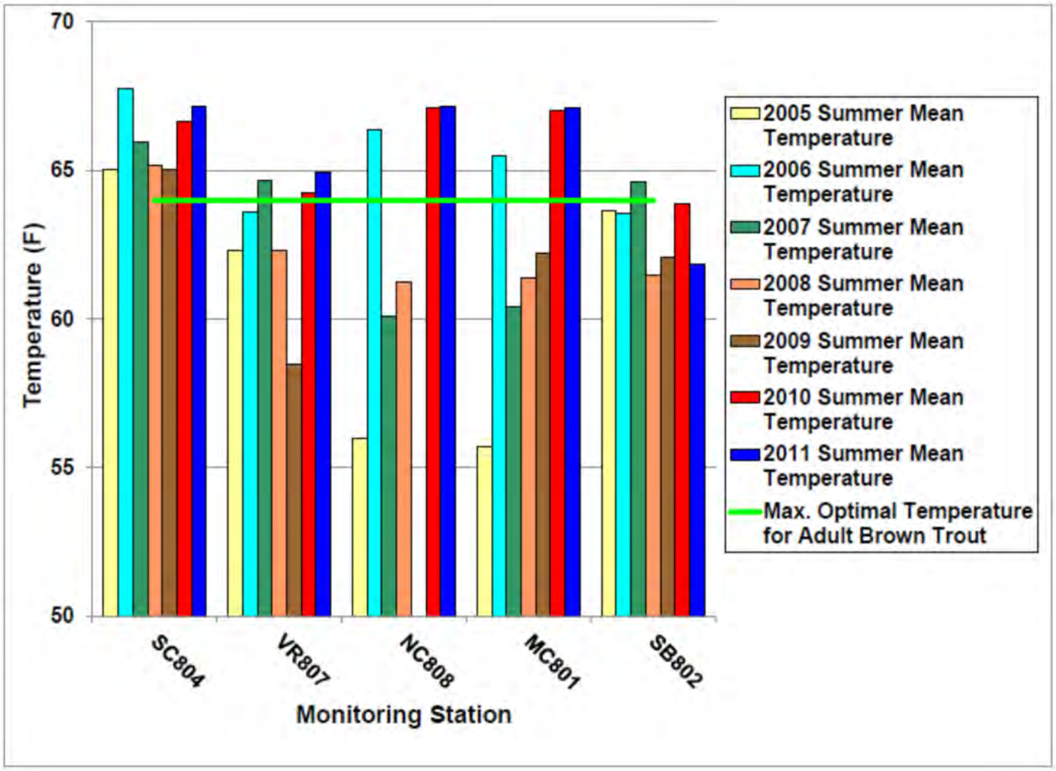
The VRWJPO provided an informal computer survey at the 2011 Dakota County Fair for two four-hour shifts, during which time an estimated 70-90 people took the survey. Approximately half of the general public taking the survey correctly identified temperature as the most important factor in trout health. Most men, almost all boys over the age of 12, and women who fish (or whose families fish) best understood the connection between trout and temperature. In 2012 and 2013, the VRWJPO attended events in Farmington and Lakeville with a "Jeopardy" game that included a question about trout and temperature. Only about one-quarter of those who attempted to respond got the correct answer relating trout and temperature.

The VRWJPO did not conduct a scientific survey to obtain data about public awareness of the trout and temperature connection. However, the VRWJPO has developed consistent messages in a variety of publications and presentations about the importance of maintaining the thermal regime in the Vermillion River.

1.4 Maintaining Stream Temperatures

Mean stream temperatures in the Vermillion River, as measured by the Vermillion River Monitoring Network, continue to hover very close to or exceed the stress threshold for brown trout (19 degrees C). During the course of the demonstration project, 2010-2012, air temperatures (which are most directly correlated with stream temperatures) were much hotter than usual. August 2010 and July 2011 were the hottest months during the time period, 4-8 degrees F above normal and 4-6 degrees F above normal respectively. This is reflected in Figure 1.0 of mean summer temperatures in the trout stream reaches of the Vermillion River. The tributaries in the western watershed, South, Middle, and North Creeks, consistently exceed the 19 degree C stress threshold, whereas the main stem segments and South Branch seem to maintain a cooler thermal regime. (Monitoring results from 2012, currently in draft, are consistent with this picture: mean stream temperature at South Creek was 19.6 degrees C at 220th Street and mean stream temperature at Middle Creek was 18.7 degrees C at Hwy. 3.)

Figure 1.0: Mean Summer Temperatures for Vermillion River Monitoring Network Stations Located in Trout Stream Reaches, 2005-2011



While river temperatures are close to or exceeding the 19 degrees C stress threshold for brown trout, especially in the months of July and August, the trout population continues to reproduce and expand to other reaches. This illustrates how many other factors, such as groundwater inflow, refuge areas, shade, and geomorphology, influence both stream temperature and trout survival.

1.5 Recommendations

Many aspects of the physical environment affect stream temperature, and many of these are beyond the VRWJPO's control (climate and weather, for example). Further studies of strategies to reduce stream temperatures are warranted. However, the studies of the Vermillion River conducted to date give the VRWJPO sufficient information to take action that will assist with management decisions within the watershed. Among the most important:

- The VRWJPO's Runoff Volume Control Standard should be sufficient to prevent heat loading to the Vermillion River from new development. It should be implemented consistently for new development. Hot spots in areas developed before the VRWJPO Runoff Volume Control Standard was established (basically, before 2006) should be considered for stormwater retrofits that will reduce heat loading from existing land uses.
- When selecting best management practices (BMPs) for reducing heat loading to the river, Low Impact Design (LID) practices and volume reduction/infiltration BMPs are the first and best choice, for new developments or retrofits.
- Cold groundwater inflow is essential to maintaining stream temperatures in the optimal range (14-18 degrees C) for brown trout. Preventing groundwater depletion is important for many reasons, and maintaining cool stream temperature is one of them. Groundwater should be protected through water conservation measures, monitoring water appropriations, protecting recharge zones, re-using stormwater, and using infiltration practices whenever possible.
- Shade reduces runoff temperatures and protects the river from the hottest conditions, but developing a protective shade canopy takes time. The VRWJPO and partners could develop a long-term strategy to establish riparian forested buffers along the Vermillion River and its tributaries and encourage shading of impervious areas, such as parking lots, in cases where stormwater retrofits are not feasible.

The presence of a self-sustaining trout population and trophy-level trout stream in a growing metropolitan county is a valued resource, requiring years of effort and a focus on improvements in water quality. The trout, however, are only the most recognizable member of the Vermillion River's complex ecosystem. Increasing stream temperatures affect other fish, amphibians, macroinvertebrates, insects, plants, birds, mammals, and microscopic aquatic organisms. Increases in stream temperature, which reduce dissolved oxygen and speed up chemical processes, affect all of these aquatic species, not just the high-profile brown trout. A healthy river supports a healthy diversity of living things. The VRWJPO will continue to manage the watershed to achieve both.