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Water Quality Study of the Bayfield River Downstream of the Municipality of Bluewater's Bayfield Sewage Treatment Facility

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OVERVIEW

Huber Environmental Consulting Inc. was retained by B.M. Ross to conduct a water sampling study below the discharge of the Bayfield wastewater treatment facility during the spring/summer of 2011. This study included taking water chemistry and bacteriological samples both upstream and at a number of locations downstream in the Bayfield River. A simple mixing zone study was also undertaken during using a conductivity meter to document the size and extent of the mixing zone under the streamflow conditions present during the sampling. Preliminary streamflow information was obtained from the Water Survey Canada website for their stream gauge on the Bayfield River 02FF007. Photographs were also taken to document the physical conditions in the river during the sampling.

BACKGROUND

The Bayfield sewage treatment facility is located approximately 750 m north of Huron County Road No.3 and 2.5 km east of the east boundary of the community of Bayfield. This wastewater treatment facility consists of a twin celled facultative sewage lagoon system followed by intermittent sand filtration. According to the existing Certificate of Approval, this facility is rated at an average daily raw sewage flow not to exceed 1072 m^3/day for any period of time greater than one calendar year.

The discharge is to the Bayfield River approximately 3.5 km upstream from the point where the Bayfield River discharges to Lake Huron. Treated effluent is typically discharged intermittently in the spring and fall between March to June and October to December. The actual number of days of discharge varies from 50 to 100 days per year depending mainly on weather conditions.

Since the actual treatment facility is located above the river valley, the discharge cascades over an approximate 50 meter vertical drop to the forested valley floor before entering near the head of a side channel to the Bayfield River. It is estimated that the upper end of this side channel is separated from the main Bayfield River for all periods other than spring melt and following major precipitation events. This side channel receiving the treated wastewater discharge flows collecting seepage from the valley walls for approximately 700 to 800 meters before connecting with the main Bayfield River.

The Water Survey of Canada Stream Gauge 02FF007 Bayfield River near Varna is located at the 1st concession upstream of the Bayfield Wastewater Treatment Facility. This gauge has been collecting continuous water level and streamflow information at this location for the last 41 years. The flow in the Bayfield River is considered natural or non-regulated.

The Bayfield River has been part of the Provincial Water Quality Monitoring Program since 1964. However, presently only station 08004000802 Bayfield River, Huron County Rd 31, North of Varna (1975 to present) and station 08004000202 Bayfield River, Kippen Rd, Egmondville (1964 to present) are active stations and both are located upstream of the treated discharge from Bayfield. Between the period 1964 to 1975, water quality samples were taken downstream at station 08004000102 Bayfield River, Hwy 21 when it was part of the network.

INTRODUCTION

Water samples were taken as part of this study on June 14 and July 5, 2011 from the locations shown in Figure 1 and described below.

Station	UTM Zone	Easting	Northing	Accuracy	Location
1	17T	447076	4823139	+-4 m	Bayfield treated effluent @ v notch weir
2	17T	447167	4823274	+-10m	Bayfield treated effluent @ discharge structure
3	17T	447695	4823748	+-6 m	Bayfield treated effluent prior to confluence with Bayfield River
4	17T	447137	4823785	+-7m	upstream in Bayfield River
5	17T	447079	4823945	+-8m	100 m D/S of the confluence with the Bayfield River 1/3 across from south side
6	17T	447085	4823949	+-8m	100 m D/S of the confluence with the Bayfield River 2/3 across from south side
7	17T	445260	4824611	+-8m	Bayfield River at end of road in Wildwood Trailer Park
8	17T	443443	4824162	+-8m	Bayfield River beside gas pumps @ Harbour Lights Marina

Insitu water temperature, pH and conductivity measurements were taken with a Hanna Instruments Model HI 98129 Combo temperature, pH & EC meter. Dissolved oxygen was measured on June 4, 2011 by the use of a Hack Dissolved Oxygen kit while for the July sampling, a YSI Model 55D Dissolved Oxygen Meter was used.

Preliminary streamflow information was obtained from the Water Survey Canada website for their stream gauge on the Bayfield River near Varna (02FF007) for the dates the samples were taken.

The lagoon treated waste water is applied to the intermittent sand filters on an alternating basis by the use of a timer and pumps. The filtered waste water is then collected and directed

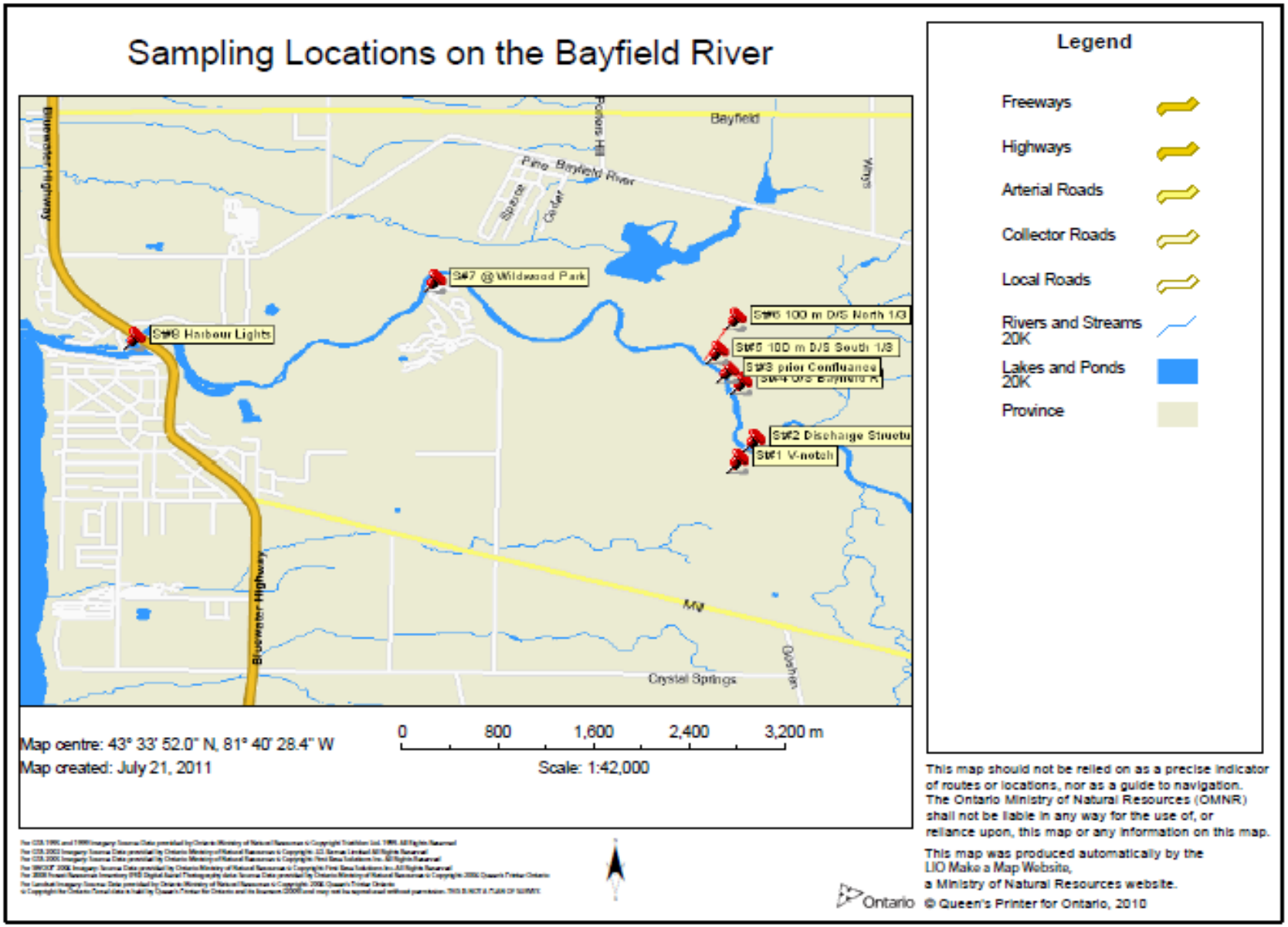


Figure 1: Map showing chemical and bacteriological sampling locations used on the Bayfield River during this 2011 survey.

through a the v-notch weir which incorporates a flow totalizer. The total daily volume of discharge is calculated by taking a daily reading at approximately the same time and subtracting the previous day's reading. Based strictly on visual observations, it appeared that the treated wastewater discharge rate was approximately twice as much on the first sampling day compared to the second sampling date. This comment is based on observations made at the discharge structure at the bottom of the embankment and flow in the corrugated pipe prior to entering the side channel.

Monitoring Results

The chemical and bacteriological monitoring results are summarized in Table 1. As shown by Table 1, the effluent from the Bayfield Sewage Treatment Facility would be considered of very high quality for the parameters measured. The existing Certificate of Approval approving their discharge allows for the discharge concentration of 10 mg/l BOD5, 10 mg/l suspended solids, 0.5 mg/l total phosphorous and 4.0 mg/l total ammonia. The average concentrations of these parameters during our sampling was <3 mg/l BOD5, <2 mg/l suspended solids, 0.14 mg/l total phosphorous and <0.1 total ammonia. Sampling of the side channel prior to mixing with the Bayfield River showed these parameters to typically be further reduced prior to mixing with the Bayfield River. Comparing the downstream samples in the Bayfield River to the upstream sampling station revealed no significant change in any of the parameters monitored that could be contributed to the treated discharge from the Bayfield Sewage Treatment Facility.

Discussion of Water Quality Monitoring Results

As stated previously, the effluent from the Bayfield Waste Water Treatment Facility would be considered of very high quality. During our sampling, the parameters that are regulated by their Certificate of Approval were only about 20% of the concentrations which they are legally allowed to discharge. To obtain an indication of how typical the effluent was on the days of our sampling, we compared our sample results to the routine monitoring of the discharge which is required by their Certificate of Approval. As shown in Table 3, the samples taken by Huber Environmental Consulting Inc. were very similar to the samples taken by the Ontario Clean Water Agency (OCWA) the operators.

As to what is considered acceptable river water quality, this is defined by the Ontario Provincial Water Quality Objectives (PWQO's). Of the various other chemical and bacteriological parameters shown in Table 1, there are only PWQO's for unionized ammonia (based on the laboratory measured total ammonia concentration and the in-situ or field measured water temperature and pH), pH, dissolved oxygen, total phosphorus and Ecoli.

Table 1: Water quality monitoring data of Bayfield's treated discharge and the Bayfield River at select locations in 2011.

Date	Location	BOD5 mg/l	TSS mg/l	T. Phos mg/l	S. Phos mg/l	T.Amm mg/l	TKN mg/l	NO2 mg/l	NO3 mg/l	Cl⁻ mg/l	Cond. mg/l	Ecoli /100 cc	F. pH	F. Temp C°	F. DO mg/l
6/14/11	Eff @ V notch	< 4	2	0.15	0.10	<0.1	0.6	<0.06	11.1	96	792	-	-	-	-
7/5/11		<2	<2	0.12	0.12	0.1	0.5	<0.06	2.25	120	770	9	7.98	23.4	7.64
6/14/11	Eff Structure	<4	7	0.14	0.17	<0.1	1.0	<0.06	11.5	94	793	-	7.49	19.9	-
7/5/11		<2	<2	0.14	0.10	<0.1	<0.5	<0.06	2.13	120	759	12	8.28	21.4	9.23
6/14/11	Prior to con	<4	15	0.10	0.06	0.3	0.6	0.12	2.11	57	749	-	7.76	18.8	5.20
7/5/11		<2	8	0.11	0.10	<0.1	<0.5	<0.06	1.04	130	719	97	8.01	21.1	8.01
6/14/11	U/S Bayfield R	<4	4	0.04	0.07	<0.1	0.8	<0.06	5.92	24	559	-	8.45	20.5	-
7/5/11		<2	6	<0.03	<0.03	<0.1	<0.5	<0.06	5.08	33	511	34	8.76	23.0	12.39
6/14/11	100 m D/S South	<4	6	0.03	0.04	<0.1	0.8	<0.06	6.03	24	559	-	8.64	18.9	-
7/5/11		<2	10	<0.03	<0.03	0.1	<0.5	<0.06	5.10	33	503	29	8.80	22.9	11.40
6/14/11	100 m D/S North	<4	7	0.04	<0.03	<0.1	1.0	<0.06	6.11	23	544	-	8.65	19.2	-
7/5/11		<2	8	<0.03	<0.03	<0.1	0.7	<0.06	5.13	31	505	31	8.72	23.2	10.68
6/14/11	Wildwood Park	<4	3	0.04	0.03	<0.1	1.9	<0.06	5.45	23	522	-	8.41	25.2	-
7/5/11		<2	5	<0.03	<0.03	<0.1	1.0	<0.06	4.54	32	481	30	8.37	25.5	13.70
6/14/11	H.L. Marina	<4	8	0.06	<0.03	<0.1	<0.5	<0.06	5.91	23	548	-	8.56	20.5	-
7/5/11		<2	24	<0.03	0.06	<0.1	0.6	<0.06	5.10	32	492	64	8.33	24.4	8.47

Preliminary streamflow as recorded at Federal Gauge (02FF007) Bayfield River near Varna

June 24, 2011	2.45 cms
July 5, 2011	1.30 cms

Table 3: Comparison of effluent samples taken by the plant operators versus HEC Inc.

Date	CBOD5	Susp.Solids	T. Phos.	T. Amm.	Ecoli	Field pH	Field Temp	Field O2
	mg/l	mg/l	mg/l	mg/l	/100 cc	pH	°C	mg/l
5/4/2011				0.1				
5/6/2011				0.2				
5/16/2011	<2	2	0.09	<0.1	<2			
5/15/2011	<2	2	0.09	<0.1	<2			
6/14/2011	**<4**	**2**	**0.15**	**<0.1**				
6/29/2011	<2	9	0.14	<0.1	660	7.31	19.5	
7/4/2011	<2	<2	0.06	<0.1	40	7.41	20.5	
7/5/2011	**<2**	**<2**	**0.12**	**0.1**	**9**	**7.98**	**23.4**	**7.64**
7/11/2011	<2	2	0.1	0.1		7.64	25.5	
7/18/2011	5	2	0.13	<0.1		7.79	26.5	7.49

samples in **bold** and highlighted taken by HEC Inc.

The Provincial Water Quality Objective for Unionized Ammonia is 0.020 mg/l. The percentage of unionized ammonia (NH_3) in aqueous ammonia solutions is different under different water temperatures and pH's. The maximum total ammonia measured in the Bayfield River was 0.1 mg/l which under the measured field pH and water temperature conditions relates to a unionized ammonia concentration of 0.024 mg/l. All the other water samples from the Bayfield River came back <0.1 mg/l total ammonia nitrogen or less than the detection limit. This unionized ammonia criterion has at least a safety factor of 10 prior to it impacting on any form of aquatic life. In fact, during every sampling event, minnows and fish fry were observed in the side channel prior to any mixing of the treated effluent with the main Bayfield River and larger bass where observed holding in the initial mixing zone. The factor that resulted in the elevated unionized ammonia is the pH of the river. PH can naturally fluctuate diurnally in a water body as a result of the respiration and photosynthesis of the aquatic plants.

The water quality objective for pH is for it to remain in the range of 6.5 to 8.5. The pH measured in the Bayfield River typically was above 8.5 and had a maximum concentration of 8.8 during our sampling. Since the pH sampled in the Bayfield Waste Water Treatment Facility was consistently less than measured upstream in the Bayfield River, the discharge was not directly negatively impacting on the pH in the river. Any exceedance in pH would appear to originate upstream of the confluence with the discharge from the Bayfield facility. It would appear that the exceedance of the above mentioned unionized ammonia criterion had nothing to do with the treated waste water discharge from Bayfield.

The PWQO for dissolved oxygen (DO) to protect warm water biota is $48^{\%}$ saturation or 4 mg/l at the warmer temperatures measured during our survey. All DO measurements taken during the survey were above 4 mg/l thus meeting the criteria. In fact all the samples in the Bayfield River were at over $100^{\%}$ saturation. This is not surprising because of the natural re-

aeration that occurs in the river as a result of the long series of riffles and rapids as shown in the attached pictures. The Bayfield River is a migratory river for trout during the spring and fall. It is expected that this reach of the river would also meet the more restrictive cold water biota criteria during those periods of the year.

Total phosphorus is probably the parameter of most potential concern in the discharge from the Bayfield facility. The PWQO for total phosphorus for a riverine environment is 0.03 mg/l. Total phosphorus is not directly lethal or toxic to the various forms of aquatic life but was established to prevent excessive plant growth in rivers. As shown by the sampling data, the total phosphorus concentration in the discharge was reduced as it flowed down the side channel prior to mixing with the main Bayfield River. This reduction was probably a result of dilution, assimilation and uptake by aquatic plants and sedimentation. During our 1st sampling run, the upstream concentration of total phosphorus in the Bayfield River was 0.07 mg/l exceeding the criteria. The concentration of total phosphorus then decreased below the confluence with the side channel. During this sampling run, the Bayfield River would have been considered a Policy 2 receiver for total phosphorus based on the upstream sample. However, it should be noted that the total phosphorus concentration in the side channel as a result of the treated waste water discharge did not increase the total phosphorus concentrations in the river downstream. During the 2nd sampling, the upstream Bayfield River sample contained <0.03 mg/l total phosphorus. All other downstream monitoring stations also contained less than <0.03 mg/l total phosphorus other than down near the mouth in the backwater beside the marina. This sample would infer that the Bayfield River at the point of discharge would be a Policy 1 receiver for total phosphorus.

To get an idea of the typical total phosphorus concentration in the Bayfield River upstream of the discharge, the 2009 Provincial Water Quality Monitoring Network Data Base was reviewed because it was the most recent data downloadable. The closest active station is St# 08004000802 which is at the 1st bridge upstream on Huron County Rd 31, north of Varna. Five water samples were taken between March and July of 2009. The total phosphorus concentration is those samples were 0.040 mg/l, 0.018 mg/l, 0.011 mg/l, 0.012, and 0.018 mg/l. This would strongly suggest that the samples taken during our survey were representative and for extended periods of time during the summer, this stretch of the Bayfield River would be a Policy 1 river for total phosphorus.

Ecoli (*Escherichia coli*) was another parameter that was monitored and has a PWQO. The PWQO for Ecoli to protect recreational water uses is 100 organisms per 100 ml. All samples including the treated effluent sample contained less than 100 Ecoli /100 ml and thus met the criteria.

Plume Study Results

A conductivity meter was used to estimate the size of the mixing zone of the treated effluent in the Bayfield River. Conductivity readings were taken at the south shore, approximately a ¼ way across, approximately a ½ way across, approximately a ¾ way across and along the north shore. The various downstream measuring locations and values are shown in

Table 2. On June 14, 2011, the streamflow in the Bayfield River was approximately 2.45 cms (m^3/s) at the Federal Gauge upstream near Varna while on July 5 the streamflow was 1.30 cms.

During the June 14 survey, the discharge hugged the south bank for over 100 meters prior to being completely mixed across the river at approximately 250 meters below the confluence. On July 5, the discharge plume was completely mixed across the river by 100 meters downstream.

Table 2: Mixing Zone Study Below the Bayfield Wastewater Treatment Works in the Bayfield River

sampling date June 14, 2011						
location	Conductivity	South shore	1/4 across	1/2 way	3/4 across	north shore
discharge structure	793					
prior to confluence	750					
U/S Bayfield River	524					
≈ 30 yds D/S conflu		581	552	554	555	558
≈ 70 yds D/S conflu		586	565	560	561	561
≈ 100 yds D/S conflu		584	569	561	560	558
≈ 250 yds D/S conflu		565	565	564	564	565
@ Wildwood Park	505					
@ Harbour Lights	537					
sampling date July 5, 2011						
discharge structure	734					
prior to confluence	697					
U/S Bayfield River	516					
≈ 100 yds D/S conflu		508	503	504	505	505
@ Wildwood Park	500					
@ Harbour Lights	480					

notes
conductivity measurements taken with a Hanna Combo pH & EC meter
measurements shown in µ/s

Discussion of Mixing Study Results

The Ministry of the Environments policy that deals with mixing zones states that "Mixing zones should be as small as possible and not interfere with beneficial uses". It goes on to say "Conditions within a mixing zone must not result in toxic conditions or irreparable environmental damage including risk to ecosystem integrity and human health nor interfere with water supply, recreational or other water uses.

The side channel receiving the treated waste water discharge enters the Bayfield River from the south in a ponded embayment type of area. This is shown in one of the following attached pictures. During the first survey, the flow from the side channel basically remained

Picture showing confluence of the side channel that receives the treated waste water discharge and the Bayfield River on July 5, 2011.

along the south bank through the different riffle areas until a kink in the river approximately 250 meters below the confluence. At this small bend in the river to the south, the side channel flow traversed across the complete riffle mixing rapidly under the streamflow conditions present during our sampling on June 14, 2011. During our July 5, 2011 sampling when the streamflow in the Bayfield River dropped to nearly half of what is was on the previous sampling, the side channel flow mixed much faster and was completely mixed within the first 100 meters downstream.

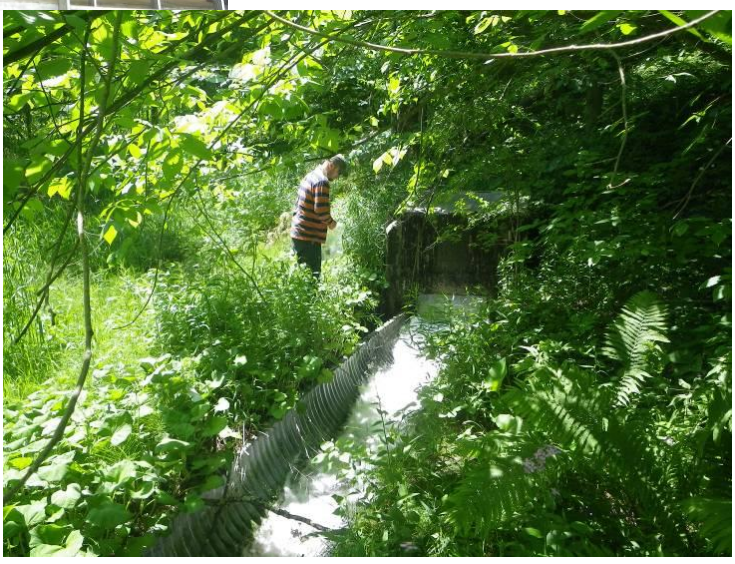
Due to circumstances beyond our control, readings were not taken from the totalizer at the V-notch weir on the days preceding our sampling and on the actual day of our sampling. These readings would have allowed us to estimate the dilution that was achieved in the Bayfield River during our sampling events. However, because of the intermittent nature of the way the waste water is applied to the sand filters, the actual rate of discharge would have varied throughout the day anyway. This would result in a series of slugs being discharged to the side channel and making their way downstream. Since it appeared that the vast majority of water in this side channel was treated wastewater, it is expected that the water quality of the side channel would be relatively consistent and only really vary in result to quantity discharging to the Bayfield River at any point in time throughout the day. Whatever, the rate of discharge was during our study; it appeared not to impact on the quality of the Bayfield River.

Additional pictures taken during the survey

Treated waste water being applied to the intermittent sand filters.

Under drainage from sand filters passing through V-notch weir.

Discharge structure at bottom of the river valley.



Size of side channel that receives treated effluent prior to mixing with the Bayfield River.

Bayfield River looking downstream from the confluence with the side channel.

Bayfield River looking upstream and across the river from the upstream sampling location.

Bayfield River downstream in the area of complete mixing during the first sampling run.

Bayfield River at end of road in Wildwood Trailer Park.

Bayfield River at Harbour Lights Marina near the gas pumps.

Conclusions

The Bayfield River through this stretch would have to be considered a high quality river and based on the chemical and bacteriological samples taken during our study was not seriously negatively impacted by the treated waste water discharge from Bayfield. The upstream river water quality, effluent quality and streamflows were all within typical ranges during the study.

Other observations that support the apparent nonimpact of the treated waste water discharge based on the chemical and bacterial monitoring is that no increase in algae growth was observed in the riffles upstream to downstream of the discharge. The rocky hard substrate of the Bayfield River through this stretch is ideal for filamentous green algae (Cladophora). During both surveys, special notice was taken of the riffle areas both upstream and downstream of the confluence along north side and south side of the river within the mixing zone. No visible difference was observed and in fact very little algae were observed on the rocks.

The shallow rocky nature of the Bayfield River as shown in the following picture is ideal for natural re-aeration keeping the dissolved oxygen levels high to support the various forms of

aquatic life present. One of the few species of aquatic life that would not find this type of habitat ideal is mussels. Most species of native mussels require softer and finer sediment so they can burrow into the sediment and filter out the phytoplankton drifting by.

Another observation that would support the non-impactive nature of the discharge was the presence of minnows and aquatic invertebrates in the side channel receiving the treated waste water discharge. During both surveys minnows and surface aquatic invertebrates were observed in the side channel between the treated discharge and confluence with the Bayfield River. A large bass appeared to make the actual confluence its home territory scurrying away every time we passed through the area during both surveys.

During the first survey in June we met fly fishermen who fished for trout both upstream and downstream of the discharge from the Bayfield treatment facility. We also observed people fishing downstream at the end of the road in the Wildwood Trailer Park during both sampling events.

The findings of this study are consistent with the conclusions of the *2010 Biological Monitoring Report For The Bayfield River In The Vicinity Of The Bayfield Sewage Treatment Plant* prepared by John Westwood. His report concluded "In summary, the BioMap (d) WQI values for rivers indicate unimpaired water quality conditions at Site 1, Site 2 and Site 3 in the Bayfield River upstream and downstream from the discharge of the community of Bayfield's STP as the (d) WQI values of 13.5, 13.3 and 14 were >9. The BioMap (q) WQI values of 3.06, 3.13 and 3.16 were > 2.4. The BioMap (q) WQI values indicate unimpaired water quality conditions."

In summary, based on all the chemical and bacteriological data and our visual observations made during our survey, the treated wastewater discharge from Bayfield (Municipality of Bluewater) does not appear to be noticeably impacting on the Bayfield River.

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