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Wastewater System Capacity Study

Marine on St. Croix, Minnesota

N13.119324

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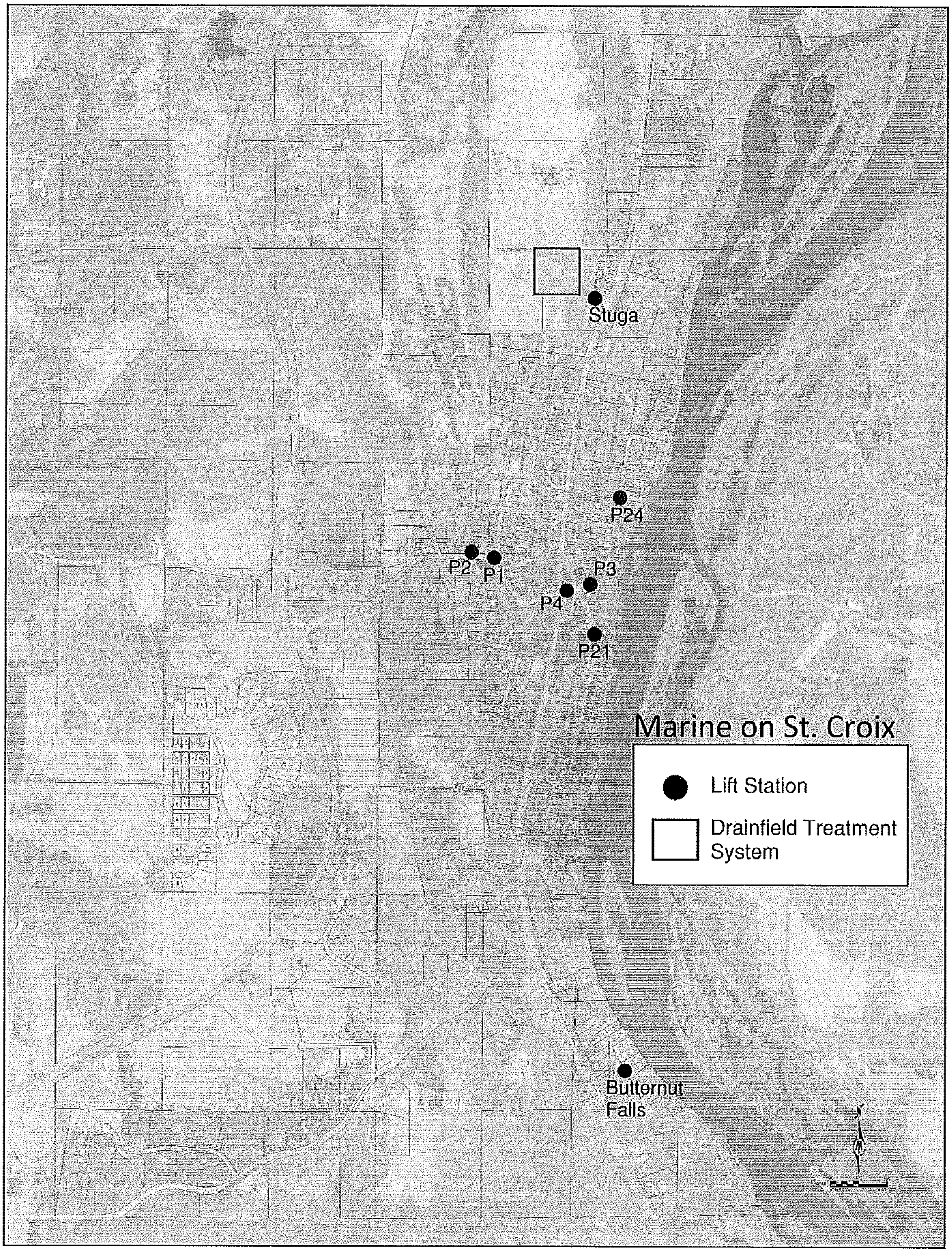

Figure 1. Marine on St. Croix Wastewater System

PART 1 – COLLECTION SYSTEM CAPACITIES

The collection system was analyzed to determine the capacity of both the lift stations and forcemains (FMs), and to determine how much of that capacity is currently in use with respect to the proposed additional flows. Table 1 summarizes the basic sizes and capacities associated with the existing lift station and forcemains. Structure capacity indicates the largest recommended pump size for installation in the existing structure, and is based on 10 States Standards for lift station design. It takes into account the station operating depths listed in existing plan sheets and a worst-case scenario with 10 pump starts per hour. Pump capacities for each station were determined using a combination of recent drawdown tests, flow meter readings, and data from existing plans.

Table 1 – Lift Station & Forcemain Details

Lift Station	Structure Ø	Structure Capacity	Pump Capacity[1]	FM Size	FM Capacity[2]
P1	10 ft.	200 gpm	60 gpm	4"	400 gpm
P2	4 ft.	30 gpm	28 gpm	1.5"	80 gpm
P3	8 ft.	65 gpm	61 gpm	2"	150 gpm
P4	6 ft.	250 gpm	79 gpm	4"	400 gpm
P21	6 ft.	70.7 gpm	120 gpm*	1.5"	80 gpm
P24	4 ft.	30 gpm	20 gpm	2"	150 gpm
Butternut Falls	5 ft.	195 gpm	45 gpm*	3"	220 gpm
Stuga	4 ft.	--	8.7 gpm	--	--

[1]For single pump. Assumes that stations were designed for one pump running during normal operation
[2]Assumes 10 ft./sec velocity in pipes 3" and larger and 15 ft./sec velocity in smaller pipes, based on 10 States Standards
*Drawdown or existing plan data was not available so some assumptions were made

Just because the pump size in an existing station exceeds its capacity listed above of the structure or forcemain does not mean that either of those pieces is in immediate need of replacement. The structure design capacity is based on an extreme scenario with the station running at maximum capacity for an extended time period, which rarely happens. For example, based on recent runtime data Station P21 runs an average of less than two hours per day, and during peak days around four hours. Forcemain capacity is based on flow velocity in the pipe and the main purpose of defining capacity is to limit energy waste due to excessive headloss. For an existing station such as P21, assuming that no major problems in regular operation have been noted by City staff and that pump capacity is not a concern, the other parameters should be taken into consideration but do not indicate that immediate action is required.

Figure 2, below, is a graphical representation of how flow moves through Marine on St. Croix's lift stations and forcemains in the collection system. Also represented are locations within the system that additional connections are being proposed (indicated by the dashed lines). This information was used to determine how specific lift stations within the system would be affected by the various sources of new flow. The stations and forcemains that would need to process additional flow if the proposed connections are performed include: P1, P2, P3, P21, Butternut Falls, and Stuga.

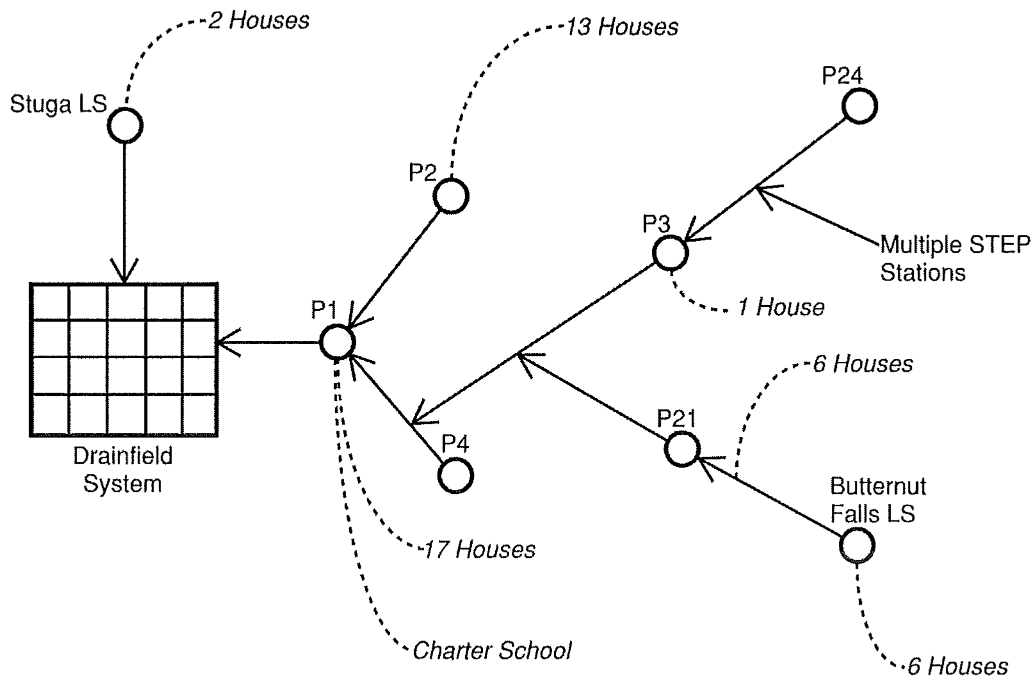

Figure 2. Wastewater Collection System with Proposed Flows

In order to determine the impact of the proposed new connections on the system, flows from these sources were estimated. For new households to be added to the system, an average of 2.3 persons per household was used, based on US Census data for Marine on St. Croix. An average daily flow of 100 gallons per person per day was used, based on 10 States Standards for wastewater. Ideally this accounts for flow from water use in the dwellings, as well as inflow and infiltration (I/I). For the charter school which is to be reoccupied, it is known that there will be approximately 250 people in the building during school days. Based on US standards, a flow of 10 gallons/occupant/day was used for a total of 2,500 gallons per day. Table 2 displays the average and peak day flows for the last two years, based on hourly runtime data and the pump capacities listed in Table 1. Table 2 also includes the estimated average and peak day flows with the proposed new connections included.

Table 2 – Affected Lift Station Flows, Runtimes, & Capacities			
	2016-2018	Including Proposed Connections*†	Pump/Structure/ Forcemain Capacity
P1			
Avg. Day Flow (gpm)	25	34	60/200/400 gpm
Max. Day Flow (gpm)	60	69	
Avg. Day Runtime (hrs.)	10.0	13.4	
Max. Day Runtime (hrs.)	24.0	27.4	
P2			
Avg. Day Flow (gpm)	2.2	4.3	28/30/80 gpm
Max. Day Flow (gpm)	4.9	7.0	
Avg. Day Runtime (hrs.)	1.9	3.7	
Max. Day Runtime (hrs.)	4.2	6.0	
P3			
Avg. Day Flow (gpm)	5.2	5.4	61/65/150 gpm
Max. Day Flow (gpm)	11.1	11.2	
Avg. Day Runtime (hrs.)	2.0	2.1	
Max. Day Runtime (hrs.)	4.4	4.4	
P21			
Avg. Day Flow (gpm)	9.5	11.4	120/70/80 gpm
Max. Day Flow (gpm)	20	22.2	
Avg. Day Runtime (hrs.)	1.9	2.3	
Max. Day Runtime (hrs.)	4.1	4.4	
Butternut Falls			
Avg. Day Flow (gpm)	2.6	3.5	45/195/220 gpm
Max. Day Flow (gpm)	7.4	8.4	
Avg. Day Runtime (hrs.)	1.4	1.9	
Max. Day Runtime (hrs.)	4.0	4.5	
Stuga			
Avg. Day Flow (gpm)	0.9	1.2	8.7/47/150 gpm
Max. Day Flow (gpm)	2.3	2.6	
Avg. Day Runtime (hrs.)	2.6	3.4	
Max. Day Runtime (hrs.)	6.2	7.1	

*Includes new estimated flows from additional houses and charter school

†Some extreme daily runtimes were excluded if they were determined to be due to human error or a system occurrence unrelated to influent flow conditions

Based on the information in Table 2, Lift Stations P2, P3, P21, and the Butternut Falls and Stuga lift stations would have the capacity to handle the additional flow without issue. However, Lift Station P1, which pumps the majority of the City's wastewater to the treatment facility, already runs on average 10 hours per day. On maximum days the station runs continuously and sometimes with more than one of the station's three pumps operating. In the past two years there have been over 30 days when P1 ran for 15 hours or more. Because P1 is the City's main lift station, it would need to handle nearly all flow from the proposed new connections. Whether or not new connections to the system are ultimately allowed, it would be advisable for the City to consider upsizing the pumps in Lift Station P1 from 60-gpm capacity to 100 or 120-gpm. Upsizing the pumps would singlehandedly increase the capacity of the majority of the collection system and reduce the possibility of an unplanned discharge of raw wastewater due to extreme flows or an incident within the infrastructure, such as pump failure. As noted in Tables 1 & 2, both the structure and forcemain for P1 have the capacity to accommodate larger pumps.

According to information provided by the City which shows the location of the properties proposed to be connected to the system, a number of areas would require additional City infrastructure to be built before connection would be feasible. This infrastructure includes additional runs of gravity sewer, manholes, a new grinder lift station, and two new lengths of small-diameter forcemain. A map detailing these system expansions and a breakdown of the associated costs have been provided to the City separate from this report.

PART 2 – TREATMENT FACILITY CAPACITY

Capacity of the existing drainfield treatment system was analyzed, as well as the effect that the proposed new connections would have on this capacity. For this analysis, flow data from January 2010-February 2019 was used to determine average, maximum, and total flows treated by the facility.

Considered first is the system's capacity for daily influent flow. The treatment facility was constructed in 1986 to treat 49,500 gallons per day average wet weather (AWW) flow and 41,100 gallons per day of average annual (AA) flow. A study of the treatment system was performed in 2010 which analyzed the treatment system as a whole, including flow data from 2000-2009. The average daily flows have stayed extremely consistent, with values for both the 2000-2009 period and the 2010-early 2019 period nearly identical at 29,000 gallons per day. Based on the flows laid out in Table 2, it's conservatively estimated that the proposed connections could result in an increased daily flow of 12,850 gallons. Table 3 communicates the effects that the proposed connections would have on average day and monthly peak day flows to the treatment facility. While the projected average daily flow remains sufficiently under the facility's design capacity, it's possible that the peak day flows in a year could surpass it.

Table 3 – Treatment System Daily Flows

2010-2019 Avg. Daily Flow (gal.)	29,000
2010-2019 Monthly Peak Day Flow (gal.)*	40,000
Projected Avg. Daily Flow (gal.)†	41,850
Projected Monthly Peak Day Flow (gal.)*†	52,850

*Represents average of monthly peak day flows 2010-2019. Some actual peak day flows have been higher

†Includes flow from additional proposed connections

The State Disposal System (SDS) permit for the Marine on St. Croix Treatment Facility includes flow limits of 49,500 gallons per day for Calendar Month Average and 74,000 gallons per day for Daily Maximum. Based on the data analyzed, the first limit has never been exceeded, while the latter was exceeded on four occasions in the 2010-2019 time period. These exceedances presumably happened during extreme precipitation events, and were mainly the result of inflow and infiltration (I/I) from a combination of clear water leaking into pipes and structures through cracks and cross-connections such as roof drains or foundation sump pumps being directly connected to the sanitary system. The City is currently looking into options for reducing the percentage of wastewater originating from I/I, including inspection of the City-owned portion of the system and private properties in order to detect improper cross-connections. It is highly encouraged that the City follow through with these plans, as reducing I/I flow will increase the capacity and lengthen the lifespan of both the collection and treatment systems.

Considered second is the ultimate capacity of the drainfield treatment system. Unlike a traditional mechanical treatment plant, a drainfield's lifespan is difficult to predict with any precision, due to the variability and lack of measurability of the factors involved. As wastewater is allowed to percolate into the soils surrounding the drainfield trenches, the accumulation of biosolids and cell matter from the wastewater and its digestion inevitably plugs up pore spaces between the soil particles until the water can no longer drain away and instead is pushed towards the surface. When this will occur depends on a wide range of factors, including the amount and characteristics of the wastewater, the varying soil conditions in the area, how well the system is maintained, etc. When the lifespan of the drainfield is exceeded the drainfield must be abandoned and a new system constructed in a different location.

The 2010 system evaluation estimated that the drainfield had approximately 131,000,000 gallons of total capacity remaining, and that the system would require replacement in 2023. Based on flow data over the past decade, approximately 96,700,000 of this capacity has been consumed, leaving 34,300,000 gallons. At current daily flow rates this equates to approximately 3.2 years of life left, meaning the system would require replacement in 2022. If the proposed connections were to be allowed, conservatively this could reduce the life of the system to 2.3 years, meaning replacement towards the end of 2021 instead. This does not represent a significant difference in the treatment system lifespan.

As was stated in the 2010 evaluation, the remaining lifespan of the drainfield calculated above represents a worst-case scenario and was based on the assumed flows and lifespan of the system when it was constructed. It is highly likely that the system's capacity is larger and that it will continue to operate beyond the dates stated above. The City has been diligent in rotating flow between the facility's cell banks which allows the others to rest, meaning that the life of the system should be maximized. At present time, no aboveground discharge has been noted and there have been no permit violations in the groundwater wells surrounding the facility. The dates stated above serve more to remind the City of the approximate timeframe that they must be planning and preparing for with regards to the eventual replacement of this treatment system. The City has already begun planning for this replacement, and a site adjacent to the existing system has been identified. If a capital improvement plan for Marine on St. Croix's wastewater system is drafted in the near future, replacement of the treatment system should be included and a specific year identified. Although the system may continue to function past the determined replacement date, the goal of doing this is to have funds allocated and a detailed plan in place for replacement when the current drainfield does ultimately reach the end of its life. In the meantime, the City should continue to maintain it as they have been and to monitor it closely for signs of deterioration.

In summary, it appears that the existing treatment system has the capacity to handle the proposed connections. However, it is recommended that the City prioritize work to reduce I/I flows into the system, as this reduction in I/I could offset some of the proposed flows into the system.

MARINE ON ST. CROIX SANITARY SYSTEM INFLOW & INFILTRATION ANALYSIS

An analysis was performed on Marine on St. Croix's collection system to try to determine where the majority of inflow & infiltration (I/I) originates from. I/I are stormwater and groundwater (clear water) which enter the sanitary sewer system through a number of sources, including leaks in pipes and other buried infrastructure, openings in manhole lids, and improper connections of sump pumps and downspouts to the sanitary system. These flows are undesirable because they are not comprised of wastewater in need of treatment, and take up capacity in the collection and treatment systems, shortening the life of infrastructure and potentially forcing expansion of the systems earlier than would otherwise be necessary.

The purpose of the analysis was to try and pinpoint the most significant sources of I/I within the sanitary collection system. Historical lift station runtime data, which was obtained as part of Phase 1 of this wastewater system study, was used in the analysis. In Phase 1 of the study, historical runtimes for the City's lift stations were translated into flows based on pump capacity and were used to determine average and maximum flows passing through the stations. For the purpose of trying to determine I/I flows in each area of the City, the maximum runtimes (flows) were compared to the average runtimes (flows) for the past two years. The assumption made is that essentially any flow greater than average is due to I/I, especially during precipitation events or snow melt in the spring. Because there is likely some amount of I/I entering the system even on an average day (no weather event), this is not an extreme assumption. The results of the analysis are shown below, in Table 1.

Table 1 – Marine on St. Croix Estimated I/I Flows

Lift Station	Pump Capacity[1]	Avg. Day Station Runtime (hrs.)	Max. Day Station Runtime (hrs.)	Avg. Day Station Flow (gal.)	Max. Day Station Flow (gal.)	Peaking Factor
P1	60 gpm	10.0	24.0	36,000	86,500	2.40
P2	28 gpm	1.9	4.2	3,200	7,100	2.20
P3	61 gpm	2.0	4.4	7,500	16,000	2.12
P4	79 gpm	4.0	11.2	19,100	53,300	2.78
P21	120 gpm*	1.9	4.1	13,600	29,200	2.14
P24	20 gpm	1.8	5.2	2,200	6,300	2.88
Butternut Falls	45 gpm*	1.4	4.0	3,700	10,700	2.88
Stugga	8.7 gpm	2.6	6.2	1,300	3,300	2.44

[1]For single pump. Assumes that stations were designed for one pump running during normal operation

Peaking factors for all of the lift stations fell between 2 and 3. This is not unexpected, as a community of Marine on St. Croix's size might be expected to have a peaking factor closer to 4 (10 States Standards for Wastewater). Based on the consistency of the peaking factor values, there don't appear to be any considerable point sources for I/I. Instead, it originates from all parts of the City uniformly. Sources of I/I, including leaking pipes, fixtures, and services, and improper cross-connections with stormwater infrastructure, should continue to be addressed systematically and throughout the community.