TECHNICAL MEMORANDUM

Date: February 15, 2024

To: Honorable City Council, Marine on St. Croix

From: Jacob Humburg, PE
Daniel Foster, EIT

Subject: Drainfield Treatment System Evaluation
Marine on St. Croix, Minnesota
Technical Memorandum
Project No.: 0N1.133074

I. Project Background

The City of Marine on St. Croix has authorized Bolton & Menk, Inc. to complete an evaluation of their wastewater treatment facility. The goal of the evaluation is to try to determine where the system is in its design life and to identify any significant repairs or improvements needed to maintain the system and maximize its useful life. This evaluation of the system was performed with assistance from a licensed subsurface sewage treatment professional, Midwest Sewer Services.

II. Facility Description

Marine on St. Croix treats its wastewater using a subsurface treatment system (SSTS), more specifically a Class D drainfield system. The system is classified as a large subsurface treatment system (LSTS) because it is designed for a daily flow of more than 10,000 gallons, necessitating a Minnesota Pollution Control Agency (MPCA) permit. It is designed to accommodate an Average Wet Weather (AWW) design flow of 49,500 gallons per day (gpd), an Average Annual (AAW) flow of 41,100 gpd, and a Daily Maximum Flow of 74,000 gpd. The facility is associated with four ground water monitoring wells (one upgradient and three downgradient). A drain tile system exists around the drainfield that discharges into a ditch near Highway 95. The SDS permit is not included in this memo because of its length but aside from the maximum daily design flow value stated above, the only permit limit is for nitrogen in two of the downgradient groundwater monitoring wells on the facility property: 10 mg/L Nitrate + Nitrite, Total (as N). Though they aren’t permitted, the city is required to test for and report a number of other values.

The treatment system consists of 20 closed loop trench drainfield cells in four zones. Wastewater is pumped to the head of the system via lift station and from there the system operates by gravity to evenly distribute flow to each active drainfield cell. A splitter structure is associated with every two drainfield cells, with a buried ball valve between the splitter structure and each cell to control or shut off flow. Four cells are operated at a time on six-month rotations, so each cell train rests for 18 months before being put back into service. The cells are arranged in linear north-south trains, and the operators manually adjust each splitter box valve to try and evenly distribute flow to all four operating cells. Each train has an extra “overflow” cell, so each train technically consists of five cells. See the first attachment to this memo for a layout of the system, created from the existing plans.

III. Existing Flows and Loadings

The flows in Marine on St. Croix have been trending downwards over the past 4 years. The downtrend in receiving flows is likely due to the sanitary sewer rehabilitations completed in recent years. Updating the city's infrastructure reduces the flows due to inflow and infiltration (I/I) during precipitation events. The city has had zero violations for exceeding the Monthly average flow over this period. See Figure 1, below, for historical flow values compared to permitted limits.

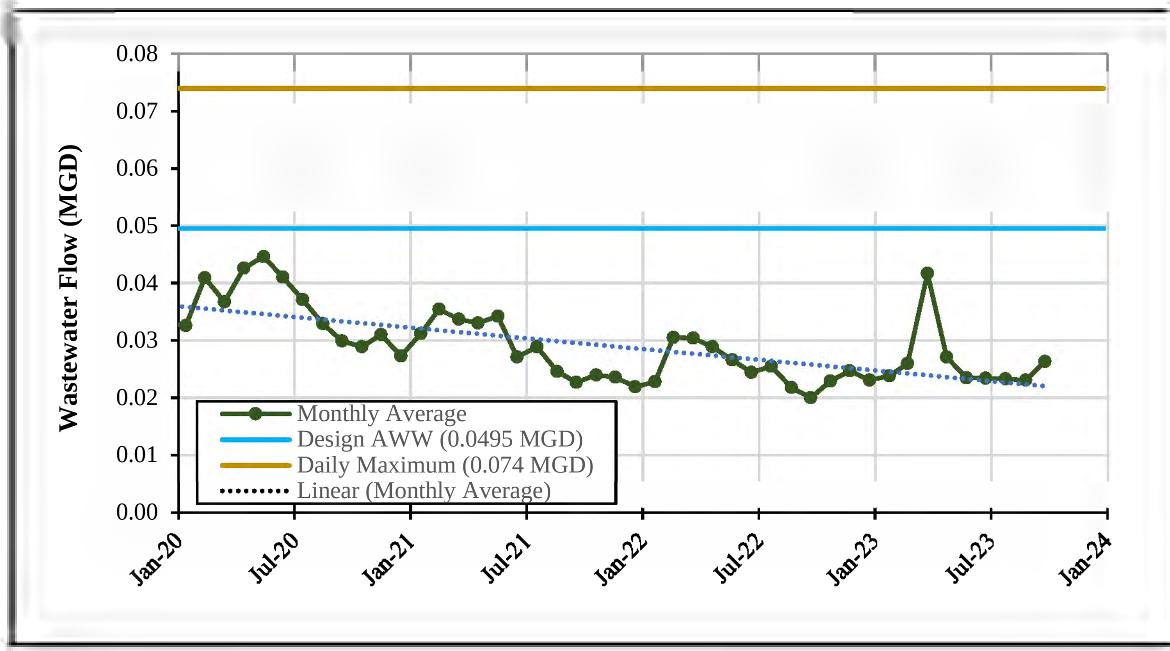


Figure 1 – Historical Monthly Average Wastewater Flows

The nitrogen loadings are well below the allowable concentration of 10 mg/L Calendar Month Maximum. The historical average concentration is below 0.5 mg/L in both monitoring wells. Based on this data, the city has a very low risk of a permit violation for Total Nitrogen. It is possible that the trend towards decreasing flows could affect the wastewater quality, increasing the strength of the wastewater with less I/I to dilute it, but it seems unlikely that this will change the quality of the wastewater enough that it could present issues. If for some reason a long-term issue were to arise with high nitrogen levels in one or more groundwater monitoring wells, it is likely that a new permit limit would be added which would trigger the need for additional (nitrogen removal) treatment at the system.

IV. System Evaluation & Findings

On December 27, 2023, Bolton & Menk and a licensed SSTS professional, Midwest Sewer Services (MSS), met with city representatives on-site at the system to evaluate it. The evaluation consisted of two main parts: 1) examining the soils immediately surrounding the drainfield cells and 2) visually examining to the extent the physical components of the system to the extent possible.

Drainfield/Soils

The evaluation consisted of excavating the tops of the infiltration cells in 4 locations around the site to examine soil conditions. The locations chosen included two cells at the "highest" end of the trains and two at the lowest, and included the cell train currently in use and the one most recently operated, through the fall of 2023. The excavations were performed right at the edge of the cells so as to see the conditions where wastewater first meets the surrounding soils without damaging the cells themselves. The first attachment to this memo shows the 4 excavation locations, and the second shows pictures taken of each excavation.

MSS inspected the soil conditions looking for signs of recent ponding or significant biomat build-up. Biomat refers to a black layer that is formed from Bacteria and microorganisms. Biomat treats the wastewater physically, chemically, and biologically before it reaches groundwater, and it typically forms where the filter rock meets the native soils. While the biomat is necessary for treatment, excessive biomat formation is a negative sign for many reasons as it can mean reduced soil permeability and cause ponding and ultimately failure of the system. Excessive biomat usually is a sign that the system is near the end of its design life and/or that the cells are not being properly operated. The first two excavations were performed on cells that are currently in operation. The last two were taken from the cells that were in operation in the last cycle. The general results of the excavations are shown in Table 1, below.

Table 1 - Inspection of Soil Conditions		
Excavation	**Cell**	**Findings**
1	4a	no observable biomat or ponding
2	2	no observable biomat or ponding
3	13	minimal biomat and no ponding
4	15	no observable biomat or ponding

The drainfield portion of the system appears to be in good condition good condition. There was little if any biomat observed, and the sandy soils beneath the cells improve the outlook of this portion of the system. It is impossible to determine an exact design life remaining in a system of this type, but if the system continues to be properly maintained and the cells rotated, it seems likely that the drainfield portion of the system has substantial life remaining.

Physical Infrastructure

The inspection of the control structure manholes found that many are in poor condition. The concrete in these structure, in particular the grout forming the bottom inverts, is deteriorating and exposing the aggregate. This likely has to do with the corrosive nature of the wastewater entering the treatment system. While much of the solids in the wastewater have been removed by septic tanks in the system, the wastewater must pass through one or more lift stations and a nearly mile-long forcemain before reaching the treatment system. Anaerobic conditions in these parts of the system promote the formation of hydrogen sulfide (H_2S), which in turn can cause the formation of sulfuric acid once the wastewater reaches open air again (such as in the splitter structures). The third attachment to this memo

The operators have completed routine cleanouts of the structures due to excess material in the control structures, likely both from solids in the wastewater and the deterioration of the structures themselves.

The other visible portion of the treatment system which has experienced deterioration is the inspections ports located at one end or the other of each drainfield cell trench (11 ports total per cell). These visually mark the approximate edge of the drainfield and extend down into the gravel drainfield trenches to allow the operators to observe the water level in a drainfield trench if water is present. Because they are constructed of plastic these tend to be susceptible to damage by wildlife, weather, mowing, and other maintenance activities. A number of these inspection ports are damaged to some degree.

V. Recommendation

As has already been discussed, the drainfield cells of this treatment system appear to be in good condition and it appears that the system as a whole is not near the end of its life. No guarantee can be made with this kind of system given its dependency on hard-to-predict factors like groundwater and soil conditions, but provided it continues to be properly maintained and operated, it seems that the system has significant life left. There are really no improvements that can be done on the drainfield cells themselves of a system of this type – if and when the drainfields fail, the typical procedure is to abandon the system and construct a new one nearby.

However, given its apparent remaining life, in order to ensure that this system continues to operate smoothly the physical infrastructure of the system that experiences deterioration must be maintained or replaced as its life ends. In the case of this system, this primarily means the concrete control manhole structures. These are shallow (generally 3'-4' deep) 36"-diameter manholes with inverts poured in the bottom to direct flow.

There are a few options that could be considered in dealing with these manholes. One would be replacement in kind of the existing structures. Most of these manholes have lasted 40 years or more and replacing in kind would in theory provide at least this same lifespan again. Alternately, additional steps could be taken to prolong and protect the life of the new structures, including coating the structures or using a specialized material for them, such as fiberglass or polymer concrete. Table 2 includes estimated costs per structure for these options, as well as a total cost if all 10 structures were to be addressed at once.

Table 2 – Control Manhole Replacement Costs

Option	Cost per Structure	Cost for All Structures
Concrete repair & coating	$5,500	$55,000
Replace in kind	$10,000	$100,000
Replace and coat	$12,500	$125,000
Fiberglass structures*	$14,000	$140,000

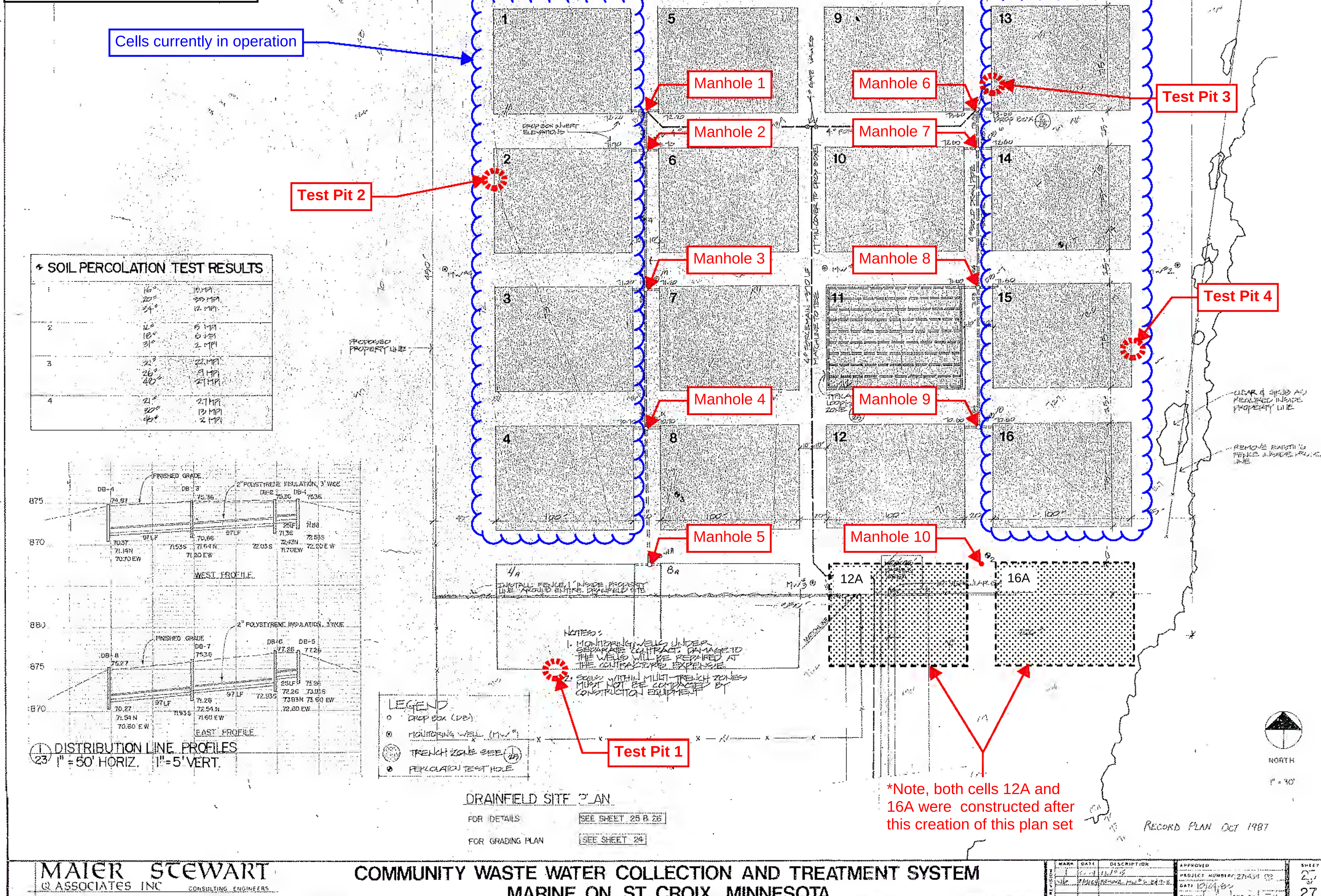
*A price could not be obtained for a polymer concrete structure, but assumption is that it would be similar to fiberglass

Based on the information available, the ball valves associated with each control structure are in good working condition. However, simply because of their age, if the control structures are being replaced then replacement of the valves at the same time could be considered.

The only other piece of the system recommended to be replaced or improved is the plastic inspection ports that have been damaged. These can be replaced by the operators at any time, preferably with Sch 40 PVC or stronger, to continue to mark the edges of the drainfield cells and maintain visibility down into the cells themselves.

Attachment 1: Site Layout

Appendix A


Cells currently in operation
Last operational in April-23 to Sept-23
Manhole 1
Manhole 2
Manhole 3
Manhole 4
Manhole 5
Manhole 6
Manhole 7
Manhole 8
Manhole 9
Manhole 10
Test Pit 1
Test Pit 2
Test Pit 3
Test Pit 4
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
12A
16A
*Note, both cells 12A and 16A were constructed after this creation of this plan set
SOIL PERCOLATION TEST RESULTS
1 16" 10 MPI 20" 35 MPI 34" 12 MPI
2 12" 5 MPI 18" 6 MPI 31" 2 MPI
3 22" 22 MPI 26" 9 MPI 40" 27 MPI
4 21" 27 MPI 20" 13 MPI 45" 2 MPI
WEST PROFILE
EAST PROFILE
DISTRIBUTION LINE PROFILES
1" = 50' HORIZ. 1" = 5' VERT.
LEGEND
DROP BOX (DB)
MONITORING WELL (MW)
TRENCH ZONE SEE 23
PERCOLATION TEST HOLE
NOTES:
DRAINFIELD SITE PLAN
FOR DETAILS SEE SHEET 25 & 26
FOR GRADING PLAN SEE SHEET 24
NORTH
RECORD PLAN OCT 1987
MAIER STEWART & ASSOCIATES INC CONSULTING ENGINEERS
COMMUNITY WASTE WATER COLLECTION AND TREATMENT SYSTEM
MARINE ON ST. CROIX, MINNESOTA
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Attachment 2: Excavation Photos


Test Pit 1


Test Pit 2


Test Pit 3


Test Pit 4

Attachment 3: Control Structure Photos


Manhole 1

Manhole 2


Manhole 3


Manhole 3

Manhole 4


Manhole 5

Manhole 5


Manhole 6


Manhole 7


Manhole 8

Manhole 9


Manhole 10