Technical Brief –Stormwater Management
Kehoe Marine Construction

515 Thousand Islands Parkway
Lansdowne, Ontario

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April 28, 2023

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1 Introduction

This technical brief is prepared in support of Stormwater Management (SWM) planning and design for Kehoe Marine Construction (KMC), located at 515 Thousand Islands Parkway in Lansdowne, Ontario.This property is situated on the shoreline of McCraes Bay on the St. Lawrence River east of Gananoque, Ontario, and is neighbored by a small commercial marina to the west (Peck's Marina), and a wetland area transitioning to Weston Island to the east. The property is bounded by Thousand Islands Parkway to the north. The project location is shown in Figure 1.1.

The property uses primarily industrial / office building space and open site storage and staging areas supporting the KMC operations.The KMC property in McCrae's Bay has been the site of marine construction and commercial marina operations for 65 years. The site is one of a very limited number of locations in the region providing opportunity for loading and off-loading of heavy construction materials for marine transport. Typical KMC operations include the following:

- KMC marine construction operations,
- Third-party materials handling,
- Essential services barging, and
- Sewage pump-out services.

Riggs Associates Ltd. (Riggs) was retained by KMC in 2022 to provide design and permitting services in support of proposed development at the site includinga new shorewall with expanded site operations area, re-grading and future site paving. The proposed shoreline work and site improvements have been approved by relevant permitting agencies. Fisheries habitat compensation was required to secure approval from Fisheries and Oceans Canada. Riggs provided a SWM concept in association with the proposed site improvements and has been retained to complete the detailed design of the SWM measures in support of an Environmental Compliance Approval (ECA).

It is noted that an application for an ECA was made by KMC in July 2022 for stormwater management associated with proposed site development not including the shoreline work and site improvements. The proposed development at that time included a new office building, associated parking along with associated drainage and stormwater management measures.

KMC has progressed with some of these site improvements as well as initial works in support of the shorewall construction and site expansion, including the fisheries habitat compensation work.

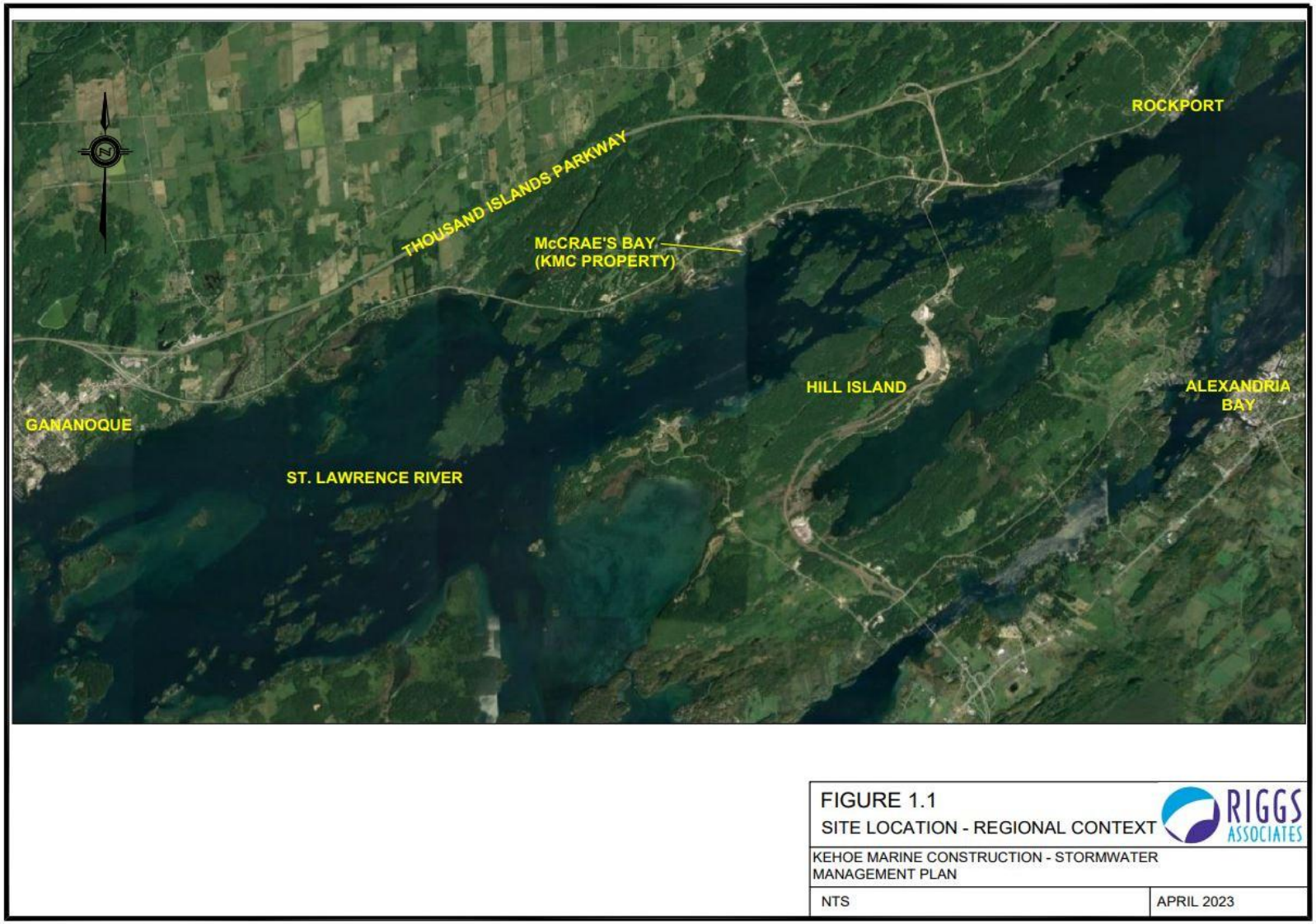


Figure 1.1: Site Location – Regional Context

This report and associated proposed SWM plan is intended to supersede the previous SWM plan and July 2022 ECA. As such, this SWM plan addresses the site development proposed as the basis of the July 2022 ECA and subsequently proposed development associated with the new shorewall construction and associated site improvements. As such, the SWM plan references "pre-development conditions" and post-development conditions" as follows:

- Pre-development conditions – existing conditions prior to July 2022 ECA submission
- Proposed Development conditions – future conditions with proposed shorewall construction, site improvements and re-grading, new site buildings and paving and SWM facilities as per this SWM Plan.

2 Study Area and Site Characteristics

2.1 Overview

KMC provides construction, maintenance, and repair services for a broad range of marine structures throughout the Great Lakes region, ranging from residential shoreline and dockage structures to municipal, provincial and federal heavy civil/marine facility structures including marinas, docks, wharves and breakwaters. The property is largely a commercial/industrial site and includes a large fabrication shop, office, maintenance building and a large yard area used for temporary materials storage of wood, steel, and rock. The site is one of a very limited number of locations in the region providing opportunity for loading and offloading of heavy construction materials for marine transport.

The northern shoreline of McCraes Bay is heavily influenced by the local marine operation developments. The existing shoreline stabilization works including a mix of rock revetments, gabion baskets, steel and concrete walls are generally in disrepair. There are two boat launches and a number of floating dock connections along the shoreline of the property. The east and west limits of the bay are shallow with significant aquatic and emergent vegetation. An aerial image of the pre-development site (spring, 2022) is presented in Figure 2.1. It should be noted that in this image (Figure 2.1), the new office building is shown under construction.Select photos of the shoreline and associated structures are presented in Appendix A.

Depths within McCraes Bay are typically less than 2 m (below chart datum), increasing to greater than 2 m in the dredged areas and central portion of the bay. The bay is generally well protected with limited wave activity and minimal currents.

Figure 2.1: Pre-development Site Conditions (spring, 2022)

2.2 Pre-developmentSite and Drainage Conditions

Currently, stormwater on the property generally flows uncontrolled in a north to south direction to the St Lawrence River.The majority of the property discharges across the existing operations area and deteriorating shoreline transporting sediments during heavy rainfall events. The easterly portion of the site discharges to the existing wetland area; this drainage includes overland runoff from the residential area southeast of the original office building and storm sewer discharge from two catch basins in the parking area to the north of the original office building. Roof drainage is generally conveyed by roof leaders to buried drains. The original office roof drain discharges to the storm sewer noted above. Roof drains from the two shop buildings in the central portion of the property drain to tiles which discharge to the River at the south shoreline. Each of these roof drains has a single catch basin which captures limited local site runoff under pre-development conditions. These catch basins appear to serve primarily as access points for the roof drain connections. There are no stormwater quality control measures presently employed on the property.

Drawing MA-01 shows the topography and detailed layout of the property under the pre-development conditions. The entire site is 3.22 ha in area. Two paved driveways allow entry to the property from Thousand Islands Parkway. Most of the property under pre-development conditions is gravel, with a large patch of asphalt connecting the eastern entrance driveway to the fabrication building and an existing maintenance building, as well as extending north towards Thousand Islands Parkway to provide additional parking area. Landscaped areas are situated around the existing residential building, with additional grassed/open areas that extend south along the shoreline from Thousand Islands Parkway to the existing boathouse.To the west of the property is a small commercial development known as Peck's Marina.

The estimated surface area and runoff characteristics for the predevelopment condition are as per Table 2.1.

Table 2.1:Pre-Development Site Characteristics

Surface	Area (ha)	"C"
Asphalt	0.39	0.9
Gravel	1.94	0.5
Rooftop	0.31	0.9
Open/Grassed	0.58	0.25
Total	**3.22**	**0.54**

Previous Riggs investigations have found that the property is at significant risk to wave uprush and associated flooding due to the relatively lowlying nature of the property. Using the instantaneous 100 year water level of 75.9 m in a simulated wave uprush analysis,the wave uprush limit was estimated to be 76.05 m elevation. This wave uprush extends several meters beyond the top of shoreline slope onto the site under the pre-development conditions.

2.3 Proposed Development Conditions

Proposed development conditions provide for general improvement to the current operating capacity of the site. These improvements will provide for safer working conditions with adequate materials handling spaces and improved capacities to manage site runoff. Details of the proposed development condition are shown in Drawing MA-02. As previously noted, the SWM plan presented herein is intended to accommodate the development conditions proposed under the July 2022 ECA submission as well as the more recently proposed shoreline reconstruction and site improvements.Recently completed construction includes a new 330 m^2 +/- office building with associated paved parking and limited landscaping in the northwest portion of the site.A summary of the key elements of the site works constituting changes from the pre-development conditions to proposed development condition includes:

- Recently completed construction as noted above,
- Reconstruction of the shorewall with a new alignment to accommodate site expansion and re-grading,
- Construction of a new boat launch,
- Removal of an existing 250 m^2 +/- residential building,
- Removal of an existing (265m^2+/-)covered storage (tent) structure and replacement with a new larger (1000 m^2 +/-) covered storage structure to the south of the original office building,
- Paving of the central and southern portions of the site, and
- Construction of new stormwater management facilities.

Proposed site development surface areas and runoff coefficients are summarized in Table 2.2.

Table 2.2:Proposed Development Site Characteristics

Surface	Area (ha)	"C"
Asphalt	1.85	0.9
Gravel	0.51	0.5
Rooftop	0.42	0.9
Open/Grassed	0.55	0.25
Total	**3.34**	**0.73**

Proposed drainage conditions associated with the scope of the new developments will involve increased runoff surface area due to the shoreline expansion, increased asphalt areas and revised grading. Proposed drainage patterns and site development is as depicted in Drawing MA-02. As indicated by comparison of Table 2.1 and Table 2.2, there is an overall increase in site area and runoff coefficients.

3 Review of SWM Criteria and Opportunities

Quantity control is not a primary concern for this site, where runoff is discharged directly to the St Lawrence River. While the proposed site improvements will increase runoff coefficients, they will also provide for a more robust shoreline and reduced erosion potentialin the event that major flows spill over the shorewall.

There is an obligation to provide stormwater management quality controls for proposed development. Typical water quality control requirements for the St. Lawrence River in this area are 80% TSS removal.

Catchment delineations for the site are presented in Drawing MA-03. All proposed site development will occur on the western and central portions of the property, generally focused within catchments A through F. There is some site re-grading in catchment N associated with flood storage compensation efforts and replacement of an existing covered storage building with a larger structure. In this area, an existing residential building has also been removed.

Areas A through F currently drain to the south and discharge over of the deteriorating shorewall structures. The proposed site development will generally maintain this pre-development drainage pattern. Drainage area H will be unaffected by the proposed development and therefore, will continue to drain via the existing storm sewer, discharging to the wetland area near the northeast corner of the property. The proposed grading in area N as required to provide some flood storage compensation for the new wall will generally maintain the discharge patterns in this area, with overland flow to the St. Lawrence River and wetland area. The revised grading near the top of slope in this area and relocation and replacement of the covered storage structure will result in some minor adjustments to drainage patterns locally around the covered storage structure.

There are a number of site-related constraints that impact stormwater management opportunities for this site. Key constraints include:

- The southern portion of the site under pre-development conditions is relatively low-lying in comparison to the 100 year flood limit. Pre-development site grades along the shoreline are on the order of 75.7 m +/- while the instantaneous 100 year water level is 75.90 m. Wave uprush further exacerbates the flood hazards in this area.
- The lowest finished floor elevation in the fabrication shop (76.025 m) constrains the ability to significantly increase site grades in this area and therefore limits ability to provide for stormwater management above the 100 year flood level., and
- Due to the nature of the business, site operations including materials management and storage do not permit the development of any significant natural areas or areas of significant infiltration potential throughout much of the site, and furthermore, operations are intensified along the shoreline and therefore natural buffers and infiltration areas in the lower portions of the property where drainage collects are not feasible.

Given the site constraints noted above and their relevance to the portion of the property affected by the proposed development, the most viable option to achieve any significant stormwater quality management is the implementation of an end-of-pipe oil-grit separator unit.

The proposed stormwater management design for the site is presented in the following section.

4 SWM Design

Key elements of the proposed stormwater management plan for this property are highlighted below and detailed in Drawing MA-03.

- Stormwater quality treatment will be provided by a jellyfish oil-grit filtration (OGF) chamber sized for the specific site characteristics to provide water quality management in accordance with the minimum site requirement of 80% TSS removal. Given experience with traditional oil grit separators and long-term performance below expected levels, the OGF unit with certified performance characteristics has been sized in accordance with current regulatory objectives.
- Surface runoff from catchment areas draining to the shorewall will be captured in a trench drain that traverses the southern portion of the site. This approach will allow capture of the runoff without need for significant depth of burial of drainage systems and associated increased submergence of outlet elevations as would occur with a standard catch basin to pipe system. The trench drain will feed the OGF unit.
- Proposed site grading and shorewall elevations (76.30 m) will isolate the OGF inlet (trench drain) from the defined 100 year instantaneous still water levels (75.9 m) and will provide significant protection against wave overtopping inflow to the system.
- Roof leaders that do not presently discharge to the ground surface will be maintained in their tile conduits and discharged through the new shorewall to the river. Roof materials are steel and therefore do not introduce any significant contaminants. Existing catch basins where roof leaders combine and connect to discharge drains will be maintained but grates will be replaced with water-tight lids to prevent surface drainage from discharging uncontrolled.
- Discharge from Catchment H will generally remain unchanged, captured by two catch basins and discharging via storm sewer to the wetland area near the northwest corner of the property.
- Discharge from Catchment N will continue to drain via surface flow over the shoreline to the St. Lawrence River and local wetland area. The re-graded area will result in some change in surface treatment in this area. Pre-development conditions are a mix of grass and granular, while proposed development conditions will increase the granular surface. This area is to be used for inert material storage.

Overall, the proposed stormwater management plan will provide for treatment of approximately 1.87 ha of site runoff that is presently unmanaged. Runoff coefficients are expected to increase in this area due to proposed development paving plans, but overall, the proposed stormwater management measures provide for treatment of runoff volumes far in excess of any increased runoff or new surfaces associated with the proposed development.

Specific design considerations associated with the OGF and the trench drain are discussed in the following sections.

4.1 OGF Design Considerations

The Jellyfish filter (OGF) holds an Environmental Technology Verification (ETV) registration and is sized by the supplier on a site specific basis in accordance with the certified testing performance. The OGF is designed to operate at specified capacity under a head of 457 mm, measured from the invert of the outlet pipe (filter deck elevation) to the crest of the bypass weir in the upstream drainage system. The bypass weir is included to ensure that the OGF is not placed under sustained hydraulic heads significantly in excess of the system performance limitations.

Although the OGF will function properly with a submerged outlet as long as the design hydraulic head conditions are available, it is generally desirable to place the unit to minimize submergence. An opposing constraint is the need to place the unit deep enough to capture the inlet drainage system and provide the design head on the system. To this end, the limited relief between surface grades and local St Lawrence River levels presents challenges in setting critical design elevations at this site.

For this installation, the OGF filter deck has been set at an elevation of 75.10 m. This stipulated a bypass weir elevation of 75.56 m to generate the design head on the system. It is noted that the jellyfish deck at 75.10 m elevation will not be submerged until the 90th percentile St Lawrence River water elevation is reached. A plot of historic St. Lawrence River water levels at Alexandria Bay gauging station is included in Appendix B.Under extreme conditions, when the St Lawrence River rises above this elevation, the bypass weir will be effective before the design head of 457 mm is achieved and the performance of the OGF will begin to diminish. Full bypassing of the system would occur when St Lawrence River levels reach 75.56 m elevation, or the 99th percentile water level.

While design performance (capture) of the OGF diminishes between the 90th percentile water level and the 100 year water instantaneous water level, it is noted that the proposed system captures the entirety of the site draining to the present shorewall location, and therefore provides SWM quality management for areas in excess of those modified under the proposed conditions. It is also noted that the proposed site grading raises all land-based operations above the 100 year instantaneous water level and eliminates the

majority of wave uprush influence from the operational site area, thereby significantly improving runoff management capabilities.

Site grades will require that the top of the OGF unit is raised above grade. This installation scenario has been confirmed to be feasible with the supplier. The OGF is situated north of the trench drain near the fabrication building in order to protect it from site operations.

Details of the OGF configuration are presented on Drawing MA-05.

4.2 Trench Drain Design Considerations

The trench drain system capacity has been assessed against the 2 year design rainfall intensity assuming a 15 minute inlet time, and also against the 25 mm water quality rainfall, assuming a 15 minute storm duration. The 2 year rainfall intensity with 15 minutes inlet time based on Ontario Ministry of Transportation (MTO) design Intensity Duration Frequency (IDF) Curves is 54.3 mm/hr. Assuming the 25 mm water quality event rainfall occurs within a 15 minute inlet time suggests a rainfall intensity of 100 mm/hr. It is noted that this rainfall intensity is roughly equivalent to a 25 year 15 minute rainfall intensity. Peak flows generated by these rainfall intensities are presented in Appendix B.

Assuming the trench drain runs full to the bottom of grate elevation at its upstream end, and flows with a 0.3% water surface slope to the OGF, the capacity of the westerly portion of the trench drain is estimated to be approximately 0.19 m^3/s at its downstream limits, while the capacity of the easterly portion of the trench drain is estimated to be approximately 0.24 m^3/s at its downstream limits.

These flow capacities are well in excess of the 2 year flow and marginally below the flow generated by runoff from the 25 mm event with a 15 minute duration. This trench drain capacity calculation assumes normal Manning's flow and does not account for flow or storage on the surface of the asphalt above the trench drain.

Because the design flow treatment rate of the OGF is approximately 40.4 L/s, it is recognized that the OGF is the limiting capacity element in the system. A trench capacity in excess of the OGF treatment flow rate ensures that the system will deliver the flow to the OGF at a rate required to achieve the treatment criteria.

The splitter manhole provides for a sediment sump depth of approximately 0.8 m to reduce loading of coarse materials to the OGF. In the event that there is a malfunction of the drainage system, site grades are set to spill at the southwest corner of the site at elevation 75.95 m in order to prevent flooding of finished floor elevations. This permits approximately 50 mm of ponding above the lowest portion of the trench drain grate. The proposed top of shorewall elevation of 76.30 m provides significant protection against

wave overtopping minimizing risk of overloading the OGF due to wave overtopping volumes.

The cap of the splitter will rise above site grades in order to achieve the necessary operational grades for the OGF bypass. Details of the trench drain and splitter chamber are presented in Drawing MA-04.

5 Closure

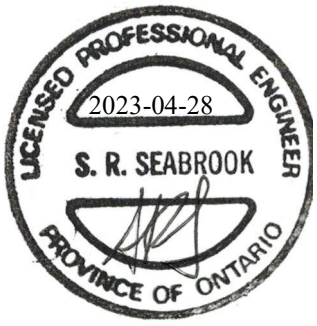
The proposed stormwater management plan for this site is based on an Oil-Grit Filter system to be fed by a trench drain along the southern portion of the site, capturing runoff from the western and central portions of the property. There is presently no stormwater management for the site, and as such, the capture area provides for treatment of site runoff well in excess of any increased runoff generated by the proposed development in comparison with pre-development conditions.

For the area captured, the OGF provides for 89% TSS removal for a capture rate in excess of 90% of the average annual runoff. It is recognized that diminished performance will be achieved as St. Lawrence River water levels increase above the 90th percentile historic level and design head on the OGF is reduced.

The proposed stormwater management plan represents an optimization of runoff capture and treatment opportunities for this challenging site which requires heavy marine operations at the water's edge on a relatively low-lying site.

Prepared by: _____
Andy Tarrant, EIT

Reviewed by: _____
Stu Seabrook, P.Eng



APPENDIX A
SELECT SITE PHOTOS

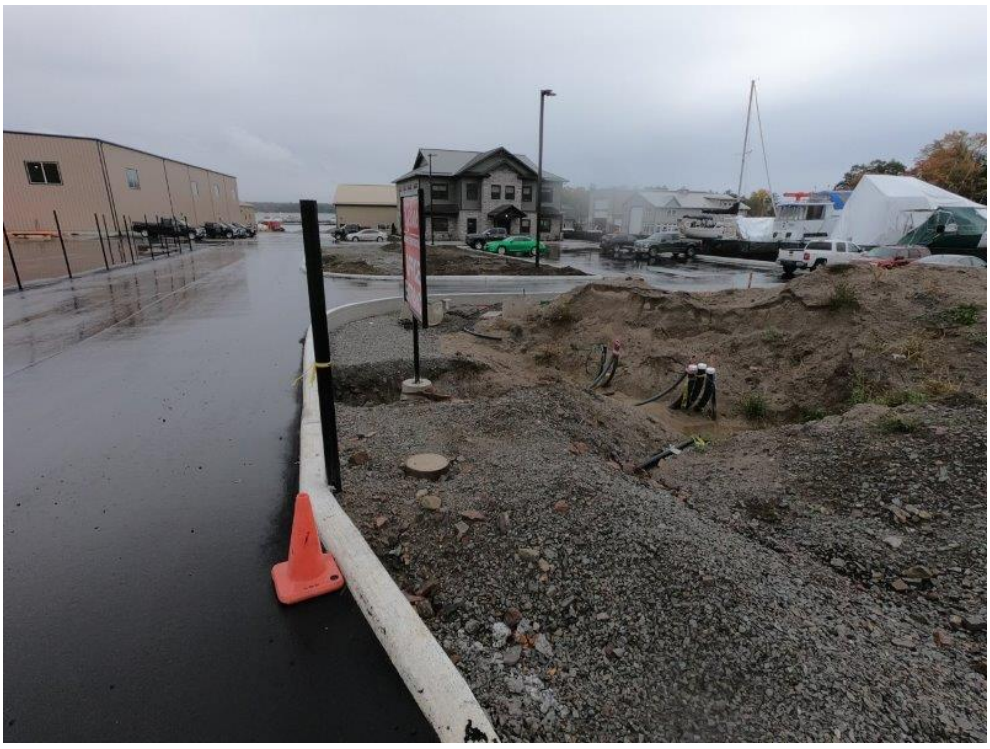


Photo A1: Looking SE from Thousand Islands Parkway, western driveway entering property (2022)

Photo A2: Looking East along Thousand Islands Parkway, western driveway entering property (2022)

Photo A3: Looking South from Thousand Islands Parkway, eastern driveway entering property (2022)

Photo A4: Looking southeast towards shoreline and existing buildings, eastern driveway entering property (2022)

Photo A5: Looking Northeast alongshoreline, North end of gabion wall section (2022)

Photo A6: Looking Southwest along shoreline towards boathouse, North end of gabion wall section (2022)

Photo A7: Looking Northeast along the shoreline towards the boathouse, at rip-rap revetment (2022)

Photo A8: Rip-Rap Revetment (2022)

Photo A9: Looking Southeast from existing boat ramp (2022)

Photo A10: Upland of boat ramp, existing central building (2022)

Photo A11: Boat launch and existing SSP wall, looking Southwest towards Peck's Marina (2022)

Photo A12: Looking South towards shoreline along West edge of property. New office building (2022)

Photo A12: Existing large maintenance building and fabrication shop (2022)

Photo A13: Pre-development aerial view of site (2020)

Photo A14: Aerial view of site (2020)

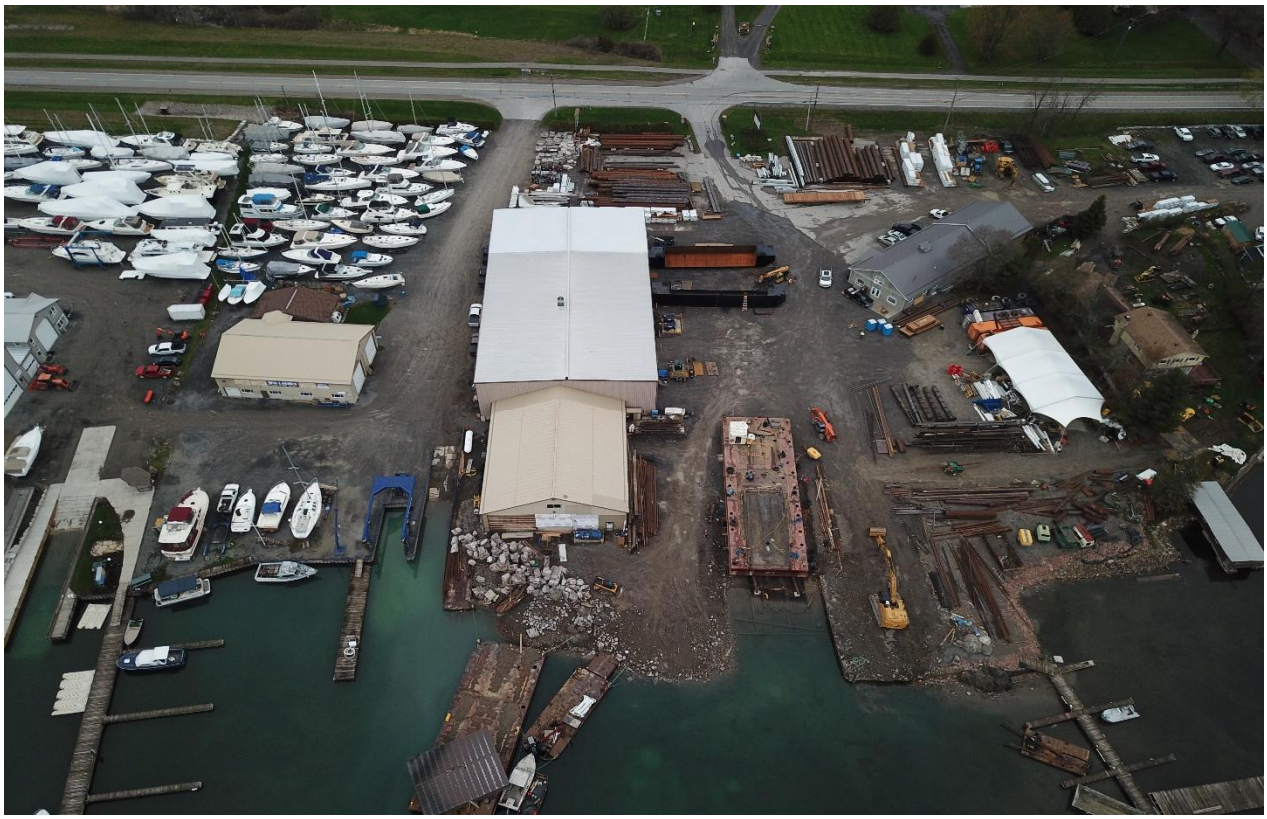
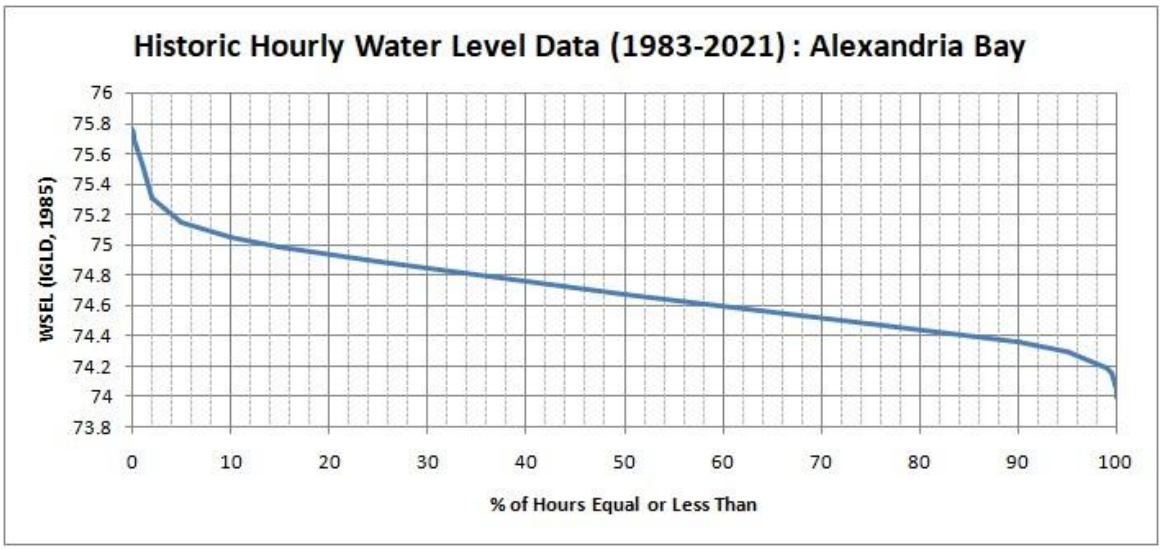


Photo A15: Aerial view of site (November 29, 2021)

APPENDIX B:
DRAINAGE AND STORMWATER MANAGEMENT PARAMETERS

WATER LEVEL AND RAINFALL DATA



Lansdowne MTO Rainfall

Intensity Duraton Frequency Values (MTO)

Duration (min)	Rainfall Intensity (mm/hr) by Return Period (yrs) 2	5	10	25	50	100
5	117	155.6	180.6	212.4	236.6	259.6
10	72.1	95.9	111.3	130.9	145.6	159.9
15	54.3	72.2	83.8	98.6	109.6	120.4
30	33.4	44.5	51.6	60.7	67.5	74.2
60	20.6	27.4	31.8	37.4	41.6	45.7
120	12.7	16.9	19.6	23	25.6	28.2
360	5.9	7.8	9.1	10.7	11.9	13.1
720	3.6	4.8	5.6	6.6	7.3	8
1440	2.2	3	3.4	4.1	4.5	5

IDF Parameters

	Return Period					
Parameter	2	5	10	25	50	100
A	20.6	27.4	31.8	37.4	41.6	45.7
B	-0.699	-0.699	-0.699	-0.699	-0.699	-0.699

15 Min Rainfall Intensities

tc (min)	15	15	15	15	15	15
I (mm/hr)	54.3	72.2	83.8	98.6	109.6	120.4

TRENCH DESIGN

DRAINAGE DESIGN															PAGE:	1 OF 1
Kehoe Marine Construction				***Trench Drain***												
				Flows by Rational Method				Intensity = 100 mm/hr (2yr rainfall - 15 min Tc)							DESN:	SRS
LANSDOWNE, ONTARIO				Q = 0.0028*C*I*A (m^3/s)												
				A = AREA (ha)				HDPE Pipe n =		0.013						
				C = RUNOFF COEFFICIENT				Concrete Drain n =		0.013						
	LOCATION			AREA (Ha)							CUM	CONCENTRATION TIME			RAINFALL	PEAK
AREA	STREET	FROM	TO	"C"	"C"	"C"	"C"	"C"	"C"	Ac	Ac		IN		INTEN.	FLOW
				0.25	0.40	0.50	0.60	0.90	0.95			INLET	PIPE	TOTAL	(mm/hr)	(m^3/s)
A		A	B	0.043						0.01	0.01	15.00		15.00	100	0.003
B		B	C	0.048				0.089		0.09	0.10	15.00		15.00	100	0.029
C		C	D	0.035				0.005		0.01	0.12	15.00		15.00	100	0.033
D		D	TD West					0.129		0.12	0.23	15.00		15.00	100	0.065
E		E	TD West	0.039				0.465		0.43	0.66	15.00		15.00	100	0.185
F		F	TD East	0.069				0.669		0.62	0.62	15.00		15.00	100	0.173
G		G	TD East					0.283		0.25	0.87	15.00		15.00	100	0.245

Trench Drain - constant WSEL slope assessment (East of Jellyfish, catchments F,G)

Water Surface Slope			0.3	% =	0.003							
Grate Thickness			0.075	m								
Drain Width			0.5	m								
n			0.013									
Trench	Trench	Trench	Grate	Top	Bottom							Grate
Station	Btm Slp	Invert	Slope	Grate	Grate	WSEL	Flow	Area	R	V	Q	Clearance
							Depth					
0	0.0054	75.85	0.0014	76.15	76.075	76.075	0.225	0.1125	0.118421	1.016022	0.11	0.00
1	0.0054	75.84	0.0014	76.15	76.074	76.072	0.227	0.1137	0.119083	1.019802	0.12	0.00
2	0.0054	75.84	0.0014	76.15	76.072	76.069	0.230	0.1149	0.119737	1.023538	0.12	0.00
3	0.0054	75.83	0.0014	76.15	76.071	76.066	0.232	0.1161	0.120386	1.027229	0.12	0.00
4	0.0054	75.83	0.0014	76.14	76.069	76.063	0.235	0.1173	0.121028	1.030877	0.12	0.01
5	0.0054	75.82	0.0014	76.14	76.068	76.06	0.237	0.1185	0.121663	1.034483	0.12	0.01
6	0.0054	75.82	0.0014	76.14	76.066	76.057	0.239	0.1197	0.122293	1.038048	0.12	0.01
7	0.0054	75.81	0.0014	76.14	76.065	76.054	0.242	0.1209	0.122916	1.041572	0.13	0.01
8	0.0054	75.81	0.0014	76.14	76.064	76.051	0.244	0.1221	0.123533	1.045055	0.13	0.01
9	0.0054	75.80	0.0014	76.14	76.062	76.048	0.247	0.1233	0.124144	1.048499	0.13	0.01
10	0.0054	75.80	0.0014	76.14	76.061	76.045	0.249	0.1245	0.124749	1.051905	0.13	0.02
11	0.0054	75.79	0.0014	76.13	76.059	76.042	0.251	0.1257	0.125349	1.055272	0.13	0.02
12	0.0054	75.79	0.0014	76.13	76.058	76.039	0.254	0.1269	0.125943	1.058603	0.13	0.02
13	0.0054	75.78	0.0014	76.13	76.056	76.036	0.256	0.1281	0.126531	1.061896	0.14	0.02
14	0.0054	75.77	0.0014	76.13	76.055	76.033	0.259	0.1293	0.127114	1.065153	0.14	0.02
15	0.0054	75.77	0.0014	76.13	76.054	76.03	0.261	0.1305	0.127691	1.068375	0.14	0.02
16	0.0054	75.76	0.0014	76.13	76.052	76.027	0.263	0.1317	0.128263	1.071562	0.14	0.03
17	0.0054	75.76	0.0014	76.13	76.051	76.024	0.266	0.1329	0.128829	1.074714	0.14	0.03
18	0.0054	75.75	0.0014	76.12	76.049	76.021	0.268	0.1341	0.12939	1.077833	0.14	0.03
19	0.0054	75.75	0.0014	76.12	76.048	76.018	0.271	0.1353	0.129946	1.080919	0.15	0.03
20	0.0054	75.74	0.0014	76.12	76.046	76.015	0.273	0.1365	0.130497	1.083972	0.15	0.03
21	0.0054	75.74	0.0014	76.12	76.045	76.012	0.275	0.1377	0.131043	1.086992	0.15	0.03
22	0.0054	75.73	0.0014	76.12	76.044	76.009	0.278	0.1389	0.131584	1.089982	0.15	0.03
23	0.0054	75.73	0.0014	76.12	76.042	76.006	0.280	0.1401	0.13212	1.09294	0.15	0.04
24	0.0054	75.72	0.0014	76.12	76.041	76.003	0.283	0.1413	0.132651	1.095867	0.15	0.04
25	0.0054	75.72	0.0014	76.11	76.039	76	0.285	0.1425	0.133178	1.098765	0.16	0.04
26	0.0054	75.71	0.0014	76.11	76.038	75.997	0.287	0.1437	0.133699	1.101632	0.16	0.04
27	0.0054	75.70	0.0014	76.11	76.036	75.994	0.290	0.1449	0.134216	1.104471	0.16	0.04
28	0.0054	75.70	0.0014	76.11	76.035	75.991	0.292	0.1461	0.134729	1.107281	0.16	0.04
29	0.0054	75.69	0.0014	76.11	76.034	75.988	0.295	0.1473	0.135237	1.110062	0.16	0.05
30	0.0054	75.69	0.0014	76.11	76.032	75.985	0.297	0.1485	0.13574	1.112816	0.17	0.05
31	0.0054	75.68	0.0014	76.11	76.031	75.982	0.299	0.1497	0.13624	1.115542	0.17	0.05
32	0.0054	75.68	0.0014	76.10	76.029	75.979	0.302	0.1509	0.136734	1.118242	0.17	0.05
33	0.0054	75.67	0.0014	76.10	76.028	75.976	0.304	0.1521	0.137225	1.120914	0.17	0.05
34	0.0054	75.67	0.0014	76.10	76.026	75.973	0.307	0.1533	0.137711	1.123561	0.17	0.05
35	0.0054	75.66	0.0014	76.10	76.025	75.97	0.309	0.1545	0.138193	1.126182	0.17	0.05
36	0.0052	75.66	0.0077	76.09	76.017	75.967	0.311	0.1556	0.138632	1.128562	0.18	0.05
37	0.0052	75.65	0.0077	76.08	76.010	75.964	0.313	0.1567	0.139066	1.13092	0.18	0.05
38	0.0052	75.65	0.0077	76.08	76.002	75.961	0.316	0.1578	0.139498	1.133259	0.18	0.04
39	0.0052	75.64	0.0077	76.07	75.994	75.958	0.318	0.1589	0.139926	1.135576	0.18	0.04
40	0.0052	75.64	0.0077	76.06	75.986	75.955	0.320	0.16	0.140351	1.137874	0.18	0.03
41	0.0052	75.63	0.0077	76.05	75.979	75.952	0.322	0.1611	0.140772	1.140151	0.18	0.03
42	0.0052	75.62	0.0077	76.05	75.971	75.949	0.324	0.1622	0.141191	1.142409	0.19	0.02
43	0.0052	75.62	0.0077	76.04	75.963	75.946	0.327	0.1633	0.141606	1.144647	0.19	0.02
44	0.0052	75.61	0.0077	76.03	75.956	75.943	0.329	0.1644	0.142018	1.146866	0.19	0.01
45	0.0052	75.61	0.0077	76.02	75.948	75.94	0.331	0.1655	0.142427	1.149067	0.19	0.01
46	0.0052	75.60	0.0077	76.02	75.940	75.937	0.333	0.1666	0.142833	1.151248	0.19	0.00
47	0.0052	75.60	0.0077	76.01	75.933	75.934	0.335	0.1677	0.143235	1.153411	0.19	0.00
48	0.0052	75.59	0.0077	76.00	75.925	75.931	0.338	0.1688	0.143635	1.155556	0.20	-0.01
49	0.0052	75.59	0.0077	75.99	75.917	75.928	0.340	0.1699	0.144032	1.157683	0.20	-0.01
50	0.0052	75.58	0.0077	75.98	75.909	75.925	0.342	0.171	0.144426	1.159792	0.20	-0.02
51	0.0052	75.58	0.0077	75.98	75.902	75.922	0.344	0.1721	0.144817	1.161884	0.20	-0.02
52	0.0052	75.57	0.0077	75.97	75.894	75.919	0.346	0.1732	0.145205	1.163958	0.20	-0.02
53	0.0052	75.57	0.0077	75.96	75.886	75.916	0.349	0.1743	0.14559	1.166016	0.20	-0.03
54	0.0052	75.56	0.0077	75.95	75.879	75.913	0.351	0.1754	0.145972	1.168056	0.20	-0.03
55	0.0052	75.56	0.0077	75.95	75.871	75.91	0.353	0.1765	0.146352	1.17008	0.21	-0.04
56	0.0052	75.55	0.0077	75.94	75.863	75.907	0.355	0.1776	0.146728	1.172087	0.21	-0.04
57	0.0052	75.55	0.0077	75.93	75.856	75.904	0.357	0.1787	0.147102	1.174078	0.21	-0.05
58	0.0052	75.54	0.0077	75.92	75.848	75.901	0.360	0.1798	0.147474	1.176054	0.21	-0.05
59	0.0052	75.54	0.0077	75.92	75.840	75.898	0.362	0.1809	0.147842	1.178013	0.21	-0.06
60	0.0052	75.53	0.0077	75.91	75.832	75.895	0.364	0.182	0.148208	1.179956	0.21	-0.06

61	0.0052	75.53	0.0077	75.90	75.825	75.892	0.366	0.1831	0.148572	1.181885	0.22	-0.07
62	0.0051	75.52	0.0000	75.90	75.825	75.889	0.368	0.18415	0.148916	1.183711	0.22	-0.06
63	0.0051	75.52	0.0000	75.90	75.825	75.886	0.370	0.1852	0.149259	1.185523	0.22	-0.06
64	0.0051	75.51	0.0000	75.90	75.825	75.883	0.372	0.18625	0.149598	1.187322	0.22	-0.06
65	0.0051	75.51	0.0000	75.90	75.825	75.88	0.375	0.1873	0.149936	1.189108	0.22	-0.06
66	0.0051	75.50	0.0000	75.90	75.825	75.877	0.377	0.18835	0.150271	1.19088	0.22	-0.05
67	0.0051	75.50	0.0000	75.90	75.825	75.874	0.379	0.1894	0.150604	1.192639	0.23	-0.05
68	0.0051	75.49	0.0000	75.90	75.825	75.871	0.381	0.19045	0.150935	1.194385	0.23	-0.05
69	0.0051	75.49	0.0000	75.90	75.825	75.868	0.383	0.1915	0.151264	1.196118	0.23	-0.04
70	0.0051	75.48	0.0000	75.90	75.825	75.865	0.385	0.19255	0.15159	1.197838	0.23	-0.04
71	0.0051	75.47	0.0000	75.90	75.825	75.862	0.387	0.1936	0.151915	1.199546	0.23	-0.04
72	0.0051	75.47	0.0000	75.90	75.825	75.859	0.389	0.19465	0.152237	1.201242	0.23	-0.03
73	0.0051	75.46	0.0000	75.90	75.825	75.856	0.391	0.1957	0.152557	1.202925	0.24	-0.03
74	0.0051	75.46	0.0000	75.90	75.825	75.853	0.393	0.19675	0.152875	1.204596	0.24	-0.03
75	0.0051	75.45	0.0000	75.90	75.825	75.85	0.396	0.1978	0.153191	1.206255	0.24	-0.03
76	0.0051	75.45	0.0000	75.90	75.825	75.847	0.398	0.19885	0.153505	1.207902	0.24	-0.02
77	0.0051	75.44	0.0000	75.90	75.825	75.844	0.400	0.1999	0.153817	1.209537	0.24	-0.02
78	0.0051	75.44	0.0000	75.90	75.825	75.841	0.402	0.20095	0.154126	1.211161	0.24	-0.02
79	0.0051	75.43	0.0000	75.90	75.825	75.838	0.404	0.202	0.154434	1.212773	0.24	-0.01
80	0.0051	75.43	0.0000	75.90	75.825	75.835	0.406	0.20305	0.15474	1.214374	0.25	-0.01
81	0.0051	75.42	0.0000	75.90	75.825	75.832	0.408	0.2041	0.155044	1.215964	0.25	-0.01
82	0.0051	75.42	0.0000	75.90	75.825	75.829	0.410	0.20515	0.155346	1.217542	0.25	0.00
83	0.0051	75.41	0.0000	75.90	75.825	75.826	0.412	0.2062	0.155646	1.21911	0.25	0.00
84	0.0051	75.41	0.0000	75.90	75.825	75.823	0.414	0.20725	0.155944	1.220666	0.25	0.00
85	0.0051	75.40	0.0000	75.90	75.825	75.82	0.417	0.2083	0.156241	1.222212	0.25	0.00
86	0.0051	75.40	0.0000	75.90	75.825	75.817	0.419	0.20935	0.156535	1.223747	0.26	0.01
87	0.0051	75.39	0.0000	75.90	75.825	75.814	0.421	0.2104	0.156828	1.225272	0.26	0.01
88	0.0051	75.39	0.0000	75.90	75.825	75.811	0.423	0.21145	0.157118	1.226786	0.26	0.01
89	0.0051	75.38	0.0000	75.90	75.825	75.808	0.425	0.2125	0.157407	1.228289	0.26	0.02
90	0.0051	75.38	0.0000	75.90	75.825	75.805	0.427	0.21355	0.157695	1.229783	0.26	0.02
91	0.0051	75.37	0.0000	75.90	75.825	75.802	0.429	0.2146	0.15798	1.231266	0.26	0.02
92	0.0051	75.37	0.0000	75.90	75.825	75.799	0.431	0.21565	0.158264	1.23274	0.27	0.03
93	0.0051	75.36	0.0000	75.90	75.825	75.796	0.433	0.2167	0.158546	1.234203	0.27	0.03
94	0.0051	75.36	0.0000	75.90	75.825	75.793	0.435	0.21775	0.158826	1.235656	0.27	0.03
95	0.0051	75.35	0.0000	75.90	75.825	75.79	0.438	0.2188	0.159104	1.2371	0.27	0.03

Notes:
For trench capacity assume rectangular trench with Manning's flow

Trench Drain - constant WSEL slope assessment (West of Jellyfish, catchments A-E)

Water Surface Slope			0.3	% =	0.003							
Grate Thickness			0.075	m								
Drain Width			0.5	m								
n			0.013									
Trench	Trench	Trench	Grate	Top	Bottom							Grate
Station	Btm Slp	Invert	Slope	Grate	Grate	WSEL	Flow	Area	R	V	Q	Clearance
							Depth					
0	0.0051	75.60	0.0000	75.90	75.825	75.825	0.225	0.1125	0.118421	1.016022	0.11	0.00
1	0.0051	75.59	0.0000	75.90	75.825	75.822	0.227	0.11355	0.119	1.019332	0.12	0.00
2	0.0051	75.59	0.0000	75.90	75.825	75.819	0.229	0.1146	0.119574	1.022608	0.12	0.01
3	0.0051	75.58	0.0000	75.90	75.825	75.816	0.231	0.11565	0.120143	1.02585	0.12	0.01
4	0.0051	75.58	0.0000	75.90	75.825	75.813	0.233	0.1167	0.120707	1.029059	0.12	0.01
5	0.0051	75.57	0.0000	75.90	75.825	75.81	0.236	0.11775	0.121267	1.032235	0.12	0.02
6	0.0051	75.57	0.0000	75.90	75.825	75.807	0.238	0.1188	0.121821	1.035378	0.12	0.02
7	0.0051	75.56	0.0000	75.90	75.825	75.804	0.240	0.11985	0.122371	1.038491	0.12	0.02
8	0.0051	75.56	0.0000	75.90	75.825	75.801	0.242	0.1209	0.122916	1.041572	0.13	0.02
9	0.0051	75.55	0.0000	75.90	75.825	75.798	0.244	0.12195	0.123456	1.044622	0.13	0.03
10	0.0051	75.55	0.0000	75.90	75.825	75.795	0.246	0.123	0.123992	1.047642	0.13	0.03
11	0.0051	75.54	0.0000	75.90	75.825	75.792	0.248	0.12405	0.124523	1.050632	0.13	0.03
12	0.0051	75.54	0.0000	75.90	75.825	75.789	0.250	0.1251	0.12505	1.053593	0.13	0.04
13	0.0051	75.53	0.0000	75.90	75.825	75.786	0.252	0.12615	0.125572	1.056526	0.13	0.04
14	0.0051	75.53	0.0000	75.90	75.825	75.783	0.254	0.1272	0.12609	1.059429	0.13	0.04
15	0.0051	75.52	0.0000	75.90	75.825	75.78	0.256	0.12825	0.126604	1.062305	0.14	0.05
16	0.0051	75.52	0.0000	75.90	75.825	75.777	0.259	0.1293	0.127114	1.065153	0.14	0.05
17	0.0051	75.51	0.0000	75.90	75.825	75.774	0.261	0.13035	0.127619	1.067974	0.14	0.05
18	0.0051	75.51	0.0000	75.90	75.825	75.771	0.263	0.1314	0.12812	1.070768	0.14	0.05
19	0.0051	75.50	0.0000	75.90	75.825	75.768	0.265	0.13245	0.128617	1.073536	0.14	0.06
20	0.0051	75.50	0.0000	75.90	75.825	75.765	0.267	0.1335	0.12911	1.076278	0.14	0.06
21	0.0051	75.49	0.0000	75.90	75.825	75.762	0.269	0.13455	0.129599	1.078994	0.15	0.06
22	0.0051	75.49	0.0000	75.90	75.825	75.759	0.271	0.1356	0.130084	1.081685	0.15	0.07
23	0.0051	75.48	0.0000	75.90	75.825	75.756	0.273	0.13665	0.130566	1.084351	0.15	0.07
24	0.0051	75.48	0.0000	75.90	75.825	75.753	0.275	0.1377	0.131043	1.086992	0.15	0.07
25	0.0051	75.47	0.0000	75.90	75.825	75.75	0.277	0.13875	0.131517	1.08961	0.15	0.08
26	0.0051	75.47	0.0000	75.90	75.825	75.747	0.280	0.1398	0.131986	1.092203	0.15	0.08
27	0.0051	75.46	0.0000	75.90	75.825	75.744	0.282	0.14085	0.132453	1.094773	0.15	0.08
28	0.0051	75.46	0.0000	75.90	75.825	75.741	0.284	0.1419	0.132915	1.09732	0.16	0.08
29	0.0051	75.45	0.0000	75.90	75.825	75.738	0.286	0.14295	0.133374	1.099843	0.16	0.09
30	0.0051	75.45	0.0000	75.90	75.825	75.735	0.288	0.144	0.133829	1.102345	0.16	0.09
31	0.0051	75.44	0.0000	75.90	75.825	75.732	0.290	0.14505	0.134281	1.104824	0.16	0.09
32	0.0051	75.44	0.0000	75.90	75.825	75.729	0.292	0.1461	0.134729	1.107281	0.16	0.10
33	0.0051	75.43	0.0000	75.90	75.825	75.726	0.294	0.14715	0.135174	1.109716	0.16	0.10
34	0.0051	75.43	0.0000	75.90	75.825	75.723	0.296	0.1482	0.135615	1.11213	0.16	0.10
35	0.0051	75.42	0.0000	75.90	75.825	75.72	0.298	0.14925	0.136053	1.114523	0.17	0.11
36	0.0051	75.42	0.0000	75.90	75.825	75.717	0.301	0.1503	0.136487	1.116895	0.17	0.11
37	0.0051	75.41	0.0000	75.90	75.825	75.714	0.303	0.15135	0.136919	1.119247	0.17	0.11
38	0.0051	75.41	0.0000	75.90	75.825	75.711	0.305	0.1524	0.137347	1.121578	0.17	0.11
39	0.0051	75.40	0.0000	75.90	75.825	75.708	0.307	0.15345	0.137772	1.12389	0.17	0.12
40	0.0051	75.40	0.0000	75.90	75.825	75.705	0.309	0.1545	0.138193	1.126182	0.17	0.12
41	0.0051	75.39	0.0000	75.90	75.825	75.702	0.311	0.15555	0.138612	1.128454	0.18	0.12
42	0.0051	75.39	0.0000	75.90	75.825	75.699	0.313	0.1566	0.139027	1.130707	0.18	0.13
43	0.0051	75.38	0.0000	75.90	75.825	75.696	0.315	0.15765	0.139439	1.132941	0.18	0.13
44	0.0051	75.38	0.0000	75.90	75.825	75.693	0.317	0.1587	0.139848	1.135156	0.18	0.13
45	0.0051	75.37	0.0000	75.90	75.825	75.69	0.319	0.15975	0.140255	1.137353	0.18	0.14
46	0.0051	75.37	0.0000	75.90	75.825	75.687	0.322	0.1608	0.140658	1.139532	0.18	0.14
47	0.0051	75.36	0.0000	75.90	75.825	75.684	0.324	0.16185	0.141058	1.141693	0.18	0.14
48	0.0051	75.36	0.0000	75.90	75.825	75.681	0.326	0.1629	0.141455	1.143835	0.19	0.14
49	0.0051	75.35	0.0000	75.90	75.825	75.678	0.328	0.16395	0.14185	1.145961	0.19	0.15

STANDARD OFFLINE
Jellyfish Filter Sizing Report

Project Information

Date	Thursday, October 27, 2022
Project Name	KCE
Project Number	
Location	Guelph

Jellyfish Filter Design Overview

This report provides information for the sizing and specification of the Jellyfish Filter. When designed properly in accordance to the guidelines detailed in the Jellyfish Filter Technical Manual, the Jellyfish Filter will exceed the performance and longevity of conventional horizontal bed and granular media filters.

Please see ***www.ImbriumSystems.com*** *for more information.*

Jellyfish Filter System Recommendation

The Jellyfish Filter model JF8-7-2 is recommended to meet the water quality objective by treating a flow of 40.4 L/s, which meets or exceeds 90% of the average annual rainfall runoff volume based on 44 years of KINGSTON PUMPING STATION rainfall data for this site. This model has a sediment capacity of 455 kg, which meets or exceeds the estimated average annual sediment load.

Jellyfish Model	Number of High-Flo Cartridges	Number of Draindown Cartridges	Manhole Diameter (m)	Treatment Flow Rate (L/s)	Sediment Capacity (kg)
JF8-7-2	7	2	2.4	40.4	455

The Jellyfish Filter System

The patented Jellyfish Filter is an engineered stormwater quality treatment technology featuring unique membrane filtration in a compact stand-alone treatment system that removes a high level and wide variety of stormwater pollutants. Exceptional pollutant removal is achieved at high treatment flow rates with minimal head loss and low maintenance costs. Each lightweight Jellyfish Filter cartridge contains an extraordinarily large amount of membrane surface area, resulting in superior flow capacity and pollutant removal capacity.

Maintenance

Regular scheduled inspections and maintenance is necessary to assure proper functioning of the Jellyfish Filter. The maintenance interval is designed to be a minimum of 12 months, but this will vary depending on site loading conditions and upstream pretreatment measures. Quarterly inspections and inspections after all storms beyond the 5-year event are recommended until enough historical performance data has been logged to comfortably initiate an alternative inspection interval.

Please see ***www.ImbriumSystems.com*** *for more information.*

Thank you for the opportunity to present this information to you and your client.

Performance

Jellyfish efficiently captures a high level of Stormwater pollutants, including:

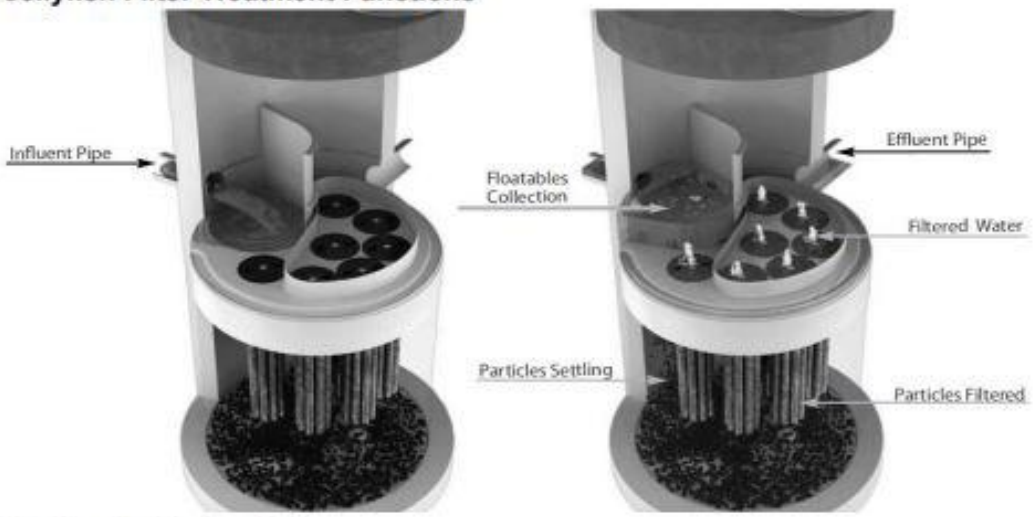
- ☑ 89% of the total suspended solids (TSS) load, including particles less than 5 microns
- ☑ 59% TP removal & 51% TN removal
- ☑ 90% Total Copper, 81% Total Lead, 70% Total Zinc
- ☑ Particulate-bound pollutants such as nutrients, toxic metals, hydrocarbons and bacteria
- ☑ Free oil, Floatable trash and debris

Field Proven Peformance

The Jellyfish filter has been field-tested on an urban site with 25 TARP qualifying rain events and field monitored according to the TARP field test protocol, demonstrating:

- A median TSS removal efficiency of 89%, and a median SSC removal of 99%;
- The ability to capture fine particles as indicated by an effluent d50 median of 3 microns for all monitotred storm events, and a median effluent turbidity of 5 NTUs;
- A median Total Phosphorus removal of 59%, and a median Total Nitrogen removal of 51%.

Jellyfish Filter Treatment Functions



Pre-treatment and Membrane Filtration

Project Information

Date:	Thursday, October 27, 2022
Project Name:	KCE
Project Number:	
Location:	Guelph

Designer Information

Company:	Gannett Fleming
Contact:	David Jackson
Phone #:	

Notes

Rainfall

Name:	KINGSTON PUMPING STATION
State:	ON
ID:	4175
Record:	1960 to 2003
Co-ords:	44°14'N, 76°29'W

Drainage Area

Total Area:	1.865 ha
Imperviousness:	91.5%

Upstream Detention

Peak Release Rate:	n/a
Pretreatment Credit:	n/a

Design System Requirements

Flow Loading	90% of the Average Annual Runoff based on 44 years of KINGSTON PUMPING STATION rainfall data:	**32.7 L/s**
Sediment Loading	Treating 90% of the average annual runoff volume, 7126 m³, with a suspended sediment concentration of 60 mg/L.	**428 kg***

** Indicates that sediment loading is the limiting parameter in the sizing of this Jellyfish system*

Recommendation

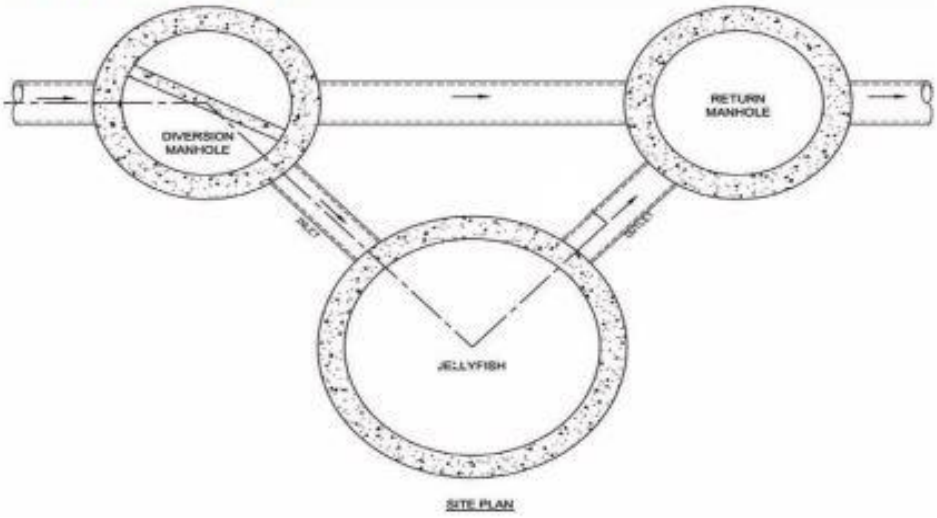
The Jellyfish Filter model JF8-7-2 is recommended to meet the water quality objective by treating a flow of 40.4 L/s, which meets or exceeds 90% of the average annual rainfall runoff volume based on 44 years of KINGSTON PUMPING STATION rainfall data for this site. This model has a sediment capacity of 455 kg, which meets or exceeds the estimated average annual sediment load.

Jellyfish Model	Number of High-Flo Cartridges	Number of Draindown Cartridges	Manhole Diameter (m)	Wet Vol Below Deck (L)	Sump Storage (m³)	Oil Capacity (L)	Treatment Flow Rate (L/s)	Sediment Capacity (kg)
JF4-1-1	1	1	1.2	2313	0.34	379	7.6	85
JF4-2-1	2	1	1.2	2313	0.34	379	12.6	142
JF6-3-1	3	1	1.8	5205	0.79	848	17.7	199
JF6-4-1	4	1	1.8	5205	0.79	848	22.7	256
JF6-5-1	5	1	1.8	5205	0.79	848	27.8	313
JF6-6-1	6	1	1.8	5205	0.79	848	28.6	370
JF8-6-2	6	2	2.4	9252	1.42	1469	35.3	398
JF8-7-2	**7**	**2**	**2.4**	**9252**	**1.42**	**1469**	**40.4**	**455**
JF8-8-2	8	2	2.4	9252	1.42	1469	45.4	512
JF8-9-2	9	2	2.4	9252	1.42	1469	50.5	569
JF8-10-2	10	2	2.4	9252	1.42	1469	50.5	626
JF10-11-3	11	3	3.0	14456	2.21	2302	63.1	711
JF10-12-3	12	3	3.0	14456	2.21	2302	68.2	768
JF10-12-4	12	4	3.0	14456	2.21	2302	70.7	796
JF10-13-4	13	4	3.0	14456	2.21	2302	75.7	853
JF10-14-4	14	4	3.0	14456	2.21	2302	78.9	910
JF10-15-4	15	4	3.0	14456	2.21	2302	78.9	967
JF10-16-4	16	4	3.0	14456	2.21	2302	78.9	1024
JF10-17-4	17	4	3.0	14456	2.21	2302	78.9	1081
JF10-18-4	18	4	3.0	14456	2.21	2302	78.9	1138
JF10-19-4	19	4	3.0	14456	2.21	2302	78.9	1195
JF12-20-5	20	5	3.6	20820	3.2	2771	113.6	1280
JF12-21-5	21	5	3.6	20820	3.2	2771	113.7	1337
JF12-22-5	22	5	3.6	20820	3.2	2771	113.7	1394
JF12-23-5	23	5	3.6	20820	3.2	2771	113.7	1451
JF12-24-5	24	5	3.6	20820	3.2	2771	113.7	1508
JF12-25-5	25	5	3.6	20820	3.2	2771	113.7	1565
JF12-26-5	26	5	3.6	20820	3.2	2771	113.7	1622
JF12-27-5	27	5	3.6	20820	3.2	2771	113.7	1679

Jellyfish® Filter

Jellyfish Filter Design Notes

- Typically the Jellyfish Filter is designed in an offline configuration, as all stormwater filter systems will perform for a longer duration between required maintenance services when designed and applied in off-line configurations. Depending on the design parameters, an optional internal bypass may be incorporated into the Jellyfish Filter, however note the inspection and maintenance frequency should be expected to increase above that of an off-line system. Speak to your local representative for more information.



Jellyfish Filter Typical Layout

- Typically, 18 inches (457 mm) of driving head is designed into the system, calculated as the difference in elevation between the top of the diversion structure weir and the invert of the Jellyfish Filter outlet pipe. Alternative driving head values can be designed as 12 to 24 inches (305 to 610mm) depending on specific site requirements, requiring additional sizing and design assistance.
- Typically, the Jellyfish Filter is designed with the inlet pipe configured 6 inches (150 mm) above the outlet invert elevation. However, depending on site parameters this can vary to an optional configuration of the inlet pipe entering the unit below the outlet invert elevation.
- The Jellyfish Filter can accommodate multiple inlet pipes within certain restrictions.
- While the optional inlet below deck configuration offers 0 to 360 degree flexibility between the inlet and outlet pipe, typical systems conform to the following:

Model Diameter (m)	Minimum Angle Inlet / Outlet Pipes	Minimum Inlet Pipe Diameter (mm)	Minimum Outlet Pipe Diameter (mm)
1.2	62°	150	200
1.8	59°	200	250
2.4	**52°**	**250**	**300**
3.0	48°	300	450
3.6	40°	300	450

- The Jellyfish Filter can be built at all depths of cover generally associated with conventional stormwater conveyance systems. For sites that require minimal depth of cover for the stormwater infrastructure, the Jellyfish Filter can be applied in a shallow application using a hatch cover. The general minimum depth of cover is 36 inches (915 mm) from top of the underslab to outlet invert.
- If driving head caclulations account for water elevation during submerged conditions the Jellyfish Filter will function effectively under submerged condtions.
- Jellyfish Filter systems may incorporate grated inlets depending on system configuration.
- For sites with water quality treatment flow rates or mass loadings that exceed the design flow rate of the largest standard Jellyfish Filter manhole models, systems can be designed that hydraulically connect multiple Jellyfish Filters in series or alternatively Jellyfish Vault units can be designed.

STANDARD SPECIFICATION
STORMWATER QUALITY – MEMBRANE FILTRATION TREATMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

Specifies requirements for construction and performance of an underground stormwater quality membrane filtration treatment device that removes pollutants from stormwater runoff through the unit operations of sedimentation, floatation, and membrane filtration.

1.2 REFERENCE STANDARDS

ASTM C 891: Specification for Installation of Underground Precast Concrete Utility Structures
ASTM C 478: Specification for Precast Reinforced Concrete Manhole Sections
ASTM C 443: Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM D 4101: Specification for Copolymer steps construction

CAN/CSA-A257.4-M92
Joints for Circular Concrete Sewer and Culvert Pipe, Manhole Sections and Fittings Using Rubber Gaskets

CAN/CSA-A257.4-M92
Precast Reinforced Circular Concrete Manhole Sections, Catch Basins and Fittings

Canadian Highway Bridge Design Code

1.3 SHOP DRAWINGS

Shop drawings for the structure and performance are to be submitted with each order to the contractor. Contractor shall forward shop drawing submittal to the consulting engineer for approval. Shop drawings are to detail the structure's precast concrete and call out or note the fiberglass (FRP) internals/components.

1.4 PRODUCT SUBSTITUTIONS

No product substitutions shall be accepted unless submitted 10 days prior to project bid date, or as directed by the engineer of record. Submissions for substitutions require review and approval by the Engineer of Record, for hydraulic performance, impact to project designs, equivalent treatment performance, and any required project plan and report (hydrology/hydraulic, water quality, stormwater pollution) modifications that would be required by the approving jurisdictions/agencies. Contractor to coordinate with the Engineer of Record any applicable modifications to the project estimates of cost, bonding amount determinations, plan check fees for changes to approved documents, and/or any other regulatory requirements resulting from the product substitution.

1.5 HANDLING AND STORAGE

Prevent damage to materials during storage and handling.

PART 2 – PRODUCTS

2.1 GENERAL

2.1.1 The device shall be a cylindrical or rectangular, all concrete structure (including risers), constructed from precast concrete riser and slab components or monolithic precast structure(s), installed to conform to ASTM C 891 and to any required state highway, municipal or local specifications; whichever is more stringent. The device shall be watertight.

2.1.2 Cartridge Deck The cylindrical concrete device shall include a fiberglass deck. The rectangular concrete device shall include a coated aluminum deck. In either instance, the insert shall be bolted and sealed watertight inside the precast concrete chamber. The deck shall serve as: (a) a horizontal divider between the lower treatment zone and the upper treated effluent zone; (b) a deck for attachment of filter cartridges such that the membrane filter elements of each cartridge extend into the lower treatment zone; (c) a platform for maintenance workers to service the filter cartridges (maximum manned weight = 450 pounds (204 kg)); (d) a conduit for conveyance of treated water to the effluent pipe.

2.1.3 Membrane Filter Cartridges Filter cartridges shall be comprised of reusable cylindrical membrane filter elements connected to a perforated head plate. The number of membrane filter elements per cartridge shall be a minimum of eleven 2.75-inch (70-mm) diameter elements. The length of each filter element shall be a minimum 15 inches (381 mm). Each cartridge shall be fitted into the cartridge deck by insertion into a cartridge receptacle that is permanently mounted into the cartridge deck. Each cartridge shall be secured by a cartridge lid that is threaded onto the receptacle, or similar mechanism to secure the cartridge into the deck. The maximum treatment flow rate of a filter cartridge shall be controlled by an orifice in the cartridge lid, or on the individual cartridge itself, and based on a design flux rate (surface loading rate) determined by the maximum treatment flow rate per unit of filtration membrane surface area. The maximum design flux rate shall be 0.21 gpm/ft² (0.142 lps/m²).

Each membrane filter cartridge shall allow for manual installation and removal. Each filter cartridge shall have filtration membrane surface area and dry installation weight as follows (if length of filter cartridge is between those listed below, the surface area and weight shall be proportionate to the next length shorter and next length longer as shown below):

Filter Cartridge Length (in / mm)	Minimum Filtration Membrane Surface Area (ft2 / m2)	Maximum Filter Cartridge Dry Weight (lbs / kg)
15	106 / 9.8	10.5 / 4.8
27	190 / 17.7	15.0 / 6.8
40	282 / 26.2	20.5 / 9.3
54	381 / 35.4	25.5 / 11.6

2.1.4 Backwashing Cartridges The filter device shall have a weir extending above the cartridge deck, or other mechanism, that encloses the high flow rate filter cartridges when placed in their respective cartridge receptacles within the cartridge deck. The weir, or other mechanism, shall collect a pool of filtered water during inflow events that backwashes the high flow rate cartridges when the inflow

event subsides. All filter cartridges and membranes shall be reusable and allow for the use of filtration membrane rinsing procedures to restore flow capacity and sediment capacity; extending cartridge service life.

2.1.5 Maintenance Access to Captured Pollutants The filter device shall contain an opening(s) that provides maintenance access for removal of accumulated floatable pollutants and sediment, removal of and replacement of filter cartridges, cleaning of the sump, and rinsing of the deck. Access shall have a minimum clear vertical clear space over all of the filter cartridges. Filter cartridges shall be able to be lifted straight vertically out of the receptacles and deck for the entire length of the cartridge.

2.1.6 Bend Structure The device shall be able to be used as a bend structure with minimum angles between inlet and outlet pipes of 90-degrees or less in the stormwater conveyance system.

2.1.7 Double-Wall Containment of Hydrocarbons The cylindrical precast concrete device shall provide double-wall containment for hydrocarbon spill capture by a combined means of an inner wall of fiberglass, to a minimum depth of 12 inches (305 mm) below the cartridge deck, and the precast vessel wall.

2.1.8 Baffle The filter device shall provide a baffle that extends from the underside of the cartridge deck to a minimum length equal to the length of the membrane filter elements. The baffle shall serve to protect the membrane filter elements from contamination by floatables and coarse sediment. The baffle shall be flexible and continuous in cylindrical configurations, and shall be a straight concrete or aluminum wall in rectangular configurations.

2.1.9 Sump The device shall include a minimum 24 inches (610 mm) of sump below the bottom of the cartridges for sediment accumulation, unless otherwise specified by the design engineer. Depths less than 24 inches may have an impact on the total performance and/or longevity between cartridge maintenance/replacement of the device.

2.2 PRECAST CONCRETE SECTIONS

All precast concrete components shall be manufactured to a minimum live load of HS-20 truck loading or greater based on local regulatory specifications, unless otherwise modified or specified by the design engineer, and shall be watertight.

2.3 JOINTS All precast concrete manhole configuration joints shall use nitrile rubber gaskets and shall meet the requirements of ASTM C443, Specification C1619, Class D or engineer approved equal to ensure oil resistance. Mastic sealants or butyl tape are not an acceptable alternative.

2.4 GASKETS Only profile neoprene or nitrile rubber gaskets in accordance to CSA A257.3-M92 will be accepted. Mastic sealants, butyl tape or Conseal CS-101 are not acceptable gasket materials.

2.5 FRAME AND COVER Frame and covers must be manufactured from cast-iron or other composite material tested to withstand H-20 or greater design loads, and as approved by the

local regulatory body. Frames and covers must be embossed with the name of the device manufacturer or the device brand name.

2.6 DOORS AND HATCHES If provided shall meet designated loading requirements or at a minimum for incidental vehicular traffic.

2.7 CONCRETE All concrete components shall be manufactured according to local specifications and shall meet the requirements of ASTM C 478.

2.8 FIBERGLASS The fiberglass portion of the filter device shall be constructed in accordance with the following standard: ASTM D-4097: Contact Molded Glass Fiber Reinforced Chemical Resistant Tanks.

2.9 STEPS Steps shall be constructed according to ASTM D4101 of copolymer polypropylene, and be driven into preformed or pre-drilled holes after the concrete has cured, installed to conform to applicable sections of state, provincial and municipal building codes, highway, municipal or local specifications for the construction of such devices.

2.10 INSPECTION All precast concrete sections shall be inspected to ensure that dimensions, appearance and quality of the product meet local municipal specifications and ASTM C 478.

PART 3 – PERFORMANCE

3.1 GENERAL

3.1.1 Verification – The stormwater quality filter must be verified in accordance with ISO 14034:2016 Environmental management – Environmental technology verification (ETV).

3.1.2 Function - The stormwater quality filter treatment device shall function to remove pollutants by the following unit treatment processes; sedimentation, floatation, and membrane filtration.

3.1.3 Pollutants - The stormwater quality filter treatment device shall remove oil, debris, trash, coarse and fine particulates, particulate-bound pollutants, metals and nutrients from stormwater during runoff events.

3.1.4 Bypass - The stormwater quality filter treatment device shall typically utilize an external bypass to divert excessive flows. Internal bypass systems shall be equipped with a floatables baffle, and must avoid passage through the sump and/or cartridge filtration zone.

3.1.5 Treatment Flux Rate (Surface Loading Rate) – The stormwater quality filter treatment device shall treat 100% of the required water quality treatment flow based on a maximum design treatment flux rate (surface loading rate) across the membrane filter cartridges of 0.21 gpm/ft² (0.142 lps/m²).

3.2 FIELD TEST PERFORMANCE

At a minimum, the stormwater quality filter device shall have been field tested and verified with a minimum 25 TARP qualifying storm events and field monitoring shall have been conducted according to the TARP 2009 NJDEP TARP field test protocol, and have received NJCAT verification.

3.2.1 Suspended Solids Removal - The stormwater quality filter treatment device shall have demonstrated a minimum median TSS removal efficiency of 85% and a minimum median SSC removal efficiency of 95%.

3.2.2 Runoff Volume – The stormwater quality filter treatment device shall be engineered, designed, and sized to treat a minimum of 90 percent of the annual runoff volume determined from use of a minimum 15-year rainfall data set.

3.2.3 Fine Particle Removal - The stormwater quality filter treatment device shall have demonstrated the ability to capture fine particles as indicated by a minimum median removal efficiency of 75% for the particle fraction less than 25 microns, an effluent d_{50} of 15 microns or lower for all monitored storm events.

3.2.4 Turbidity Reduction - The stormwater quality filter treatment device shall have demonstrated the ability to reduce the turbidity from influent from a range of 5 to 171 NTU to an effluent turbidity of 15 NTU or lower.

3.2.5 Nutrient (Total Phosphorus & Total Nitrogen) Removal - The stormwater quality filter treatment device shall have demonstrated a minimum median Total Phosphorus removal of 55%, and a minimum median Total Nitrogen removal of 50%.

3.2.6 Metals (Total Zinc & Total Copper) Removal - The stormwater quality filter treatment device shall have demonstrated a minimum median Total Zinc removal of 55%, and a minimum median Total Copper removal of 85%.

3.3 INSPECTION and MAINTENANCE

The stormwater quality filter device shall have the following features:

3.3.1 Durability of membranes are subject to good handling practices during inspection and maintenance (removal, rinsing, and reinsertion) events, and site specific conditions that may have heavier or lighter loading onto the cartridges, and pollutant variability that may impact the membrane structural integrity. Membrane maintenance and replacement shall be in accordance with manufacturer's recommendations.

3.3.2 Inspection which includes trash and floatables collection, sediment depth determination, and visible determination of backwash pool depth shall be easily conducted from grade (outside the structure).

3.3.3 Manual rinsing of the reusable filter cartridges shall promote restoration of the flow capacity and sediment capacity of the filter cartridges, extending cartridge service life.

3.3.4 The filter device shall have a minimum 12 inches (305 mm) of sediment storage depth, and a minimum of 12 inches between the top of the sediment storage and bottom of the filter cartridge tentacles, unless otherwise specified by the design engineer. Variances may have an impact on the total performance and/or longevity between cartridge maintenance/replacement of the device.

3.3.5 Sediment removal from the filter treatment device shall be able to be conducted using a standard maintenance truck and vacuum apparatus, and a minimum one point of entry to the sump that is unobstructed by filter cartridges.

3.3.6 Maintenance access shall have a minimum clear height that provides suitable vertical clear space over all of the filter cartridges. Filter cartridges shall be able to be lifted straight vertically out of the receptacles and deck for the entire length of the cartridge.

3.3.7 Filter cartridges shall be able to be maintained without the requirement of additional lifting equipment.

PART 4 – EXECUTION

4.1 INSTALLATION

4.1.1 PRECAST DEVICE CONSTRUCTION SEQUENCE

The installation of a watertight precast concrete device should conform to ASTM C 891 and to any state highway, municipal or local specifications for the construction of manholes, whichever is more stringent. Selected sections of a general specification that are applicable are summarized below.

4.1.1.1 The watertight precast concrete device is installed in sections in the following sequence:

- aggregate base
- base slab
- treatment chamber and cartridge deck riser section(s)
- bypass section
- connect inlet and outlet pipes
- concrete riser section(s) and/or transition slab (if required)
- maintenance riser section(s) (if required)
- frame and access cover

4.1.2 The precast base should be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, should be installed in accordance with the precast concrete manufacturer's recommendations.

4.1.3 Adjustment of the stormwater quality treatment device can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets should be repaired or replaced as necessary to restore original condition and watertight seals. Once the stormwater quality treatment device has been constructed, any/all lift holes must be plugged watertight with mortar or non-shrink grout.

4.1.4 Inlet and Outlet Pipes Inlet and outlet pipes should be securely set into the device using approved pipe seals (flexible boot connections, where applicable) so that the structure is watertight, and such that any pipe intrusion into the device does not impact the device functionality.

4.1.5 Frame and Cover Installation Adjustment units (e.g. grade rings) should be installed to set the frame and cover at the required elevation. The adjustment units should be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover should be set in a full bed of mortar at the elevation specified.

4.2 MAINTENANCE ACCESS WALL
In some instances the Maintenance Access Wall, if provided, shall require an extension attachment and sealing to the precast wall and cartridge deck at the job site, rather than at the precast facility. In this instance, installation of these components shall be performed according to instructions provided by the manufacturer.

4.3 FILTER CARTRIDGE INSTALLATION Filter cartridges shall be installed in the cartridge deck only after the construction site is fully stabilized and in accordance with the manufacturer's guidelines and recommendations. Contractor to contact the manufacturer to schedule cartridge delivery and review procedures/requirements to be completed to the device prior to installation of the cartridges and activation of the system.

PART 5 – QUALITY ASSURANCE

5.1 FILTER CARTRIDGE INSTALLATION Manufacturer shall coordinate delivery of filter cartridges and other internal components with contractor. Filter cartridges shall be delivered and installed complete after site is stabilized and unit is ready to accept cartridges. Unit is ready to accept cartridges after is has been cleaned out and any standing water, debris, and other materials have been removed. Contractor shall take appropriate action to protect the filter cartridge receptacles and filter cartridges from damage during construction, and in accordance with the manufacturer's recommendations and guidance. For systems with cartridges installed prior to full site stabilization and prior to system activation, the contractor can plug inlet and outlet pipes to prevent stormwater and other influent from entering the device. Plugs must be removed during the activation process.

5.2 INSPECTION AND MAINTENANCE

5.2.1 The manufacturer shall provide an Owner's Manual upon request.

5.2.2 After construction and installation, and during operation, the device shall be inspected and cleaned as necessary based on the manufacturer's recommended inspection and maintenance guidelines and the local regulatory agency/body.

5.3 REPLACEMENT FILTER CARTRIDGES When replacement membrane filter elements and/or other parts are required, only membrane filter elements and parts approved by the manufacturer for use with the stormwater quality filter device shall be installed.

END OF SECTION

APPENDIX C:
STORMWATER MANAGEMENT DRAWINGS
(Provided Separately in Digital Format)