FOSTER WHEELER ENVIRONMENTAL CORPORATION

May 27, 1999
File #: 1284-0034-99-0300

Commanding Officer
Northern Division
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop #82
Lester, PA 19113
Attn: Code 4022 (S. Lehman)

RE: U.S. NAVY CONTRACT NO. N62472-94-D-0398
DELIVERY ORDER NO. 0034-010, NWS EARLE, COLTS NECK, NJ
PRELIMINARY EVALUATION REPORT FOR BILGE WATER
TREATMENT PLANT SYSTEM UPGRADES

Mr. Lehman:

The following represents a preliminary evaluation report of the referenced bilge water treatment plant located in Building R-30, waterfront area, pursuant to the memorandum from Steve Lehman dated January 22, 1999. Bilge water from ships docked at the pier is transported to the Bilge Water Plant via rail tank cars. Tank cars being utilized have capacities of 10,000, 12,000 or 14,000 gallons. The bilge water that is processed through the Bilge Water Plant is a mixture of potable water, seawater, and contaminants from a number of sources. The typical contaminants may include fuels, oils, hydraulic fluids, detergents, septic waters, Aqueous Film Forming Foam (AFFF), solvents and paints.

The basis for the bilge water treatment plant evaluation is due to the high operation and maintenance costs and persistent fouling of the existing treatment system. The system fouling is primarily occurring in the existing ultrafiltration (UF) membranes. Once the UF units become fouled, the process flow rate is greatly reduced from approximately 10 gpm down to 1–3 gpm. The replacement cost of the fouled UF units is substantial and occurs more frequently than estimated at the time of the existing system's original design. By extending the life of UF units, if possible, the operation and maintenance costs can be reduced. The UF fouling issues are further described below.

There are several tasks that this evaluation report identifies and provides potential solutions. The first task is to increase the process capacity of the treatment system to 20 gallons per minute (gpm) from the current capacity of 10 gpm. The second task is to increase the overall removal efficiency of the treatment system by modifying some of the system components and/or adding other components. The third task is to increase the process capacity of only the oil/water separator to 50 gpm for water batches that are known to contain only oily water.

Table 1 represents a compilation of several laboratory analytical reports to establish a basis for potential influent bilge water quality. Table 1 lists the contaminants and their anticipated average and maximum concentrations in the influent stream to the oil/water separator as well as the discharge permit limits. In

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addition, the mass rates for the various contaminants are calculated in Table 1, assuming a process flow rate of 20 gpm.

EXISTING TREATMENT SYSTEM:

The existing influent transfer pump is currently set-up to pump water at approximately 10 gpm @ 30 psi. The pump is configured in a belt & sheave arrangement so operating flow rates can be adjusted. By modifying the belts & sheaves the maximum flow rate that can be produced by the existing pump would be approximately 20 gpm @ 10 psi, but the pump would be turning at about 600 RPM. The pump motor speed should remain below 300 RPM to minimize emulsion effects by the pump. If the motor size is increased to 3.0 horsepower (from the existing 2.0 Hp), the pump could produce a maximum of 25 gpm @ 10 psi, but the pump motor speed would again be 600 RPM. To produce higher process flow rates (up to 50 gpm) at a lower RPM (< 300 RPM), the pump and motor would need to be replaced. As an option, the existing pump could be upgraded (potentially used with the existing motor) for a 25 gpm flow rate and an identical pump and motor could be installed in parallel to operate at total flow rate 50 gpm when needed.

The existing oil/water separator is currently sized for a process flow rate of 10 gpm. A retrofit kit is available from the manufacturer (Facet International, Inc.) to increase the process flow rate to a maximum of 20 gpm. The kit requires the change-out of the packing material, the lid, and other minor changes to the separator. In addition, it is required that the influent pressure pump is removed and a vacuum pump installed after the separator. The existing configuration is set up so that the influent water stream is lifted from below ground piping, therefore, a different configuration would need to be pursued if this is the desired oil/water separator type.

A vortex type particulate separator is located after the oil/water separator. The existing vortex type particulate separator causes a large flow restriction. An additional or a larger vortex separator should be installed to increase the flow capacity or replaced with a different type of particulate removal device (i.e. sand filter, bag filter, etc.) to provide greater flow capacity.

The existing UF membranes are currently the primary concern due to excessive fouling and the subsequent cost in replacing them. The fouling of the UF units can be due to several causes such as incompatible solvents in the process stream, inadequate VOC pretreatment, improper recirculation rates/pressures, improper UF membrane cleaning procedures, or any combination these possibilities. These are some of the potential causes that FWENC was able to determine without performing any pilot tests.

The UF units are intended to operate as part of a recirculation loop at a relatively high flow rate (200 gpm) compared to the actual process flow rate (10–20 gpm). The UF units are also sensitive to the operating pressures through the UF filter housings. If the balance between the flow rate and operating pressure is not correct, fouling can occur very quickly. The optimum operating conditions can be determined through bench scale tests or with the full-scale system on-site.

To increase the process flow rate through the UF units, several possibilities exist. The existing UF units can be replaced with similar UF units that have a larger surface area (95 ft^2 with larger housings instead of

40 ft^2), but with the same pore size (100,000 nominal molecular weight cutoff [NMWC]). The existing UF units can be replaced with the same size surface area filters, but with a larger pore size (300,000 or 500,000 NMWC). The existing UF units can remain and just add more UF units (add 8 to 16 more units) to increase the flow rate. Any combination of these options is also possible.

Another option for the UF units is to use silica ceramic tube cartridges instead of the existing polymeric cartridges. The advantage to the silica ceramic cartridges is that they resist some solvents better than the existing polymeric cartridges. However, there are several disadvantages in using the silica ceramic cartridges. The tube lumen diameter is larger (2 - 3 mm) than the existing cartridges (1 mm), which means that the housings would contain less tubes and less overall surface area per cartridge, which translates to lower removal potential per cartridge. A larger lumen diameter also requires a significantly higher recirculation rate (i.e. larger recirculation pump, piping, fittings, etc.). To equate the removal potential to the existing cartridges, additional filter housings and a larger capacity pump would need to be installed. The silica ceramic cartridges are also more costly (generally 3 to 4 times higher) to purchase and are prone to fouling almost as often as compared to the existing polymeric cartridges. In addition, the silica ceramic cartridges have an adverse reaction to phenols.

ALTERNATE TREATMENT EQUIPMENT:

OPTION 1:

The first observation is that the bilge water that has been sitting in the railcar tanks for a period of time is suddenly drained into a sump and pumped through the system. This process agitates and re-emulsifies the oil(s) in the bilge water and makes it more difficult to separate the oil(s) back out. By using the idle time of the bilge water in the railcars to our advantage, the bilge water could be gravity drained directly through a below ground oil/water separator. The separated water could then be pumped through the system for final treatment.

The below ground oil/water separator provides a good alternative by minimizing the re-emulsification effects caused by transferring the bilge water from the rail cars to the treatment system. The disadvantage of this approach is that there is little room available for the installation of such a unit below ground on-site. The shallow water table and the proximity to the bay would complicate the installation with tidal effects and salinity factors. Another difficulty is that the existing below grade piping would have to be rearranged to accommodate this unit.

OPTION 2:

As an alternative, a different treatment technology could be added to the existing treatment train. The influent wastewater stream could be directed through a larger oil/water separator at 20 gpm (50 gpm maximum). The effluent from the oil/water separator could then be directed through a dissolved air floatation (DAF) unit, tertiary filter and then either polished with the existing UF units or discharged to the Publicly Owned Treatment Works (POTW).

The DAF unit is used to remove suspended solids and emulsified oils from the wastewater stream. The DAF unit uses compressed air to produce microscopic bubbles along with a coagulant and a flocculent (long-chain polymer). The floc particles float to the surface of the DAF unit where they are continuously skimmed off into a holding tank. Higher density particles settle to the bottom of the DAF unit where an auger mechanism continuously directs the solids to a separate collection chamber. The coagulants and flocculents each need to be contained, mixed and properly metered into the DAF unit. The actual amounts of coagulant and flocculent to be metered will periodically vary and must be continuously monitored.

The tertiary filter is used to remove suspended solids and metals. Tertiary filters are generally used in sets of three to facilitate automatic use and cleaning. Through instrumentation and controls sequencing, the three units will work separately to treat the wastewater stream and work in pairs to backwash the third unit. The units are automatically alternated to be on-line. The units process the wastewater stream continuously, even during the backwashing cycle. The backwash water would be circulated into a holding tank for solids separation.

The DAF and tertiary filter units will provide good treatment for the removal of emulsified oils. However, the disadvantage of the DAF unit is that it requires frequent monitoring while operating, and the system generates additional waste streams (flocculation foam and solids) that need to be managed and disposed. The DAF unit should not be operated unattended as per the manufacturer's recommendations. Also, there is an added expense for coagulants and flocculents, which need to be metered into the DAF at a continuous rate. The tertiary filter can run with little supervision, but the backwashing cycle will require a tank to recycle into, which is another waste stream. Both the DAF and tertiary filter units require an oil/water separator as pretreatment and polish treatment of UF units, granular activated carbon or other similar units. In addition, auxiliary equipment that is needed to properly operate a DAF system are an equalization tank, filter press, and other sludge management equipment.

OPTION 3:

Similar to Option 2, the effluent from the oil/water separator could be directed through a new treatment unit, an air stripper. A shallow tray type air stripper would work well for the removal of volatile organic compounds (VOCs). A counter-current air stream is forced upward through a series of perforated trays at the same time the wastewater stream is flowing downward. This process greatly agitates the wastewater stream and VOCs are released into the effluent vapor stream. The effluent wastewater stream would proceed to additional treatment processes. The influent wastewater stream to the air stripper is generally filtered of particulates to reduce stripper fouling. The effluent wastewater stream of the air stripper is generally filtered due to the air stripper process itself causing the oxidation and precipitation of metals.

The air stripper would provide good VOC removal, but the effluent vapor stream may need to be treated prior to discharge to the atmosphere. The air stripper off-gas is generally treated with a catalytic/thermal oxidizer or vapor-phase granular activated carbon. High off-gas concentrations of chlorinated compounds could produce acid gases by an oxidizer (which would have to be scrubbed) or a high carbon change-out frequency. The off-gas treatment costs could be very significant.

OPTION 4:

The use of an organo-clay filter unit to remove oils, VOCs, and some suspended solids would be another potential treatment method, similar to Option 2, with the effluent of the oil/water separator entering the organo-clay filter. The organo-clay filter is a pressure vessel that contains chemically modified clay and anthracite filtration media. The anthracite is placed at the bottom of the filter housing and is used to better facilitate drainage through the filter unit. The organo-clay filter unit is backwashed when its pressure differential is 15 pounds per square inch (psi). When backwashing the filter unit does not reduce the pressure differential, the organo-clay filter media must be changed-out.

The organo-clay filter unit is recommended by the manufacturer to be operated with a particulate filter installed between the organo-clay filter and the UF units. The particulate filter should be capable of filtering down to 0.5 microns (μm). In addition, the manufacturer recommends that liquid-phase granular activated carbon should be placed on-line as a final polish after the UF units.

The organo-clay filter unit would provide good VOC and suspended solids removal after the oil/water separator. This filter unit can operate with minimum supervision and most often unattended. The disadvantage of this unit is that the filter media would need to be changed-out periodically. Based upon loading estimates, the filter media would need to be backwashed weekly and changed-out after approximately 25 days assuming a constant operation of 20 gpm. An additional tank would be installed for backwashing activities.

OPTION 5:

Treatment of the bilge water stream could be accomplished utilizing liquid-phase granular activated carbon adsorbers after the oil/water separator. The liquid-phase carbon adsorbers could also be used to polish the wastewater stream after the UF units, after an air stripper or a number of other combinations. Liquid-phase carbon adsorbers operate best when used as a polish treatment for the removal of VOCs. In addition, the wastewater stream entering the liquid-phase carbon adsorbers should be filtered of particulates, which could mask the carbon granules and reduce the adsorption potential.

The liquid-phase carbon adsorbers are an efficient treatment for VOCs when used as a polishing method. However, certain chemical compounds that could be processed as part of the bilge water stream could have an adverse reaction with the carbon if they are present in sufficient concentration (i.e. ketones). Also, depending upon the mass loading rate onto the carbon adsorbers (if they are the only treatment after the oil/water separator) the cost associated with carbon change-outs could be excessive. Therefore, the carbon adsorbers would be best used as a polish.

PRELIMINARY COST OF NEW EQUIPMENT:

FWENC has obtained preliminary cost estimates from equipment vendors for the large equipment items, which could be used for system upgrades. Costs for labor, subcontractor fees and other minor equipment

and instrumentation/controls have not been included unless otherwise indicated. The large equipment item costs are presented in the table below for each option.

Option	Description	Cost
1	Below ground oil/water separator	$28,500
	Influent pump	$3,500
	(Plus other treatment equipment to be selected below)	
2	Oil/water separator	$8,000
	Influent pump	$3,500
	Dissolved air flotation (with metering & mixing components)	$100,000
	Automatic tertiary filters	$30,000
	Equalization tank and control/instrumentation systems	$50,000
	Filter press and sludge management equipment	$30,000
3	Shallow tray air stripper (off-gas treatment is additional)	$24,000
	Oil/water separator	$8,000
	Influent pump	$3,500
	Transfer pump	$3,500
	Particulate filters (2 units)	$3,000
4	Organo-clay filter	$6,000
	Organo-clay media change-out and disposal (per event)	$2,200
	Influent pump	$3,500
	Transfer pump	$3,500
	Backwash/holding tank	$2,000
	Particulate filter	$1,500
	Liquid-phase carbon adsorbers for polishing (2 units)	$3,000
5	Liquid-phase carbon adsorbers (2 units)	$20,000
	Oil/water separator	$8,000
	Influent pump	$3,500
	Transfer pump	$3,500
	Particulate filter	$1,500

Other costs, which FWENC has obtained, were for a new full-scale system approach. These costs ranged from $116,000 to $202,000. These systems utilized the DAF type treatment, however, the scale of the systems would occupy most of the room in the existing building and did not adequately address the reuse of the existing UM. Additionally, these approaches were not intended to be procured and installed in steps. They must be installed and operated as a package system.

RECOMMENDATIONS:

It is FWENC's recommendation that the best approach to the enhancement of the bilge water treatment system is to proceed in steps. The first step would be to maximize the usefulness of the existing UM. Following discussions with the UF membrane manufacturer, there was some concern that the UF units

were not being properly or thoroughly cleaned or that maybe the operation could be modified to produce better efficiency. The manufacturer's concern stems from the fact that since the bilge water treatment application using the UF units could contain a dramatic change in contaminants and their concentrations from batch to batch, the operation and cleaning procedures should be dynamic. To accomplish this, the recirculation pump rates/pressures should be frequently monitored and modified if needed. Also, a different or modified solvent or cleaning procedure could be performed to clean the UF units than what is currently being done. The switching of the UF units to a silica ceramic type would be costly compared to the limited benefit and is not recommended.

The next step would be to perform a pilot test with organo-clay filter units. FWENC currently has two organo-clay filter units that could be connected to the existing bilge water treatment system and operated to determine their effectiveness under on-site conditions.

Pending the results of the pilot testing, a larger oil/water separator and the organo-clay filter would be installed as the next step. The organo-clay filters can be added between the oil/water separator and the UF units as a step treatment. The organo-clay filters would prolong the life of the UF units. Other ancillary equipment needed for this arrangement would be: larger capacity influent pump(s), an additional transfer pump between the oil/water separator and the organo-clay filter, a particulate filter between the organo-clay filter and the UF units, and a holding tank to be used for backwashing the organo-clay filter (see Figure 1). As a potential further step, the addition of liquid-phase granular activated carbon could be installed as a final system polish.

Please contact me at (215) 702-4066 or Michael Heffron at (215) 702-4015 with any questions.

Sincerely,

Brian K. Blanchard
Senior Mechanical Engineer

Michael Heffron, P.G.
Delivery Order Manager

cc: L. Burg (NWS-Earle)
D. DiCesare (FWENC)
A. Holcomb (FWENC)
File

TABLE 1: ANTICIPATED INFLUENT CONCENTRATIONS AND MASS RATES
Bilge Water Treatment Plant, Building R-30
NWS - Earle, Colts Neck, NJ

Parameter	Average Concentration (ug/L)	Maximum Concentration (ug/L)	Process Flow Rate (gpm)	Average Mass Rate (lbs/hr)	Maximum Mass Rate (lbs/hr)	Discharge Limit (ug/L)
Volatiles						
methyl tertiary butyl ether	26.2	176.3	20	0.000262	0.001765	- -
acetone	34.8	193.7	20	0.000348	0.001940	- -
methylene chloride	404.7	5454	20	0.004052	0.054612	- -
1,1-dichloroethane	0.4	5.6	20	0.000004	0.000056	- -
2-butanone	4.6	23.5	20	0.000046	0.000235	- -
chloroform	88.2	1150	20	0.000883	0.011515	- -
1,1,1-trichloroethane	0.131	1.83	20	0.000001	0.000018	- -
benzene	97.2	1319	20	0.000973	0.013207	- -
bromodichloromethane	0.537	7.52	20	0.000005	0.000075	- -
4-methyl-2-pentanone	1.51	11.1	20	0.000015	0.000111	- -
toluene	1,545	21,407	20	0.0155	0.2144	- -
ethylbenzene	2,377	33,122	20	0.0238	0.3317	- -
m&p-xylenes	7,251	101,018	20	0.0726	1.0115	- -
o-xylenes	6,054	84,293	20	0.0606	0.8440	- -
1,4-dichlorobenzene	52.1	726.4	20	0.000522	0.007274	- -
Semi-Volatiles						
2-methylphenol	3.09	26.5	20	0.000031	0.000265	- -
4-methylphenol	2.26	19.9	20	0.000023	0.000199	- -
2,4-dimethylphenol	5.26	46.1	20	0.000053	0.000462	- -
benzoic acid	0.338	4.4	20	0.000003	0.000044	- -
naphthalene	3.2	28.6	20	0.000032	0.000286	- -
2-methylnaphthalene	239,767	2,246,232	20	2.401	22.492	- -
phenanthrene	1,717	22,325	20	0.0172	0.2235	- -
di-n-butylphthalate	0.146	1.9	20	0.000001	0.000019	- -
bis (2-ethylhexyl) phthalate	0.08	1.04	20	0.000001	0.000010	- -
total petroleum hydrocarbons	3,412,475	15,539,000	20	34.17	155.60	- -
Metals						
beryllium	155.8	1870	20	0.00156	0.01872	- -
cadmium	170.2	2340	20	0.00170	0.02343	110
chromium	168.5	2320	20	0.00169	0.02323	23
copper	1,399	15,500	20	0.01401	0.15521	150
lead	18.5	107	20	0.000185	0.001071	150
mercury	0.636	3.7	20	0.000006	0.000037	200
nickel	292	2,470	20	0.00292	0.02473	200
selenium	637	7,010	20	0.00638	0.07019	- -
thallium	15.7	131	20	0.000157	0.001312	- -
zinc	1531	14,800	20	0.0153	0.1482	700
Other						
BOD (mg/L)	42.9	50	20	0.430	0.501	250
Total Suspended Solids (mg/L)	104.5	283.2	20	1.046	2.836	250
Total Organic Carbon (mg/L)	18.7	48	20	0.187	0.481	250
pH (S.U.)	6.99	7.5	20			6.0 - 9.0

NOTES:

Source = Analytical Data Reports from NWS-Earle Bilge Water Plant, 1998 - 1999

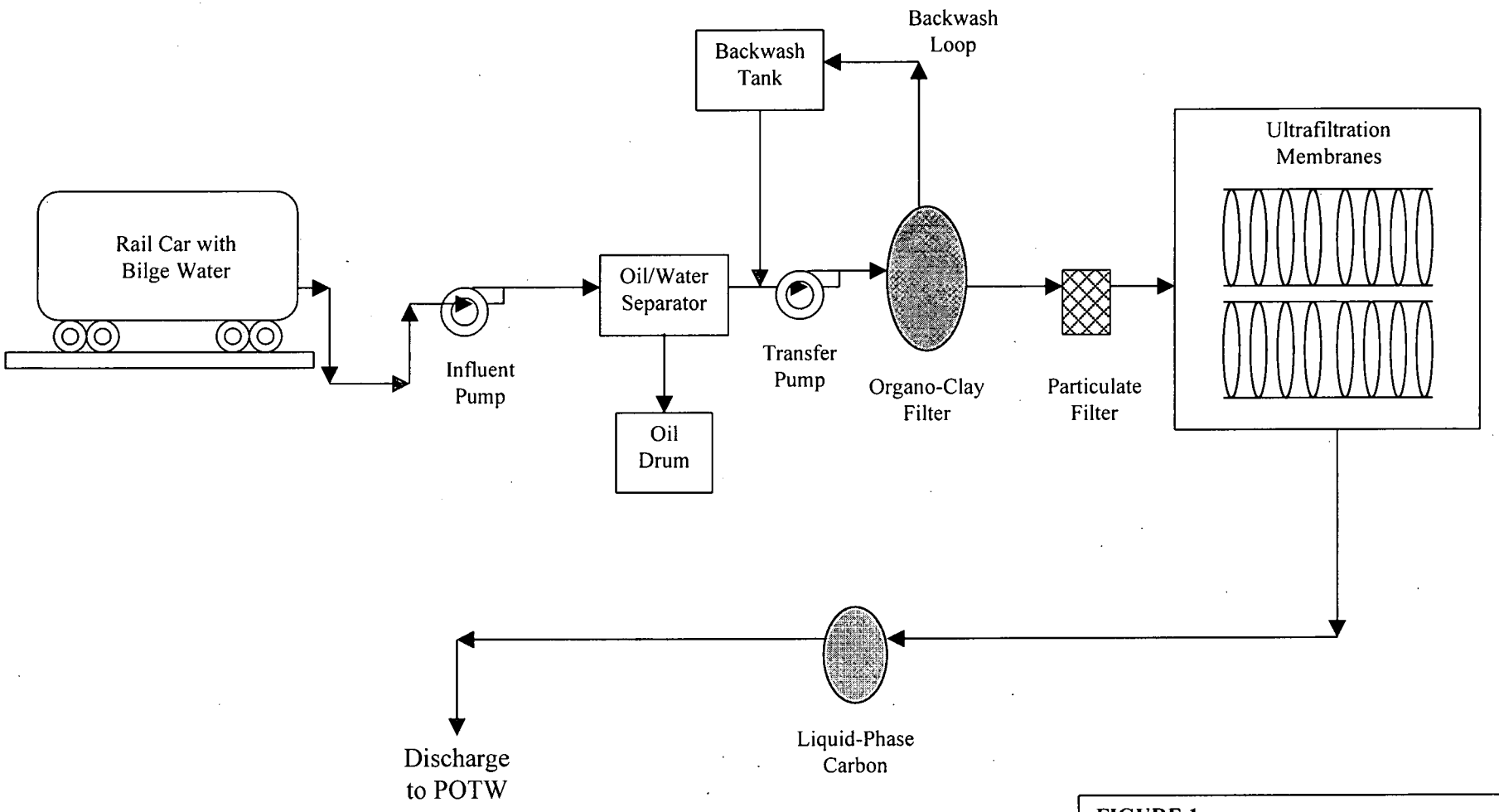

FIGURE 1

PROPOSED PROCESS FLOW DIAGRAM
(Option 4)
Bilge Water Treatment Plant, Building R-30
NWS – EARLE, Colts Neck, NJ