Briefing for OMSAP workshop on ambient monitoring revisions
March 31-April 1, 2003

Massachusetts Water Resources Authority

Environmental Quality Department
ENQUAD Report ms-083

Information Briefing to Outfall Monitoring Science Advisory Panel

To: Dr. Andrew Solow, Chair OMSAP
From: Dr. Andrea Rex, Director, Environmental Quality, MWRA
Cc: OMSAP, IAAC, PIAC
Date: March 21, 2003
Subject: Briefing materials for review of effluent, fish and shellfish, sediment contamination and hard-bottom community monitoring

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MWRA is in the process of reviewing its outfall monitoring program, using the process described in its NPDES discharge permit. As the Outfall Monitoring Science Advisory Panel requested, a two-day workshop has been scheduled for March 31 and April 1, 2003 to review the Outfall Ambient Monitoring Plan. The monitoring areas for review include effluent, fish and shellfish, sediment contamination, and hard-bottom communities. Briefing materials for each of these four monitoring areas, together with an introduction, are attached. MWRA is preparing a CD of appendices that include related synthesis reports and additional data. The CD will be available on MWRA's website, or can be obtained on disk from MWRA on request.

A second two-day workshop to review water column monitoring is scheduled for June 18 and 19, 2003, and a later one-day workshop will be scheduled to review benthic community monitoring.

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I INTRODUCTION

Since 1985, MWRA has worked to minimize the effects of wastewater discharge on the marine environment by ending the discharge of sludge and inadequately treated effluent into Boston Harbor, reducing pollutants at their source, improving wastewater treatment to modern standards, and providing increased dilution. Concerns about potential effects of moving the effluent outfall from the harbor to Massachusetts Bay have been recognized by MWRA and by the joint permit for the outfall issued by the U.S. Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection (MADEP).

MWRA is committed to ensuring good treatment and to conduct monitoring necessary to ensure that environmental impact of the discharge is minimal. This commitment is formalized in MWRA's discharge permit, which requires MWRA to monitor the effluent and the ambient receiving waters for compliance with permit limits and in accordance with the monitoring plan (MWRA 1991, 1997a). EPA and MADEP have established an independent panel of scientists, the Outfall Monitoring Science Advisory Panel (OMSAP), to review monitoring data and provide advice on key scientific issues related to the permit. The monitoring plan can be modified, under OMSAP's guidance, to incorporate new scientific information and improved understanding resulting from the monitoring.

In the current fiscal year, MWRA will spend over $5 million on effluent monitoring and environmental studies of Massachusetts Bay.

Table I-A. Breakdown of July 2002-June 2003 permit-required monitoring costs by project area

Project area	MWRA cost	Cost-share
Effluent	$330,000	$79,000
Outfall	$3,702,000	$895,000
water column	1,835,000	595,000
benthos	1,155,000	300,000
fish/shellfish	368,000	
pathogens	344,000	
Model	$136,000	$52,000
Permit reporting and management	$900,000	
Total	$5,068,000	$1,026,000

MWRA's outfall monitoring program (MWRA, 1991, 1997a) was originally designed to determine the effects on Massachusetts Bay of five years of discharge of primary-treated effluent followed by continued discharge of secondary-treated effluent. The expected contaminant loads from the discharge (EPA, 1988) were based on very imprecise estimates. Because of concern about the effects of a primary treated discharge on dissolved oxygen, organic loading to the sea floor, and accumulation of toxic contaminants, the monitoring program was quite

comprehensive. Due to outfall construction delays, the secondary treatment plant was completed before offshore discharge started. In addition, effluent flow is lower than had been estimated, meaning more of the flow receives secondary treatment. Finally, measured toxic contaminant concentrations are lower than had been assumed in outfall siting studies even for full secondary treatment (see Table I-B.) There are now more than two years of post-discharge monitoring to compare with baseline conditions; monitoring results to date document minimal environmental effect. Thus it is appropriate to revisit the monitoring program, as recommended by the National Research Council (NRC, 1990), and refocus it on the potential for long-term chronic effects. Ongoing effluent monitoring will remain the core of the monitoring program.

Table I-B: Projected Supplemental Environmental Impact Statement (SEIS) Contaminant Loadings (EPA, 1988) *vs.* Measured Loadings (pounds/day)

	SEIS projection (average day, year 2020)	2000 actual (relatively low percentage secondary)	2002 actual (high percentage secondary)
Flow (million gallons/day)	390	381	336
Percent of flow receiving secondary treatment	100	85	96
Cadmium	4.2	0.4	0.2
Chromium	21.2	5.1	3.8
Copper	72	60.1	40.3
Lead	29.9	<10.4	<5.5
Mercury	1.3	0.11	0.07
Nickel	53.8	10.7	8.3
Silver	1.8	1.9	1.2
Zinc	207.9	124.8	84.7
total DDT	0.033	0.005	0.004
total PCB	0.3	0.02	0.006

The monitoring task areas under discussion at the March 31-April 1, 2003 OMSAP workshop include effluent, fish and shellfish, sediment chemistry, and hard-bottom community monitoring. For each area, this briefing package includes a brief summary of the monitoring approach, a description of key results, and MWRA recommendations for monitoring plan modifications.

No modifications are being recommended to effluent monitoring at this time. Recommended changes to the fish and shellfish monitoring are in frequency of sampling, and, for flounder, deletion of two sampling stations. Sediment chemistry monitoring would include more integration of results from grab samples, sediment cores, and sediment traps, with most stations having the full suite of contaminants analyzed every third year rather than every year. Recommended changes to the hard-bottom study are to drop one or more of the highly variable stations and to add a more distant reference station.

References

EPA. 1988. Boston Harbor Wastewater Conveyance System. Supplemental Environmental Impact Statement (SEIS). Boston: Environmental Protection Agency Region 1.

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NRC. 1990. Managing Troubled Waters: The Role of Marine Monitoring. National Research Council. National Academy Press, Washington, DC. 125pp.

II MWRA EFFLUENT MONITORING

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II-1 Ensuring Effluent Quality: Pollution Prevention and Wastewater Treatment

The most important part of protecting Massachusetts Bay from pollution is ensuring that the final treated effluent is as clean as possible. MWRA accomplishes this through a vigorous pretreatment program and pollution prevention initiatives that minimize toxic contaminants entering the waste stream, and by maintaining and operating the treatment plant well. The MWRA toxic reduction and control program sets and enforces limits on the types and amounts of pollutants that industries can discharge into the sewer system. This has the important effect of minimizing contaminants in effluent and in the sludge that is removed during secondary treatment, enabling beneficial re-use of treated sludge.

Secondary treatment further reduces the concentrations of contaminants of concern (except nutrients) that are in the effluent that is ultimately discharged to Massachusetts Bay.

To prevent accidental discharge of pollutants to the system, MWRA has implemented best management practice plans for the Deer Island plant, its headworks facilities, the combined sewer overflow facilities, and the sludge pelletizing plant. Best management practices include daily visual inspections and immediate corrective response. Effectiveness of BMP measures are assessed by non-facility staff.

The extensive monitoring required in MWRA's stringent discharge permit, and the additional monitoring required in the Ambient Monitoring Plan and the Contingency Plan demonstrate how well the flow is treated.

MWRA is not proposing modifications to the effluent requirements in the Ambient Monitoring Plan at this time. Effluent monitoring data are presented here in detail because these results show that the plant is performing as well or better than anticipated in initial environmental impact studies during the treatment plant's design phase, and because the quality of the effluent provides a foundation for changes that MWRA will propose in the fish and shellfish and sediment contamination monitoring.

Pollution prevention

Details of MWRA's pollution prevention program are in the "*Massachusetts Water Resources Authority Industrial Waste Report, No. 18 October 2002*" on the web at http://www.mwra.com/sewer/html/trac_indust02.pdf. In addition to regulation of industrial discharges, MWRA's recent initiatives include programs for source reduction of mercury from dental facilities and household hazardous waste education programs. The report shows that in FY02 (ending June, 2002) there was no evidence of interference with treatment by toxic contaminants at the Deer Island Treatment Plant (DITP); sludge pellets met EPA Type 1 sludge criteria and met Massachusetts DEP criteria for Type 1 sludge except for molybdenum. In

August, 2002 however, a high-sulfate industrial discharge to DITP did cause an upset of the secondary treatment process, discussed further below in section II-3.

Table II-1.A summarizes levels of influent organic and metal contaminants to the Deer Island Treatment Plant, which have remained at low levels since the early 1990's.

Table II-1.A Influent contaminant loadings

Constituent	Loading (lbs/day)	
	2001	2002
Arsenic	2.4	2.2
Chromium	15.0	10.0
Copper	188	172
Lead	37.2	25.3
Mercury	0.67	0.48
Nickel	14.4	11.0
Silver	4.9	3.9
Zinc	321	294
VOA	532	485
Pesticides	0.040	0.043
Phthalates[1]	58.9	64.1
Total phenols	104	120
PAHs[2]	28.5	26.5

[1]**Phthalates:**
BIS(2-ETHYLHEXYL)PHTHALATE
BUTYL BENZYL PHTHALATE
DI-N-BUTYLPHTHALATE
DI-N-OCTYLPHTHALATE
DIETHYL PHTHALATE
DIMETHYL PHTHALATE

[2]**PAH's** are estimated based on 9 samples and include
2-METHYLNAPHTHALENE
ACENAPHTHENE
ACENAPHTHYLENE
ANTHRACENE
BENZO(A)ANTHRACENE
BENZO(A)PYRENE
BENZO(B)FLUORANTHENE
BENZO(GHI)PERYLENE
BENZO(K)FLUORANTHENE
CHRYSENE
DIBENZO(A,H)ANTHRACENE
DIBENZOFURAN
FLUORANTHENE
FLUORENE
INDENO(1,2,3-CD)PYRENE
NAPHTHALENE
PHENANTHRENE
PYRENE

Effects of Secondary Treatment

Biological secondary treatment effectively removes the remaining contaminants except for nutrients. Figure II-1A shows how the proportion of flows receiving secondary treatment increased as construction on the DITP progressed; the final battery of secondary treatment was completed in the spring of 2001 (mid FY2001). Figure II-1.B shows how solids discharges from MWRA sources including Deer Island and Nut Island treatment plants and sludge decreased by 80% since the beginning of the Boston Harbor project and Figure II-1.C illustrates how biochemical oxygen-demanding constituents also dramatically declined.

Figure II-1.A MWRA primary and secondary treated flows 1990-2002

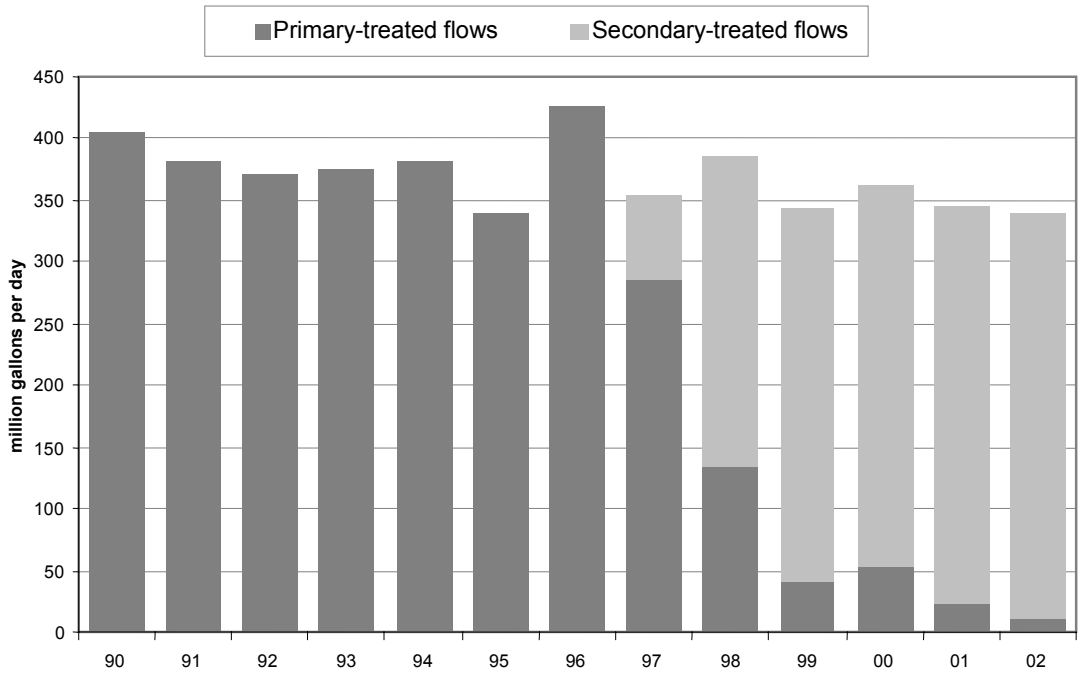


Figure II-1.B MWRA solids discharges 1988-2002

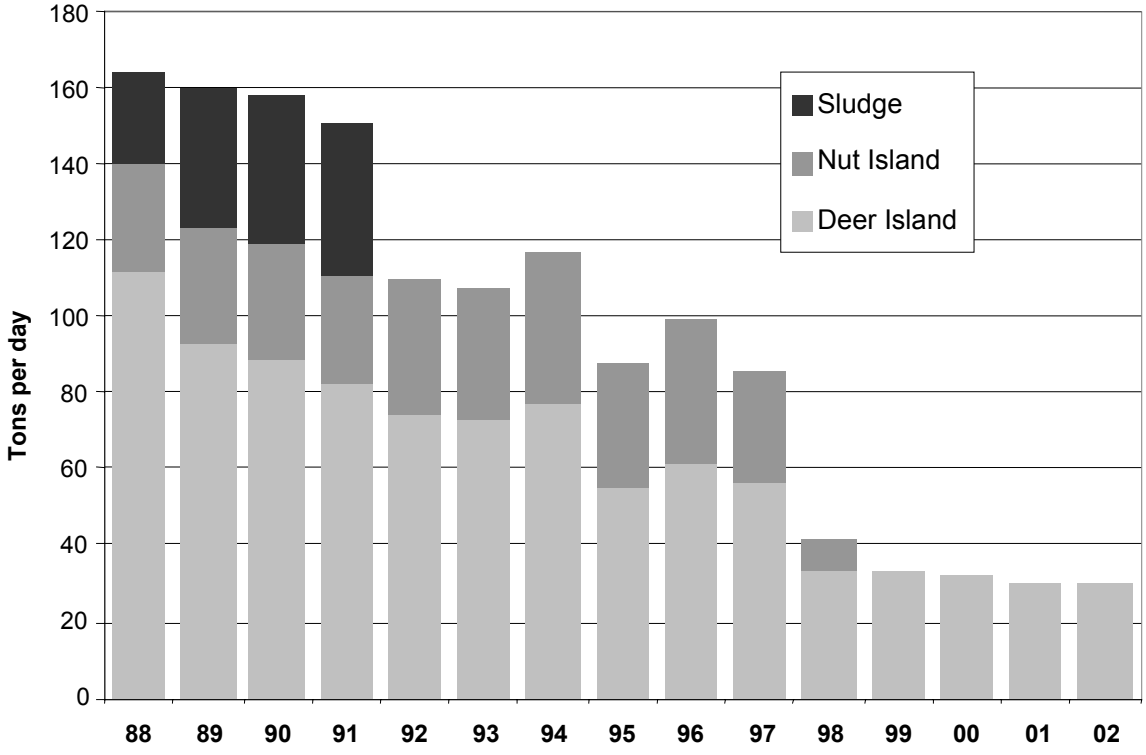


Figure II-1.C Biochemical Oxygen Demand in MWRA Discharges 1994-2002

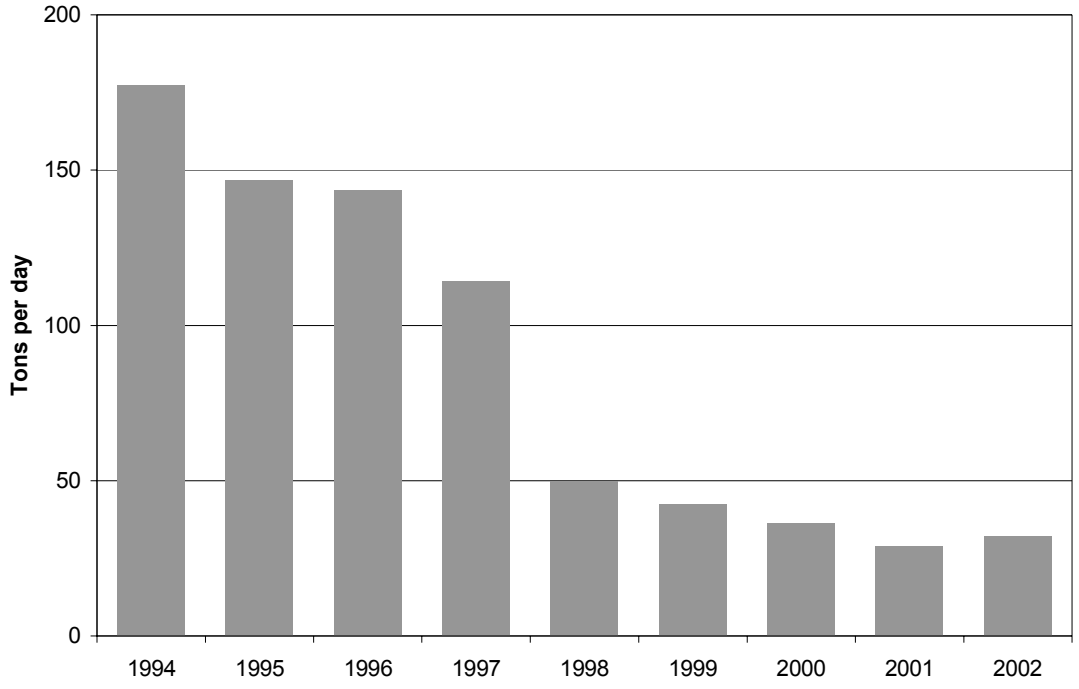


Table II-1.B shows that the percent of flow receiving activated sludge secondary treatment since FY1999 has increased. The percent of flow receiving secondary treatment varies with rainfall; the more it rains, the smaller the proportion of flow receiving secondary treatment. Thus, 88% of flow received secondary treatment in FY2001, a wet period, and 98% of flow received secondary treatment in FY2002, a dry period. Note, however that TSS and BOD removal were high in both those years.

Table II-1.B TSS and BOD removal efficiencies

MWRA Fiscal Year (July-June)	TSS removal (%)	BOD or cBOD removal (%)	Percent of flow receiving secondary treatment
FY1999	87	80	86
FY 2000	89	83	89
FY 2001	91	89	88
FY2002	92	90	98

Operation and Maintenance Requirements in Permit

MWRA's discharge permit requires that MWRA submit an operation and maintenance plan to regulatory agencies, and report on the results of the implementation of that plan annually. The most recent report is on the web at: http://www.mwra.com/harbor/pdf/omstatus02.pdf

The report summarizes operation and maintenance activities at the treatment plant, conveyance facilities and pipelines, and the sludge pelletizing facilities.

II-2 Tracking effluent quality: Monitoring requirements

MWRA's effluent monitoring requirements are laid out in three different areas of the permit: standard discharge monitoring requirements reported to regulatory agencies monthly in the National Polluant Discharge Elimination Program (NPDES) Discharge Monitoring Reports (DMRs), additional requirements in the outfall Contingency Plan, and requirements in the Ambient Monitoring Plan.

Monitoring questions

In the Ambient Monitoring Plan (AMP), the monitoring questions on effluent quality address whether MWRA is meeting its permit limits, thus the monitoring to answer these questions will continue. The questions in the AMP are:

1. Do effluent pathogens exceed permit limits?
2. Does acute or chronic toxicity of effluent exceed permit limits?
3. Do effluent contaminant concentrations exceed permit limits?
4. Do conventional pollutants in the effluent exceed permit limits?

Additional effluent monitoring requirements in the Monitoring Plan and the Contingency Plan beyond those in the NPDES DMR monitoring address emerging issues that the Outfall Monitoring Task Force saw as concerns, for example nutrient loading, newer pathogen indicators, and non-standard low-detection methods for measuring contaminants in the effluent. The tables in Section II-2 list the effluent parameters measured for the different types of permit requirements, and Section II-3 presents results of effluent monitoring.

Permit discharge monitoring requirements

These requirements, shown in Table II-A, are typical for wastewater treatment permits, and are not subject to modification under the Ambient Monitoring Plan provisions of the permit. Some of the parameters have limits and some are "report only."

Table II-2.A MWRA permit-required DMR monitoring for Deer Island Treatment Plant effluent

Parameter	Sample Type	Frequency	Limit
Flow	Flow meter	Continuous	report only
Flow dry day	Flow meter	Continuous	436 MGD annual average
cBOD	24-hr composite	1/day	40 mg/L weekly 25 mg/L monthly
TSS	24-hr composite	1/day	45 mg/L weekly 30 mg/l monthly
pH	Grab	1/day	not <6 or >8
Fecal coliform bacteria	Grab	3/day	14,000 col/100ml
Total residual chlorine	Grab	3/day	631ug/L daily 456 ug/L monthly
PCB, Aroclors	24-hr composite	1/month	0.045 ng/L
Toxicity LC50	24-hr composite	2/month	50%
Toxicity C-NOEC	24-hr composite	2/month	1.5%
Settleable solids	Grab	1/day	Report
Chlorides (influent only)	Grab	1/day	
Mercury	24-hr composite	1/month	
Chlordane	24-hr composite	1/month	
4,4' – DDT	24-hr composite	1/month	
Dieldrin	24-hr composite	1/month	
Heptachlor	24-hr composite	1/month	
Ammonia-nitrogen	24-hr composite	1/month	
Total Kjeldahl nitrogen	24-hr composite	1/month	
Total nitrate	24-hr composite	1/month	
Total nitrite	24-hr composite	1/month	
Cyanide, total	Grab	1/month	
Copper, total	24-hr composite	1/month	
Total arsenic	24-hr composite	1/month	
Hexachlorobenzene	24-hr composite	1/month	
Aldrin	24-hr composite	1/month	
Heptachlor epoxide	24-hr composite	1/month	
Total PCBs	24-hr composite	1/month	
Volatile organic compounds	Grab	1/month	

Monitoring requirements in the Contingency Plan

All of the DMR effluent monitoring limits have Contingency Plan thresholds; the Warning Level thresholds are the permit limitations. The Contingency Plan specifies additional thresholds for the parameters in Table II-2.B.

Table II-2.B Parameters reported as required in the Contingency Plan

Parameter	Sample type	Frequency
Plant performance	not applicable	annual
Annual nitrogen load	composite	annual (based on 5 samples/month)
Floatables (being developed)	7-day composite	1/month
Oil and Grease	grab	weekly

Monitoring requirements in Ambient Monitoring Plan.
The Ambient Monitoring Plan details requirements (Table II-2.C) beyond those included in ordinary discharge monitoring. More frequent and additional nutrient measurements are required, and non-standard low-detection limit methods are used to measure toxic contaminants.

Table II-2.C Ambient Monitoring Plan parameters for effluent

Parameter	Sample type	Frequency
Nutrients		
Total Kjeldahl nitrogen	composite	weekly
Ammonia	composite	weekly
Nitrate	composite	weekly
Nitrite	composite	weekly
Total phosphorus	composite	weekly
Total phosphate	composite	weekly
Acid base neutrals	composite	bimonthly
Volatile Organic Compounds	grab	bimonthly
Low detection limit analyses		
Cadmium	24-hr composite	weekly
Copper	24-hr composite	weekly
Chromium	24-hr composite	weekly
Mercury	24-hr composite	weekly
Lead	24-hr composite	weekly
Molybdenum	24-hr composite	weekly
Nickel	24-hr composite	weekly
Silver	24-hr composite	weekly
Zinc	24-hr composite	weekly
17 chlorinated pesticides	24-hr composite	weekly
Extended list of PAHs	24-hr composite	weekly
LABs	24-hr composite	weekly
20 PCB congeners	24-hr composite	weekly

Special studies outlined in Ambient Monitoring Plan.
The Ambient Monitoring Plan calls for an evaluation of indicators of human pathogens, but does not explicitly define how MWRA must carry out this evaluation. MWRA has collected data for two projects that address this requirement:

- Anthropogenic viruses and viral indicators in DITP influent and effluent
- *Enterococcus* in DITP influent and effluent

The Ambient Monitoring Plan also calls for an evaluation of effluent tracers. MWRA is co-sponsoring, with Sea Grant, a University of Massachusetts and Tufts University study of endocrine disruptors in Deer Island influent and effluent, in Boston Harbor, and around the new outfall site (these data are not yet available). MWRA's investigators have also measured sulfur and nitrogen isotope patterns in effluent to help determine if nitrogen isotopes may be a useful tracer in evaluating a zone of effect of the effluent. MWRA evaluates proposals to study emerging potential effluent tracers on an ongoing basis as new scientific developments occur. Another special study with the Woods Hole Oceanographic Institution is examining the utility of a gel membrane sensor to detect what proportion of copper in the effluent is bioavailable (data not yet available).

II-3. Effluent Monitoring Results

This section presents results from all the types of effluent monitoring done by MWRA, including the more "routine" effluent monitoring, and more specialized testing required in the Contingency Plan and Ambient Monitoring Plan. Table II-3.A shows how Deer Island effluent quality has changed for "conventional pollutants." (Note that flows from DITP increased in FY99 when the Nut Island Treatment Plant was closed and south system flows transferred to DITP).

Table II-3.A Deer Island effluent characterization, FY94-FY02 (July 1993-June 2002)

Parameter	FY94*	FY95*	FY96*	FY97*	FY98*	FY99	FY00	FY01	FY02
Average flow (MGD)	249	236	250	265.0	296.2	349.7	356	367.3	316.6
Average concentrations									
TSS (mg/L)	73.0	65.0	44.0	41.2	25.4	21.5	17.8	15.4	16.0
cBOD (mg/L)	ND	117.5	82.5	72.7	27.2	22.5	15.0	12.2	13.0
Settleable Solids (ml/L)	0.5	0.4	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Total Kjeldahl Nitrogen (mg/L)	21.7	23.0	22.5	21.9	20.4	23.4	21.8	23.6	25.9
Ammonia Nitrogen (mg/L)	12.6	14.4	14.5	13.1	15.1	18.0	17.6	17.6	21.2
Nitrates (mg/L)	1.04	0.08	0.30	0.34	0.42	0.22	0.69	0.70	0.89
Nitrites (mg/L)	0.10	0.08	0.63	0.11	0.20	0.30	0.95	0.20	0.34
Orthophosphates (mg/L)	2.15	2.22	1.53	1.68	1.71	1.97	1.90	1.90	2.30
Total Phosphorus (mg/L)	2.92	3.35	3.42	2.90	2.77	2.93	3.00	2.80	3.10
Average loading (tons/day)									
TSS	52.1	45.3	27.0	28.7	16.8	14.2	26.5	23.6	21.1
cBOD	ND	114.5	87.1	82.4	32.6	34.0	23.8	19.4	16.9
Settleable Solids	0.4	0.3	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Total Kjeldahl Nitrogen	22.5	22.6	23.4	24.3	25.2	34.2	32.4	36.1	34.2
Ammonia nitrogen	8.97	10.05	8.88	9.12	9.97	11.90	26.16	27.00	28.00
Nitrates	0.74	0.06	0.18	0.23	0.28	0.15	1.03	1.10	1.20
Nitrites	0.07	0.06	0.39	0.08	0.13	0.20	1.41	0.30	0.40
Orthophosphates	2.23	2.18	1.60	1.86	2.11	2.87	2.82	2.91	3.04
Total Phosphorus	3.03	3.30	3.57	3.20	3.42	4.27	4.46	4.29	4.09

*North System only. FY99 and later include South System data.

Permit discharge monitoring results: compliance with regulatory limits

Table II-3.B summarizes the results of effluent monitoring since the permit was effective. Details of monitoring results for individual tests follow.

Table II-3.B Summary of effluent monitoring results for DMR reporting

Parameter	Permit limits	Monitoring Results		
		Sep 6 – Dec 31 2000	2001	2002
Toxicity	Acute: effluent LC50<50% for shrimp and fish Chronic: effluent NOEC for fish survival and growth and sea urchin fertilization <1.5% effluent	No violations	One violation of chronic fish growth and one violation of sea urchin fertilization	No violations
Fecal coliform bacteria	<14,000 fecal coliforms/100 mL (monthly 90th percentile, weekly geometric mean, maximum daily geometric mean, and minimum of 3 consecutive samples)	No violations	One violation of daily geometric mean level	No violations
Total suspended solids	no more than 45 mg/L weekly 30 mg/L monthly	No violations	No violations	Two weekly violations One monthly violation
Carbonaceous biochemical oxygen demand	no more than 40 mg/L weekly, 25 mg/L monthly	No violations	No violations	No violations
Residual chlorine	no more than 631 ug/L daily, 456 ug/L monthly	One daily violation = 900 ug/L; before automated feedback for dechlorination	No violations	No violations
pH	not <6 or >8	One violation = 5.8, sampling artifact	No violations	No violations
PCBs as Aroclor	Aroclor= no more than 0.045 ng/L	No violations	No violations	No violations
Average dry day flow	Flow no more than 436 MGD annual average of dry days	Not applicable	No violations	No violations

Whole effluent toxicity. The MWRA tests effluent toxicity every month at DITP. Effluent toxicity provides an overall view of effluent quality, ensuring that the effluent does not adversely affect the environment. In 1989, the EPA found that the probable cause of most acute toxicity in DITP's waste stream was due to surfactants. Surfactants are most commonly used in household detergents to improve cleansing power. No acute toxicity could be attributed to metals or pesticides.

The MWRA permit requires four tests for effluent toxicity testing. 48-hr acute static toxicity tests using the mysid shrimp (*Americamysis bahia*) and the inland silverside fish (*Menidia beryllina*) measure the short-term lethal effects caused by the effluent. A chronic survival and growth test using *Menidia* and a chronic fertilization test using the sea urchin (*Arbacia*

punctulata) both measure subtle toxic impacts over a longer period of time. The results of these tests for 2001 and 2002 are in Table II-3.C.

Table II-3.C Toxicity test results for Deer Island Treatment Plant effluent 2001 and 2002

	Acute toxicity LC50 (%) Permit limit minimum = 50%		Chronic toxicity NOEC (%) Permit limit minimum = 1.5%	
Month-year	*Menidia* (Inland silverside)	*Americamysis* (Mysid shrimp)	*Menidia* (Inland silverside) growth	*Arbacia* (Sea urchin) fertilization
January-01	100	100	50	1 (failure)
February-01	79.1	100	12.5	25
March-01	100	100	100	50
April-01	100	100	1 (failure)	100
May-01	100	100	50	25
June-01	76.3	100	50	50
July-01	75.2	100	50	25
August-01	87	100	25	6.25
September-01	82.4	100	25	100
October-01	69.5	100	6.25	50
November-01	63.1	100	25	100
December-01	68.3	70.7	50	*
January-02	97.7	95.6	50	25
February-02	100	100	50	100
March-02	100	100	25	100
April-02	100	100	100	25
May-02	100	100	50	50
June-02	72.2	100	50	100
July-02	68.3	100	50	100
August-02	68.3	100	50	50
September-02	100	100	50	50
October-02	100	100	50	100
November-02	64.9	100	50	100
December-02	100	100	50	100

*Not able to perform test due to lack of viable *Arbacia* gametes

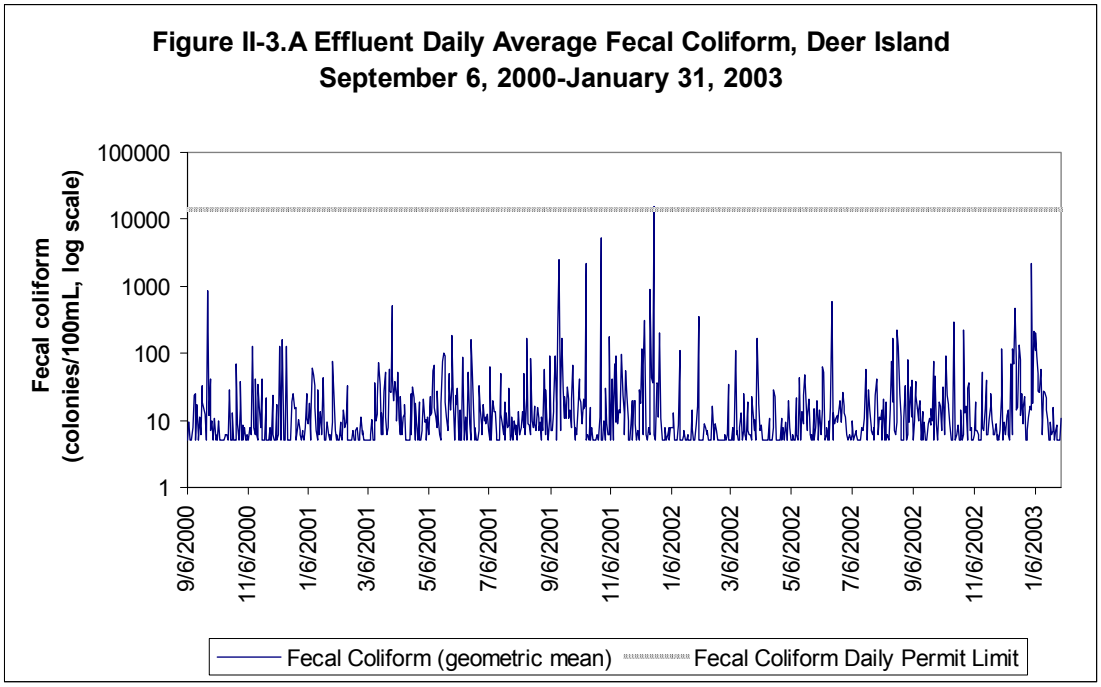
The LC50 (Lethal Concentration 50%) is the concentration of effluent in a sample that causes mortality to 50% of the test population during the duration of the test. The NOEC (No Observed Effect Concentration) is the concentration of effluent in a sample to which organisms are exposed in a life cycle or partial life cycle test that has no adverse effects. An NOEC limit of 1.5% means that 1.5% of the sample is effluent, and the remainder dilution water. Any acute LC50 below 50% or chronic NOEC below 1.5% would violate the NPDES limit.

There have been two toxicity test failures since the outfall began operating. In January 2001, the chronic sea urchin fertilization test failed, likely because the test organisms were in sub-optimal

condition. This test result is discussed in detail in the notification to EPA and DEP in MWRA's repository libraries and on the web at: http://www.mwra.com/harbor/pdf/px022301.pdf.

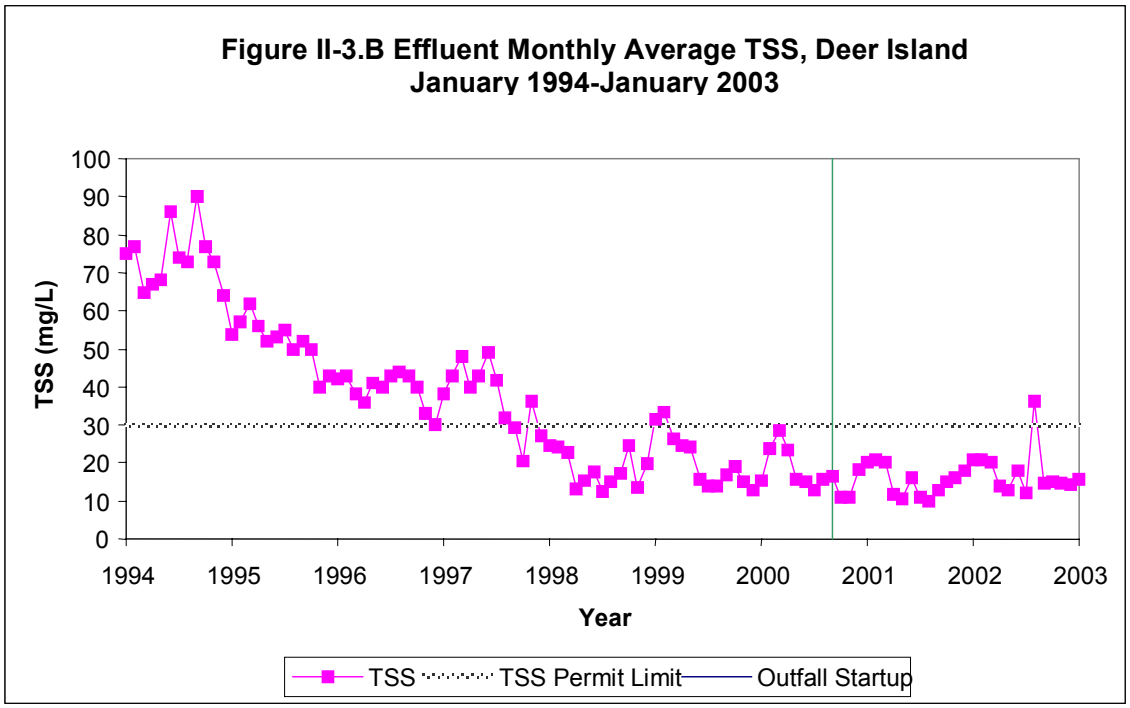
In April 2001, the inland silverside fish chronic growth test failed, but this result is likely to have been due to variability in the fish rather than to toxicity of the effluent. Detailed descriptions of these test results are discussed in detail in the notification to EPA and DEP in MWRA's repository libraries and on the web at: http://www.mwra.com/harbor/pdf/px051801.pdf.

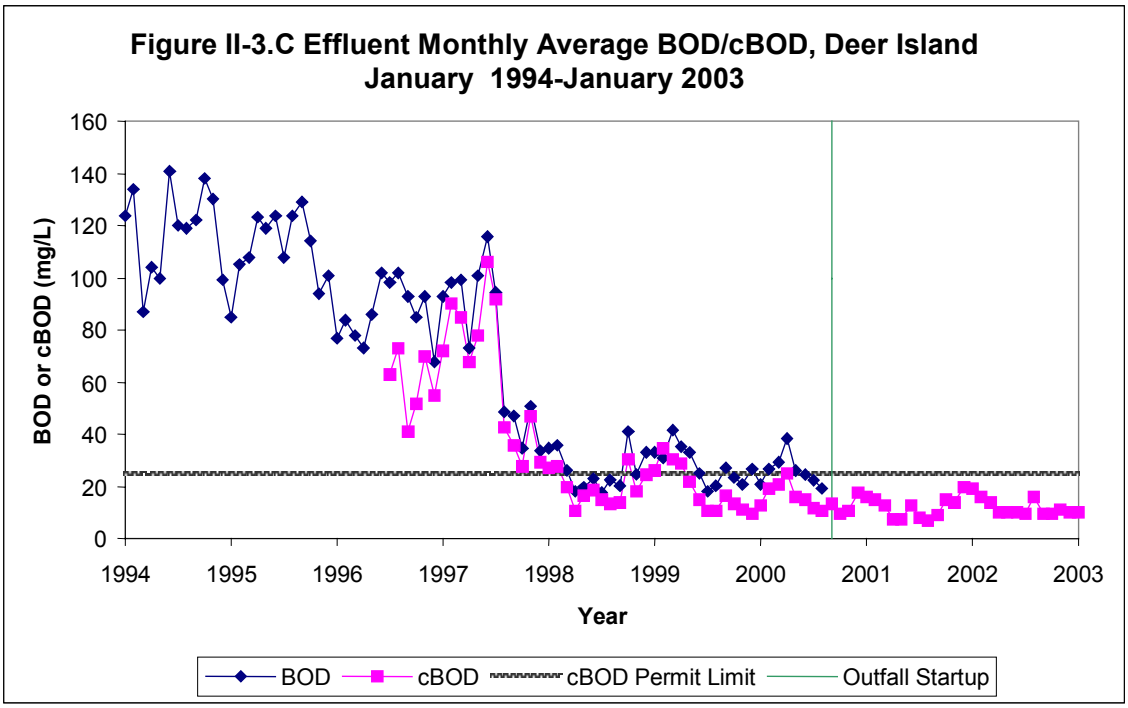
Fecal coliform. For fecal coliform, the daily geometric mean of three samples per day has a discharge limit of 14,000 colonies/100mL. Figure II-3.A shows average daily fecal coliform since the NPDES permit became effective in September 2001. There has been one permit violation of fecal coliform, on December 18, 2001, when the daily geometric mean for fecal coliform was 15,597 colonies/100mL. The cause of this violation was a brief drop in total chlorine residual in the disinfection basin due to increased plant flow. With less chlorine and greater wastewater volume, the effectiveness of disinfection fell, leaving greater numbers of fecal coliform bacteria in the effluent. Excepting the one permit violation noted above, the results for Deer Island have been well below the limit, for the monthly geometric means and for the additional limits for fecal coliform of not more than three consecutive samples measuring over 14,000 colonies/100mL and no more than 10% of the samples in a month measuring over 14,000 colonies/100 mL. These three limits were not approached.



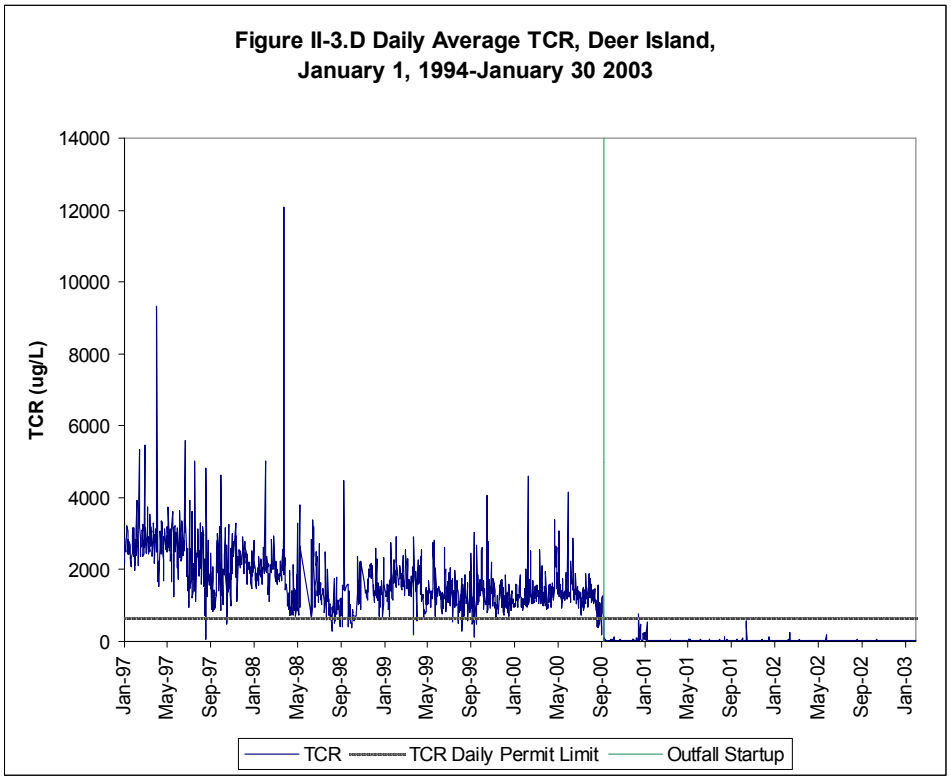
Total suspended solids and carbonaceous biochemical oxygen demand. For total suspended solids (TSS) and carbonaceous biochemical oxygen demand (cBOD), the permit limits monthly and weekly average concentrations. Figures II-3.B and II-3.C show that the monthly averages for TSS and cBOD generally were well below the regulatory discharge limits of 25 mg/L for cBOD and 30 mg/L for TSS for monthly average concentration. Both parameters have improved markedly from the historical trends before secondary treatment began in 1997.

In August, 2002, TSS exceeded the permit limitations (and by definition exceeded the Contingency Plan warning level thresholds) for weekly and monthly values. The high TSS in August, 2002 were caused by an "upset" of the secondary treatment plant process: high sulfate industrial waste discharged to the plant during an experiment caused an overgrowth of filamentous bacteria which prevented effective secondary treatment. See http://www.mwra.com/harbor/pdf/200208tpx.pdf for a detailed explanation of this exceedance and how it was handled at the treatment plant to minimize potential impacts. Note that there was no exceedance of BOD during that time period, reflecting the fact that secondary treatment, although compromised, was still removing oxygen-demanding constituents.





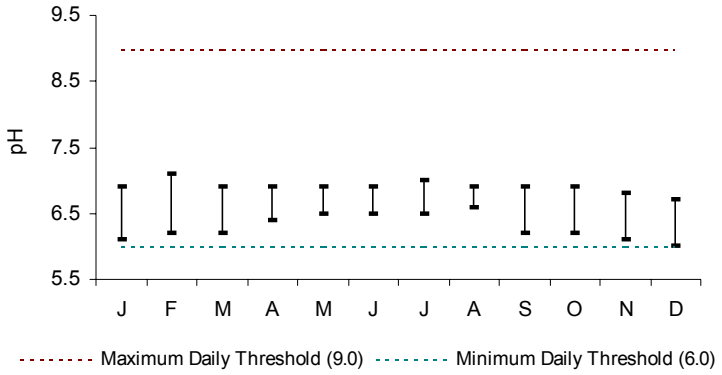
Total chlorine residual. Figure II-3.D shows how the chlorine residual in the effluent discharged from Deer Island has dropped dramatically since 1997. Chlorine is necessary for effective disinfection of the wastewater, but because it can have toxic effects on marine life it is



desirable to minimize the amount of chlorine remaining in the final effluent after treatment. As secondary treatment came on line, beginning in mid-1997, the amount of chlorine necessary for effective disinfection decreased. Then, when the new outfall began operating in September 2000, dechlorination also began, greatly reducing the chlorine residual.

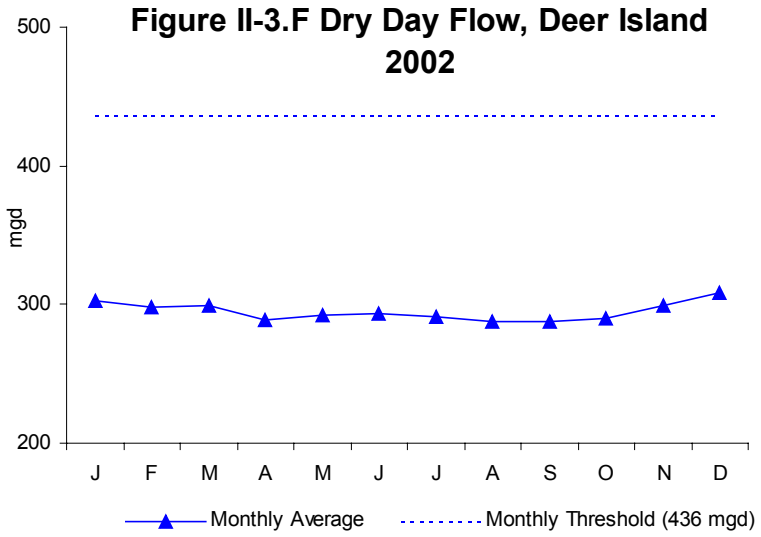
pH. DITP effluent tends to be acidic because the pure oxygen used in secondary treatment causes the production of relatively large amounts of CO_2, which when dissolved in the wastewater, increases its acidity. The CO_2 off-gasses as the effluent tumbles down the shaft from the treatment plant to the outfall tunnel. There was a single pH violation early in the operation of the outfall, because the sampling method was not allowing for a period of off-gassing. Since the sampling method was adjusted, pH measurements have been within permit limits. Figure II-3.E shows the range by month for daily pH for 2002.

Figure II-3.E pH in Deer Island Effluent, 2002

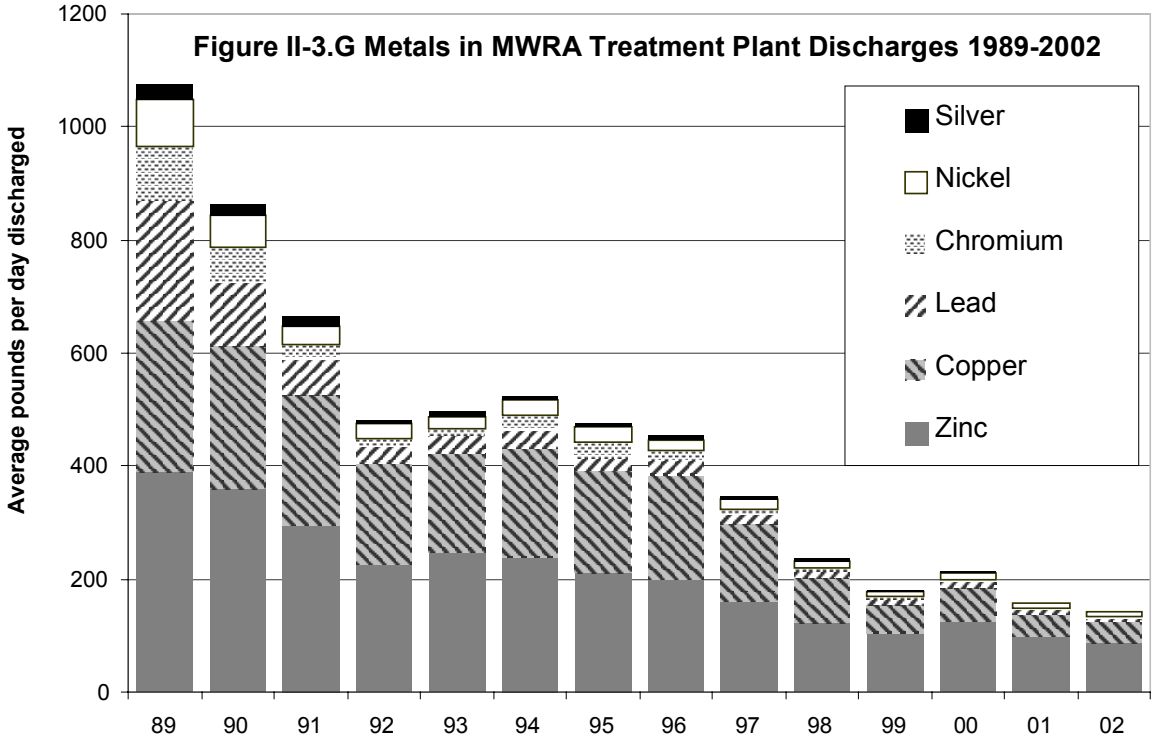


Aroclors. These PCBs have never been detected in MWRA effluent by EPA standard methods. However, PCBs are detected as part of the Ambient Monitoring Plan sampling, when specialized low-level detection methods are used; see Table II-3.F, and further discussion below.

Dry Day Flow. Average dry day flow has been well within permit limits (Figure II-3.F).



Priority pollutants (metals) in MWRA discharges. MWRA has no numerical limits for most priority pollutants, but must report on test results. Figure II-3.G shows how metals in MWRA effluent have dropped over time. Further discussion of priority pollutant results follows in the discussion of results of the low-detection level sampling required by the Ambient Monitoring Plan.

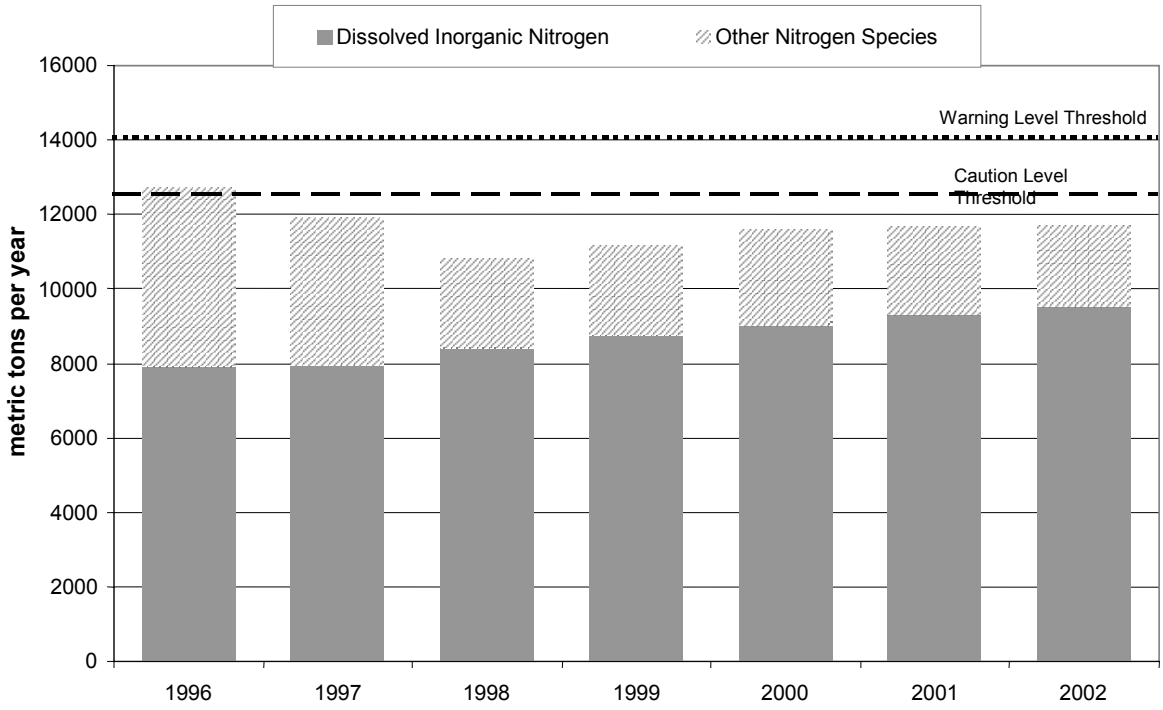


Contingency Plan Results

Plant performance. This Contingency Plan threshold assesses overall treatment plant performance; the Deer Island Treatment Plant meets the threshold if there are fewer than 5 permit violations in a year, thus qualifying for the American Metropolitan Sewerage Association's "Silver Award." DITP received the Silver Award in 2001, and is applying for the award for 2002, having had fewer than 5 violations.

Total nitrogen load. The total nitrogen load from MWRA treatment facilities has remained stable and below the Contingency Plan Caution Level threshold of 12,500 metric tons/year. (The Warning Level threshold is 14,000 metric tons/year.) Figure II-3.H shows that in 1996, before secondary treatment, total nitrogen would have exceeded the Caution Level threshold. Nitrogen levels have remained below 12,000 metric tons since secondary treatment began in 1997. The amount of dissolved inorganic nitrogen has increased since 1996, as anticipated, because secondary treatment converts organic nitrogen to inorganic nitrogen (ammonia + nitrate/nitrite).

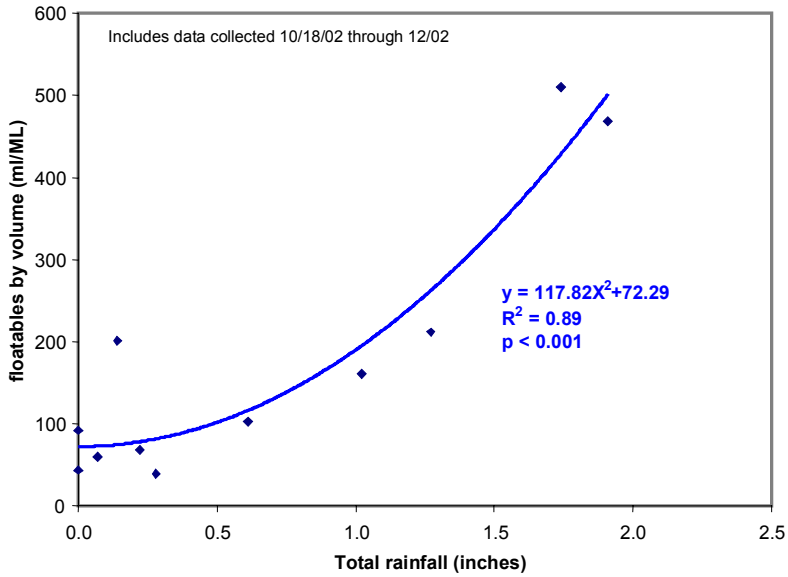
Figure II-3.H. MWRA Treatment Plant Nitrogen Discharges 1996-2002



Floatables. MWRA has designed and constructed a floatables sampling device which screens small bits of solid matter from the final effluent. The floatables threshold is still being developed. Although the sampling and measurement methods are still being refined, preliminary data indicate that:

- the floatables sampling device is working well, and gives a representative sample of what is discharged in the effluent;
- visual observations confirm that most of the material is broken into small pieces, less than an inch in diameter;
- floatables of special concern (condoms, plastic bags) are very rarely found;
- the average amount of floatables discharged is 11 gallons or 12 kg per 100 mgd;
- approximately 86% of this material (by weight) is degradable, and 14% is non-degradable
- thus, on average, about six gallons of non-degradable floatables are discharged per day;
- volume and weight of total floatables are highly and consistently correlated during normal plant operations; and
- the proportion of floatables in the effluent increases with rainfall events, and can be described by a polynomial equation, as shown in **Figure II-3.I**. (When DITP reaches its maximum pumping capacity of 1,200 mgd, the amount of flow, and presumably floatables reaches a maximum.)

Figure II-3.I Effluent floatables are a function of rain



Oil and Grease. A second measure of effluent quality in the Contingency Plan is oil and grease, measured as petroleum hydrocarbons (PHC). As shown in Figure II-3.J, and Table II-3.D PHC has averaged less than 0.2 mg/L, well below the 15 mg/L threshold.

Figure II-3.J Petroleum Hydrocarbons in DITP effluent

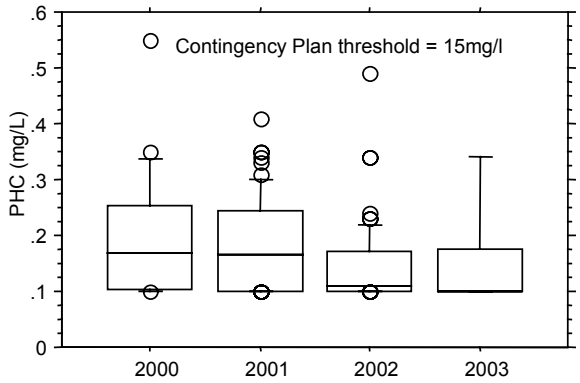


Table II-3.D Petroleum Hydrocarbons in DITP effluent, descriptive statistics (mg/L)

	All years	2000	2001	2002	2003
Mean	.167	.201	.181	.144	.152
Std. Dev.	.085	.116	.083	.070	.105
Std. Error	.007	.027	.010	.009	.047
Count	153	19	64	65	5
Minimum	.100	.100	.100	.100	.100
Maximum	.550	.550	.410	.490	.340

Ambient Monitoring Plan Results: Detailed effluent characterization study, using low detection limit methods.

Metals

Low detection limit effluent monitoring for metals is conducting using NPDES approved methods, based on inductively coupled plasma atomic emission spectrometry (ICP) or graphite furnace atomic absorption spectrometry (GFAA).

Priority pollutant concentrations in Deer Island effluent are very low. Table II-3.E compares concentrations of priority pollutant metals in DITP effluent to water quality criteria.

Table II-3.E. Comparison of Deer Island Treatment Plant effluent to water quality criteria FY02 (July 2001-June 2002)

Acute

	Total Recoverable Maximum (ug/L)	Total Dissolved Maximum (ug/L)	Dilution	Estimated Concentration in ZID	Acute Criteria*** (ug/L)	Times Detected
Arsenic	0.4	0.4	50	0.008	69	0 of 23
Copper	22.2	18.4	50	0.37	4.8	87 of 107
Lead	4.3	4.1	50	0.082	210	5 of 75
Mercury	0.053	0.045	50	0.0009	1.8	74 of 88
Nickel	5.38	5.33	50	0.11	74	76 of 76
Silver	1.06	0.901	50	0.018	1.9	72 of 75
Zinc	51.2	48.4	50	0.97	90	75 of 75

Chronic

	Total Recoverable Average (ug/L)	Total Dissolved Average (ug/L)	Dilution	Estimated Concentration in ZID	Chronic Criteria*** (ug/L)	Times Detected
Arsenic	0.4	0.4	70	0.006	36	0 of 23
Copper	12.6	10.5	70	0.15	3.1	87 of 107
Lead	1.38	1.31	70	0.019	8.1	5 of 75
Mercury	0.0181	0.0154	70	0.00023	0.94	74 of 88
Nickel	2.7	2.7	70	0.038	8.2	76 of 76
Silver	0.309	*	70	*	**	72 of 75
Zinc	27.7	26.2	70	0.37	81	75 of 75

ZID: Zone of Initial Dilution
* No applicable conversion factor
** No applicable criteria
*** Criteria from National Recommended Water Quality Criteria for Priority Toxic Pollutants, Federal Register, December 10, 1998
Total Dissolved Max Conc (Col D) = Total Recoverable Max Conc (Col C) * Criteria Maximum Concentration (CMC, see below)
Total Dissolved Avg Conc (Col D) = Total Recoverable Average Conc (Col C) * Criteria Continuous Concentration (CCC, see below)

Conversion factors for "Acute" and "Chronic"

	CMC	CCC
As	1	1
Cu	0.83	0.83
Pb	0.951	0.951
Hg	0.85	0.85
Ni	0.99	0.99
Ag	0.85	*
Zn	0.946	0.946

Federal Register 12/10/98, 98-30272

The majority of priority pollutant parameters were below detection levels. Those that were detected had relatively low concentrations. All of the maximum values measured, except for copper, met acute receiving water quality criteria in effluent *before dilution*. All the average values, except for copper, met the chronic receiving water criteria in the effluent *before dilution*. The water quality criteria apply *after* initial dilution (at the outfall, the acute initial dilution is approximately 50:1, chronic is 70:1). Attachment S in the NPDES permit gives calculation details for estimating the receiving water concentrations based on effluent concentrations.

Organic Contaminants

Low detection limit effluent monitoring for organic contaminants includes pesticides, polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAH), semivolatile organics (ABN), and volatile organics (VOA). The analytical methods for organics are derived from the EPA methods approved for the NPDES program, but modified to achieve increased sensitivity. In particular, selected ion monitoring (SIM) gas chromatography / mass spectrometry (GC/MS) is used to increase the sensitivity of the PAH method.

Twenty-four hour composite samples of Deer Island Treatment Plant (DITP) effluent are collected at least weekly and tested for most organic parameters. Due to their volatility, VOA samples collected as grab samples in samples twice a month.

DITP effluent results for organic parameters for FY02 are summarized in Table II-3.E with all concentrations in parts-per-trillion (ng/L).

Volatile Organic contaminants. (VOA). Six of 43 VOA parameters were detected in 25 grab samples. Detected contaminants were at low parts-per-billion (µg/L) concentrations, and none of these contaminants have water quality criteria for toxicity to marine life. The maximum observed value for tetrachloroethene slightly exceeded the 10^{-6} human health criteria for this compound *before dilution* of the effluent.

Semivolatile Organics (ABN). Only one ABN parameter was detected, in one of 25 samples collected during FY02. Bis(2-ethylhexyl)phthalate (BEHP) was detected in a sample collected 14-Sep-2001 at 14 µg/L. This exceeds the 10^{-6} human health criteria for BEHP (5.9 µg/L) by about a factor of two *before dilution* of the effluent.

Table II-3.E. Comparison of Deer Island Treatment Plant effluent to water quality criteria FY02 (July 2001-June 2002)

Component	N of samples Detected	Maximum of samples detected (ng/L)	Mean of samples detected (ng/L)	Acute Criteria ** (ng/L)	Chronic Criteria **	Human Health Criteria** (ng/L)
Acetone	23 of 25	28,000	8,040	B	B	B
Carbon Disulfide	1 of 25	5,610	5,610	B	B	B
Chloroform	24 of 25	8,580	6,170	B	B	470,000
Methylene Chloride	9 of 25	5,890	3,570	B	B	1,600,000
Tetrachloroethene	20 of 25	12,800	5,480	B	B	8,850
Toluene	1 of 25	2,810	2,810	B	B	200,000,000
Bis(2-ethylhexyl)phthalate	1 of 25	14,000	14,000	B	B	5,900
Total NOAA PAH	52 of 52	1,274	285	B	B	B
Chrysene	52 of 52	67.9	17.5	B	B	49
Phenanthrene	52 of 52	226	26.8	B	B	B
Chlordane	48 of 62	58.2	4.67	90	4	2.2
04,4'-DDT	7 of 62	1.49	0.58	30	1	0.59
Lindane	51 of 62	9.7	2.06	160	B	63
Heptachlor	6 of 62	6.27	2.87	90	4	0.21
Total DDT	40 of 62	4.27	1.33	B	B	B
Total PCB	42 of 59	5.72	1.30	B	30	0.17

B - No applicable criteria

** National Recommended Water Quality Criteria for Priority Toxic Pollutants, Federal Register, December 10, 1998

Polycyclic aromatic hydrocarbons (PAH). Certain individual PAHs are routinely detected in DITP effluent samples at sub-parts-per-billion concentrations. These results are summarized in Table II-3.E as "Total NOAA PAH" because this is the grouping used in the Contingency Plan threshold for mussels. The NOAA PAH are 24 individual PAH components. None of these have water quality for toxicity to marine life, but seven of the 24 have been listed as probable human carcinogens and are assigned a value of 49 ng/L as 10^{-6} human health criteria (HHC). The average measured concentrations for all seven of these compounds were below the HHC during FY02, with mean measured concentrations ranging from 10% to 40% of the HHC *before dilution*. Chrysene, which had the highest measured single sample concentration amongst the seven for the year, is listed as an example in Table II-3.E. Phenanthrene, which had the highest measured single sample concentration amongst the other 17 PAH, is also listed as an example in Table II-3.E.

Pesticides. A few individual pesticides are detected in DITP effluent at parts-per-trillion (ng/L) levels. Chlordane, lindane (gamma-BHC), 4,4'-DDD, and 4,4'-DDE were frequently detected during FY02. The maximum detected concentration of lindane was well below the acute water quality criteria and the average measured concentration was well below the HHC for this compound. The average detected concentration of 4,4'-DDT in seven samples that had detectable levels was slightly below the HHC *before dilution* as well.

Chlordane is measured as the sum of six individual components in MWRA effluent (cis- and trans-chlordane, cis- and trans-nonachlor, heptachlor and heptachlor epoxide). Some or all of

these were detected in 48 of 62 effluent samples. The average measured concentration exceeded both the chronic water quality criteria and the 10^{-6} human health criteria before dilution.

Polychlorinated biphenyls (PCBs). The NPDES-approved methods for PCBs are based on detecting and quantifying the Aroclors, which are industrial mixtures of PCBs. There is no NPDES approved method for Total PCB or for individual PCB congeners. There are a total of 209 possible PCB congeners, but only about 140 congeners are found in the virgin industrial mixtures. Due to the multiplicity of possible sources, weathering, and possible biological transformation, detecting Aroclors is not reliable as a measure of the Total PCB content of DITP effluent.

MWRA developed a method for determining 67 individual PCB congeners based on dual-column gas chromatography with electron capture detection (GC/ECD). This method is capable of detecting sub-parts-per-trillion (ng/L) levels of these congeners. Samples are tested using the 67-congener list on a monthly basis, and for a shorter list of congeners that matches those analyzed in the tissue and sediment samples on a weekly basis.

PCBs as Aroclors is the only organic contaminant that has a numeric discharge limit in the DITP NPDES permit. The limit is 0.045 ng/L based on the human health criterion and the expected amount of effluent dilution. Aroclors have not been detected in a DITP effluent sample since the current NPDES permit went into effect. However, the 1998 revised water quality criteria are intended to be compared to a sum of congeners or homologues. The average concentration of PCB congeners detected exceeds the HHC value before dilution of the effluent. Some recent high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS) data indicates that PCB data for the effluent may be strongly impacted by positive interferences. MWRA will be looking in to this issue further.

Trends in priority pollutants

The low-level detection analyses enable MWRA to detect trends, for example Figures II-3.K and II-3.L show how mercury loadings and PAH loadings in MWRA effluent have decreased, respectively, as the proportion of effluent receiving secondary treatment has increased.

Low-detection level analyses for the pesticide chlordane (Figure II-3.M) show that the levels in DITP effluent, although low, increase during the summer, possibly indicating increased use or disposal of this banned chemical during the gardening season.

Figure II-3.K Mercury loading in DITP effluent as a function of secondary treatment

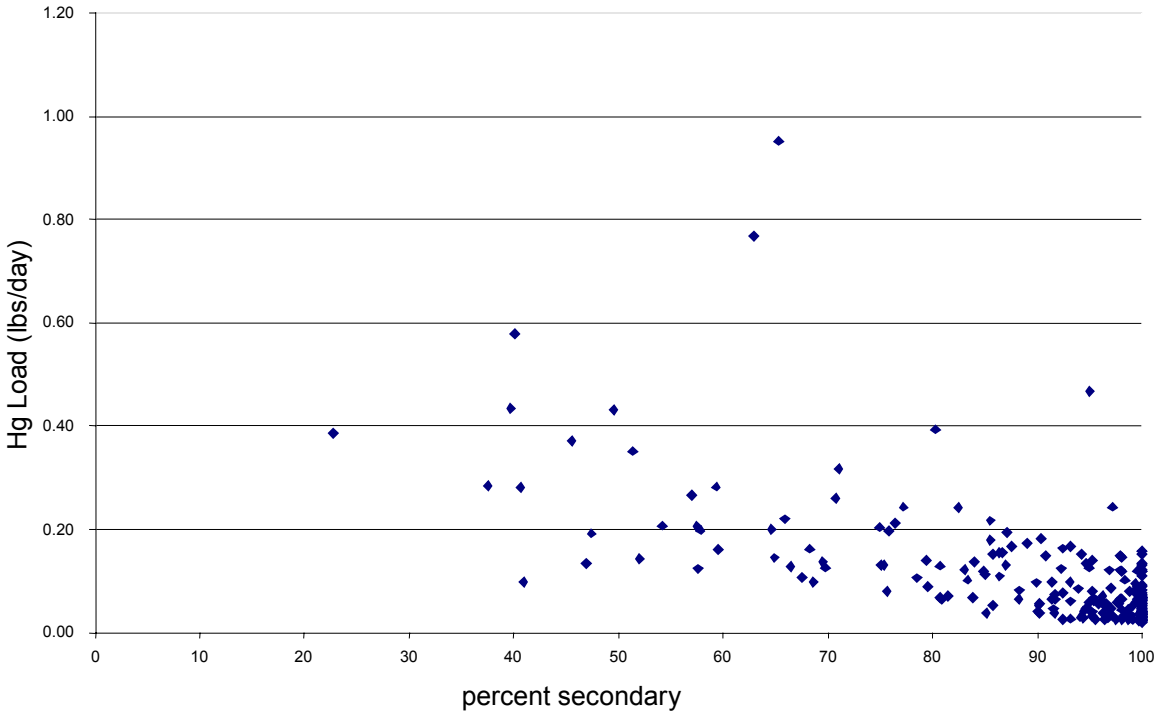
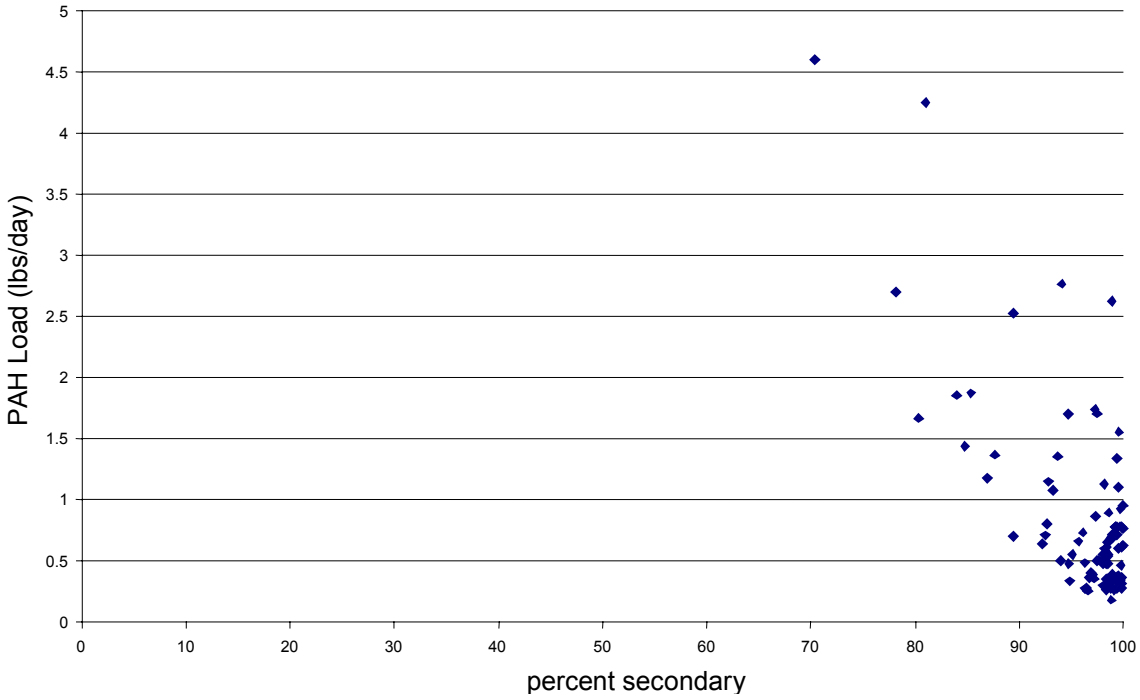
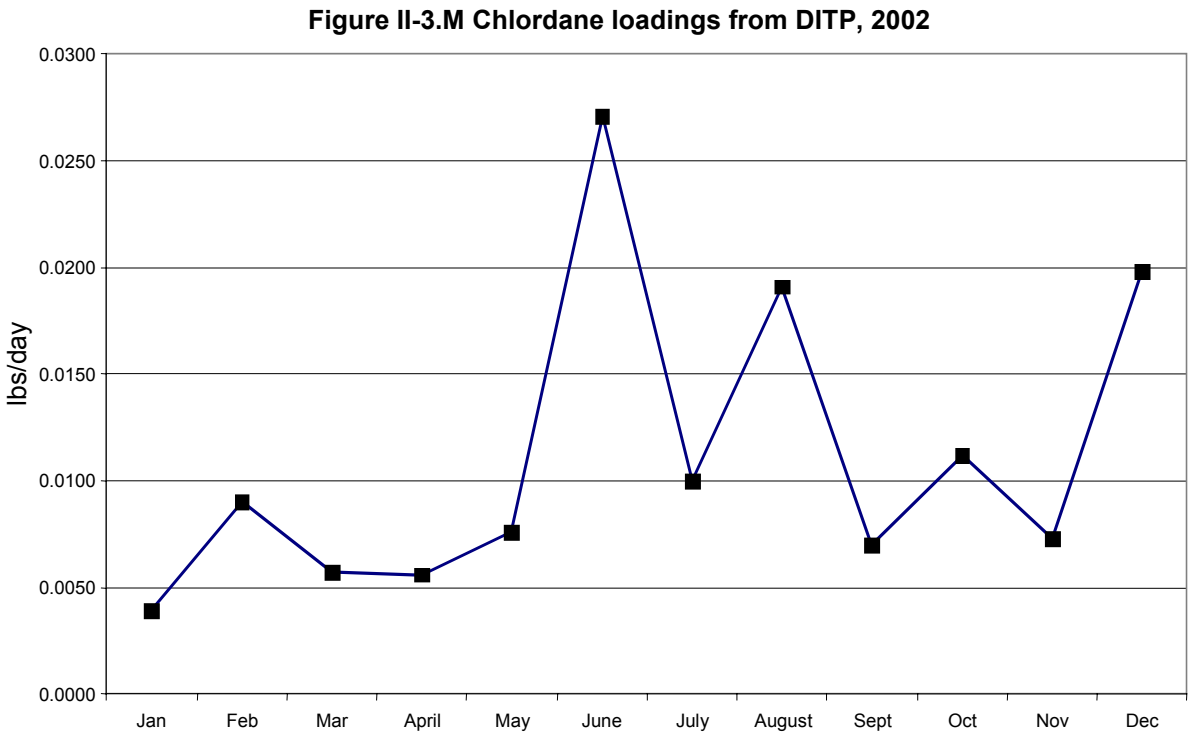


Figure II-3.L PAH loading in DITP effluent as a function of secondary treatment





Ambient Monitoring Plan: Special Effluent Studies

Pathogens and their indicators: *Enterococcus*, anthropogenic viruses and bacteriophage.

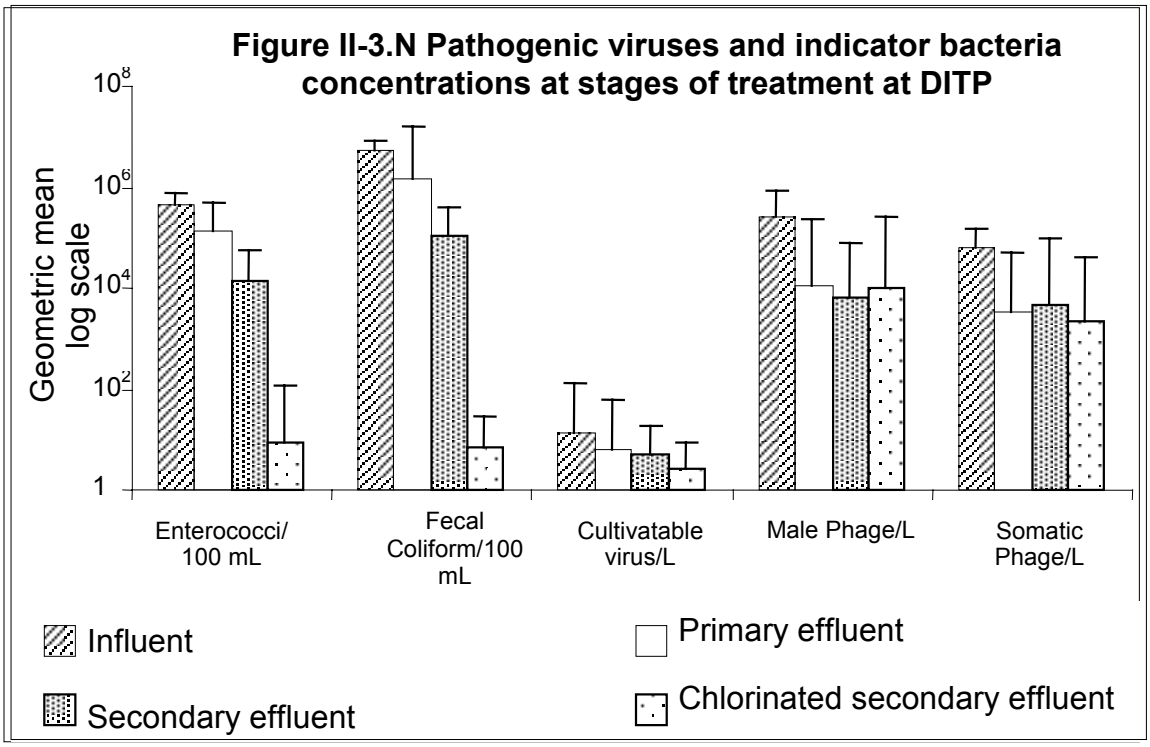
Massachusetts Water Quality Standards use fecal coliform bacteria counts as the indicator of the risk of human pathogens; therefore the Deer Island discharge must meet permit limits for fecal coliform. The Ambient Monitoring Plan calls for an evaluation of other indicators of human pathogens. Together with virologists at the University of New Hampshire, MWRA has conducted studies of the following pathogens: cultivatable enteroviruses including poliovirus, coxsackie virus and echovirus; adenovirus 40/41; rotavirus; and astrovirus. Samples are collected from influent and effluent to assess the presence of human pathogens in raw wastewater and the effectiveness of treatment on pathogen removal. Detailed descriptions of the methods used in this study are on the web at http://www.mwra.com/harbor/enquad/pdf/ms-073.pdf . In addition to the pathogens, MWRA studies four pathogen indicators: male-specific bacteriophage, somatic bacteriophage, and the indicator bacteria *Enterococcus* spp and fecal coliform. (MWRA also monitors the presence of pathogens and indicators in Boston Harbor and Massachusetts Bay, but this discussion is restricted to effluent monitoring.)

Bacteriophage have been suggested by some investigators as indicators that may better mimic the behavior of viral pathogens during treatment and in the environment than do bacterial indicators. Table II-3.G shows the units of measurement for each parameter, and the arithmetic and geometric mean values found in DITP wastewater at each stage of treatment.

Table II-3.G Changes in bacteria and virus counts in Deer Island wastewater through the treatment process.

	Arithmetic Mean Geometric Mean			
	Influent	Primary effluent	Secondary effluent	Chlorinated secondary effluent
Enterococcus (Col/100mL)	457,000 500,000	135,000 205,000	14,000 24,300	9 88
Fecal Coliform (Col/100mL)	5,130,000 5,550,000	1,410,000 3,350,000	112,000 175,000	7 12
Cultivatable Virus (MPN/L)	13.2 37.93	6.3 54.26	4.9 7.26	2.75 3.88
Male Phage (PFU/L)	246,000 408,000	11,500 103,000	6,460 56,000	10,000 75,700
Somatic Phage (PFU/L)	60,300 82,100	3,390 42,800	4,680 34,400	2,090 14,100

These data are also shown as bar graphs with standard errors indicated in Figure II-3.N.

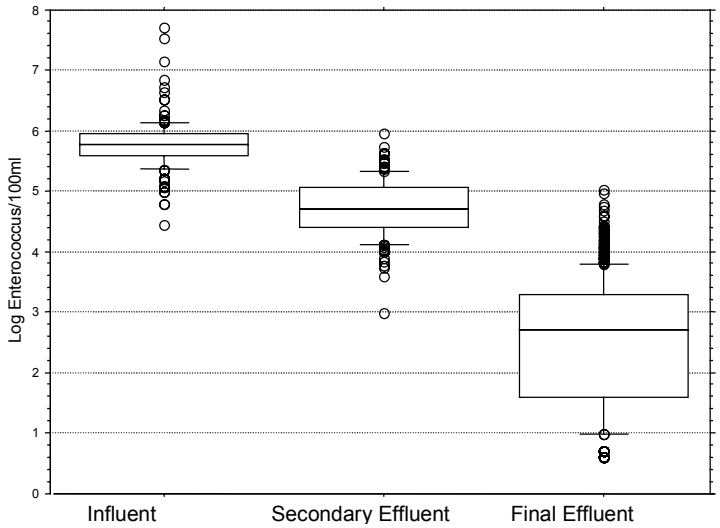


These microorganisms differed in their responses to the three phases of treatment. The bacteria indicators fecal coliform and enterococci showed large and significant decreases in counts as

treatment progressed: secondary treatment decreased average counts 10-fold, and disinfection of the effluent further decreased average counts 1,000-fold. For pathogenic cultivatable viruses, although the error bars overlap, the biggest difference in counts was after secondary treatment, with a relatively small effect of disinfection. For both the bacteriophages, the biggest change in numbers was after primary treatment, with little effect of either secondary treatment or disinfection. Again, the error bars overlap. These data suggest the indicator bacteria do not respond to treatment the same way the viral pathogens do, but that phages are not a better indicator of the presence of pathogenic viruses than are indicator bacteria.

Figure II-3.O shows results from all the *Enterococcus* samples in Deer Island wastewater collected after the new outfall went on-line. The box plots show frequency distributions of daily geometric means. Although *Enterococcus* are effectively reduced by secondary treatment and disinfection, about 10% of the samples exceed 10^4 col/100 ml. EPA recommends that *Enterococcus* be used to indicate the presence of human health risk in marine waters. In the future, Massachusetts may change its standard from fecal coliform to *Enterococcus* for marine waters. (The FDA shellfish program still requires the measurement of fecal coliform in monitoring shellfish-growing waters.) Although it is not possible to predict what a permit limit would be,[1] the box plot shows that at the present level of chlorination (which consistently results in low levels of fecal coliform) it is likely that about 10% of samples would exceed an *Enterococcus* criterion. Thus, future use of the *Enterococcus* indicator may necessitate higher levels of chlorination (and more sodium bisulfate for dechlorination).

Figure II-3.O. Deer Island Treatment Plant *Enterococcus* counts, September 5, 2000-December 31, 2002



[1] If EPA criteria were applied in a manner comparable to the existing fecal coliform limit a criterion of 35 col/100 ml (which applies at a bathing beach), times a dilution factor of 70 would give a hypothetical 2,450 col/100 ml limit in effluent. If the EPA suggested criterion for "infrequent full body contact" of 500 col/100 ml were used, the hypothetical limit could be 35,000 col/100 ml. The existing permit limit for fecal coliform is 14,000 col/100 ml.

Reporting on effluent quality. Results of effluent monitoring required by MWRA's permit and Contingency Plan are reported to regulatory agencies, OMSAP, and the public rapidly and in a variety of communication vehicles. MWRA's routine monthly discharge monitoring reports are placed in repository libraries in Hyannis and at MWRA headquarters, and are published on MWRA's website at:http://www.mwra.com/harbor/html/ditp_performance.htm.
A unique requirement in MWRA's discharge permit is that all treatment plant permit violations are reported within five days to regulatory agencies, OMSAP and the public, and noticed on MWRA's website and in repository libraries. In addition, EPA maintains a listserve which actively notifies those on the list of a permit violation. Quarterly Contingency Plan effluent reports are posted on MWRA's web site at: http://www.mwra.com/harbor/pdf/cpqeff.pdf and are also placed in the repository libraries. Annual summary reports of NPDES compliance, that give detailed effluent quality data are available on MWRA's web site at: http://www.mwra.com/harbor/enquad/. Finally, the annual Outfall Monitoring Overview, published each year, summarizes effluent quality data and effluent Contingency Plan results. The most recent Outfall Monitoring Overview is available at repository libraries and on the web at http://www.mwra.com/harbor/enquad/pdf/2002-18.pdf.

II-4 Conclusions and Recommendations

MWRA's effluent monitoring is intensive and thorough. The "normal" conventional and priority pollutant constituents are measured frequently (for example, most facilities only measure whole effluent toxicity quarterly while DITP carries out these tests monthly). In addition, MWRA is on the "cutting edge" of effluent quality monitoring in several areas:

- low detection-limit measurements of toxic contaminants
- developing a sampling method for quantifying "floatables"
- measuring viral pathogens, bacteriophage and *Enterococcus.*

The results of effluent monitoring show that

1. DITP is operating as designed, and consistently meets permit limits and Contingency Plan thresholds.
2. Discharges of solids and BOD have decreased by 80%, compared to the old treatment plants.
3. Discharges of priority pollutants are well below SEIS predictions, and in most cases meet receiving water quality criteria even before dilution.
4. Low detection level effluent analyses of PAH, pesticides and PCBs help MWRA to define an effluent signature. Changes in the treatment plant performance are detectable over much shorter time scales than can be expected with sediment and tissue monitoring. Characteristic ratios of various PAH components, PCB congeners and pesticide components should also help to separate the MWRA contribution from other sources of these parameters to Massachusetts Bay over time.
5. Total nitrogen discharges have decreased slightly, and the amount of dissolved inorganic nitrogen species has increased about 10% as expected with secondary treatment
6. Pathogenic viruses are detectable in final effluent, but at very low numbers: secondary treatment effectively removes pathogens.

MWRA has found that the ability to detect trace levels of contaminants in its effluent aids in the interpretation of other ambient monitoring data, especially for evaluation of fish and shellfish data and toxicity testing. The pattern of certain organic contaminants can help determine whether MWRA effluent might be a source of contamination found in the environment. The effluent data provide valuable feedback to the treatment plant operators and the pollution prevention team. MWRA is recommending no changes to the Ambient Monitoring Plan Effluent Monitoring projects at this time.

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